ARHAI Scotland

Antimicrobial Resistance and Healthcare Associated Infection

NHS National Services Scotland

Hospital onset COVID-19 mortality in Scotland

7 March 2020 to 31 December 2021

Publication date: 2 March 2022

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Introduction

Antimicrobial Resistance and Healthcare Associated Infection (ARHAI) Scotland, part of National Services Scotland, works closely with Public Health Scotland to deliver the COVID-19 response. This sixth release provides data for COVID-19 hospital onset mortality in Scotland for the period 7 March 2020 to 31 December 2021. A report for period 1 July 2020 to 30 September 2020 was not published due to the small number of COVID-19 cases during this time.

Nosocomial transmission of SARS-CoV-2 has contributed significantly to the overall burden of infection within hospital settings. To help to understand nosocomial risk, ARHAI Scotland publish a weekly report on **COVID-19 hospital onset cases** and a monthly rapid review of literature that includes **epidemiology of COVID-19 in healthcare settings**. Deaths occurring in patients with COVID-19 are an important measure of patient outcome. Therefore, monitoring COVID-19 mortality in hospital patients and publishing the data is critical in the development and monitoring of local and national improvement plans to improve patient outcomes, inform the development of infection prevention and control measures and remobilisation plans, and shape policy and guide research.

This report describes 28-day all-cause mortality in cases of COVID-19 that were identified during an inpatient stay in an NHS hospital in Scotland, including those cases which are thought to have developed the infection as a result of nosocomial transmission.

Main points

- Different methodologies are employed to measure mortality in cases of COVID-19. This report uses 28-day all-cause mortality in laboratory confirmed cases of COVID-19 rather than deaths where suspected or confirmed COVID-19 is listed on the death certificate. This methodology is aligned with the daily reporting of deaths by Public Health Scotland.

- Overall, nearly a quarter of patients who were diagnosed with COVID-19 during an inpatient stay died within 28 days of their first positive test for SARS-CoV-2.

- Just over a quarter of patients who developed probable or definite hospital onset COVID-19 died within 28 days (28.2%). The difference in all-cause mortality between the onset categories can be explained by differences in the demographics of cases. Cases with probable or definite hospital onset COVID-19 are older than cases diagnosed in the first two days of admission to hospital and it would be anticipated that these patients are sicker as they require hospital care.

- After statistical analysis there is no evidence that patients developing nosocomial COVID-19 (probable or definite hospital onset status) are at an increased risk of death compared with other patients diagnosed with COVID-19 on day 1 or 2 of admission (non-hospital onset status).

- After controlling for potential confounding effects of hospital onset status (when the patient first tested positive during their admission), age, sex, patient co-morbidities (Charlson score) and vaccination status, patients who were first diagnosed with COVID-19 in hospital had lower odds of death within 28 days in waves 2 and 3 compared with wave 1.

- The effect of the COVID-19 vaccine on preventing severe outcomes is evident in these analyses. Inpatients who had been vaccinated with either one, two, or three doses had had lower odds of death within 28 days compared with those who had not been vaccinated. Protection from severe outcome by vaccination, particularly in hospital inpatients and those at risk of hospitalisation, is critical to reducing poor outcomes in patients who develop COVID-19, including nosocomial COVID-19.

- Nosocomial cases of COVID-19 have already been in hospital for 8 days or more for another reason prior to testing positive for SARS-CoV-2. These patients are also more likely to die from other causes and these are not distinguished in all-cause mortality estimates.

- Asymptomatic testing for SARS-CoV-2 has increased since the beginning of the pandemic. This will have increased case ascertainment including those with mild or asymptomatic disease who may have a lower risk of dying from COVID-19. It was not possible to distinguish between symptomatic cases and asymptomatic cases identified by testing policies, nor control for this during these analyses.

- Preventing transmission of SARS-CoV-2 in all settings is critical to reducing morbidity and mortality from COVID-19. Infection prevention and control precautions and early detection and management of cases is vital in efforts to reduce the spread of SARS-CoV-2 in hospital settings.

Results and commentary

COVID-19 deaths by hospital onset status

A total of 22,077 cases of COVID-19 diagnosed during an inpatient stay in Scotland between the first case identified in hospitals on the 7 March 2020 and 31 December 2021 were able to be linked for analysis. This includes 3,396 cases for the period October 2021 to December 2021. The total number of these patients who died within 28 days (all-cause) for the period 7 March 2020 to 31 December 2021 was 5,049 (22.9%) which includes 483 deaths from cases occurring in the period October 2021 to December 2021 (14.2%).

Cases of COVID-19 were categorised based on date of first positive SARS-CoV-2 PCR test following admission to a health board. Patients where the first positive sample was taken on day 1 or 2 of admission were considered most likely to have acquired SARS-CoV-2 in the community. For patients where the first positive sample was taken on days 3-7 (indeterminate hospital onset), it is not possible to determine where acquisition was likely to have taken place, i.e. in the community or during their hospital stay. Patients where the first positive samples were taken on days 8-14 (probable hospital onset) and days 15+ (definite hospital onset) are likely to have acquired SARS-CoV-2 via nosocomial transmission within the health board.

A total of 1,986 patients with probable or definite hospital onset COVID-19 died within 28 days of their first positive sample (28.2%) since March 2020. Mortality was highest among patients with probable (28.9%) or definite hospital onset COVID-19 (27.9%) when compared to non-hospital onset mortality ($p<0.001$, unadjusted for confounding) (**Table 1**). Cases and deaths included in each pandemic wave (wave 1: specimen date ≤26/07/2020; wave 2: specimen date >26/07/20 & ≤16/05/21; wave 3 >16/05/2021) are shown in **Table 2**. The distribution of 28-day all-cause mortality by age and sex for each of the hospital onset categories is described in **Table 3**. The highest unadjusted all-cause mortality was reported in male patients ($p<0.001$, unadjusted for confounding) and in older age groups, where risk of death increased with increasing age ($p<0.001$, unadjusted for confounding). This is in line with the outputs from the logistic regression model described below (**Appendix 3**). Patients in older age groups are more likely to die from other causes and

these are not distinguished in all-cause mortality estimates. The median age of patients who died following a probable or definite hospital onset COVID-19 diagnosis (79 years) was higher than those patients with likely community acquisition (day 1 or 2 of admission) (68 years, unadjusted p<0.001).

A logistic regression model was developed to adjust for potential confounding between the onset categories (**Appendix 3**). The model included all cases of COVID-19 identified during an inpatient hospital stay and the reference group was selected as those cases thought most likely to have acquired the infection in the community (day 1 or 2 of admission). The pandemic wave was included as survival may have improved as knowledge of the course of the infection improved or the severity of disease changed over time. The vaccination status was also included in the model to adjust for the effects of the vaccine on reducing severe outcomes including the risk of dying.

After adjustment for the confounding effects of age, sex, co-morbidities (Charlson score), vaccination status and pandemic wave, there was no significant difference between all-cause mortality in cases of indeterminate, probable and definite hospital onset COVID-19 compared with patients diagnosed with COVID-19 during the first 2 days of their admission to the health board (where the inpatient most likely acquired the virus in the community). Age, sex, co-morbidity, vaccination status and pandemic wave were all significantly associated with 28-day all-cause mortality. The model results are presented in **Appendix 3**. All-cause mortality was lower in waves 2 and 3 compared with wave 1, after adjustment for case mix (age, sex, co-morbidities, vaccination status, where patient likely acquired the virus based on hospital onset status). Patients who had been vaccinated with either one (p=0.001), two (p<0.001), or three (p<0.001) doses had had lower odds of death within 28 days compared with those who had not been vaccinated after adjustment for potential confounding.

The introduction of the vaccination programme has reduced the risk of severe COVID-19 and the risk of dying. Inpatients who had been vaccinated with either one, two or three doses had had lower odds of death within 28 days compared with those who had not been vaccinated. Protection from severe outcome by vaccination, particularly in hospital inpatients and those at risk of hospitalisation, is critical to reducing poor outcomes in patients who develop COVID-19, including nosocomial COVID-19.

Following the dominance of the Alpha and Delta variants, the Omicron variant became the dominant strain circulating in Scotland on 17th December 2021.[1, 2] The emergence of new variants can lead to an increased risk of COVID-19 hospital admissions as the new variant circulates in the community. Any future shifts in dominant strains with changes to severity of disease have implications for mortality outcome analyses and should be considered. The categories of pandemic wave included in the model are currently based on date ranges. Future models may include a category that approximates SARS-CoV-2 variant waves enabling adjustment for differences in patient outcomes as a result of variants.

There are some limitations and caveats to these modelling analyses that must be considered in the interpretation. The model included comprehensive risk factor data on age, sex, vaccination status and pandemic wave, and for the first time this report included co-morbidity data (Charlson score) within the modelling. The availability of co-morbidities has a time lag, and a Charlson score was unavailable for about 9% of hospital onset cases for the period October 2021 to December 2021, therefore estimates may be subject to change in future reports as more data becomes available. Cases who are in the probable and definite hospital onset category have a longer length of stay prior to developing COVID-19. This is indicative of underlying medical conditions which will be a risk factor for mortality, and some of these patients may have died irrespective of COVID-19. Similarly, it is not known if some of the patients in the non-hospital onset category (day 1 or 2 of admission) were emergency admissions due to a severe COVID-19 infection which has implications for the comparison with the probable and definite hospital onset mortality. This group may also include patients who were readmitted following a prior stay in hospital where acquisition could have occurred rather than in the community. Additionally, asymptomatic testing for SARS-CoV-2 has increased since the beginning of the pandemic. This will have increased case ascertainment including those with mild or asymptomatic disease who may have a lower risk of dying from COVID-19. This may affect comparisons in all-cause mortality across all onset groups and in particular the day 1 or 2 onset cases due to increased admission testing (though serial asymptomatic testing has been in place in some areas). It was not possible to distinguish between symptomatic cases and asymptomatic cases identified by testing policies and control for this during these analyses.

Table 1: COVID-19 case all-cause mortality within 28 days by onset status and reporting period in Scotland overall: specimen dates up to 31 December 2021. [1,2,3]

Hospital onset status	Oct-Dec 2021 Mortality within 28 days (n)	Oct-Dec 2021 Mortality within 28 days (%)	Oct-Dec 2021 Total Cases	Total Mortality within 28 days (n)	Total Mortality within 28 days (%)	Total Cases
Non-hospital onset (day 1 or 2 of admission)	248	12.0%	2,072	2,631	19.9%	13,200
Indeterminate hospital onset (days 3-7)	48	18.5%	259	432	23.6%	1,829
Probable hospital onset (days 8-14)	52	19.5%	266	615	28.9%	2,128
Definite hospital onset (days 15+)	135	16.9%	799	1,371	27.9%	4,920
Total	**483**	**14.2%**	**3,396**	**5,049**	**22.9%**	**22,077**

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) data, the Rapid Admission Preliminary Inpatient Data (RAPID) data or local admission data, and National Records of Scotland (NRS).
2. The data used has not been adjusted for potential factors that may affect mortality, e.g. severity of COVID-19 disease and patient comorbidities.
3. Cases diagnosed in the community (not during an inpatient stay) were excluded from these analyses.

Table 2: COVID-19 case all-cause mortality within 28 days by onset status and pandemic wave in Scotland overall: specimen dates up to 31 December 2021. [1,2,3]

Hospital onset status	Wave 1 Mortality within 28 days (n)	Wave 1 Mortality within 28 days (%)	Wave 1 Total Cases	Wave 2 Mortality within 28 days (n)	Wave 2 Mortality within 28 days (%)	Wave 2 Total Cases	Wave 3 Mortality within 28 days (n)	Wave 3 Mortality within 28 days (%)	Wave 3 Total Cases	Total Mortality within 28 days (n)	Total Mortality within 28 days (%)	Total Cases
Non-hospital onset (day 1 or 2 of admission)	947	26.8%	3,531	1,152	22.4%	5,138	532	11.7%	4,531	2,631	19.9%	13,200
Indeterminate hospital onset (days 3-7)	74	24.3%	305	260	26.8%	971	98	17.7%	553	432	23.6%	1,829
Probable hospital onset (days 8-14)	99	35.7%	277	422	30.2%	1,399	94	20.8%	452	615	28.9%	2,128
Definite hospital onset (days 15+)	342	31.7%	1,078	798	30.0%	2,657	231	19.5%	1,185	1,371	27.9%	4,920
Total	**1,462**	**28.2%**	**5,191**	**2,632**	**25.9%**	**10,165**	**955**	**14.2%**	**6,721**	**5,049**	**22.9%**	**22,077**

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) data, the Rapid Admission Preliminary Inpatient Data (RAPID) data or local admission data, and National Records of Scotland (NRS).
2. The data used has not been adjusted for potential factors that may affect mortality, e.g. severity of COVID-19 disease and patient comorbidities.
3. Cases diagnosed in the community (not during an inpatient stay) were excluded from these analyses.

Table 3: COVID-19 case all-cause mortality within 28 days, by onset status, age group and sex: specimen dates up to 31 December 2021. [1,2,3,4]

Age Group / Hospital onset status	Female mortality (n)	Female cases (n)	Female mortality (%)	Male mortality (n)	Male cases (n)	Male mortality (%)	Total mortality (n)	Total cases (n)	Total mortality (%)
0-24	4	622	0.6%	1	576	0.2%	5	1,198	0.4%
Non-Hospital Onset	4	541	0.7%	1	519	0.2%	5	1,060	0.5%
Indeterminate Hospital Onset	0	37	0.0%	0	27	0.0%	0	64	0.0%
Probable Hospital Onset	0	9	0.0%	0	5	0.0%	0	14	0.0%
Definite Hospital Onset	0	35	0.0%	0	25	0.0%	0	60	0.0%
25-44	20	1,037	1.9%	30	840	3.6%	50	1,877	2.7%
Non-Hospital Onset	12	844	1.4%	21	677	3.1%	33	1,521	2.2%
Indeterminate Hospital Onset	3	75	4.0%	4	54	7.4%	7	129	5.4%
Probable Hospital Onset	1	43	2.3%	2	29	6.9%	3	72	4.2%
Definite Hospital Onset	4	75	5.3%	3	80	3.8%	7	155	4.5%
45-64	222	1,970	11.3%	336	2,521	13.3%	558	4,491	12.4%
Non-Hospital Onset	129	1,391	9.3%	215	1,819	11.8%	344	3,210	10.7%
Indeterminate Hospital Onset	23	152	15.1%	26	186	14.0%	49	338	14.5%
Probable Hospital Onset	28	137	20.4%	34	178	19.1%	62	315	19.7%
Definite Hospital Onset	42	290	14.5%	61	338	18.0%	103	628	16.4%
65-74	401	1,832	21.9%	635	2,413	26.3%	1,036	4,245	24.4%
Non-Hospital Onset	231	1,064	21.7%	383	1,445	26.5%	614	2,509	24.5%
Indeterminate Hospital Onset	26	142	18.3%	51	218	23.4%	77	360	21.4%
Probable Hospital Onset	44	197	22.3%	65	227	28.6%	109	424	25.7%
Definite Hospital Onset	100	429	23.3%	136	523	26.0%	236	952	24.8%

75-84	736	2,828	26.0%	1,066	2,979	35.8%	1,802	5,807	31.0%
Non-Hospital Onset	369	1,402	26.3%	578	1,626	35.5%	947	3,028	31.3%
Indeterminate Hospital Onset	58	249	23.3%	79	256	30.9%	137	505	27.1%
Probable Hospital Onset	92	342	26.9%	119	332	35.8%	211	674	31.3%
Definite Hospital Onset	217	835	26.0%	290	765	37.9%	507	1,600	31.7%
85+	800	2,597	30.8%	798	1,855	43.0%	1,598	4,452	35.9%
Non-Hospital Onset	342	1,034	33.1%	346	832	41.6%	688	1,866	36.9%
Indeterminate Hospital Onset	93	260	35.8%	69	172	40.1%	162	432	37.5%
Probable Hospital Onset	118	388	30.4%	112	241	46.5%	230	629	36.6%
Definite Hospital Onset	247	915	27.0%	271	610	44.4%	518	1,525	34.0%
Total	**2,183**	**10,886**	**20.1%**	**2,866**	**11,184**	**25.6%**	**5,049**	**22,070**	**22.9%**

1. Source of data is Electronic Communication of Surveillance in Scotland (ECOSS) data, the Rapid Admission Preliminary Inpatient Data (RAPID) data or local admission data, and National Records of Scotland (NRS).
2. The data used has not been adjusted for potential factors that may affect mortality, e.g. severity of COVID-19 disease and patient comorbidities.
3. Cases diagnosed in the community (not during an inpatient stay) were excluded from these analyses.
4. Cases were excluded due to missing data (n=7)

Comparison with other mortality data in Scotland

Over the course of the pandemic, nearly a third of cases of hospital onset COVID-19 (probable and definite) died within 28 days of the first positive specimen (28.2%). Cases who are in the probable and definite category have, by the design of the case definition, been in hospital for 8 days or more for another reason prior to developing COVID-19. This is indicative of underlying medical conditions which will also be a risk factor for mortality, and some of these patients may have died irrespective of COVID-19. Additionally, patients receiving longer term treatment for COVID-19 dying more than 28 days after a positive test are not included in 28-day all-cause mortality. It is not possible to quantify this with the data currently available, and comparison with other published mortality data is difficult due to the different ways in which the deaths are defined and the populations in which they are reported.

All-cause mortality data is available for other infection types commonly associated with nosocomial infection. In 2019, nearly a fifth of cases (18.0%) of *Staphylococcus aureus* bacteraemia; 13.5% of *Clostridioides difficile* cases aged 15 years and older; and 13.2% of cases of *Escherichia coli* bacteraemia had died within 30 days of their diagnosis.[3] These mortality estimates are not directly comparable as the population of cases will include hospitalised and non-hospitalised cases and the duration of follow up differs (i.e. 28-day vs 30-day all-cause mortality).

The COVID-19 analyses are restricted to hospitalised patients and it would be anticipated that these patients are sicker as they require hospital care. Crude mortality rates in Scotland, used in the calculation of hospital standardised mortality ratios, for January 2020 to September 2021 indicate that 4.6% and 10.6% of patients aged 60-79 years and 80+ years, respectively, die within 30 days of an admission to hospital.[4] A UK study of mortality in nosocomial COVID-19 in older people reported that 27.0% of cases of nosocomial COVID-19 (diagnosed 15 or more days after admission) had died within seven days.[4] After adjustment, nosocomial mortality was lower compared with community acquired COVID-19 in hospitalised patients.

Any comparisons between differing mortality measures must be treated with caution. All-cause mortality includes deaths where COVID-19 may not have been either the underlying

or contributory cause of death. In addition, deaths due to COVID-19 infection of long duration will be underestimated in 28-day all-cause mortality, e.g. cases who have died more than 28 days after their first positive sample would not be included using 28-day all-cause mortality. All-cause mortality is not subject to the same biases as death certification that are introduced as a result of subjectivity or changes in the way deaths were registered during the early stages of the pandemic. In addition, death certification includes cases of presumed COVID-19 without a positive SARS-CoV-2 test and these are not included in 28-day all-cause mortality measure.

Implications for improved outcomes and infection prevention

Within Scotland and across the UK there are a number of organisations reviewing the evidence, contributing to the research and ensuring that key measures are reflected in the COVID-19 national response guidance.

As 28-day all-cause mortality is no different in patients admitted to hospital with likely community acquisition to those who develop nosocomial COVID-19 (probable or definite hospital onset), preventing transmission of SARS-CoV-2 in all settings is critical to reducing morbidity and mortality from COVID-19. Further work relating to the specialty or setting where these cases are being cared for will be included in future analyses. These will be essential for developing local and national focused improvement plans.

A continued focus on the broader public health interventions, including maximising vaccination uptake across all settings, along with the application of infection prevention and control precautions in line with current guidance will reduce the risk of transmission. In healthcare settings, early detection and appropriate management through testing of symptomatic patients and screening of asymptomatic patients with early identification of any contacts, particularly when there is an unexpected case or outbreak, is vital in efforts to reduce the spread of SARS-CoV-2 in these settings.

References

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Further information

Further Information can be found on the **PHS website.**

For more information on types of infections included in this report, please see the **COVID-19** pages on the PHS website.

The next release of this publication will be subject to additional cases in the intervening period.

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Appendices

Appendix 1 – Publication metadata

Publication title

Hospital onset COVID-19 mortality in Scotland

Description

This release provides information on hospital onset COVID-19 mortality, there is a need for consistent reporting using standardised case definitions.

Theme

Infections in Scotland

Topic

COVID-19

Format

Word document

Data source(s)

COVID-19 Cases:

Case data source: Electronic Communication of Surveillance in Scotland (ECOSS) via Corporate Data Warehouse

Admissions data Source: Rapid Admission Preliminary Inpatient Data (RAPID) or Local Patient Admissions Systems

Mortality data source: National Records of Scotland (NRS) via Corporate Data Warehouse

Date that data are acquired

1 February2022

Release date

2 March 2022

Frequency

Quarterly (subject to additional cases in the intervening period).

Timeframe of data and timeliness

Timeframe of this publication was decided by first positive sample in Scotland which fell into anyone of the hospital onset categories (i.e. 7 March 2020).

The latest iteration of data is 31 December 2021, therefore the data are 7 or 8 weeks in arrears.

No report was produced in November 2020 to allow sufficient data to accumulate for information governance needs and analysis to be done.

Continuity of data

Subject to additional cases in the intervening period.

Revisions statement

These data are not subject to planned major revisions. However, ARHAI Scotland aims to continually improve the interpretation of the data and therefore analysis methods are regularly reviewed and may be updated in the future.

Revisions relevant to this publication

Hospital onset data are continually validated by NHS boards, NRS and within the ECOSS laboratory database. Any changes to cases taken within hospital settings, which are validated by NHS boards, are tracked by ARHAI Scotland. Changes to retrospective mortality data for the hospital onset groups are outlined in the table below if applicable.

Hospital onset mortality as previously reported (24 November 2021)	Hospital onset mortality as currently reported	Reason
11,126 non-hospital onset and 1,863 probable hospital onset cases identified for time period March 2020-September 2021.	11,128 non-hospital onset and 1,862 probable hospital onset cases identified for time period March 2020-September 2021.	Changes to the hospital onset status of COVID-19 cases (see revisions included in the weekly Hospital Onset COVID-19 report for full details), impacts whether cases, and therefore any deaths associated with these cases, are included in this report.
2,382 deaths in non-hospital onset and 383 deaths in indeterminate hospital onset category identified for time period March 2020-September 2021.	2,383 deaths in non-hospital onset and 384 deaths in indeterminate hospital onset category identified for time period March 2020-September 2021.	

Concepts and definitions

The transmission of COVID-19 is thought to occur mainly through respiratory droplets and through contact with contaminated surfaces. As sustained community transmission has occurred as the pandemic has progressed, it has become more challenging to identify true cases of hospital transmission. A system for monitoring COVID-19 is critical to tracking nosocomial transmission in healthcare settings to inform infection, prevention and control measures. To help to understand nosocomial risk ARHAI Scotland publish weekly on **COVID-19 hospital onset cases** and monthly rapid review of the **epidemiology of COVID-19 in healthcare settings**.

Deaths occurring in patients with COVID-19 are an important measure of patient outcome. Therefore, monitoring COVID-19 mortality in hospital patients and publishing the data is critical to improve care of patients, inform the development of infection prevention and control measures, shape policy and guide research.

The data provided are national data for Scotland representing the 14 NHS boards and one NHS special health board.

The agreed nosocomial case definition for the UK is based on the number of days since admission to an NHS health board to the date of specimen sampling for a positive SARS-CoV-2 RT-PCR test. Time since admission to specimen sampling is categorised as:

- community onset (first positive specimen taken in the community)
- non-hospital onset (first positive specimen on day 1 or 2 of admission to NHS board);
- indeterminate (first positive specimen on days 3 to 7 of admission to NHS board);
- probable (first positive specimen on days 8 to 14 of admission to NHS board); and
- definite hospital onset (first positive specimen date was 15 or more days after admission to NHS board).

Note that for the purposes of this report, cases diagnosed in the community (not during an inpatient stay) were excluded from these analyses to restrict the comparisons within the hospitalised patient population.

These definitions are necessary due to the maximum incubation period of 14 days for COVID-19 (see table below):

Day of sampling post admission	Nosocomial categorisation
Before admission	Community onset COVID-19 (not included in this report)
Day 1 of admission/on admission to NHS board	Non-hospital onset COVID-19
Day 2 of admission	Non-hospital onset COVID-19
Day 3 of admission	Indeterminate hospital onset COVID-19
Day 4 of admission	Indeterminate hospital onset COVID-19
Day 5 of admission	Indeterminate hospital onset COVID-19
Day 6 of admission	Indeterminate hospital onset COVID-19
Day 7 of admission	Indeterminate hospital onset COVID-19
Day 8 of admission	Probable hospital onset COVID-19
Day 9 of admission	Probable hospital onset COVID-19
Day 10 of admission	Probable hospital onset COVID-19
Day 11 of admission	Probable hospital onset COVID-19
Day 12 of admission	Probable hospital onset COVID-19
Day 13 of admission	Probable hospital onset COVID-19
Day 14 of admission	Probable hospital onset COVID-19
Day 15 of admission and onwards to discharge	Definite hospital onset COVID-19
Post discharge	Community onset COVID-19 (not included in this report)

The hospital onset cases in this report represent cases presenting in hospital and do not include COVID-19 associated with hospital care that present on readmission to hospital or post-discharge.

Start point of duration

Admission to health board was agreed as the appropriate point to start counting the duration of hospital stay to first positive specimen date, rather than the date of admission to a single hospital, since patients can be transferred between hospitals which would lead to restarting the clock to ‘day 1’ each time and therefore underestimating the number of nosocomial infections.

Any discharges and re-admissions which occur within the same calendar day will be classed as a continuous stay; the clock will not be restarted in these instances, only when a readmission occurs on the second day or more after any discharge.

For definite, probable, indeterminate and non-hospital onset (day 1 or 2 of in-patient stay), the NHS board reported is where the first sample was taken, established either using Rapid Admission Preliminary Inpatient Data (RAPID) data and validated by the boards, or using individual NHS board’s internal admissions systems. Since the definition of hospital-onset COVID-19 was determined using date of admission to NHS board, the board assigned may not represent the board of attribution of hospital-onset COVID-19 infection (Table above).

Minimum data required for hospital onset COVID-19 cases to be validated:

- CHI number
- Date of positive SARS-CoV-2 RT-PCR test
- Date of admission to health board when patient tested positive for COVID-19
- NHS board where first positive test undertaken

Mortality definition

In this report, all-cause mortality within 28 days of the COVID-19 diagnosis (laboratory specimen date) is used. Therefore, the data includes deaths where COVID-19 may not have been either the underlying or contributory cause of death. All-cause mortality depends solely on the number of deaths identified, and is not subject to bias that may be introduced as a result of inaccuracies in completion of the death certificate or coding of the cause of death. Using 28-days as the time period makes the assumption that most deaths related to COVID-19 will occur within this timeframe. Deaths occurring after this time period are more difficult to assess as being specifically related to COVID-19, though they are known to occur. Therefore, care should be taken when interpreting this data and when comparing published data on COVID-19 mortality that use different definitions.

Wave 1 / Wave 2 / Wave 3 definition

The 26th of July 2020 was chosen as an arbitrary cut-off signifying the end of Wave 1 in Scotland, since cases of Hospital onset COVID-19 were at their lowest point over the course of the pandemic. Data from the 27th July 2020 onwards are considered Wave 2. Wave 2 was further split into wave 2a and wave 2b at the point when there was a second surge in cases in the second wave. These are (>26/07/20 & ≤27/12/20) and (>27/12/20) respectively. Data from the 17th May 2021 onwards are considered Wave 3.

Co-morbidity (Charlson Score)

Charlson Score was calculated for any case that was included in the Scottish Morbidity Records (SMR) 01 over the last 10 years.

Relevance and key uses of the statistics

Surveillance data are essential for monitoring trends and assisting in outbreak investigations and to understand the extent of ongoing transmission within the hospital setting. ARHAI offers support to NHS boards across Scotland to aid their local COVID-19 prevention strategies.

Accuracy

It is acknowledged that patients can be transferred between NHS health boards and if transferred into a different health board during the same hospital stay, then the clock would be restarted to ‘day 1’ which could lead to an underestimation of cases. However, the decision to restrict start date to admission to a single NHS health board represents the requirement to report at the health board-level. Any discharges and re-admissions which occur within the same calendar day will be overlooked - the clock will not be restarted in these instances, only when a readmission occurs on the second or more day after any discharge.

COVID-19 cases identified after discharge from hospital but within 14 days may be associated with the hospital. These cases, including those identified on readmission to hospital, are not included as hospital onset. This may result in under-reporting of COVID-19 cases associated with hospital care.

All-cause mortality depends solely on the number of deaths identified, and is not subject to bias that may be introduced as a result of inaccuracies in completion of the death certificate or coding of the cause of death.

Completeness

Surveillance data are collected using the ECOSS system that allows data collectors in NHS boards to validate ECOSS records as well as identifying additional cases that may not be included in the Electronic Communications of Surveillance in Scotland (ECOSS) system. This therefore means that completeness is near to 100%. For mortality data, sufficient time is allowed for all cases to be followed up for 28 days. Some delays in reporting of death may occur but this will be minimal and completeness is near to 100%.

Comparability

The agreed nosocomial case definition for the UK has been adopted to allow comparison across the four nations. However, geographical differences for example NHS board versus NHS Trust have to be considered. Additionally, the definition of case waves may not be comparable.

The case numbers presented here are only for those COVID-19 cases who are positive as inpatients with an admission to an NHS hospital, i.e. community cases are excluded. Additionally, the end dates are different to that of the weekly report (i.e. week end 2nd January 2022 vs. 31st December 2021). The data are therefore not wholly comparable with the weekly reporting of hospital onset cases **https://publichealthscotland.scot/publications/hospital-onset-covid-19-cases-in-scotland/.**

Deaths within this report are taken from the same data source used by Public Health Scotland (PHS) in their daily reported deaths, therefore comparisons are possible between these two sources. However, it should be noted that this report includes data until 31st December 2021 using COVID-19 specimen date, with deaths followed-up until 28th January (28 days later), whereas Publish Health Scotland report using date of death. Therefore, comparisons between each surveillance system should be treated with caution.

Accessibility

It is the policy of ARHAI Scotland to make its web sites and products accessible according to **published guidelines**.

Coherence and clarity

Previous published reports can be found at:
https://publichealthscotland.scot/publications/show-all-releases?id=20587

Value type and unit of measurement

At national level, the number and proportion of COVID-19 cases who died within 28-days (all-cause) of a COVID-19 diagnosis are classed as definite hospital onset, probable hospital onset, indeterminate hospital onset, and non-hospital onset. The data are further broken down by age group and sex. For adjusting the data to account for confounding, pandemic wave is also included in combination with age group, sex and hospital onset status.

Disclosure

The PHS protocol on **Statistical Disclosure Control Protocol** is followed.

Official Statistics designation

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Appendix 2 – Early access details

Pre-Release Access

Under terms of the "Pre-Release Access to Official Statistics (Scotland) Order 2008", ARHAI Scotland is obliged to publish information on those receiving Pre-Release Access ("Pre-Release Access" refers to statistics in their final form prior to publication). The standard maximum Pre-Release Access is five working days. Shown below are details of those receiving standard Pre-Release Access.

Standard Pre-Release Access:

Scottish Government Health Department

NHS board Chief Executives

NHS board Communication leads

Appendix 3 - Model results for adjusted hospital onset COVID-19 mortality (all-cause at 28 days) – wave 1 (≤26/07/2020), wave 2 (>26/07/2020 & ≤16/05/2021) and wave 3 (>16/05/2021).

Univariable and multivariable logistic regression results on 28-day all-cause mortality outcome of COVID-19 cases.[1]

Variable		Alive within 28 days (%)	Mortality within 28 days (%)	OR[2] (univariable)	OR[2] (multivariable)
Sex	F	8,429 (79.5)	2,176 (20.5)	-	-
	M	8,135 (74.0)	2,853 (26.0)	1.36 (1.27-1.45, p<0.001)	1.45 (1.36-1.56, p<0.001)
Age group (years)	0-49	3,351 (97.0)	103 (3.0)	-	-
	50-59	2,035 (89.2)	246 (10.8)	3.93 (3.11-5.00, p<0.001)	3.01 (2.37-3.86, p<0.001)
	60-69	2,523 (80.0)	631 (20.0)	8.14 (6.60-10.14, p<0.001)	5.79 (4.65-7.27, p<0.001)
	70-79	3,788 (72.5)	1,439 (27.5)	12.36 (10.12-15.26, p<0.001)	8.48 (6.86-10.58, p<0.001)
	80+	4,867 (65.1)	2,610 (34.9)	17.45 (14.34-21.47, p<0.001)	12.36 (10.02-15.41, p<0.001)
Charlson score	0	5,230 (90.0)	579 (10.0)	-	-
	1	3,419 (78.7)	926 (21.3)	2.45 (2.19-2.74, p<0.001)	1.63 (1.45-1.84, p<0.001)
	2	2,555 (73.3)	929 (26.7)	3.28 (2.93-3.68, p<0.001)	1.91 (1.69-2.15, p<0.001)
	3	1,812 (70.0)	776 (30.0)	3.87 (3.43-4.36, p<0.001)	2.04 (1.80-2.32, p<0.001)

	4	1,235 (68.2)	575 (31.8)	4.21 (3.69-4.79, p<0.001)	2.20 (1.92-2.53, p<0.001)
	5+	2,313 (65.0)	1,244 (35.0)	4.86 (4.35-5.43, p<0.001)	2.68 (2.38-3.02, p<0.001)
Hospital onset status	Non-hospital onset	10,261 (79.7)	2,621 (20.3)	-	-
	Indeterminate hospital onset	1,371 (76.1)	431 (23.9)	1.23 (1.09-1.38, p<0.001)	0.95 (0.84-1.08, p=0.449)
	Probable hospital onset	1,498 (70.9)	614 (29.1)	1.60 (1.45-1.78, p<0.001)	1.06 (0.94-1.18, p=0.338)
	Definite hospital onset	3,434 (71.6)	1,363 (28.4)	1.55 (1.44-1.68, p<0.001)	1.02 (0.94-1.11, p=0.611)
Pandemic wave	Wave 1 (≤26/07/20)	3,697 (71.7)	1,458 (28.3)	-	-
	Wave 2 (>26/07/20 & ≤16/05/21)	7,466 (74.0)	2,629 (26.0)	0.89 (0.83-0.96, p=0.003)	0.83 (0.77-0.90, p<0.001)
	Wave 3 (>16/05/21)	5,401 (85.1)	942 (14.9)	0.44 (0.40-0.48, p<0.001)	0.77 (0.64-0.93, p=0.006)
Vaccination status	Unvaccinated	12,410 (75.1)	4,117 (24.9)	-	-
	1st Dose	653 (82.3)	140 (17.7)	0.65 (0.53-0.78, p<0.001)	0.70 (0.57-0.85, p=0.001)
	2nd Dose	3,125 (81.4)	714 (18.6)	0.69 (0.63-0.75, p<0.001)	0.65 (0.53-0.79, p<0.001)
	3rd Dose/ Booster	376 (86.6)	58 (13.4)	0.46 (0.35-0.61, p<0.001)	0.41 (0.29-0.56, p<0.001)

1. Note that for the purposes of this report, cases diagnosed in the community (not during an inpatient stay) were excluded from these analyses to restrict the comparisons within the hospitalised patient population.
2. OR = Odds ratio.
3. Cases were excluded due to missing data (n=484)