ARHAI Scotland

Antimicrobial Resistance and Healthcare Associated Infection

NHS National Services Scotland

Hospital onset COVID-19 mortality in Scotland

07 March 2020 to 31 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 seventh release provides data for COVID-19 hospital onset mortality in Scotland for the period 7 March 2020 to 31 March 2022. 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 until April 2022 undertook 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 reporting of deaths by Public Health Scotland.

- Overall, nearly a fifth of patients who were diagnosed with COVID-19 during an inpatient stay died within 28 days of their COVID-19 episode date.

- Overall, just over a fifth of patients who developed probable or definite hospital onset COVID-19 died within 28 days (22.3%). The difference in all-cause mortality between the onset categories can be explained by differences in the demographics of cases.

- Nosocomial cases of COVID-19 (probable or definite hospital onset) 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 have already required hospital care for at least 8 days prior to testing positive. These patients are also more likely to die from other causes and these are not distinguished in all-cause mortality estimates.

- After statistical analysis there was no evidence that patients developing definite hospital onset COVID-19 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). Patients with probable hospital onset status had a small but significantly higher odds of death compared with other patients diagnosed with COVID-19 on day 1 or 2 of admission (non-hospital onset status). This is likely to be due to differences in the patient population which are unavailable to control for in this analysis.

- 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 the Delta wave and Omicron wave compared with the Pre-alpha wave (prior to 3rd January 2021). These waves signify periods in time when the variant was dominant and not the risk of death associated with each variant.

- 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/four doses 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.

- 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 are 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 31,668 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 March 2022 were able to be linked for analysis. This includes 9,333 cases for the period January 2022 to March 2022. The total number of these patients who died within 28 days (all-cause) for the period 7 March 2020 to 31 March 2022 was 5,894 (18.6%) which includes 827 deaths from cases occurring in the period January 2022 to March 2022 (8.9%).

A total of 2,445 patients with probable (sample taken on days 8-14) or definite (sample taken on day 15+) hospital onset COVID-19 died within 28 days of their COVID-19 episode date (22.3%) since March 2020. Mortality was highest among patients with probable (24.0%) or definite hospital onset COVID-19 (21.6%) when compared to non-hospital onset mortality ($p<0.001$, unadjusted for confounding) (**Table 1**). Cases and deaths included in each pandemic wave (Pre alpha wave: specimen date ≤03/01/2021; Alpha wave: specimen date >03/01/2021 & ≤16/05/2021; Delta wave: >16/05/2021 & ≤12/12/2021; and Omicron wave: >12/12/2021) 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 4**). 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 (82 years) was higher than those patients with likely community acquisition (day 1 or 2 of admission) (78 years, unadjusted $p<0.001$).

A logistic regression model was developed to adjust for potential confounding between the onset categories (**Appendix 4**). 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 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). Patients with probable hospital onset status had a small but significantly higher odds of death (OR=1.00, p=0.04) compared with other patients diagnosed with COVID-19 on day 1 or 2 of admission (non-hospital onset status). However this is likely to be due to differences in the patient population which are unavailable to control for in this analysis.

Age, sex, co-morbidity, vaccination status and variant waves were all significantly associated with 28-day all-cause mortality. The model results are presented in **Appendix 4**. All-cause mortality was lower in the Delta and Omicron waves compared with the Pre-alpha wave, after adjustment for case mix (age, sex, co-morbidities, vaccination status, where patient likely acquired the virus based on hospital onset status). Understanding of the aetiology of COVID-19 and the development/introduction of treatments will have improved survival over the course of the pandemic. It is likely that higher mortality earlier in the pandemic was due, in part, to lack of available treatment.

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/four doses had lower odds of death within 28 days compared with those who had not been vaccinated ($p<0.001$). 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] Whilst the emergence of

Omicron indicated reduced severity as measured by risk of hospitalisation, the emergence of new variants can lead to an increased severity of disease. Any future shifts in dominant strains may have implications for mortality outcome analyses and should be considered. The categories of pandemic wave included in the model are approximates of the SARS-CoV-2 variant waves acting as a proxy for differences in patient outcomes as a result of variants. The pandemic waves describe mortality outcome during defined periods of time when the variants were dominant rather than mortality associated with the variants (as variant information was not available for all cases).

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, co-morbidity data (Charlson score), vaccination status and variant waves within the modelling. The availability of co-morbidities has a time lag, and a Charlson score was unavailable for approximately 8.0% of hospital onset cases for the period January 2022 to March 2022, therefore estimates may be subject to change in future reports as more data become 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 March 2022. [1,2,3]

Hospital onset status	Jan-Mar 2022 Mortality within 28 days (n)	Jan-Mar 2022 Mortality within 28 days (%)	Jan-Mar 2022 Total Cases	Total Mortality within 28 days (n)	Total Mortality within 28 days (%)	Total Cases
Non-hospital onset (day 1 or 2 of admission)	251	5.7%	4,442	2,889	16.3%	17,771
Indeterminate hospital onset (days 3-7)	125	11.6%	1,077	560	19.0%	2,942
Probable hospital onset (days 8-14)	154	14.6%	1,054	770	24.0%	3,205
Definite hospital onset (days 15+)	297	10.8%	2,760	1,675	21.6%	7,750
Total	**827**	**8.9%**	**9,333**	**5,894**	**18.6%**	**31,668**

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 variant wave in Scotland overall: specimen dates up to 31 March 2022. [1,2,3,4]

Hospital onset status	Pre-alpha Wave Mortality within 28 days – n (%)	Pre-alpha Wave Total Cases	Alpha Wave Mortality within 28 days – n (%)	Alpha Wave Total Cases	Delta Wave Mortality within 28 days – n (%)	Delta Wave Total Cases	Omicron Wave Mortality within 28 days – n (%)	Omicron Wave Total Cases	Total Mortality within 28 days – n (%)	Total Cases
Non-hospital onset (day 1 or 2 of admission)	1,634 (25.3%)	6,451	466 (20.6%)	2,258	501 (12.3%)	4,082	288 (5.8%)	4,980	2,889 (16.3%)	17,771
Indeterminate hospital onset (days 3-7)	218 (26.7%)	816	116 (24.6%)	472	95 (18.9%)	502	131 (11.4%)	1,152	560 (19.0%)	2,942
Probable hospital onset (days 8-14)	303 (29.4%)	1,032	218 (33.4%)	652	82 (21.5%)	381	167 (14.6%)	1,140	770 (24.0%)	3,205
Definite hospital onset (days 15+)	759 (31.2%)	2,430	382 (28.8%)	1,327	208 (21.8%)	955	326 (10.7%)	3,038	1,675 (21.6%)	7,750
Total	**2,914 (27.2%)**	**10,729**	**1,182 (25.1%)**	**4,709**	**886 (15.0%)**	**5,920**	**912 (8.8%)**	**10,310**	**5,894 (18.6%)**	**31,668**

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. Definition of variant waves is included in Publication Metadata.

Table 3: COVID-19 case all-cause mortality within 28 days, by onset status, age group and sex: specimen dates up to 31 March 2022. [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	5	1,216	0.4%	3	1,147	0.3%	8	2,363	0.3%
Non-Hospital Onset	4	1,067	0.4%	3	1,045	0.3%	7	2,112	0.3%
Indeterminate Hospital Onset	0	67	0.0%	0	41	0.0%	0	108	0.0%
Probable Hospital Onset	0	15	0.0%	0	11	0.0%	0	26	0.0%
Definite Hospital Onset	1	67	1.5%	0	50	0.0%	1	117	0.9%
25-44	21	1,660	1.3%	44	1,278	3.4%	65	2,938	2.2%
Non-Hospital Onset	13	1,348	1.0%	28	959	2.9%	41	2,307	1.8%
Indeterminate Hospital Onset	3	127	2.4%	8	84	9.5%	11	211	5.2%
Probable Hospital Onset	1	63	1.6%	3	57	5.3%	4	120	3.3%
Definite Hospital Onset	4	122	3.3%	5	178	2.8%	9	300	3.0%
45-64	252	2,684	9.4%	381	3,429	11.1%	633	6,113	10.4%
Non-Hospital Onset	141	1,754	8.0%	237	2,277	10.4%	378	4,031	9.4%
Indeterminate Hospital Onset	31	254	12.2%	32	305	10.5%	63	559	11.3%
Probable Hospital Onset	33	216	15.3%	42	275	15.3%	75	491	15.3%
Definite Hospital Onset	47	460	10.2%	70	572	12.2%	117	1,032	11.3%
65-74	453	2,470	18.3%	737	3,310	22.3%	1,190	5,780	20.6%
Non-Hospital Onset	252	1,319	19.1%	418	1,810	23.1%	670	3,129	21.4%
Indeterminate Hospital Onset	31	236	13.1%	61	332	18.4%	92	568	16.2%
Probable Hospital Onset	53	274	19.3%	85	343	24.8%	138	617	22.4%
Definite Hospital Onset	117	641	18.3%	173	825	21.0%	290	1,466	19.8%

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 (%)
75-84	855	3,902	21.9%	1,227	4,157	29.5%	2,082	8,059	25.8%
Non-Hospital Onset	400	1,756	22.8%	626	2,046	30.6%	1,026	3,802	27.0%
Indeterminate Hospital Onset	78	410	19.0%	104	415	25.1%	182	825	22.1%
Probable Hospital Onset	119	506	23.5%	150	495	30.3%	269	1,001	26.9%
Definite Hospital Onset	258	1,230	21.0%	347	1,201	28.9%	605	2,431	24.9%
85+	949	3,752	25.3%	967	2,663	36.3%	1,916	6,415	29.9%
Non-Hospital Onset	379	1,325	28.6%	388	1,065	36.4%	767	2,390	32.1%
Indeterminate Hospital Onset	115	399	28.8%	97	272	35.7%	212	671	31.6%
Probable Hospital Onset	137	580	23.6%	147	370	39.7%	284	950	29.9%
Definite Hospital Onset	318	1,448	22.0%	335	956	35.0%	653	2,404	27.2%
Total	**2,535**	**15,684**	**16.2%**	**3,359**	**15,984**	**21.0%**	**5,894**	**31,668**	**18.6%**

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.

Comparison with other mortality data in Scotland

Over the course of the pandemic, over a fifth of cases of hospital onset COVID-19 (probable and definite) died within 28 days of their COVID-19 episode date (22.3%). 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.

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 December 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]

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 COVID-19 episode date 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 was no different in patients admitted to hospital with likely community acquisition to those who develop definite hospital onset COVID-19, preventing transmission of SARS-CoV-2 in all settings is critical to reducing morbidity and mortality from COVID-19.

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

(1) Sheikh A, McMenamin J, Taylor B, Robertson C; Public Health Scotland and the EAVE II Collaborators. SARS-CoV-2 Delta VOC in Scotland: demographics, risk of hospital admission, and vaccine effectiveness. Lancet. 2021 Jun 26; 397(10293): 2461-2462.

(2) Scottish Government. Coronavirus (COVID-19) update: First Minister's speech – 17 December 2021. [cited 2022 Feb 15]; Available from: URL: **https://www.gov.scot/publications/coronavirus-covid-19-update-first-ministers-speech-17-december-2021/**

(3) Antimicrobial Resistance and Healthcare Associated Infection Scotland. Healthcare Associated Infections. 2020 Annual report. ARHAI Scotland 2021 [cited 2022 Feb 15]; Available from: URL: **https://www.hps.scot.nhs.uk/web-resources-container/healthcare-associated-infection-annual-report-2020/**

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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 – Revisions to the surveillance

Description of Revision	First report revision applied	Rationale for revision
Inclusion of reinfections data	Hospital Onset COVID-19 cases in Scotland report published on 04/05/2022 (2022 Week 14 report, sample dates up to 10/04/2022).	On 1 March 2022, Public Health Scotland updated the Scottish COVID-19 national case definition to include reinfections of COVID-19. Previously COVID-19 cases were based on an individual's first positive test result only. The new definition includes both first infections and possible reinfections. Possible reinfections are defined as individuals who test positive, by PCR (polymerase chain reaction) or LFD (lateral flow device), 90 days or more after their last positive test. Note that as per the change in definitions to include LFD tests as above, positive tests after 90 days from an LFD before the 5th January 2022 are not included as a reinfection. Please see the Public Health Scotland website for more information.

Appendix 2 – 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

04 May 2022

Release date

01 June 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 March 2022, 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 (02 March 2022)	Hospital onset mortality as currently reported	Reason
13,200 non-hospital onset, 1,829 indeterminate hospital onset, 2,128 probable hospital onset, and 4,920 definite hospital onset cases identified for time period March 2020-December 2021.	13,329 non-hospital onset, 1,865 indeterminate hospital and 2,151 probable hospital onset, and 4,990 definite hospital onset cases identified for time period March 2020- December 2021.	Inclusion of reinfections cases (see appendix I for more details) and 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.
2,631 deaths in non-hospital onset, 432 deaths in indeterminate hospital onset, 615 deaths in probable hospital onset, and 1,371 deaths in definite hospital onset category identified for time period March 2020-December 2021.	2,638 deaths in non-hospital onset, 435 deaths in indeterminate hospital and 616 deaths in probable hospital onset, and 1,378 deaths in definite hospital onset category identified for time period March 2020-December 2021.	

Concepts and definitions

A COVID-19 case is defined as an individual who has tested positive for COVID-19 by SARS-CoV-2 RT-PCR (PCR), or, from 5th January 2022 onwards by PCR, Lateral Flow Device (LFD) or other point of care rapid test. LFD positive cases that are followed by a negative PCR result within 48 hours are excluded.

First positive test and reinfections for each individual are counted. Episodes of infection are described as:

- First positive test recorded for case since March 2020
- Possible reinfections defined as individuals who test positive 90 days or more after their last positive test.

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 hospital onset 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 of new infection or reinfections (90 days or more after their last positive test) taken in the community)

- non-hospital onset (first positive specimen of new infection or reinfections (90 days or more after their last positive test) on day 1 or 2 of admission to NHS board)
- indeterminate (first positive specimen of new infection or reinfections (90 days or more after their last positive test) on days 3 to 7 of admission to NHS board)
- probable (first positive specimen of new infection or reinfections (90 days or more after their last positive test) on days 8 to 14 of admission to NHS board)
- definite hospital onset (first positive specimen date of new infection or reinfections (90 days or more after their last positive test) 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 of sampling post admission	Nosocomial categorisation
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.

Admission to health board was agreed as the appropriate point to start counting the duration of hospital stay to first positive specimen date within a new infection or reinfection episode, 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 within the same health board 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 inpatient stay), the NHS board reported is where the first positive sample within a new infection or reinfection episode 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).

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.

Minimum data required to be validated:

- CHI number (or for non-Scottish residents, patient forename, surname and date of birth).
- Date of positive SARS-CoV-2 RT-PCR test within new infection or reinfection episode.
- Date of admission to health board when patient tested positive for COVID-19.
- NHS board where first positive test of new infections or reinfection episode undertaken.

Mortality definition

The definition of 28-day all-cause mortality is any death occurring within 28 days of the first COVID-19 specimen date within each infection episode. 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.

Pre-alpha Wave / Alpha Wave / Delta Wave / Omicron Wave definition

The categories of pandemic waves are approximations of the SARS-CoV-2 variant waves. The pandemic waves describe mortality outcome during defined periods of time when the variants were dominant rather than mortality associated with the variants (as variant information was not available for all cases). These dates are taken from the S-gene crossover when the proportion of isolates with S-gene target failure became higher than those that were S-gene positive (and vice versa) and then rounding to the nearest whole week in line with Hospital Onset reporting. The 3rd of January 2021 was chosen as the cut-off signifying the end of Pre-Alpha Wave in Scotland. Data from the 4th of January 2021 to 16th of May 2021 are considered Alpha Wave. Data from the 17th of May 2021 to 12th of December 2021 are referring to Delta Wave. Data from the 13th of December 2021 onwards are considered Omicron Wave. These dates were provided by Public Health Scotland and based on specimens tested in Lighthouse laboratories and Regional testing hubs.

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 3rd April 2022 vs. 31st March 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 March 2021 using COVID-19 specimen date, with deaths followed-up until 28th April (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 3 – 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 4 - Model results for adjusted hospital onset COVID-19 mortality (all-cause at 28 days)

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	12,585 (83.3)	2,525 (16.7)	-	-
	M	12,214 (78.5)	3,337 (21.5)	1.36 (1.29-1.44, p<0.001)	1.45 (1.37-1.54, p<0.001)
Age group (years)	0-49	5,472 (97.6)	134 (2.4)	-	-
	50-59	2,757 (90.9)	275 (9.1)	4.07 (3.30-5.05, p<0.001)	2.88 (2.32-3.59, p<0.001)
	60-69	3,625 (83.4)	723 (16.6)	8.14 (6.77-9.88, p<0.001)	5.46 (4.49-6.68, p<0.001)
	70-79	5,493 (76.8)	1,656 (23.2)	12.31 (10.33-14.80, p<0.001)	7.99 (6.62-9.72, p<0.001)
	80+	7,452 (70.8)	3,074 (29.2)	16.85 (14.18-20.19, p<0.001)	11.73 (9.73-14.24, p<0.001)
Charlson score	0	8,133 (92.3)	679 (7.7)	-	-
	1	5,059 (82.7)	1,055 (17.3)	2.50 (2.25-2.77, p<0.001)	1.57 (1.41-1.75, p<0.001)
	2	3,723 (77.7)	1,068 (22.3)	3.44 (3.10-3.81, p<0.001)	1.88 (1.68-2.10, p<0.001)
	3	2,624 (74.4)	901 (25.6)	4.11 (3.69-4.59, p<0.001)	2.03 (1.80-2.28, p<0.001)
	4	1,814 (73.4)	657 (26.6)	4.34 (3.85-4.89, p<0.001)	2.10 (1.85-2.38, p<0.001)
	5+	3,446 (69.6)	1,502 (30.4)	5.22 (4.73-5.77, p<0.001)	2.69 (2.42-3.00, p<0.001)

Variable		Alive within 28 days (%)	Mortality within 28 days (%)	OR[2] (univariable)	OR[2] (multivariable)
Hospital onset status	Non-hospital onset	14,306 (83.2)	2,879 (16.8)	-	-
	Indeterminate hospital onset	2,298 (80.5)	555 (19.5)	1.20 (1.08-1.33, p<0.001)	1.00 (0.90-1.12, p=0.958)
	Probable hospital onset	2,388 (75.7)	766 (24.3)	1.59 (1.46-1.74, p<0.001)	1.11 (1.00-1.22, p=0.039)
	Definite hospital onset	5,807 (77.7)	1,662 (22.3)	1.42 (1.33-1.52, p<0.001)	1.03 (0.95-1.11, p=0.469)
SARS-CoV-2 variant wave	Pre-Alpha Wave (≤03/01/21)	7,755 (72.7)	2,908 (27.3)	-	-
	Alpha Wave (>03/01/21 & ≤16/05/21)	3,492 (74.7)	1,181 (25.3)	0.90 (0.83-0.98, p=0.010)	0.95 (0.87-1.03, p=0.226)
	Delta Wave (>16/05/21 & ≤12/12/21)	4,920 (84.8)	885 (15.2)	0.48 (0.44-0.52, p<0.001)	0.77 (0.65-0.90, p=0.002)
	Omicron Wave (>12/12/21)	8,632 (90.7)	888 (9.3)	0.27 (0.25-0.30, p<0.001)	0.49 (0.41-0.58, p<0.001)
Vaccination status	Unvaccinated	14,055 (77.0)	4,191 (23.0)	-	-
	1st Dose	986 (86.3)	156 (13.7)	0.53 (0.45-0.63, p<0.001)	0.68 (0.56-0.82, p<0.001)
	2nd Dose	4,249 (83.5)	837 (16.5)	0.66 (0.61-0.72, p<0.001)	0.74 (0.63-0.87, p<0.001)
	3rd/4th Dose	5,509 (89.0)	678 (11.0)	0.41 (0.38-0.45, p<0.001)	0.56 (0.47-0.68, 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=1,007)