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Hospital admission probability and length of stay among Covid-19 confirmed cases

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Introduction

The numbers of Covid-19 confirmed cases and hospital admissions have varied across the course of the pandemic in Ireland. Three broad waves can be identified; March through July, August through November, and December through February. The majority of confirmed cases and hospital admissions have been recorded since December. This briefing note examines how relationships have varied over the course of the pandemic between cases and the two main parameters affecting hospital service demand: admissions to and lengths of stay in hospital and critical care. Particular attention is paid to variations by age in distributions of admission probabilities and average length of stay across periods of the pandemic.

Data and Methods

Data on the number of Covid-confirmed cases and admissions to general hospital and critical care are taken from the HPSC CIDR database. This file records all confirmed COVID-19 cases in the country up until a particular time point on the latest date of case notification. The CIDR data also provide information on length of stay in critical care.

To capture length of stay in general hospital beds we rely on the HPO HIPE dataset. The Covid-19 extract of the HIPE dataset captures administrative and clinical information on deaths and discharges of Covid-19 cases from all acute public hospitals nationally. Both CIDR and HIPE databases are accessed securely through the CSO Virtual Desktop Infrastructure (VDI).

We adjust the analysis, as far as possible, to focus mainly on community acquired cases.[1] In the CIDR dataset we exclude cases flagged as healthcare workers or cases with an outbreak location flag of “Nursing home” “Comm. Hosp/Long-stay unit” or

[1] A proportion of these cases that may have contracted Covid-19 in hospital. Future refinements may consider the best approach to adjusting for these cases.

"residential institution". Similarly, in the HIPE dataset we exclude Covid-19 discharges with an admission source of "Nursing home/convalescent home or other long stay accommodation". No information on the occupational status of discharges is recorded on the HIPE dataset.

There may often be a lag between case notification and hospital and critical care admission. For this reason, when examining hospitalisations and critical care admissions, we limit the analysis to case notifications at least two weeks prior to the file date (in this analysis 27th April 2021).

The distribution of length of stay for both those requiring critical care and those admitted to general hospital beds only, is heavily skewed (see Appendix, Figure A2). To avoid outliers excessively influencing average values, we trim length of stay in this analysis at the 1st and 99th percentile of the respective distributions.

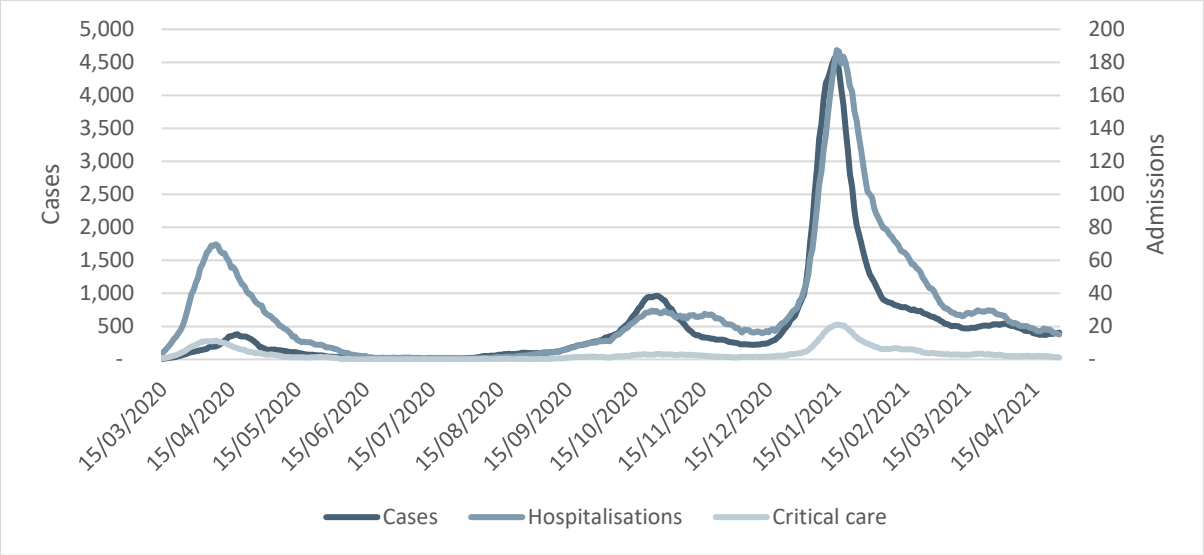
All parameters are presented with associated 95 percent confidence intervals calculated through resampling observations (500 replications) with replacement from the data.

Findings

Cases, hospitalisations, and critical care

Figure 1 provides trends in confirmed cases, hospitalisations and critical care admissions notified to HPSC over the course of the pandemic in Ireland. As can be seen, cases and admissions have varied through time. Based on these distributions, four broad periods of the pandemic are identified; March through July 2020 (wave 1), August through November 2020 (wave 2), December 2020 through February 2021 (wave 3), and March 2021 onwards. The third wave is particularly notable given the volume of cases and admissions that have been associated with it. For the data under consideration, 61.0 percent of cases, 54.3 percent of hospital admissions, and 50.4 percent of critical care admissions were recorded between December 2020 and February 2021.

FIGURE 1 Cases, hospitalisations, and critical care admissions by day (14-day rolling average)



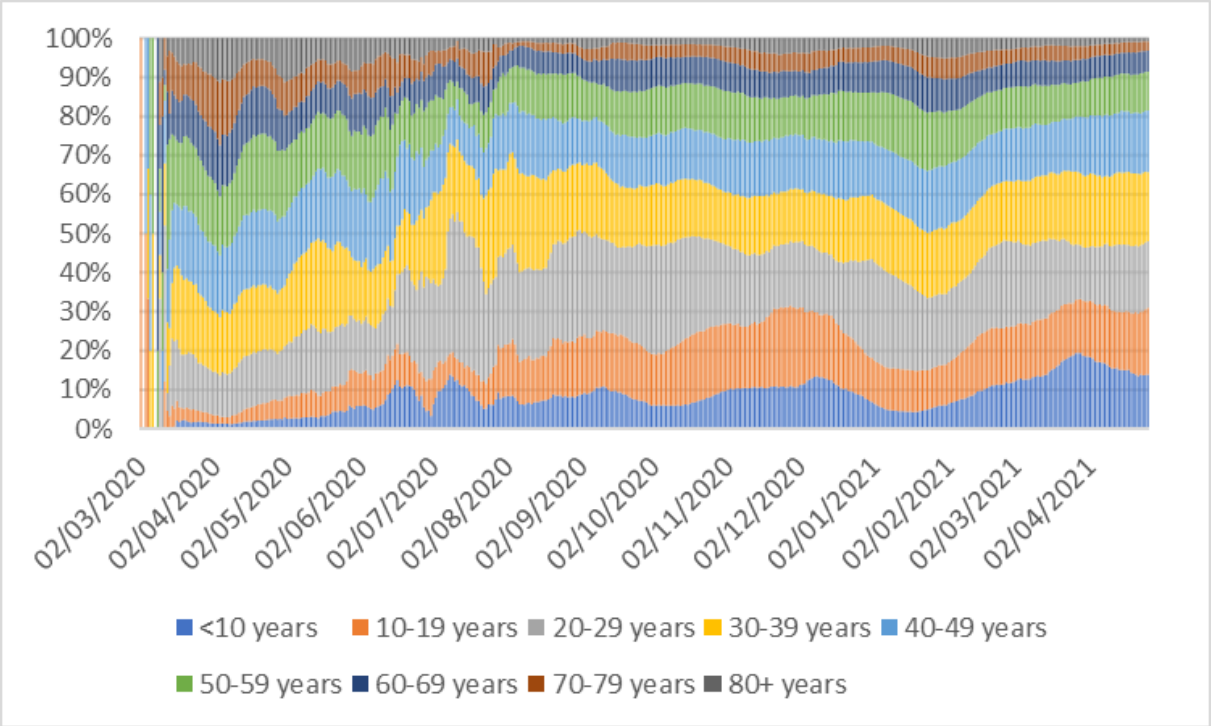
Source: Authors' analysis of CIDR database

The age distribution of cases has also fluctuated over the course of the pandemic; it is likely to have been influenced both by variations in the pattern of transmission over time and also in rates of testing in each of the age groups.

Variations in the age distribution of cases over time are illustrated in Figure 2. Relatively high shares of cases involved older individuals at the beginning of the pandemic, but younger age groups made up increasing shares as the pandemic progressed. In recent weeks there has been a noticeable reduction in the share of cases in the two oldest age cohorts; this is likely linked to high vaccination rates among this age group. At the same time, there has been an increase in the share of cases attributable to the youngest age groups peaking at the beginning of April 2021 but subsequently reducing.

Appendix B in this note takes a closer look at the daily volume and share of cases for those 18 and under. Figure B1 shows that the recent increase in cases in younger ages is driven by those in the 5-12 year age group. While this increase corresponds in time to the reopening of primary schools, other factors such as increased testing in this age group will contribute to this trend.

FIGURE 2 Share of new Covid-19 cases by age group (14-day rolling average)



Source: Authors' analysis of HPSC, CIDR file

Admission probability

Figure 3 charts average general hospital admission probability by month since the beginning of the pandemic in March 2020[2]. Admission probability was highest in March 2020 (31.2%) and declined to a low of 2.4 percent in August. Since then monthly average admission probabilities have increased. The probability of general hospital admission stands at 4.0%, for cases captured (to date) in April 2021.

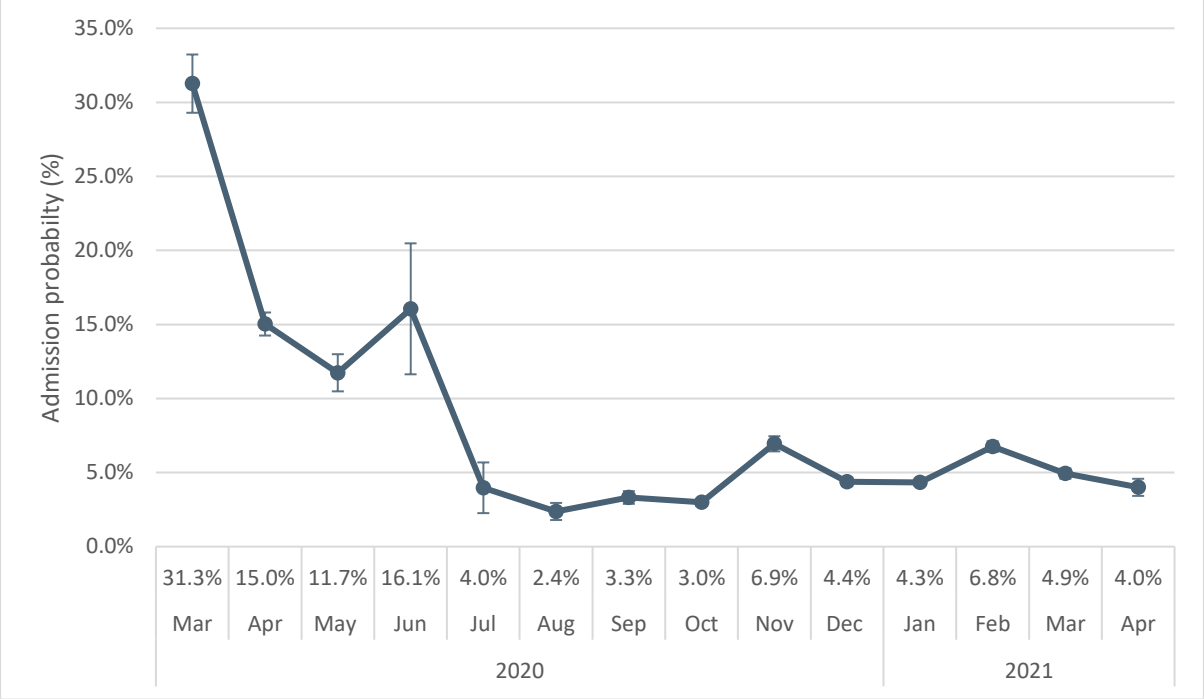
A similar trend is observable for critical care admission probabilities (Figure 4). The probability of critical care admission was highest in March 2020 at 7.3 percent, declining to a low of 0.3 percent of cases in August 2020 and remaining relatively stable since then. The probability of critical care admission is 0.4 per cent for cases captured (to date) in April 2021.

Analysis of admission probabilities at the monthly level, however, mask some interesting variation in the likelihood of hospital and critical care admission as cases surged and then declined during Wave 3 (see Appendix A, Figure A1). Specifically, admission probabilities approximately halved leading up to the peak of the third wave before rising again as cases began to decline. It is unclear what is driving this variation, and it could be related to both demand (e.g. individuals being less likely to present to hospital, or delay presentation, around Christmas) and/or supply (capacity and staff shortages influencing admission policy) factors. These counter-cyclical trends may warrant further investigation particularly if these

[2] Here an admission may refer to cases of hospital-acquired Covid-19.

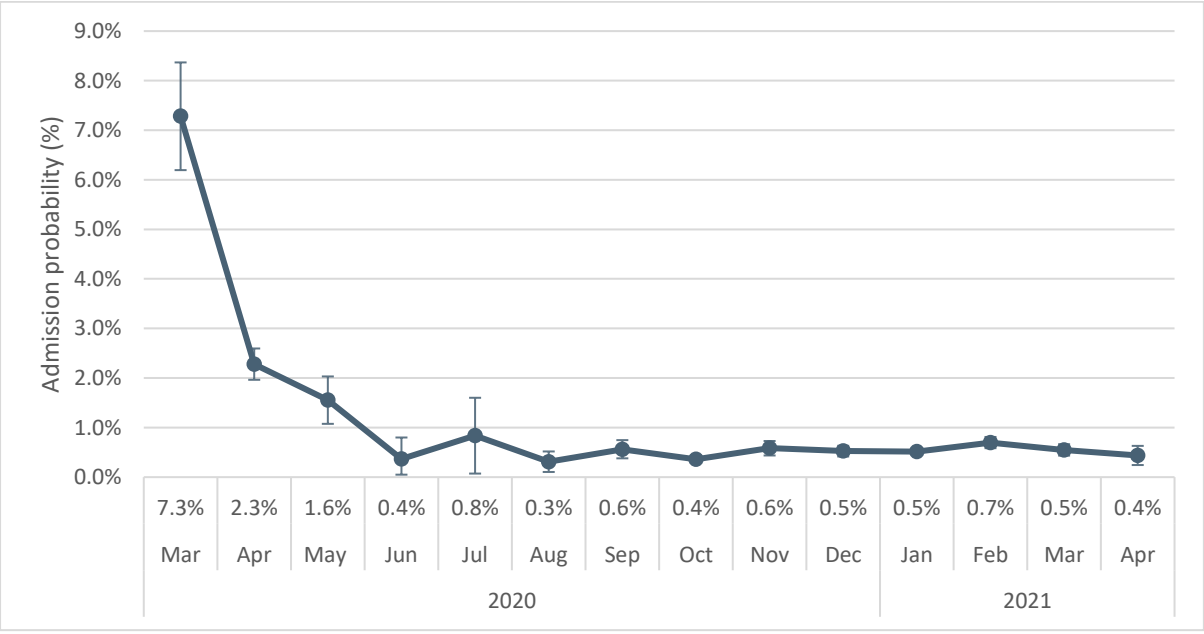
associations are not related to the time period in which the wave occurred and, as such, may be likely to repeat under a subsequent wave.

FIGURE 3 General hospital only (non-critical care) admission probability, by month



Source: Authors' analysis of CIDR database

FIGURE 4 Critical care admission probability, by month

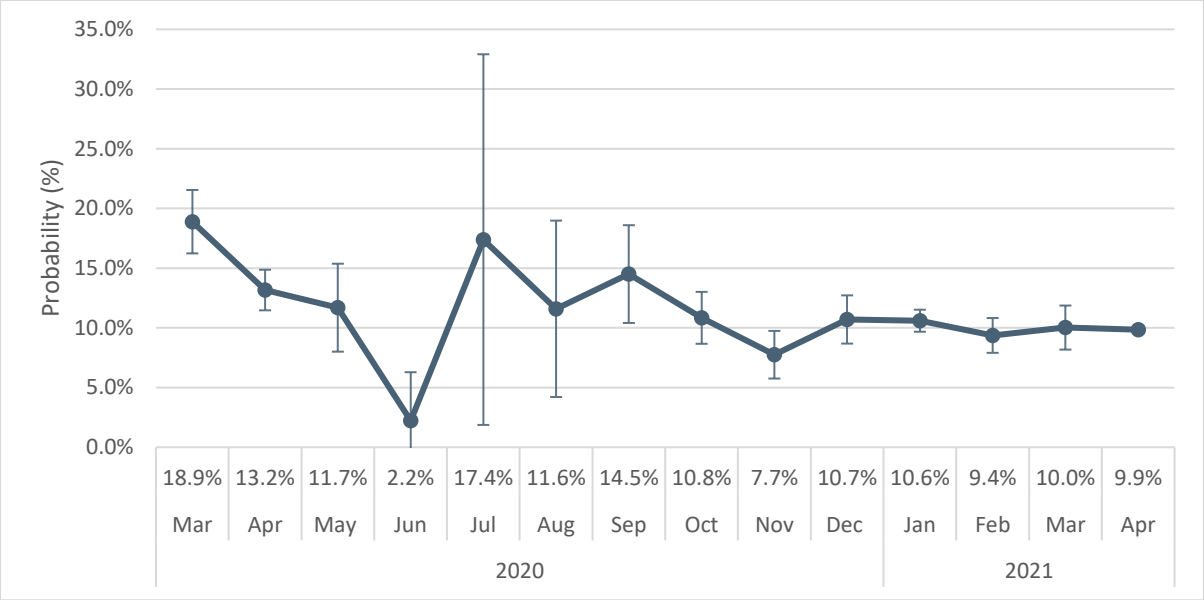


Source: CIDR database

Figure 5 tracks the probability of critical care admission following hospitalisation, by month. As both hospital admission and critical care admission probabilities follow similar trajectories over the course of the pandemic, the probability of

critical care admission following hospitalisation has remained reasonably uniform over the course of the pandemic (apart from June (2.2 percent)). In recent months the probability of critical care admission following hospitalisation has remained reasonably stable, varying between 8 and 11 per cent.

FIGURE 5 Probability of critical care admission given hospitalisation, by month

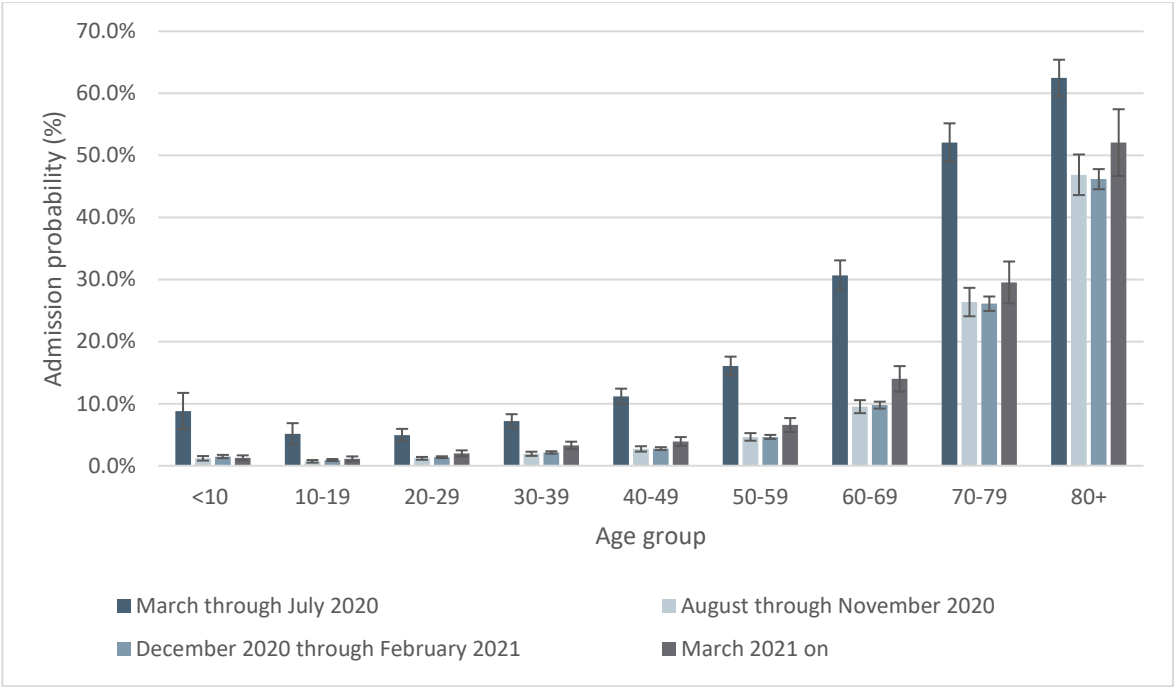


Source: Authors' analysis of CIDR database

Average admission probabilities may vary over time due to changing clinical practices (i.e. the model of care), but they may also be affected by the composition of cases (see Figure 2). In particular, if the proportion of cases made up by older age groups increases, average admission probabilities tend to rise as these groups are more likely to require hospital care. This broad pattern has held throughout the pandemic to date, although there have been some changes over time in age-specific probabilities of admission.

Figure 6 illustrates the probability of hospital admission by age for our four defined pandemic periods. Across all periods, the probability of hospital admission rises with age, peaking for those aged 80 and over. For this age group, the probability of hospital admission ranges from 46.2 per cent (December 2020 through February 2021) to 62.5 per cent (March through July 2020). Figure 6 also shows significantly higher admission probabilities across all age groups in the period March through July 2020.

FIGURE 6 Hospital admission probability by age and pandemic period

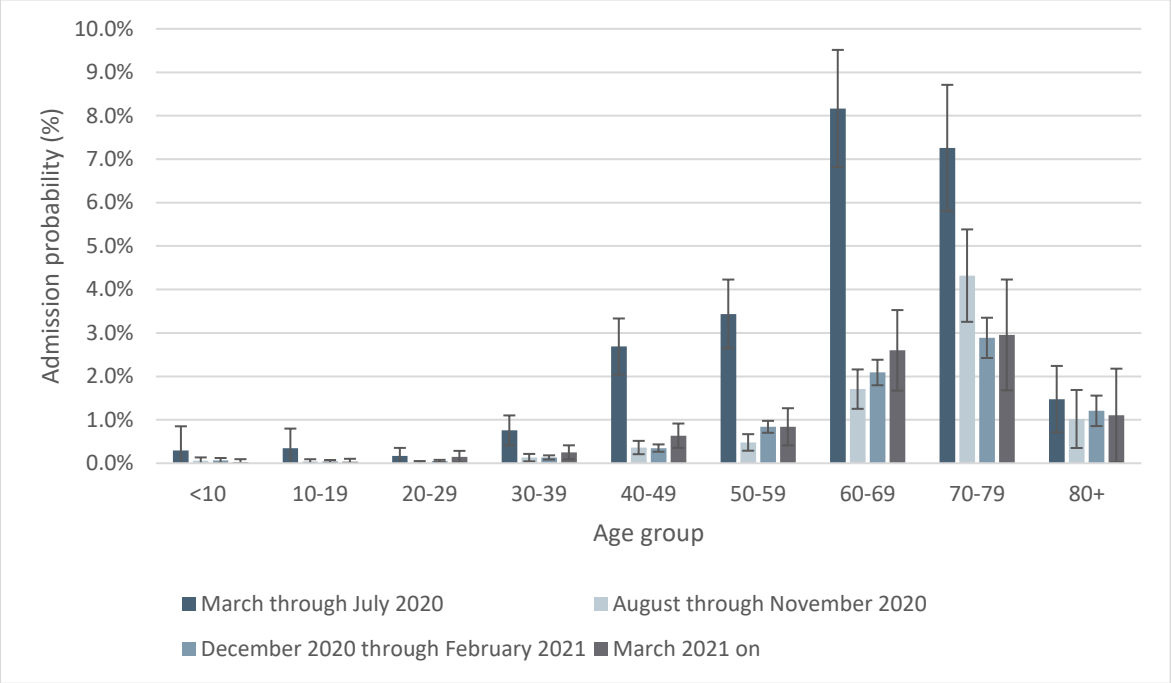


Source: *Authors' analysis of CIDR database*

Figure 7 illustrates the probability of critical care admission by age by pandemic period. Similar to Figure 6, there is a strong age gradient evident in terms of the probability of critical care admission. A notable difference, however, is that the probability of critical care admission falls dramatically for those aged 80 and over (despite this group having the highest hospital admission probability).

While Figure 4 showed higher critical care admission probabilities in the early months of the pandemic, Figure 7 shows that this also applied across age groups. In the period March through July, 8.2 percent of cases aged 60-69 years old and 7.3 per cent of cases aged 70-79 years, notified to HPSC, received critical care.

FIGURE 7 Critical care admission probability by age and pandemic period



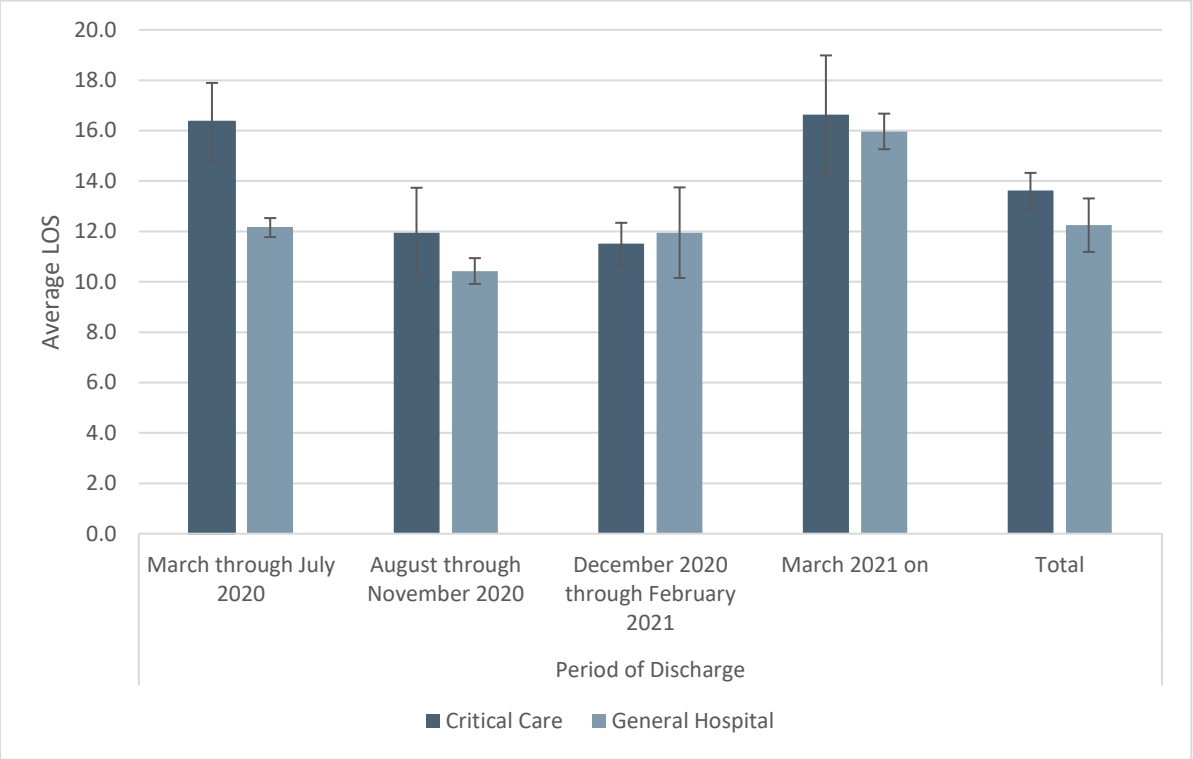
Source: *Authors' analysis of CIDR database*

Length of stay

Figure 8 charts average length of stay (ALOS) for those admitted to general hospital beds only, and for those in critical care. Over the entire pandemic period ALOS for general hospital only discharges is 12.2 (median 7 days) and 13.6 (median 9 days) for critical care stay. While ALOS appears reasonably stable across waves, some variation is observable over the course of the pandemic. Notably, general hospital (16.0 days) and critical care ALOS (16.6 days) have increased since the beginning of March 2021.

Additionally, over the course of wave 3 (December through February) notable within-wave variation has been observed for both general hospital and critical care ALOS (see Appendix A, Table A1). Average LOS for both forms of hospital care declined substantially in January this year as cases and hospitalisations peaked. A decline in cases and hospitalisations in February and March 2021 was then accompanied by large increases in ALOS. Again, these counter-cyclical trends may warrant further investigation.

FIGURE 8 Average length of hospital stay for general hospital discharges (non-critical care) and critical care discharge, by pandemic period

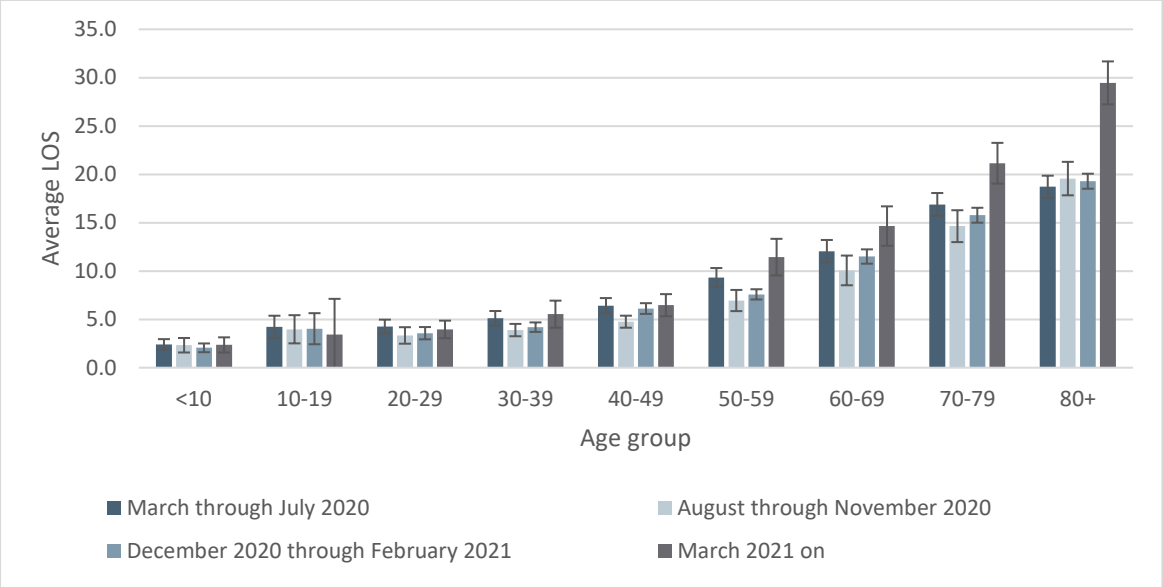


Source: *Authors' analysis of CIDR and HIPE databases*

Similar to admission probabilities, ALOS measures may also be affected by the composition of cases (see Figure 2). In particular, older age groups are not only more likely to require admission to hospital, they also spend longer in a bed once admitted.

Figure 9 illustrates ALOS in general hospital beds by age group and pandemic period. Similar to admission probabilities, across all periods there is a strong age gradient. The ALOS in a general hospital bed tends to increase with the age of discharges. The increase in overall ALOS since March 2021 shown in Figure 8 seems to be driven by older age groups recording longer average ALOS in this period relative to earlier periods.

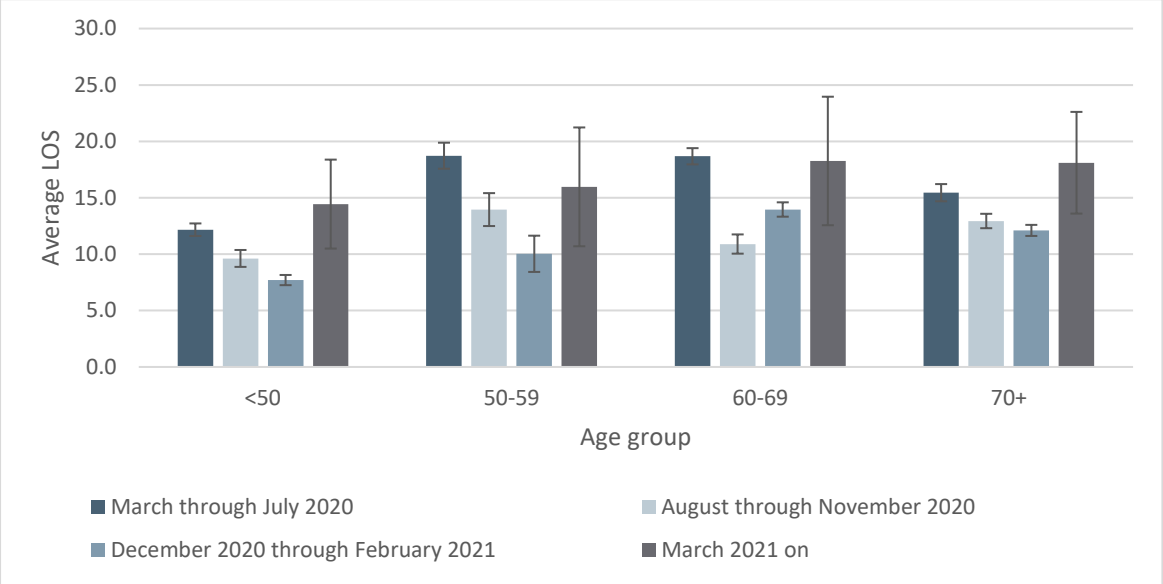
FIGURE 9 General hospital average length of stay, by age and pandemic period



Source: Authors' analysis of HIPE database

Figure 10 charts the ALOS of critical care patients by age[3] and pandemic period. In contrast to Figure 9, no obvious relationship is observable between age and ALOS in critical care. It may be that age plays less of a role in resource use within the severely ill group of patients in critical care. Higher ALOS for critical care in the both the early (wave 1) and most recent (March 2021 onwards) months of the pandemic observed in Figure 8 is consistent across age groups.

FIGURE 10 Critical care average length of stay by age and pandemic period



Source: Authors' analysis of CIDR database

It is important to note that ALOS does not fully describe the length of stay distribution for Covid-19 patients. Many cases have a very short length of stay, but

[3] Age groups have been combined for younger and older ages due to small numbers.

there is also a long tail of cases with lengths of stay well in excess of the average. In Appendix A we present length of stay distributions by wave.

Summary

The volumes of Covid-19 confirmed cases and hospital admissions have varied through the course of the pandemic in Ireland. Four broad pandemic periods were examined in this analysis; March through July 2020, August through November 2020, December 2020 through February 2021, and March 2021 onwards.

The first wave was associated with a higher share of cases made up of older age groups. Reflecting this, the first wave was also associated with significantly higher admission probabilities compared to subsequent waves. However, it is also important to note that age-specific admission probabilities were also higher in the first wave.

The third wave has been significantly different to previous waves in terms of volume of cases and admissions recorded, yet admission probabilities and length of stay have remained reasonably stable in aggregate compared with wave 2. However, there is some evidence emerging that as case number increased during the third wave, admission probabilities and ALOS fell sharply before increasing again as case numbers subsequently declined. These counter-cyclical relationships may warrant further investigation particularly to see if they are likely to repeat in the event of a future wave.

Since March 2021, overall and age-specific admission probabilities have remained stable. However, overall ALOS has increased and this appears to have been driven mainly by an increase in ALOS in older age groups.

The data also show, however, that the share of cases attributable to older age groups in recent weeks has declined and this is consistent with the prioritised roll-out of vaccinations to these groups. At the same time there has been an increase in the proportion of cases arising in younger age groups, peaking at the beginning of April and subsequently declining. Further analysis revealed this increase was largely concentrated in the 5-12 year age group. While this increase in cases corresponded with the reopening of schools it was also accompanied by more intensive testing.

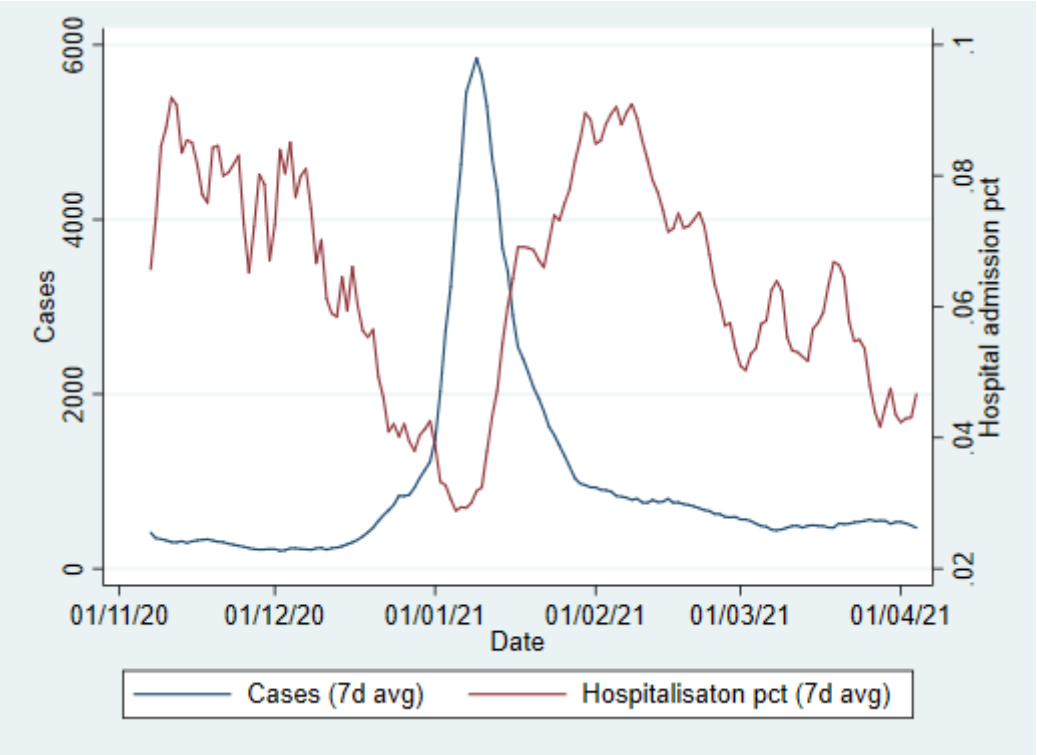
Factors including the continued and expanded rollout of vaccination to at-risk groups, the impact of new Covid-19 strains, and changing policy and behaviours, are likely to impact on the relationships examined over the coming weeks and months. We plan to issue further updates to track these changes.

Appendix A

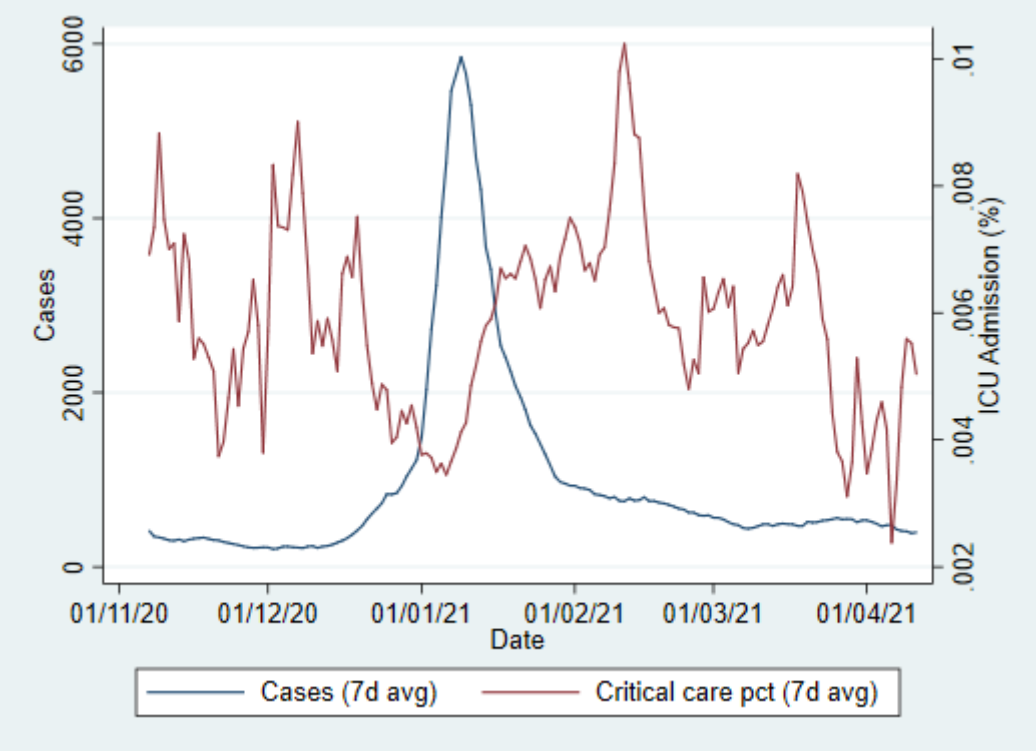
Figure A1 plots the daily number of confirmed cases (7-day rolling average) and the probability of hospital and critical care admission (7-day rolling average), respectively, from November 2020 through early April 2021. The chart suggests that as the numbers of cases increased around the time of the third wave, the probability of being admitted to hospital fell sharply before rising again as case numbers declined. It then levelled off. While the probability of critical care admission is more noisy, a similar (although less definitive) relationship is observable.

FIGURE A1 Daily number of confirmed cases (7-day rolling average) and the probability of hospital and critical care admission (7-day rolling average), respectively, from November 2020 to March 2021.

Hospital admissions



Critical care



Source: *Authors' analysis of CIDR database*

Table A1 provides summary statistics on general hospital and critical care length of hospital stay, by month of discharge, between November 2020 and March 2021 (to date). The table shows that there was a large decline in reported ALOS for both general hospital and critical care in January 2021 before large increases in ALOS are observed in February and March 2021. Median values also show an increase in length of stay in recent months.

TABLE A1 General hospital and critical care summary statistics, by month of discharge, November 2020 to March 2021 (to date)

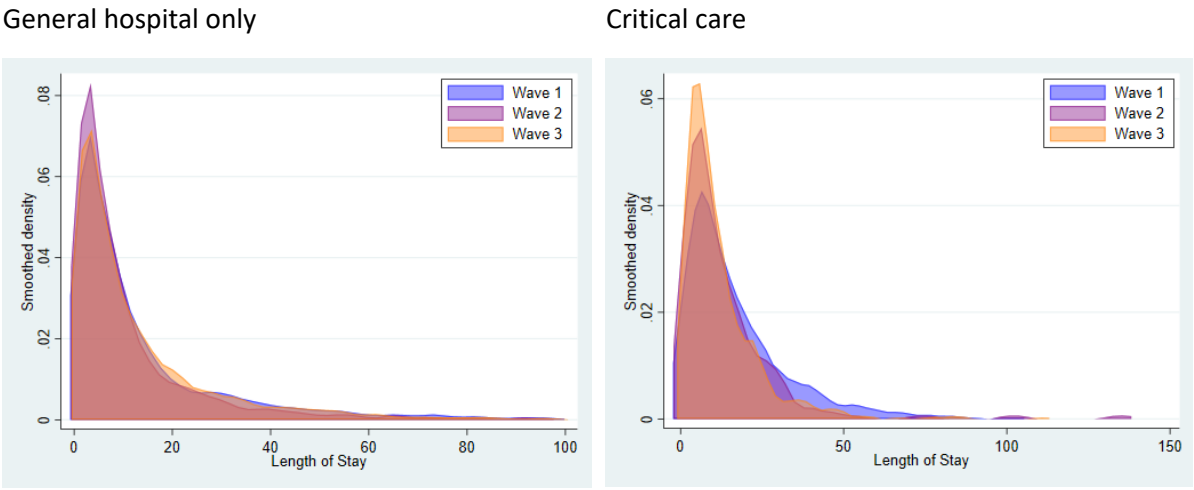
Month of discharge	Average LOS	Median	Min	Max	Obs	Lower Bound - Bootstrap	Higher Bound - Bootstrap
General Hospital							
Nov	13.9	8	1	79	811	12.8	14.9
Dec	14.0	7	1	80	755	12.8	15.1
Jan	9.4	6	1	78	3945	9.0	9.7
Feb	15.5	10	1	80	2467	14.9	16.1
Mar	17.4	10	1	79	1150	16.3	18.4
Apr	12.0	6	1	80	405	10.6	13.5
Critical Care							

Nov	11.8	8	1	44	70	9.5	14.1
Dec	14.0	9	1	76	57	9.8	18.1
Jan	8.7	7	1	57	327	8.0	9.5
Feb	15.0	11	1	57	218	13.3	16.7
Mar	18.1	11	1	70	130	15.2	21.0
Apr	12.9	7	1	60	51	9.1	16.8

Source: *Authors' analysis of CIDR and HIPE databases*

Figure A2 plots the total (untrimmed) distribution of length of stay for general hospital only and critical care discharges. Across waves, the densities appear broadly similar.

FIGURE A2 Critical care average length of stay by age and pandemic period

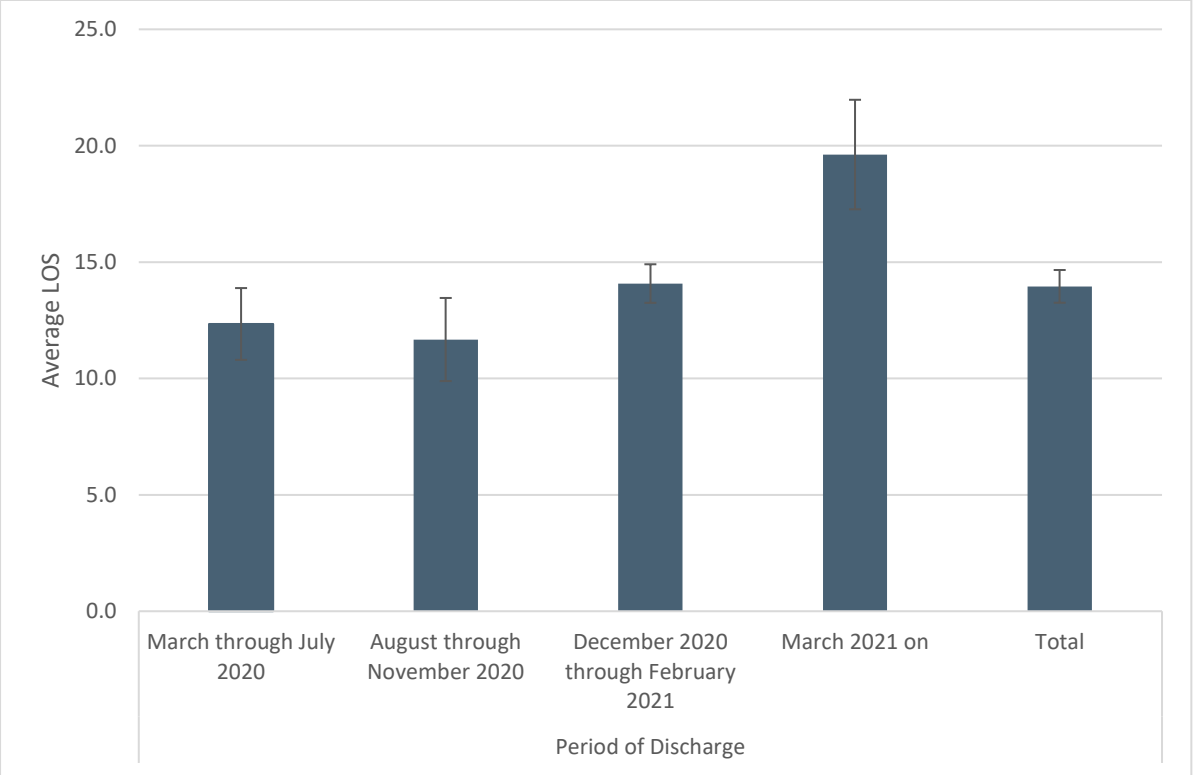


Source: *Authors' analysis of CIDR and HIPE databases*
Note: *Untrimmed LOS*

One category of length of stay excluded from the main analysis was general hospital length of stay for critical care patients. This is presented in the Figure below but represents a somewhat imprecise measure. It is estimated as a residual from the HIPE data through subtracting total hospital bed days for ITU (intensive treatment unit) discharges from their ITU bed days. In HIPE it is not possible to split this by pre and post ITU stay.

Over the entire pandemic period to date, general hospital ALOS for critical care patients was 14.0 days (median, 9 days). Reported ALOS was highest in the period from March 2021 on at 19.6 days (median, 13 days).

FIGURE A3 General hospital average length of stay for critical care discharges



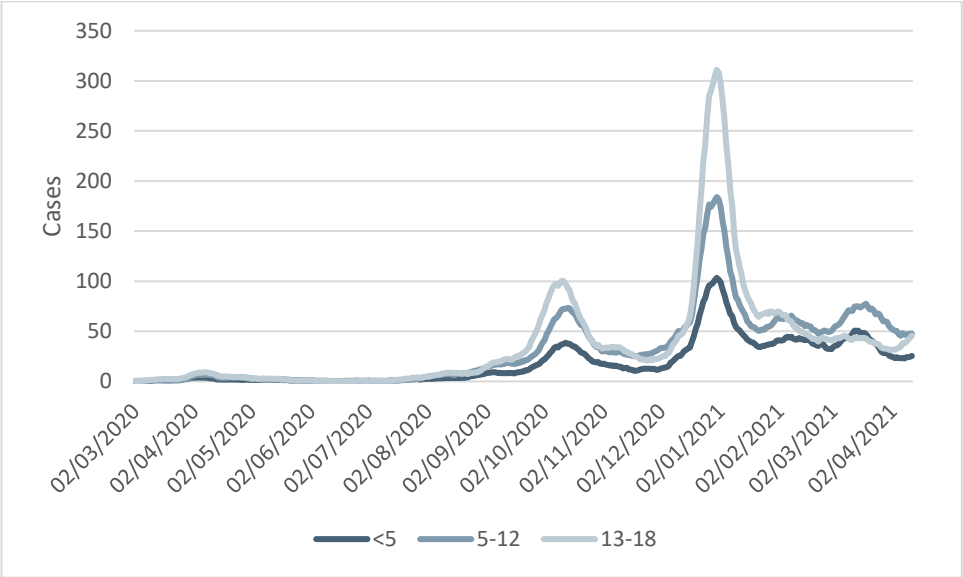
Source: *Authors' analysis of HIPE database*

Appendix B

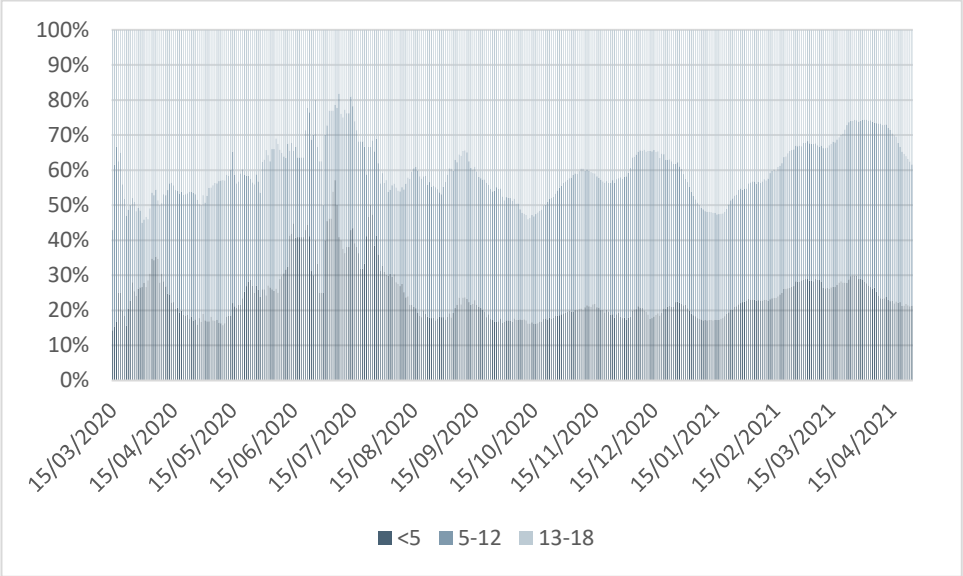
Figure B1 presents daily Covid-19 case notifications by child age group (<5, 5-12, 13-18) in terms of both volumes and shares. This figure highlights a recent relative increase in the share of cases attributable to the 5-12 year age group, peaking at the beginning of April but declining since then.

FIGURE B1 Covid-19 cases by child age group (14-day rolling average)

Volumes of cases by age group



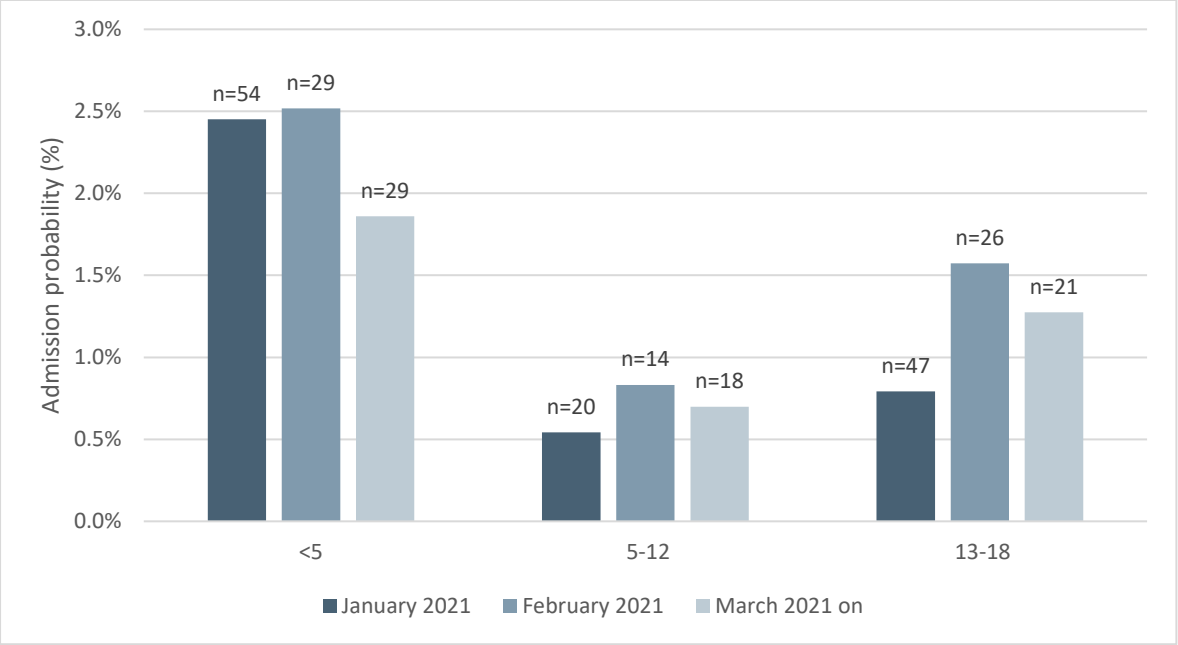
Shares of cases by age group



Source: *Authors' analysis of CIDR database*

Figure B2 charts hospital admission probability for children since January 2021 by month. Although the underlying volumes of admission are small in number, admission probabilities are consistently higher for the <5 year age group and lower for the 5-12 year age group. No clear pattern in observable in admission probability by month.

FIGURE B2 Hospital admission probability, children, since January 2021 by month.



Source: *Authors' analysis of CIDR database*