Annual Report of the Epidemiology of COVID-19 in Ireland, 2021-2022

Background

SARS-CoV-2, the virus which caused the COVID-19 pandemic, was first detected in Ireland in March 2020. A summary of the first year of the COVID-19 pandemic in Ireland has previously been published[1]. This report describes the epidemiology of COVID-19 during 2021 and 2022. During this time period there were many changes to testing policy, health seeking behaviour, population immunity (including vaccination and/or previous infection), and varying dominance of SARS-CoV-2 variants, as such it is challenging to draw conclusions when comparing data between the two years. With this in mind, this report focuses on the descriptive epidemiology of COVID-19 including cases, severe disease, outbreaks, and variants, as a whole during 2021 and 2022.[2]

Data Considerations

Data for this report are based on laboratory confirmed COVID-19 cases and outbreaks notified on Ireland's Computerised Infectious Disease Reporting (CIDR) system up to midnight on 31/12/2022 Data were extracted from CIDR system on 16/05/2023. Data are provisional and subject to ongoing review, validation and update. As a result, figures in this report may differ from previously published figures. Please see the HPSC website for COVID-19 case definitions.

Data for late December 2021, and January 2022, do not accurately reflect trends. Due to a surge in case numbers the turnaround time for processing notifications increased. Notifications between week 51, 2021 to week 2, 2022 are reduced, while notifications between weeks 3 and 4, 2022 are inflated compared to cases diagnosed during these weeks.

Hospitalised cases include hospital in-patients with a laboratory confirmed COVID-19 test. ICU cases include cases notified to CIDR who are in ICU primarily for the treatment of COVID-19 and does not include cases in ICU for other clinical conditions which have an incidental finding of COVID-19. The definition of a COVID-19 death is in line with the World Health Organization (WHO) COVID-19 death classification and reporting guidance[3]. For surveillance purposes, a death due to COVID-19 is defined as a death resulting from a clinically compatible illness, in a probable or confirmed COVID-19 case, unless there is a clear alternative cause of death that cannot be related to COVID disease (e.g. trauma).

SARS-CoV-2 variant data is based on data extracted from the National SARS-CoV-2 Whole Genome Sequencing (WGS) Programme variant database as of 14/09/2023. Data are provisional and subject to ongoing review, validation and update. As a result, figures in this report may differ from previously published figures.

Testing Policy Changes

Starting in early 2022, the testing recommendations for COVID-19 changed on a phased basis from testing of all symptomatic people to testing of only those at higher risk of severe disease. These changes impacted the number and age distributed of notified confirmed COVID-19 cases, and therefore, should be considered when comparing data from different time periods.

Public Health Prioritisation

Regional Departments of Public Health are currently prioritising the investigation and reporting of outbreaks in settings that benefit most from public health and clinical intervention. These settings include acute hospitals, nursing homes, community hospital/long-stay units, residential institutions, other

healthcare settings and vulnerable populations. For this reason, outbreaks in other settings may be underestimated.

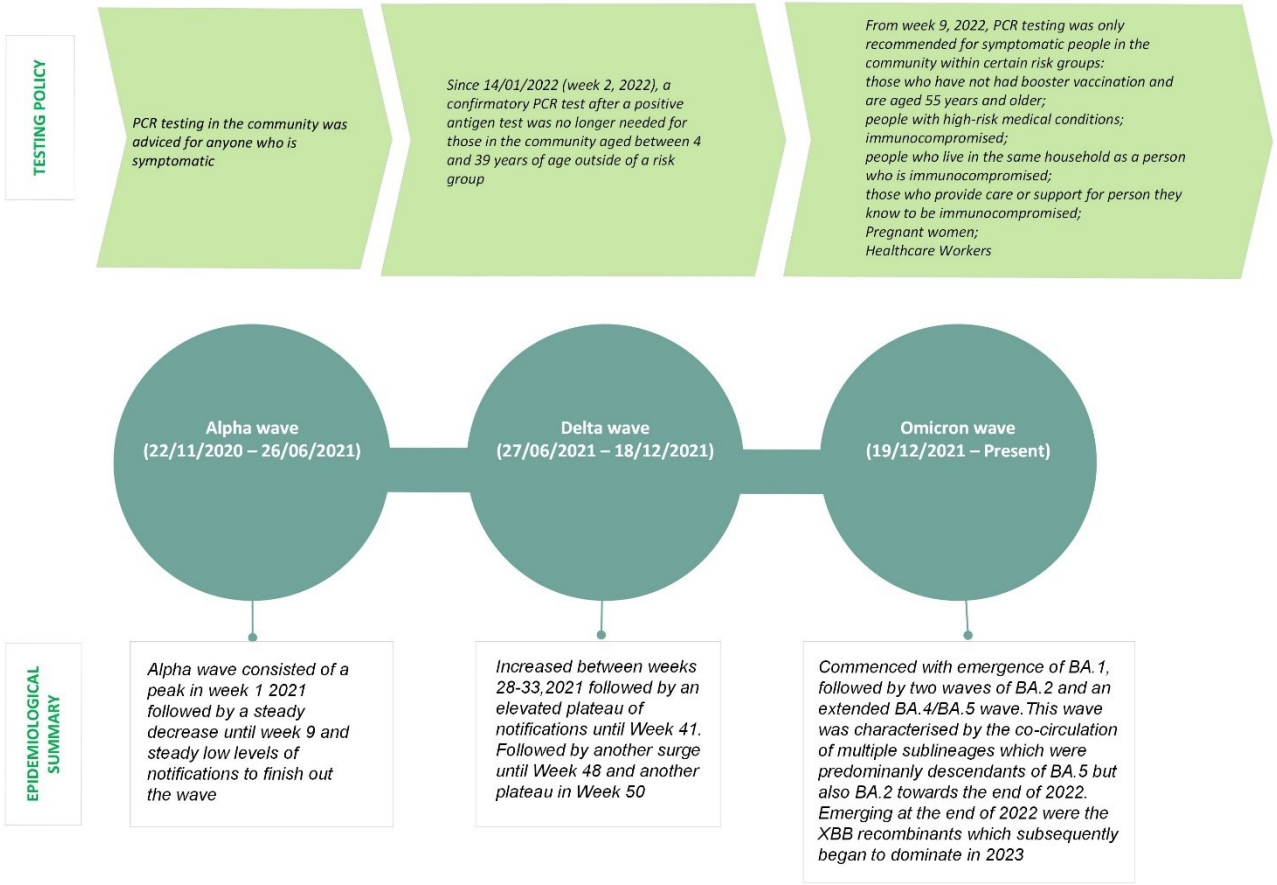

Figure 1. Summary of COVID-19 testing policies and the epidemiological situation during 2021 and 2022.

Overview of COVID-19 cases

The number of laboratory confirmed COVID-19 case notifications was lower in 2021 (n = 669,811), than in 2022 (n = 930,344) with both of these years seeing higher laboratory confirmed cases than at the start of the pandemic from March-December 2020 (n = 93,464). The highest weekly number of notifications by epidemiological date was in week 52, 2021 when there were 148,145 notified cases (Table 1).

Several waves of COVID-19 activity were observed during 2021 and 2022. Until mid-2022 these waves were driven by the emergence of new SARS-CoV-2 variants as described later. We have named the waves after the dominant variant(s) (Box 1; Figures 1, 2, 7 and 8). Wave threshold dates were determined based on available genomic data indicated variant dominance i.e. >50% prevalence.

Although, the magnitude of successive waves decreased during 2022, a not insignificant wave was observed in autumn/winter 2022. The 2022 autumn and winter waves were not driven by a particular variant, with new Omicron variants regularly emerging during this period. They may reflect an underlying winter seasonality of SARS-CoV-2 similar to other respiratory viruses.

Table 1: Summary characteristics of COVID-19 cases notified in Ireland during 2021 and 2022

	Total 2021		Total 2022	
	Number	Percentage	Number	Percentage
Total number of confirmed cases	669,811		930,344	
Cumulative incidence rate of confirmed cases per 100,000 population	14,066.1		19,537.4	
Healthcare workers	29,289	4.4	54,802	5.9
Severe cases				
Number of cases hospitalised	16,154*	2.4	32,175*	3.5
Number of cases admitted to ICU	1,658*	0.3	419*	0.1
Number of deaths among confirmed cases	3,736*	0.6	2,162*	0.2
Laboratory Tests				
Total number of tests performed	6,846,002		2,707,140	
Cumulative percent positivity		9.8		34.4

** The number of cases hospitalised, cases admitted to ICU and deaths described in the above table relate only to COVID-19 cases who were notified during this reporting period, and where the outcome is known at the time of reporting. It does not reflect all hospitalisations, ICU admissions and deaths related to COVID-19 which occurred during the period covered by the report. It also does not reflect the final number of cases hospitalised, admitted to ICU or deaths for these cases notified during this period as the outcome may not yet have occurred, or is yet to be notified*

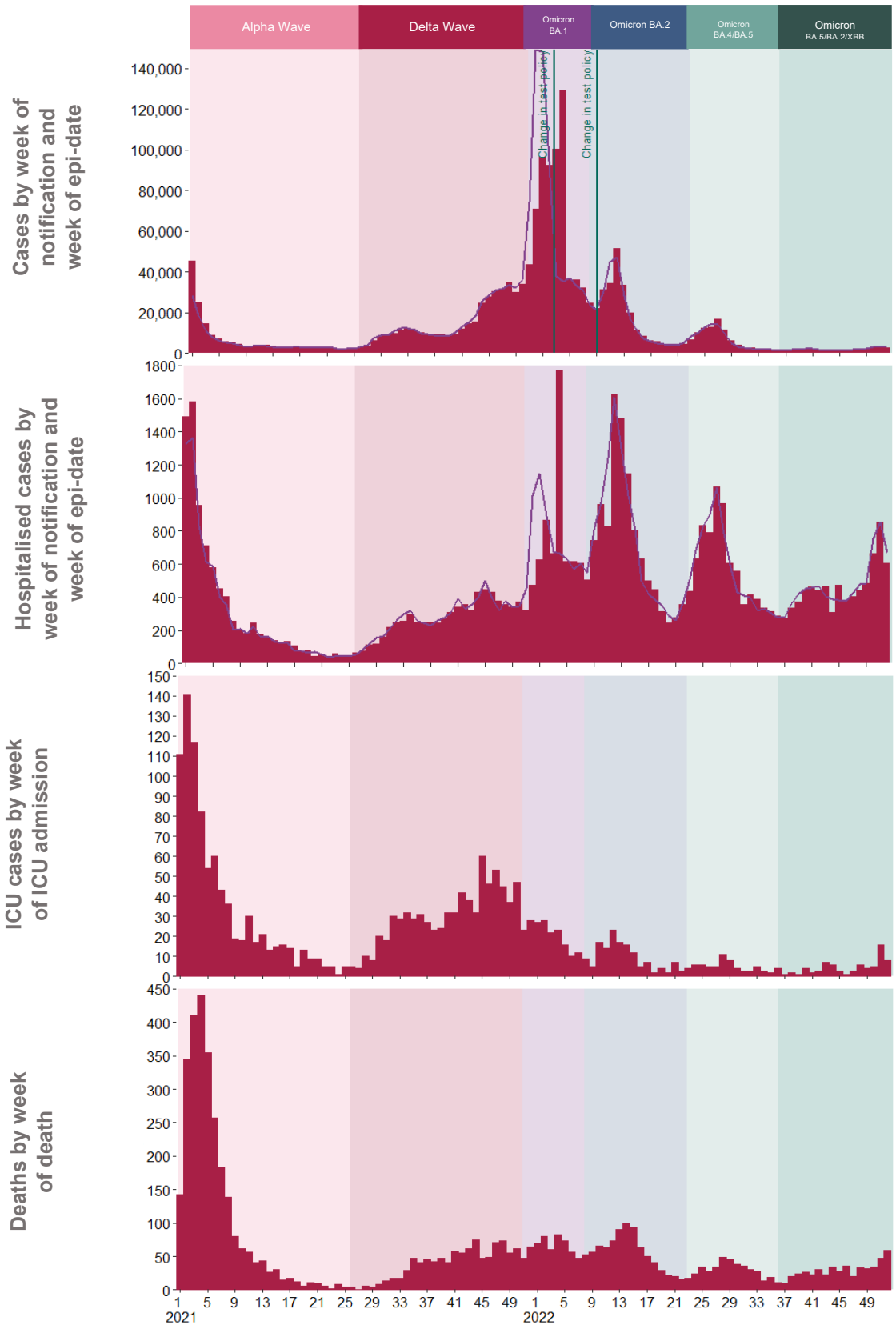

Figure 2: Number of confirmed COVID-19 cases by notification week (red bar) and epidemiological date (purple line), number of hospitalised COVID-19 cases by notification week (red bar) and epidemiological date (purple line), number of ICU cases by week of admission to ICU, and number of deaths by week of death, 2021 to 2022. The red bars represent the number of cases by notification date, week of admission or week of death. The purple line represents the number of cases by epidemiological date.

Box 1: Overview of COVID-19 waves in Ireland during 2021 and 2022

Wave	Date	Summary of epidemiological situation
B.1.1.7 (Alpha) wave	**22/11/2020 – 26/06/2021**	Alpha wave consisted of a peak in week 1 2021 followed by a steady decrease until week 9 and steady low levels of notifications to finish out the wave.
B.1.617.2 (Delta) wave	**27/06/2021 – 18/12/2021**	Delta wave consisted of an increase between weeks 28-33 2021 followed by an elevated plateau of notifications which continued until week 41 2021. This was followed by an increase in cases until week 48 2021 and another plateau until week 50. At this point Omicron had emerged as the newest dominant variant, exhibiting increased virulence which was able to overtake Delta while it was still circulating widely.
B.1.1.529 (Omicron) wave	**19/12/2021 – present**	The Omicron wave commenced with the emergence of BA.1. This initial Omicron wave was followed by two distinct waves of activity associated with BA.2 and BA.4/BA.5 variants as described below. After the BA.4/BA.5 wave, new Omicron sublineages, and recombinant have continued to emerge regularly. Since BA.4/BA.5 no new variant has resulted in a substantial wave of COVID-19 activity. Periods of increased activity have occurred. While new variants, or a combination of new variants, may have partially contributed to these, they cannot be attributed to a single new variant.
BA.1 (Omicron) subwave	**19/12/2021 – 19/02/2022**	Omicron BA.1 wave was marked by a substantial increase in transmission and notifications, reaching more than 100,000 laboratory confirmed cases notified per week. Due to a surge in case numbers the turnaround time for processing notifications increased. Notifications between 19/12/2021 and 15/01/2022 (week 51, 2021 to week 2, 2022) were reduced, while notifications between 16/01/2022 and 29/01/2022 (weeks 3 and 4, 2022) were inflated compared to cases diagnosed during these weeks. As such, during this time, notifications by epidemiological date (see technical notes) provide a more accurate description of COVID-19 cases in Ireland. Following this surge in notifications, changes were made to testing policies which reduced the number of notifications to CIDR. Therefore, the decrease in cases at the end of this wave is attributed to potentially both a decrease in transmission and change in testing policy.
BA.2 (Omicron) subwave	**20/02/2022 – 04/06/2022**	Omicron BA.2 wave consisted of an increase in cases starting in week 10, 2022 and reaching its peak in week 12, 2022 with a continued decrease until week 20, 2022.
BA.4/BA.5 (Omicron) subwave	**05/06/2022 – 01/09/2022**	Omicron BA.4/5 wave consisted of an increase in cases starting in week 23, 2022 and reaching its peak in week 27, 2022, with steady decreases until week 33, 2022.
BA.5/BA.2/XBB (Omicron) subwave	**01/09/2022 – present**	This subwave has been characterised by a proliferation of cocirculating Omicron lineages. During the late autumn and winter 2022 there were two distinct peaks. The first peak was smaller and peaked in week 40, 2022 with 2333 cases notified that week. The second peak started in week 44 and peaked in week 51 with 3603 cases notified that week. This second peak coincided with an increase in BA.2 sublineages as well as the beginning of the increase in XBB recombinant lineages which have since come to dominate the variant landscape.

Confirmed COVID-19 cases by age and sex

Table 2 summarises the age and sex distribution of confirmed cases for 2021 and 2022. The median age of confirmed cases in 2021 was 31 years (interquartile range (IQR): 19-47 years) and 15.8% of cases were aged 55 years or older. In comparison, in 2022, the median age of confirmed cases was 38 years (IQR: 23-51 years); with 19.9% of cases age 55 years of older. Age specific rates also saw a greater increase in women aged 25-54 years, and in men and women aged ≥85 years in 2022, compared to 2021 (Figure 1).

There was also a notable increase in the percentage of female cases between 2021 (50.8% female) and 2022 (55.4% female). Figure 3 below provides age pyramids for 2021 and 2022 winter seasons respectively.

Table 2: Summary characteristics by age and sex of COVID-19 cases notified in Ireland during 2021 and 2022

	Total 2021		Total 2022	
	Number	Percentage	Number	Percentage
Gender				
Males	329,779	49.2	414,904	44.6
Females	339,964	50.8	515,338	55.4
M:F ratio	0.97		0.81	
Age (years)				
Mean age	34		38	
Median age	31		38	
Interquartile range	19 - 47		23 - 51	
Age groups (years)				
0-4	29,411	4.4	39,708	4.3
5-12	81,768	12.2	75,467	8.1
13-18	52,396	7.8	62,125	6.7
19-24	86,606	12.9	79,325	8.5
25-34	118,986	17.8	154,260	16.6
35-44	112,165	16.7	189,703	20.4
45-54	82,892	12.4	145,178	15.6
55-64	56,408	8.4	91,421	9.8
65-74	29,253	4.4	48,306	5.2
75-84	13,258	2.0	29,405	3.2
85+	6,614	1.0	15,407	1.7
Unknown	54	0.0	39	0.0
Total	669,811		930,344	

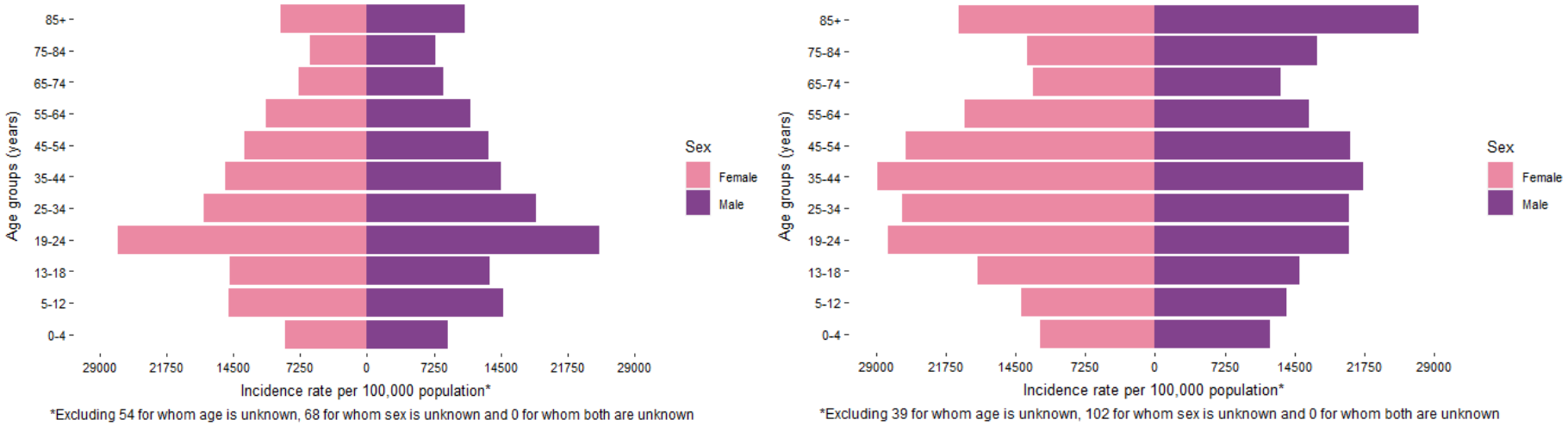

Figure 3: Cumulative age and sex specific incidence rates of confirmed COVID-19 cases per 100,000 population for 2021 (left); 2022 (right)

Hospitalisations

The number of hospitalised cases was lower in 2021 (n = 16,154) than in 2022 (n = 32,175) peaks reflecting the peaks in case notifications. The highest weekly number of hospitalised cases by epidemiological date was in week 13, 2022 when there were 1606 hospitalised cases (Table 3, Figure 1).

Similarly to case demographics, the median age of hospitalisations increased between 2021 (61 years) and 2022 (69 years). Unlike the increase in female cases between 2021 and 2022 as noted above, the percentage of female hospitalisations remained relatively stable at 49.2% in 2021 and 50.7% in 2022.

Table 3: Summary characteristics by age and sex of hospitalized COVID-19 cases notified in Ireland during 2021 and 2022

	Total 2021		Total 2022	
	Number	Percentage	Number	Percentage
Gender				
Males	8,206	50.8	15,847	49.3
Females	7,947	49.2	16,328	50.7
M:F ratio	1.03		0.97	
Age (years)				
Mean age	58		61	
Median age	61		69	
Interquartile range	40 – 77		43 – 81	
Age range	0 – 108		0 – 108	
Age groups (years)				
0-4	419	2.6	1,492	4.6
5-12	257	1.6	609	1.9
13-18	318	2.0	574	1.8
19-24	683	4.2	937	2.9
25-34	1,443	8.9	2,323	7.2
35-44	1,655	10.2	2,456	7.6
45-54	1,832	11.3	2,293	7.1
55-64	2,135	13.2	3,390	10.5
65-74	2,621	16.2	5,199	16.2
75-84	2,914	18.0	7,619	23.7
85+	1,873	11.6	5,281	16.4
Unknown	4	0.0	2	0.0
Total	16,154		32,175	

ICU admissions

In contrast to notifications and hospitalised cases, the number of ICU admissions was higher in 2021 (n = 1,678), than in 2022 (n = 425). The highest weekly number of ICU admissions by date of ICU admission was in week 2, 2021 when there were 141 ICU admissions due to COVID-19 (Table 4, Figure 1). The median age also increased from 60 years in 2021 to 65 years in 2022.

Unlike cases, which had a higher percentage of females, and hospitalisations, which were more evenly distributed, ICU admissions were predominantly male with 60.7% in 2021 and 57.2% in 2022 compared to only comprising 49.2% of cases in 2021 and 44.6% of cases in 2022. However, the trend on increases in the percentage of female ICU admissions mirrors the increases observed for notified cases.

Table 4: Summary characteristics by age and sex of cases admitted to ICU due to COVID-19 in Ireland during 2021 and 2022

	Total 2021		Total 2022	
	Number	Percentage	Number	Percentage
Gender				
Males	1,018	60.7	243	57.2
Females	660	39.3	182	42.8
M:F ratio	1.54		1.34	
Age (years)				
Mean age	58		59	
Median age	60		65	
Interquartile range	48 – 69		52 – 74	
Age range	0 – 108		0 – 97	
Age groups (years)				
0-4	10	0.6	25	5.9
5-12	7	0.4	6	1.4
13-18	12	0.7	5	1.2
19-24	23	1.4	1	0.2
25-34	91	5.4	21	4.9
35-44	170	10.1	15	3.5
45-54	317	18.9	44	10.4
55-64	400	23.8	75	17.6
65-74	451	26.9	129	30.4
75-84	178	10.6	87	20.5
85+	19	1.1	17	4.0
Unknown	0	0.0	0	0.0
Total	1,678		425	

Deaths

Similarly to ICU admissions, the number of deaths (including all deaths where COVID-19 was a direct or contributing cause of death) in COVID-19 cases was higher in 2021 (n = 3,799) than in 2022 (n = 2,201). The highest number of weekly deaths among COVID-19 cases by date of death was in week 4, 2021 when there were 440 deaths in notified COVID-19 cases (Table 5, Figure 1). The median age of deaths increased slightly from 81 years in 2021 to 83 years in 2022.

As with ICU admissions, there was a higher percentage of males in cases that died with 55.2% in 2021 and 53.6% in 2022. The trend on increases in the percentage of female ICU deaths mirrors the increases observed in notified cases.

Table 5: Summary characteristics by age and sex of deaths among COVID-19 cases in Ireland during 2021 and 2022

	2021		2022	
	Number	Percentage	Number	Percentage
Gender				
Males	2,097	55.2	1,180	53.6
Females	1,702	44.8	1,021	46.4
M:F ratio	1.23		1.16	
Age (years)				
Mean age	79		80	
Median age	81		83	
Interquartile range	72 – 87		74 – 89	
Age range	0 – 108		0 – 106	
Age groups (years)				
0-4	1	0.0	1	0.0
5-12	1	0.0	0	0.0
13-18	2	0.1	2	0.1
19-24	4	0.1	3	0.1
25-34	13	0.3	9	0.4
35-44	38	1.0	33	1.5
45-54	115	3.0	58	2.6
55-64	293	7.7	137	6.2
65-74	690	18.2	324	14.7
75-84	1,231	32.4	696	31.6
85+	1,410	37.1	938	42.6
Unknown	1	0.0	0	0.0
Total	3,799		2,201	

Outbreaks

There were a total of 14,627 COVID-19 outbreaks across a range of locations between 2021 and 2022 (Figure 4). There were fewer outbreaks notified to CIDR in 2022 (n=3,928), compared to 2021 (n=10,699). However, this is largely due the emergence of Omicron in late 2021 and as a result the prioritising by public health departments of the investigation and reporting of outbreaks in settings that benefit most from public health and clinical intervention. These settings include acute hospitals, nursing homes, community hospital/long-stay units, residential institutions, other healthcare settings and vulnerable populations. For this reason, outbreaks in other settings may be underestimated. The highest number of weekly COVID-19 outbreaks was in week 12 2021 with 453 outbreaks.

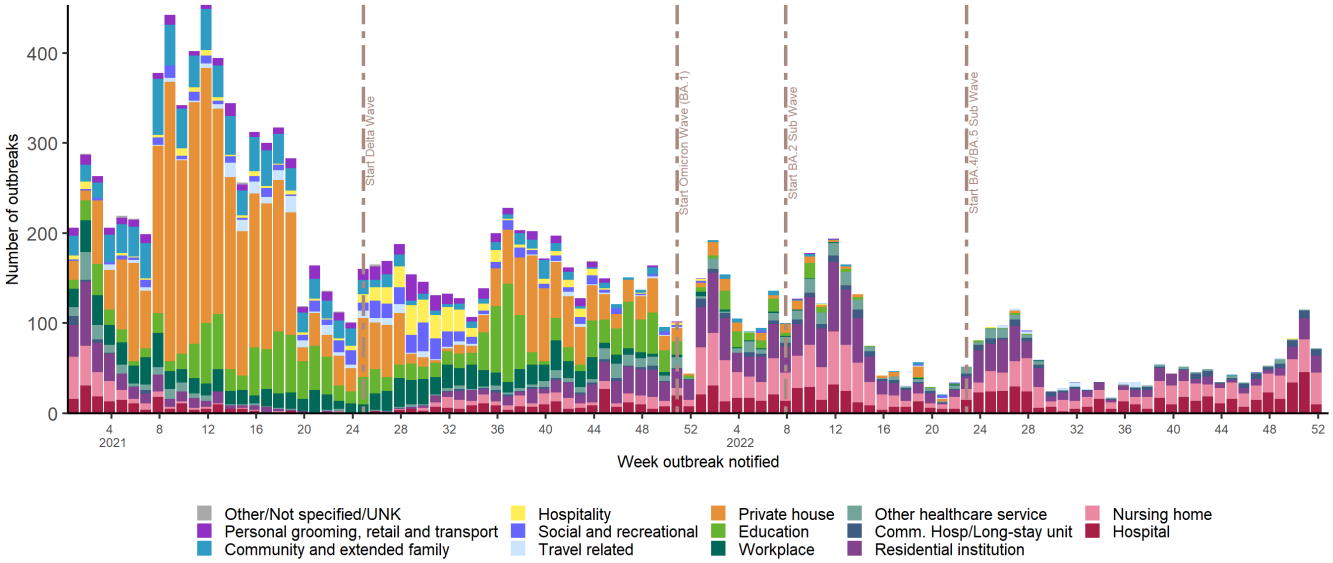

Figure 4: Number of COVID-19 outbreaks notified in Ireland in 2021 and 2022 by location and week of notification.

Outbreaks in Healthcare Settings

There was a total of 4,839 COVID-19 outbreaks associated with health and care settings in 2021 and 2022. The highest number of weekly outbreaks notified associated with nursing homes, n=59, was in week 12 2022. The highest number of weekly outbreaks notified associated with hospitals, n=46, was in week 51 2022. The highest number of weekly outbreaks notified associated with residential institutions, n=77, was in week 12 2022. The highest number of weekly outbreaks notified associated with community hospitals/long-stay units, n=10, was in week 1 2021.

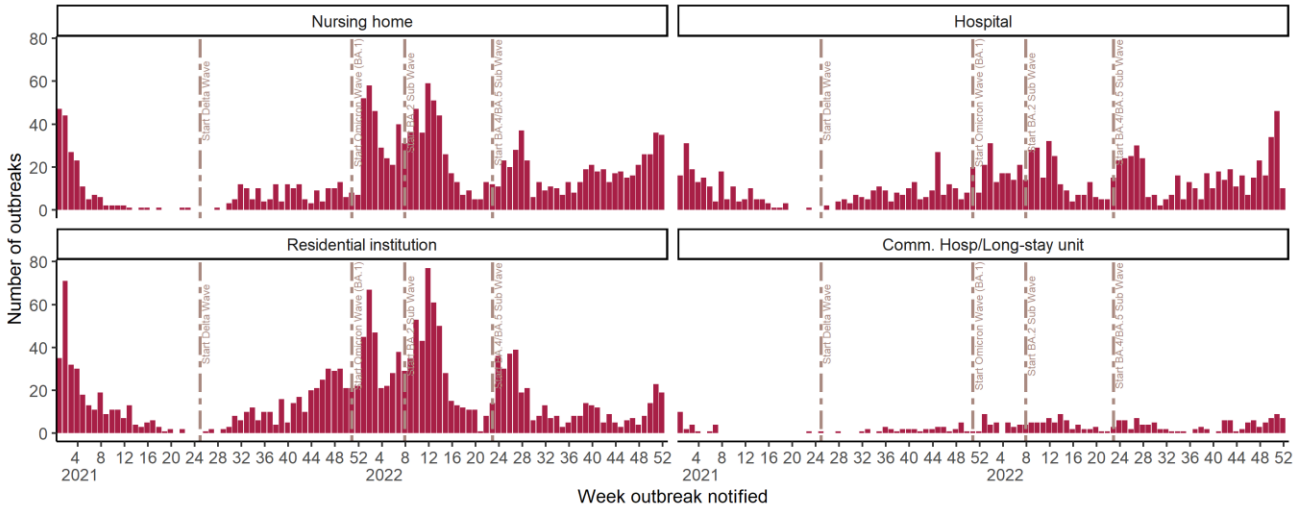

Figure 5: COVID-19 outbreaks in: acute hospitals, nursing homes, community hospitals/long-stay units and residential institutions notified in Ireland by week of notification, 2021 to 2022.

Outbreaks in Nursing Homes and Community Hospitals/Long-stay Units

There were more COVID-19 outbreaks in nursing homes and community hospitals/long-stay units in 2022, compared to 2021 (Table 6). This coincided with the emergence of the Omicron variant in late 2021. In 2022 there were with 1,413 outbreaks with 23,627 associated cases*. In 2021 there were with 427 outbreaks with 9,771 associated cases. However, the number of deaths# associated with outbreaks in these settings was higher in 2021 than in 2022 with 599 and 317 deaths, respectively.

Table 6: Number of COVID-19 outbreaks, cases* and deaths# in nursing homes and community hospitals/long-stay units

Outbreak year	Number of outbreaks	Number of cases*	Number of deaths#
2021	427	9771	599
2022	1413	23627	317
Total	1840	33398	916

*the larger among number ill, the aggregate number of confirmed cases reported and the number of confirmed linked cases. From 2022, includes cases confirmed by PCR or Antigen testing
#the larger between the aggregate number of outbreak deaths reported and the number of linked cases (confirmed and probable) who died

The median outbreak size in nursing homes and community hospitals/long-stay units remained relatively low since the COVID-19 vaccination programme commenced in January/February 2021. The median outbreak size for outbreaks reported in March 2022 increased to 21 and then reduced to 10 in December 2022.

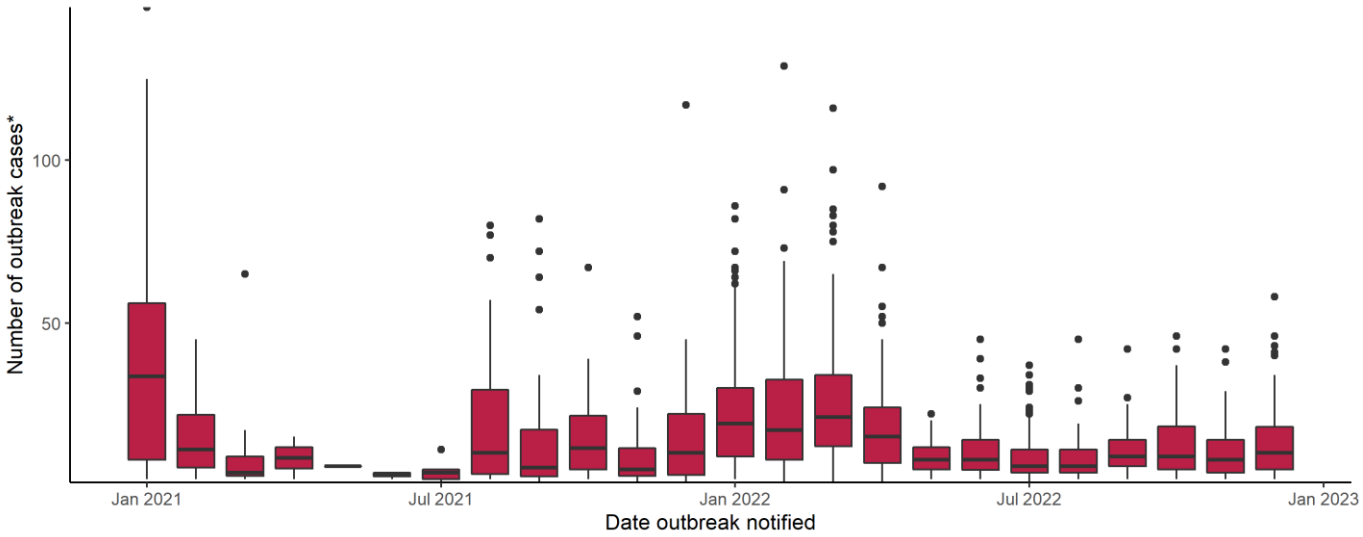

Figure 6: Distribution of COVID-19 outbreak size* by month of outbreak notification. *Outbreak size is based on the larger among number ill, the aggregate number of confirmed cases reported and the number of confirmed linked cases

SARS-CoV-2 variants summary, 2021-2022

There were a total of 98,216 SARS-CoV-2 positive specimens sequenced in Ireland during 2021 and 2022 (Figure 7). There were successive waves of dominating variants over this time period from the Alpha (B.1.1.7) variant in early 2021, through the Delta (B.1.617.2) variant (weeks 26 – 50 2021) and then Omicron and its sublineages (BA.1, BA.2, BA.4, BA.5) from Week 51 2021 onwards through 2022. The emergence of Omicron has been characterised by the evolution of a multitude of lineages often co-circulating at any one time, as well as the advent of the first dominant recombinant lineages towards the end of 2022. The Omicron XBB recombinant lineages (BA.2.75 and BA.2.10 recombinant) have since come to dominate circulating variants began to emerge towards the end of 2022 – they accounted for 7.8% of lineages in week 52 2022.

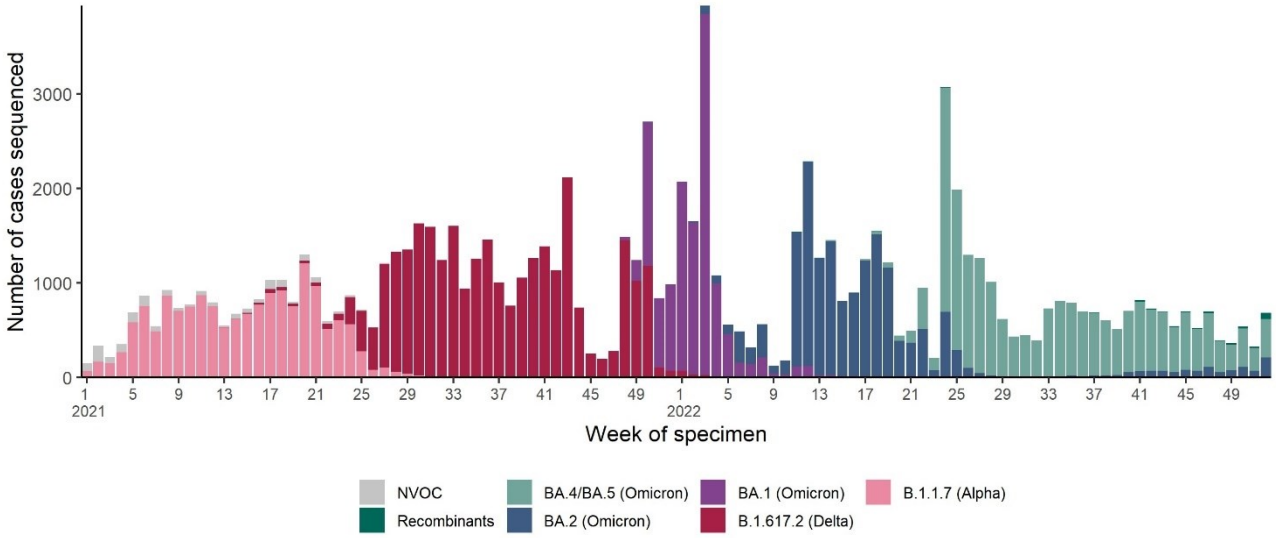

Figure 7: SARS-CoV-2 whole genome sequencing results by variant and specimen collection dates from 2021 to 2022, Ireland.

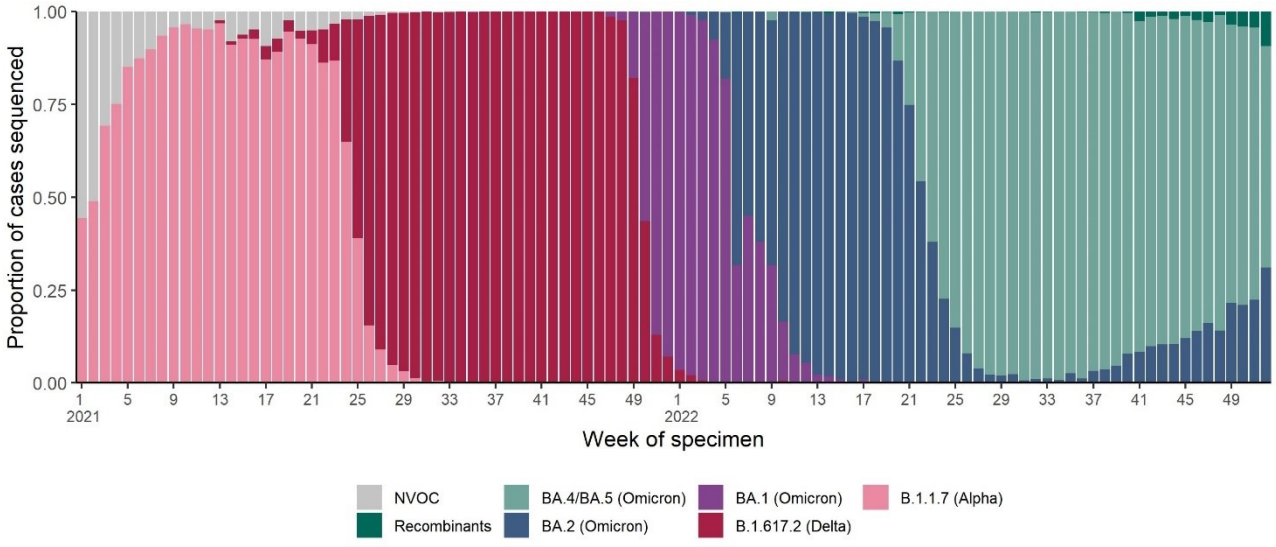

Figure 8: SARS-CoV-2 whole genome sequencing results by proportion of variant and specimen collection dates from 2021 to 2022, Ireland.

Discussion

Comparison of COVID-19 notifications for 2021 and 2022 is challenging, as there were several changes to the testing policy during 2022 as well as shifts in testing behaviours (e.g. use of antigen tests) and health seeking behaviour which mean that case notification data is not directly comparable between the two time periods. For the entirety of 2021 and up until the end of week 2 2022, PCR testing was recommended for all symptomatic persons. Since 28/02/2022 (week 9, 2022), PCR testing was only recommended for symptomatic people in the community within certain risk groups.

The number of hospitalised cases, cases admitted to ICU and cases who died are less impacted by changes in testing policy.

There were notable demographic differences between 2021 and 2022, primarily an increase in the median age of patients and an increase of the percentage of female cases across all indicators. This was particularly notable with a large increase in COVID-19 incidence in women aged 25-54 years, compared to the same age group in men. This difference in age profile may potentially be explained by the ongoing recommendation for healthcare workers to test, a high proportion of whom are women. Alternatively, this difference could be attributed to differing health seeking and/or testing behaviour between age groups and genders.

It is also notable that despite women comprising a higher percentage of overall cases, severe outcomes such as ICU admission and death were more likely to be male. Further investigations surrounding these disease severity disparities would be necessary to better define any sex related risks.

There were also differences between the circulating SARS-CoV-2 variants. Various surges were experienced in 2021 primarily due to the spread of new variants into population. The largest peak occurred in the 2021/2022 winter season when BA.1 (Omicron emerged). Sublineages of Omicron continued to circulate throughout 2022.

While Omicron was more transmissible than previous variants[4] and caused a large increase in case notifications prior to testing policy changes, hospitalisation numbers were also markedly higher likely due to testing policies in hospitals being agnostic to disease severity and ongoing screening of asymptomatic hospital patients. However, there was a clear decrease in severe outcomes such as ICU admissions and deaths.

The epidemiology of COVID-19 in terms of disease severity changed in early 2021 and throughout 2021 and 2022 after the introduction of the COVID-19 vaccination programme. While other factors including changes in dominant variants with increased virulence and less disease severity, and the protective effect of natural immunity from previous infections contributed, it is likely that Ireland's widely successful vaccination campaign is the main contributor to decreased severe disease.

Testing policies have now stabilised, which will result in more comparable yearly reviews in the future. However, the possibility of the emergence of new variants and the irregular seasonality pattern (with surges outside of the winter period) of this disease is likely to pose continued public health challenges in the short to medium future.

A detailed epidemiological report of COVID-19 for 2023 will be published in the coming months, once data are fully validated. In brief, SARS-CoV-2 continued to circulate at high levels in 2023, with intermittent waves of increased activity. However, severe disease in terms of ICU admissions and deaths has remained at low levels.

People should remain vigilant and follow public health advice on preventing the spread of SARS-CoV-2 and other respiratory viruses. If you have any symptoms, even mild ones, you should stay at home until 48 hours after your symptoms are mostly or fully gone. For advice on preventing the spread of COVID-19 and

what to do if you have symptoms go to:
https://www2.hse.ie/conditions/covid19/preventing-the-spread/
https://www2.hse.ie/conditions/covid19/symptoms/overview/

Completing your COVID-19 vaccination, including booster doses, will reduce the risk of getting severely ill from COVID-19.
For information on COVID-19 vaccination, including how to get the vaccine, go to:
https://www2.hse.ie/screening-and-vaccinations/covid-19-vaccine/

Technical Notes

1. Data Source

Data are based on statutory notifications and were extracted from Computerised Infectious Disease Reporting (CIDR) system and the HSE COVID care tracker. Data are provisional and subject to ongoing review, validation and update. As a result, figures in this report may differ from previously published figures.

2. Epidemiological date

Epidemiological date is based on the earliest of dates available on the case and taken from date of onset of symptoms, date of diagnosis, laboratory specimen collection date, laboratory received date, laboratory reported date or event creation date/notification date on CIDR. By using this date rather than event creation/ notification date, adjusts for any delays in testing/notification. Further information on epidemiological dates and weeks can be found on the HPSC website

3. Population data

Population data were taken from Census 2016. Data were aggregated into the following age groups for the analysis: 0-4 years, 5-12 years, 13-18 years, 19-24 years, 25-34 years, 35-44 years, 45-54 years, 55-64 years, 65-74 years, 75-84 years and ≥ 85 years.

4. Outbreaks

Due to the cyber-attack on the HSE IT systems on 14/05/2021, CIDR was unavailable for the reporting of COVID-19 outbreaks from 14/05/2021 to the 28/06/2021. As a result, there has been a delay in reporting for many outbreaks on CIDR. To account for this, outbreak week for all outbreaks created between 14/05/2021 and 09/10/2021 is based on the following algorithm: earliest of 1. outbreak recognition date; 2. first reported date; 3. outbreak created date. Outbreak week is based on outbreak created date for all outbreaks created on or before 13/05/2021, and on or after 10/10/2021.

5. Variant data

The following laboratories undertook WGS of suitable positive SARS-CoV-2 specimens as per the National SARS-CoV-2 WGS Programme framework and reported the data to HPSC: National Virus Reference Laboratory, Galway University Hospital, St James's Hospital, University Hospital Limerick, St Vincent's University Hospital, Cork University Hospital, Beaumont Hospital, CHI Crumlin Hospital and Enfer Laboratories.

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