RESEARCH ARTICLE

REVISED Changes in the utilisation of acute hospital care in Ireland during the first wave of the COVID-19 pandemic in 2020 [version 3; peer review: 2 approved, 1 approved with reservations]

Previously titled: 'The public health and health system implications of changes in the utilisation of acute hospital care in Ireland during the first wave of COVID 19: Lessons for recovery planning'

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Abstract

Background: Reduced and delayed presentations for non-COVID-19 illness during the COVID-19 pandemic have implications for population health and health systems. The aim of this study is to quantify and characterise changes in acute hospital healthcare utilisation in Ireland during the first wave of COVID-19 to inform healthcare system planning and recovery.
Methods: A retrospective, population-based, observational study was conducted using two national datasets, Patient Experience Time (PET) and Hospital In-Patient Enquiry (HIPE). The study period was 6th January to 5th July 2020.
Results: Comparison between time periods pre- and post-onset of the COVID-19 pandemic within 2020 showed there were 81,712 fewer Emergency Department (ED) presentations (-18.8%), 19,692 fewer admissions from ED (-17.4%) and 210,357 fewer non-COVID-19 hospital admissions (-35.0%) than expected based on pre-COVID-19 activity. Reductions were greatest at the peak of population-level restrictions, at extremes of age and for elective admissions. In the period immediately following the first wave, acute hospital healthcare utilisation remained below pre-COVID-19 levels, however, there were increases in emergency alcohol-related admissions (Rate Ratio 1.22, 95% CI 1.03, 1.43, p-value 0.016), admissions with self-harm (Rate

Open Peer Review

Approval Status ? ✓ ✓

	1	2	3
version 3 (revision) 12 Oct 2022			✓ view
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Any reports and responses or comments on the

Ratio 1.39, 95% CI 1.01, 1.91, p-value 0.043) and mental health admissions (Rate Ratio 1.28, 95% CI 1.03, 1.60, p-value 0.028). Discussion: While public health implications of delayed and lost care will only become fully apparent over time, recovery planning must begin immediately. In the short-term, backlogs in care need to be managed and population health impacts of COVID-19 and associated restrictions, particularly in relation to mental health and alcohol, need to be addressed through strong public health and health system responses. In the long-term, COVID-19 highlights health system weakness and is an opportunity to progress health system reform to deliver a universal, high-quality, sustainable and resilient health system, capable of meeting population health needs and responding to future pandemics.

Keywords
COVID-19, health systems, health services, secondary care, healthcare utilisation, public health, mental health, alcohol

article can be found at the end of the article.

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Author roles: Marron L: Conceptualization, Data Curation, Formal Analysis, Methodology, Writing – Original Draft Preparation, Writing – Review & Editing; **Burke S**: Writing – Review & Editing; **Kavanagh P**: Conceptualization, Methodology, Supervision, Writing – Original Draft Preparation, Writing – Review & Editing

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REVISED **Amendments from Version 2**

Data from the private hospitals were not available for this study, this point has been further emphasised.

The pandemic-specific arrangements through which the private hospitals partially relieved public hospital capacity deficits (but did not fully meet the need for care) is mentioned in the discussion with additional references added to the paper.

The term recovery period for Period 4, which was used to reflect the reopening of society and the easing of Public Health restrictions and the reduction in COVID-19 cases, has been replaced with the terms reopening of society, easing of Public Health restrictions and Period 4.

It is now noted that some of the variables showing significance in the logistic regression could also be explained by reverse association.

It is now noted that in Period 4, rebound admissions may not have occurred due to deaths from COVID-19 or from delayed/ lost emergency care.

Any further responses from the reviewers can be found at the end of the article

Introduction

The coronavirus disease 2019 (COVID-19) pandemic, caused by severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2), presents a significant challenge to national health systems across the globe. In addition to controlling the transmission of infection across the population and ensuring sufficiency of health services to meet demand, impacts on the provision of non-COVID-19 care are reported in many countries[1,2]. Internationally, reduced and delayed presentations for non-COVID-19 illness are linked to increased morbidity and mortality[3–5]. These changes in utilisation of healthcare have public health implications for both population health and health systems in the short term and beyond[2].

Ireland has faced these direct and indirect impacts of COVID-19 from a unique position. A decade ago, the Irish health system experienced severe cutbacks during a prolonged period of financial austerity[6]. Since 2017, a significant programme of reform entitled Sláintecare has been adopted by government[7–9]. Sláintecare is a ten-year plan for systemic health reform which seeks to tackle long-recognised health system capacity deficits and fragmentation, Ireland's over-reliance on acute hospital services, poor orientation to primary, community care services and public health, underpinned by the absence of universal access to health and social care[7,10].

The aim of this study is to describe and quantify the impact of the first wave of the COVID-19 pandemic on acute healthcare utilisation in Ireland in order to inform healthcare system planning and public health policy. This work is situated within a broader research project which is co-producing research and evidence to inform health system and policy decisions[11]. The data and analysis presented here is part of the Foundations' Living Implementation Framework with Evaluation (LIFE)[11].

Methods

Study design and setting

A retrospective, population-based, observational study was conducted to quantify and characterise acute public hospital service utilisation events in Ireland and to compare these events across different time periods with reference to the epidemiology and public health management of COVID-19. Emergency Department (ED) presentations, admissions from ED and non-COVID-19 in-patient admissions to Health Service Executive (HSE) acute public hospitals over a 26-week period from 6th January 2020 to 5th July 2020 were identified, analysed and compared with those observed over defined reference periods.

Data sources

Patient Experience Time (PET). National data ED attendances were obtained from the Patient Experience Time (PET) dataset which is an administrative dataset that contains observations of individual-level ED utilisation across 30 HSE-operated or funded hospitals[12]. PET contains information on age, sex, discharge destination, mode of arrival and referral and triage status. Clinical information is not reported and therefore patients with and without COVID-19 were included in the data used for this study. PET data does not include Minor Injury Units (MIU), private EDs, specialist EDs or direct attendance at acute assessment units.

Hospital In-Patient Enquiry (HIPE). National acute hospitals discharge data were accessed from the Hospital In-Patient Enquiry (HIPE) data via the Health Intelligence Unit (HIU) Health Atlas Ireland Analyser. HIPE is managed by the Healthcare Pricing Office (HPO) and is a well-established, quality-assured health information system that is the primary source of episode-based, aggregate clinical, demographic and administrative data on discharges from acute public hospitals in Ireland[13]. It contains information on age, sex, area of residence, admission type, date of admission and discharge along with principal diagnosis coded using the International Classification of Diseases Tenth Revision (ICD-10)[14,15]. It is used nationally to inform healthcare planning, management and activity-based funding[16].

Variables

Exposure. The exposure was to COVID-19 and the associated public health restrictions and wider socioeconomic changes within 2020. The study period was divided into four sub-periods (Table 1). These time periods reflect levels of exposure based on the *a priori* knowledge of the epidemiology of COVID-19 during the first wave, and of the public health measures implemented. Period 1 was defined as prior to the beginning of the first wave, Periods 2 and 3 were periods where progressive public health restrictions were implemented and Period 4 commenced with the easing of public health restrictions. Period 1 was defined as starting on the first Monday of January for the study period and reference periods, which were divided into the same sub-periods. The historic reference period for the PET data was a 26-week time period beginning on the first Monday of January 2019. This dataset has increased

in completeness year-on-year so restricting the reference period to 2019 allowed meaningful comparison. The historic reference period for the HIPE data was a 26-week time period beginning on the first Monday in January for 2017–2019. It was assumed that while there might be a slight variation year on year, the three-year average of hospital admissions would provide meaningful comparison[13]. For analysis within 2020, the reference period was Period 1 which was prior to the beginning of the first COVID-19 wave. To compare population rates of healthcare utilisation between pre- and post-COVID-19 time periods, two reference periods were used; the historic reference periods and Period 1 2020. The results reported in this paper primarily focus on the comparison within 2020 using Period 1 2020 as a reference period.

Outcomes. The outcomes were presentation to and admission from ED as recorded on PET and an acute hospital admission of any type for a non-COVID-19 illness. A non-COVID-19 hospital admission was defined as a hospital discharge (including death) recorded on HIPE where the diagnosis was a non-COVID-19 illness. Patients recorded with an ICD-10 diagnostic code for COVID-19 (U071 OR U072 OR B342 OR B972) were excluded for this purpose. The occurrence and characteristics of the outcomes were compared between exposure and reference periods. In order to describe stratified rates of each outcome and the characteristics of the population who experienced outcomes for the exposure and reference periods, relevant variables were included from the PET and HIPE datasets (Table 2). To explore trends further for selected clinical conditions to inform and aid recovery planning, 'tracer diagnoses' were chosen from within HIPE using defined ICD-10 codes (Table 3). These conditions were chosen following a review of the literature and from discussions with the HSE Lead for Integrated Care, for the Acute Hospitals and for Mental Health all of whom were providing frontline clinical care. The purpose of selecting the 'tracer diagnoses' was to explore healthcare utilisation trends in key clinical areas where changes in healthcare utilisation had been observed. The rationale for the selection of the 'tracer diagnoses' is outlined in Table 3.

Data analysis

Using Census 2016 data as the denominator[17], overall, age-specific and gender-specific population rates for each outcome were calculated with 95% Confidence Intervals (CI) for weekly counts across the 26-week study period and total and average weekly counts across the defined sub-periods. Rate differences with 95% CIs, and rate ratios with 95% CIs were used to compare the occurrence of the outcome across exposure and reference periods. A chi-squared test was used to test the hypothesis that there was no difference between the proportion of the population who experienced an outcome across exposure and reference periods. The characteristics of those who experienced an outcome were compared between exposure period and reference periods using a chi-squared test to investigate the null hypothesis that there was no difference in the characteristics across exposure and reference periods. Using PET data,

Table 1. Rationale for study time periods.

Time Periods	Week	Date	Rationale for Definition of the Time Period
Period 1	1–8	06/01/2020–01/03/2020	Prior to the first wave of COVID-19
Period 2	9–12	02/03/2020–29/03/2020	Some restrictions in place but prior to advice being issued to stay at home
Period 3	13–19	30/03/2020–17/05/2020	Population level public health restrictions where all were advised to stay at home
Period 4	20–26	18/05/2020–05/07/2020	Phase 1, 2 and beginning of Phase 3 of the easing of restrictions

Table 2. Variables describing population characteristics.

PET Dataset	HIPE Dataset
Date of Attendance	Date of Admission
Gender	Gender
Age	Age
Discharge Destination	Principal Diagnostic Group: Clinical Classification System-Irish Modification (CCS-IM)
Mode of Arrival	Admission Source
Mode of Referral	Discharge Destination
Triage Status	Discharge Outcome: Dead or Alive
	Admission Type
	Charlson co-morbidity index (CCI)

Table 3. Tracer diagnoses.

Diagnosis	ICD-10 Codes	Rationale for Inclusion in Study
Stroke TIA	I60.9, I61.9, I62.9, I63.0-I63.9, I64 G45.9	Evidence internationally within the literature of reduced and delayed stroke/TIA presentations and increases in morbidity and mortality[3,18–20]
STEMI NSTEMI	STEMI I21.1, I21.2, I21.3 NSTEMI I21.4 Acute MI unspecified I21.9	Evidence internationally within the literature of reduced and delayed presentations with STEMI/NSTEMI and increases in morbidity and mortality[4,21–23]
Self-harm	X60-X84	Some evidence nationally within the literature of an initial reduction in presentations with self-harm followed by a rebound increase with increasing severity of presentations[24]
Acute alcohol related presentations	F10.0-F10.9 Y90.0-Y91.0 K70.1 (acute alcoholic hepatitis) K85.2 (acute alcoholic pancreatitis) K29.2 (alcoholic gastritis)	There is limited evidence of the impact of population level restrictions and the COVID-19 pandemic on alcohol related presentations. There is evidence that presentations with self-harm had higher rates of associated substance misuse[24]
Injury	S00-S99 T00-T31	Evidence that presentations due to injuries reduced during the population level restrictions due to the COVID-19 pandemic[25,26]
Road Traffic Accidents (RTAs)	V01-04, V06, V09-V79, V87, V89, V99	It would be expected that admissions due to RTAs would decrease during population level restrictions

the effect of patient-level characteristics, including time period, were compared for association with the likelihood of admission from ED using a binary logistic regression model. Adjusted Odds Ratios (AOR) were calculated to measure the independent likelihood of admission from ED for a specific level of a characteristic relative to the reference level within the model. The purpose of the regression analysis was to assess if presentation to ED within the specific study time periods was associated with an increased likelihood of admission from ED as admission following ED presentation is an indicator of acuity[27]. The multiple logistic regression analysis could only be conducted using PET data as HIPE data are aggregate data and therefore regression analysis was not suitable. Within HIPE, initial data analysis was for all admission types, which was followed by further sub-group analysis of rates of elective and emergency non-COVID-19 hospital admissions by diagnostic group (CCS-IM)[28]. All statistical analysis was carried out using Microsoft Excel, SPSS version 26.0, Stata 15 (Stata Corporation) and Open-Source Epidemiologic Statistics for Public Health version 3.01. Level of significance for all group differences in this study was set at 5% (p-value <0.05).

Reporting guideline

The Reporting of Studies Conducted using Observational Routinely-collected Data (RECORD) guideline extended from the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement on reporting guidelines was used for this study.

Ethical approval

Ethical review was not required for this study as the research is secondary analysis of anonymised data sets. The data used in the study are controlled by the HSE in Ireland. The study authors (LM and PK) conducted data processing for the study at the HSE National Health Intelligence Unit to inform the statutory function of the HSE in Ireland to improve, promote and protect the health and welfare of the public health[29]. HIPE data are anonymised for users and usual practices regarding statistical disclosure control were applied.

Results

This paper primarily focuses on the results of the comparison between Periods 2–4 2020 and Period 1 2020. It also presents key comparisons using historic reference periods. The results of the internal comparison were reviewed against the historic reference period for both PET (2019) and HIPE (2017–2019) datasets and the results and public health implications are similar. Using both reference periods demonstrated that the overall trends in healthcare utilisation were similar despite seasonal differences for comparisons made within 2020.

Overall trends - total population, gender and age group

There was a substantial reduction in population rates of ED presentation and admission from ED in Periods 2–4 2020 compared to the historic reference period in 2019 (Figure 1 and Figure 2). Similarly, there were reductions in non-COVID-19 admissions of all types compared to historic reference periods from 2017–2019. As the reductions in non-COVID-19 hospital admissions were predominantly for elective and emergency admissions and as there were notable differences in the patterns and trends observed between elective and emergency admissions, these are presented separately in Figure 3–Figure 5 and Figure 7. Trends in elective and emergency non COVID-19 hospital admission are shown in Figure 3

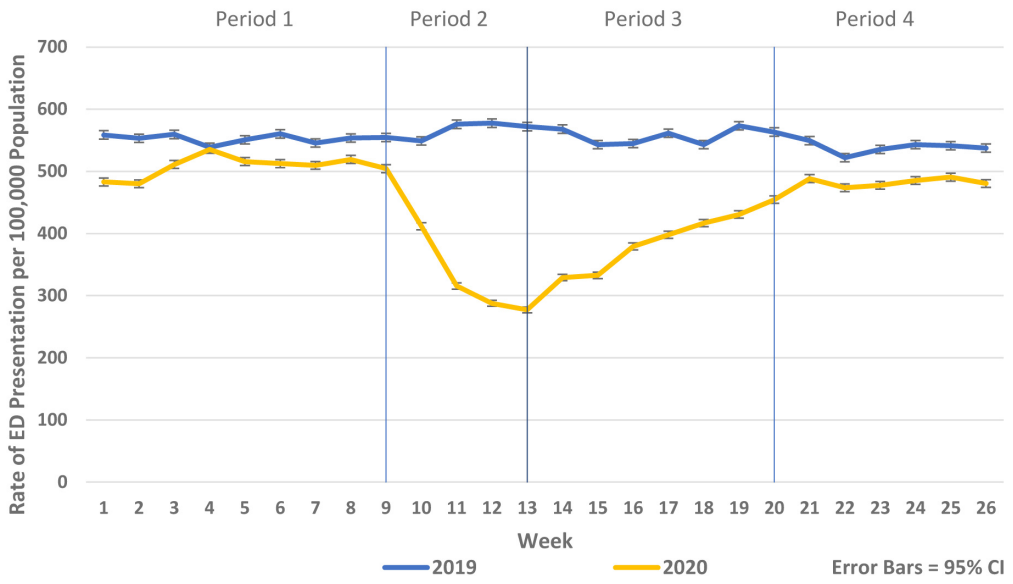

Figure 1. Weekly rate of ED presentation per 100,000 population week 1–26 2019 vs. 2020.

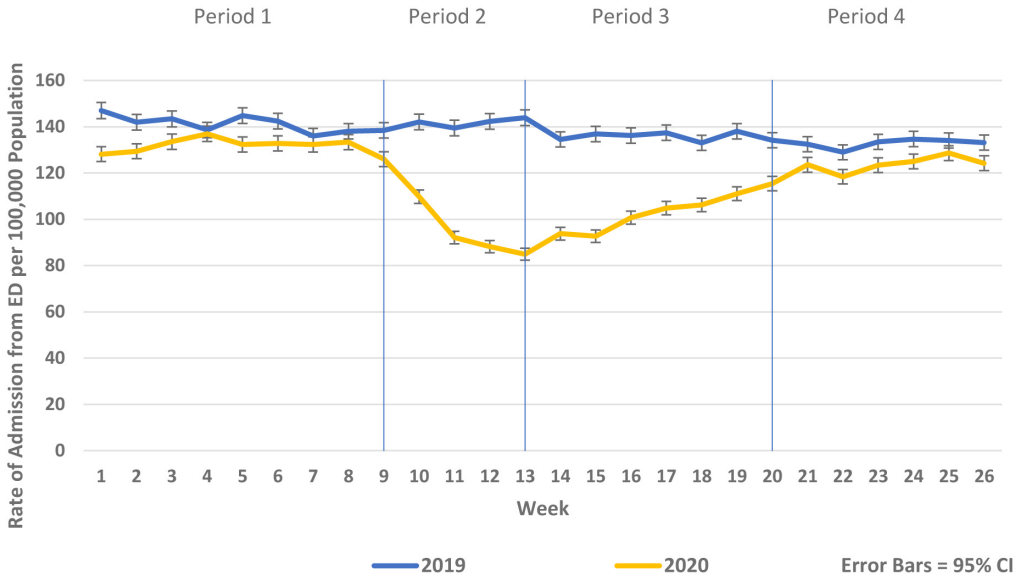

Figure 2. Weekly rate of admission from ED per 100,000 population week 1–26 2019 vs. 2020.

and Figure 4. Figure 5 outlines the results of the internal comparison within 2020 and shows reductions in Periods 2–4 2020 compared to Period 1 2020. Figure 8 shows reductions in non-COVID-19 hospital admissions for all admission types.

The greatest absolute and relative rate reductions were seen in Period 3 2020 compared to Period 1 2020 for the following:

- ED presentation (Rate Difference -142.1 per 100,000 population, 95% CI, -150.4, -133.6, p-value <0.0001 and Rate Ratio 0.72, 95% CI 0.71, 0.73, p-value <0.0001)
- Admission from ED (Rate Difference -33.2 per 100,00 population, 95% CI, -37.5, -28.9, p-value <0.0001, Rate Ratio 0.75, 95% CI 0.72, 0.78, p-value <0.0001)
- Overall non-COVID-19 acute hospital admission (Rate Difference -329.5 per 100,00 population, 95% CI, -338.8, -320.2, p-value <0.0001 and Rate Ratio 0.53, 95% CI 0.52, 0.54, p-value <0.0001)
- Non-COVID-19 emergency hospital admission (Rate Difference -50.0 per 100,00 population, 95% CI, -54.9, -45.2, p-value <0.0001 and Rate Ratio 0.71, 95% CI 0.69, 0.73, p-value <0.0001)

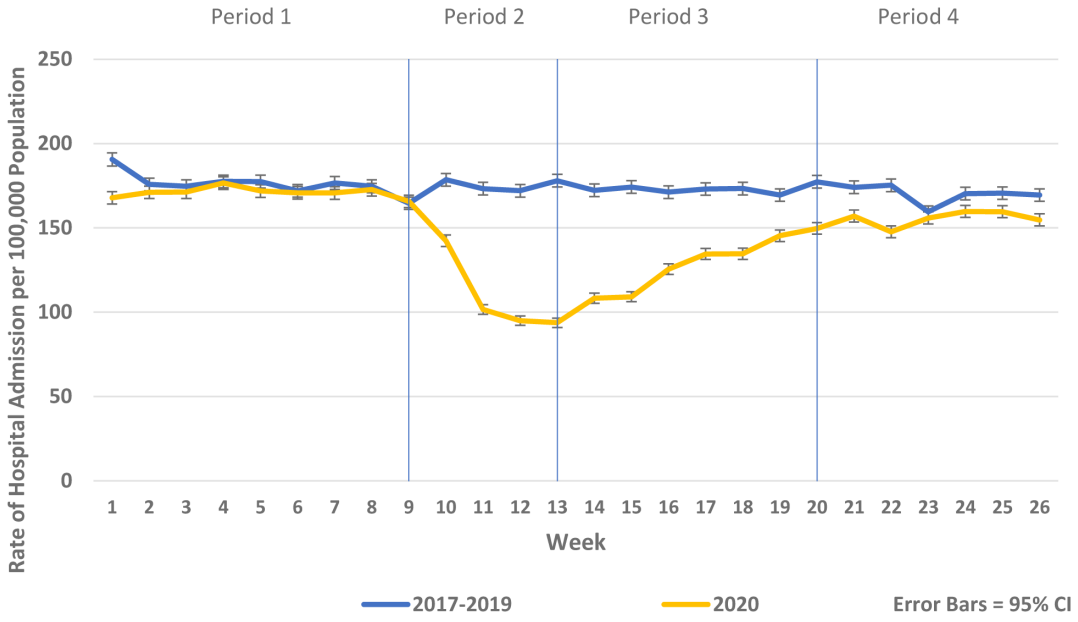

Figure 3. Weekly rate of non-COVID-19 emergency admission per 100,000 population 2017–19 vs. 2020.

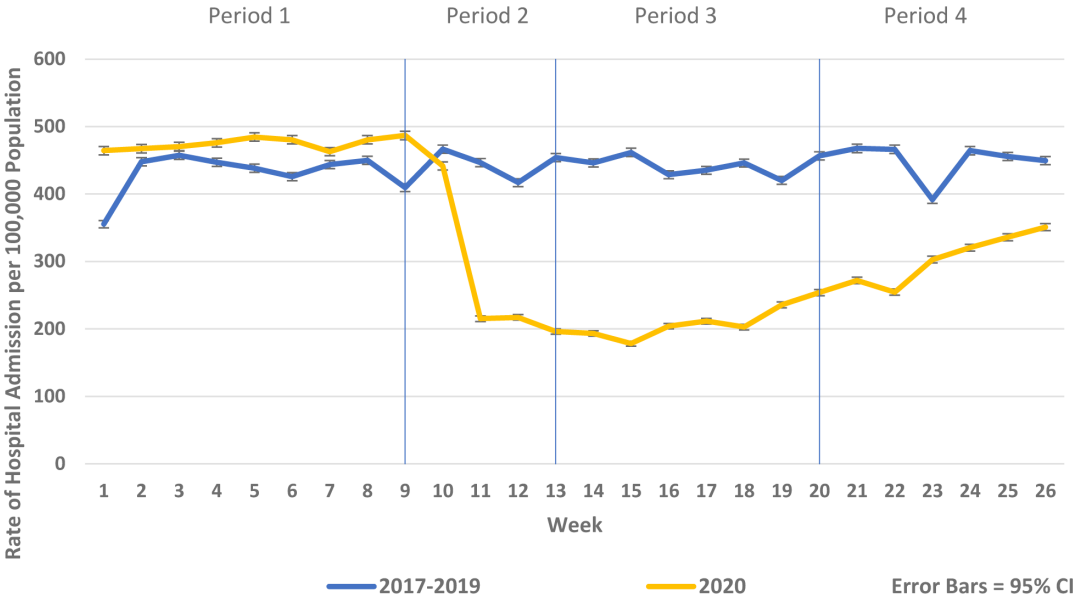

Figure 4. Weekly rate of non-COVID-19 elective admission per 100,000 population 2017–2019 vs 2020.

- Non-COVID-19 elective hospital admission (Rate Difference -270.2 per 100,00 population, 95% CI, -277.6, -262.9, p-value <0.0001 and Rate Ratio, 0.43 95% CI, 0.42, 0.44, p-value <0.0001)

Similar reductions were observed for both genders and across all age groups. The greatest relative rate reductions were in younger age groups (<45 years) while the greatest absolute rate reductions were seen in older age groups, particularly those aged over 80 years (Figure 6 and Figure 7).

Within Periods 2–4 there were 81,712 fewer ED presentations (-18.8%), 19,692 fewer admissions from ED (-17.4%) and 210,357 fewer non-COVID-19 hospital admissions (-35.0%) than what would have been expected based on Period 1 2020. This included 173,688 fewer elective care admissions

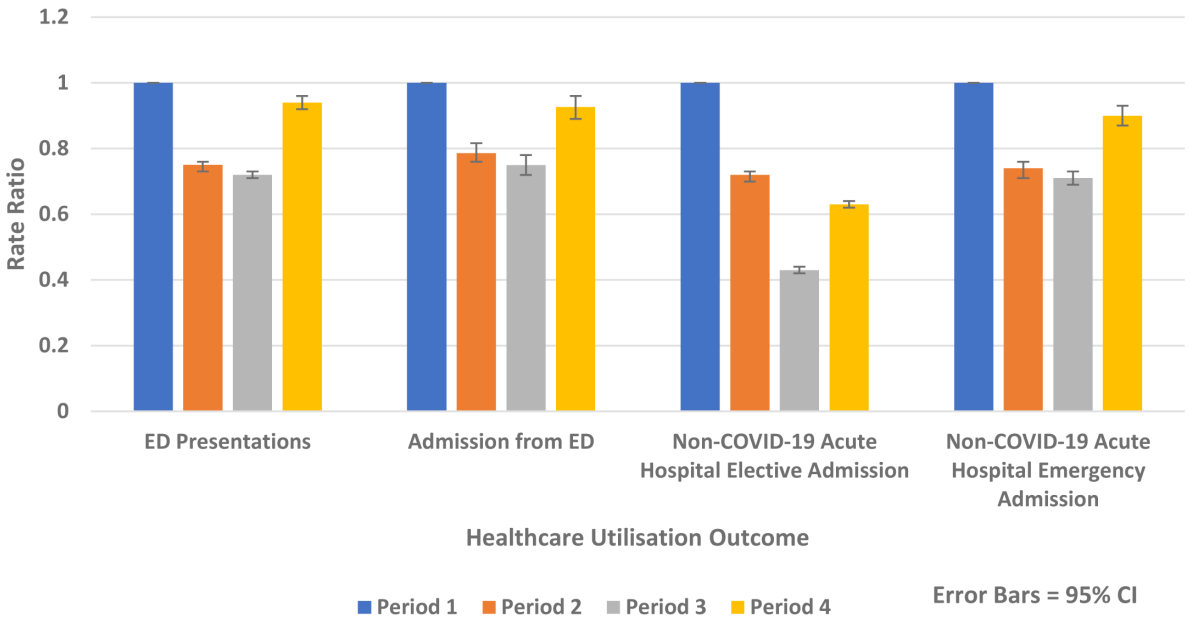

Figure 5. Rate ratios of average weekly ED presentation, admission from ED and non-COVID-19 acute hospital elective and emergency admission 2020.

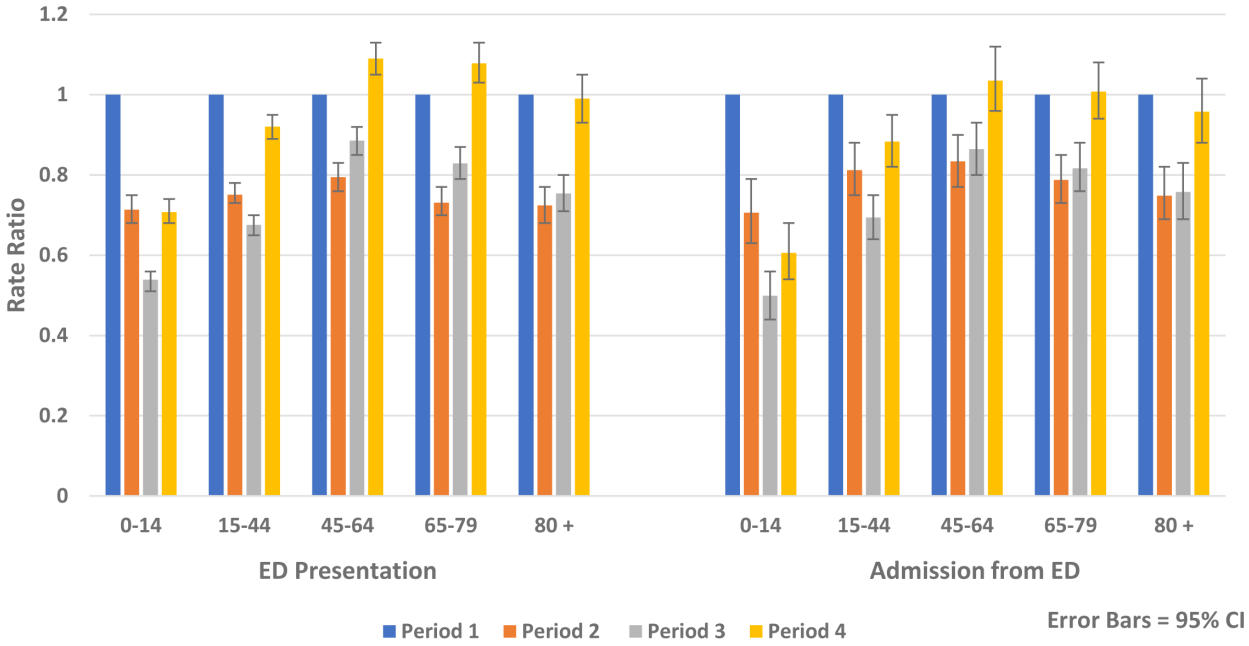

Figure 6. Rate ratio of average weekly ED presentation and admission from ED and non-COVID-19 hospital admission by age 2020.

(-42.8%) and 30,899 fewer non-COVID-19 emergency care admissions (21.0%) (Supplementary Tables A1–A3).

Trends in emergency department presentations and admissions

Analysis of ED activity indicated that a greater proportion of those presenting to ED in Periods 2–4 2020 were admitted and a greater proportion of both presentations and admissions were from older age groups (p-value <0.0001), had arrived by ambulance (p-value <0.0001) and were admitted (p-value <0.0001) compared to Period 1 2020 (Table 4 and Table 5). Factors associated with conversion to hospital admission following presentation to ED were examined for their independent association through a logistic regression model (Table 6). Being

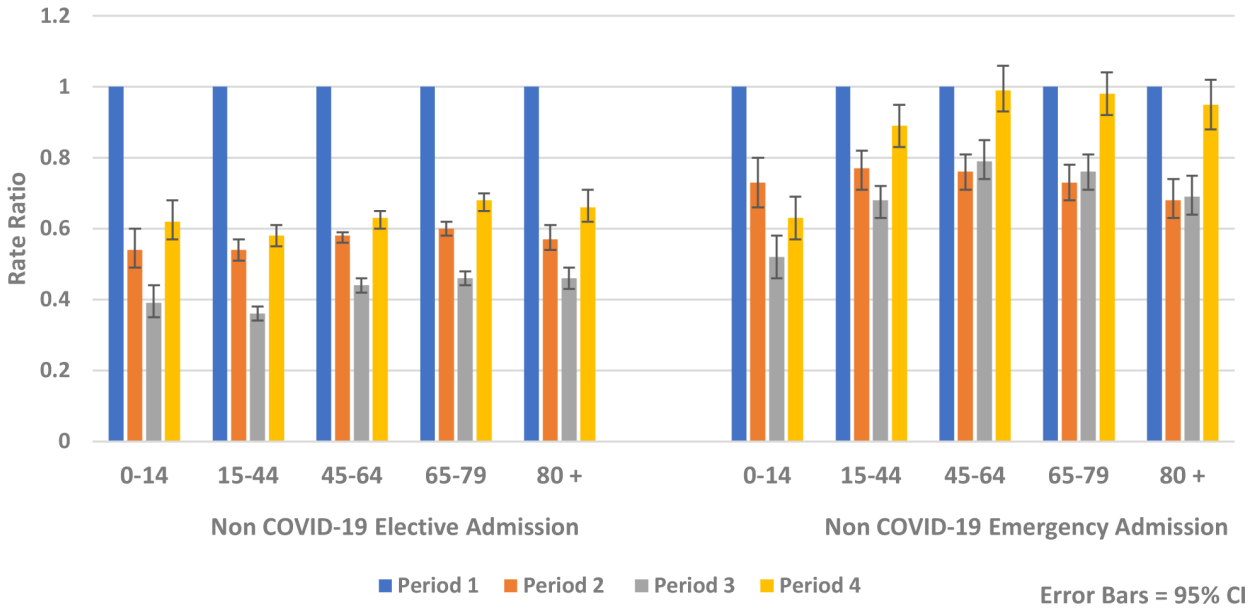

Figure 7. **Rate ratio of average weekly non-COVID-19 elective and emergency admission by age 2020.**

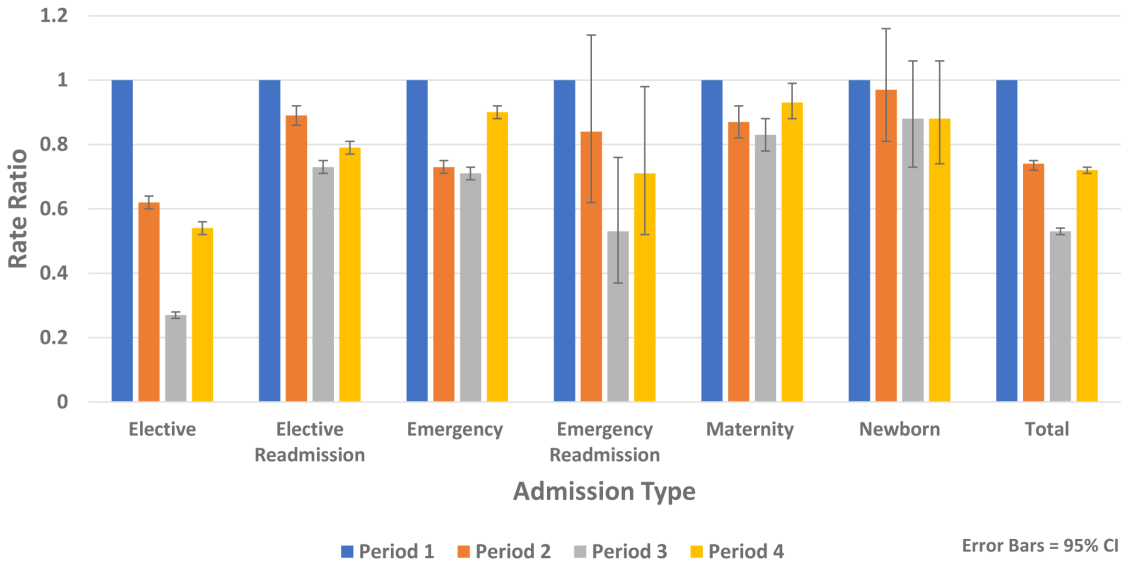

Figure 8. **Rate ratios of average weekly non-COVID-19 admission by admission type 2020.**

in a higher triage category (AOR 8.88, 95% CI 8.64, 9.13, p-value <0.0001), followed by older age (AOR 5.00, 95% CI 4.84, 5.17, p-value <0.0001) were the greatest predictors of hospital admission from ED. Independent of other factors included in the model, there was an increased likelihood of being admitted to hospital following ED presentation in Periods 2–4 compared to Period 1, which was most marked in Period 3 (AOR, 1.10, 95% CI, 1.07, 1.12, p-value <0.0001). In Period 4, ED presentations and admissions from ED returned to pre-COVID-19 levels for those aged over 45 years but remained reduced for those aged below 45 years (Figure 6).

Trends in non-COVID-19 hospital admissions

Analysis of non-COVID-19 hospital admissions using HIPE data found reductions across all diagnostic groups and all

Table 4. Comparison of the characteristics of the population that presented to ED period 2–4 2020 vs period 1 2020.

ED Presentation	Period 1 (Reference) Week 1–8		Period 2 Week 9–12		Period 3 Week 13–19		Period 4 Week 20–26	
Mode of Arrival	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	22,125.2	100.0	16,669.3	100.0	15,861.9	100.0	20,701.3	100.0
Ambulance/ Helicopter	5,031.9	22.7	4,450.5	26.7	3,906.6	24.6	4,496.4	21.7
Other	17,093.3	77.3	12,218.8	73.3	11,955.3	75.4	16,204.9	78.3
χ2 (p-value)	-	-	-	417.65 (<0.0001)	-	135.11 (<0.0001)	-	47.94 (<0.0001)
Mode of Referral	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	23,583.1	100.0	17,597.6	100.0	17,042.7	100.0	22,279.5	100.0
GP/GP OOH	8,416.0	35.7	5,434.0	30.9	5,301.7	31.1	7,109.7	31.9
Self-Referral	12,636.8	53.6	10,243.8	58.2	10,047.7	59.0	12,999.7	58.3
Other	2,530.3	10.7	1,919.8	10.9	1,693.3	9.9	2,170.1	9.8
χ2 (p-value)	-	-	-	546.28 (<0.0001)	-	874.77 (<0.0001)	-	786.95 (<0.0001)
Triage Category	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	18,754.4	100.0	14,115.5	100.0	13,692.4	100.0	17,974.9	100.0
Immediate/V urgent	4,225.3	22.5	3,281.5	23.3	2,917.7	21.3	3,624.1	20.2
Urgent	9,637.1	51.4	7,186.0	50.9	7,232.1	52.8	9,302.9	51.7
Standard/Non-Urgent	4,892.0	26.1	3,648.0	25.8	3,542.6	25.9	5,047.9	28.1
χ2 (p-value)	-	-	-	12.05 (<0.0001)	-	63.62 (<0.0001)	-	281.80 (<0.0001)
Discharge Destination	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	23,534.0	100.0	17,573.5	100.0	16,208.4	100.0	21,224.1	100.0
Admitted	6,303.0	26.8	4,953.5	28.2	4,722.0	29.1	5,842.0	27.5
Not Admitted	17,231.0	73.2	12,620.0	71.8	11,486.4	70.9	15,382.1	72.5
χ2 (p-value)	-	-	-	51.05 (<0.0001)	-	195.44 (<0.0001)	-	23.18 (<0.0001)
Age Group	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	24,196.3	100.0	18,077.4	100.0	17,434.4	100.0	22,783.4	100.0
Age 0–14	4,895.1	20.2	3,493.5	19.3	2,637.9	15.1	3,463.4	15.2
Age 15–44	8,659.8	35.8	6,503.0	36.0	5,849.1	33.5	7,971.0	35.0
Age 45–64	4,971.6	20.5	3,949.8	21.8	4,404.1	25.3	5,420.3	23.8
Age 65–79	3,599.0	14.9	2,631.8	14.6	2,982.4	17.1	3,878.7	17.0
Age 80+	2,070.8	8.6	1,499.3	8.3	1,560.9	9.0	2,050.0	9.0
χ2	-	-	-	72.70 (<0.0001)	-	2,168.12 (<0.0001)	-	193.80 (<0.0001)
Gender	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	24,203.5	100.0	18,084.8	100.0	17,440.0	100.0	22,791.1	100.0
Males	12,195.9	50.4	9,305.0	51.5	8,763.4	50.2	11,504.8	50.4
Females	12,007.6	49.6	8,779.8	48.5	8,676.6	49.8	11,286.3	49.6
χ2 (p-value)	-	-	-	23.82 (<0.0001)	-	0.59 (0.444)	-	0.29 (0.592)

Table 5. Comparison of the characteristics of the population admitted from ED period 2–4 2020 vs period 1 2020.

Admission from ED	Period 1 (Reference) Week 1–8		Period 2 Week 9–12		Period 3 Week 13–19		Period 4 Week 20–26	
Mode of Arrival	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	5,927.0	100.0	4,662.6	100.0	4,364.4	100.0	5,402.6	100.0
Ambulance/ Helicopter	2,452.1	41.4	2,222.3	47.7	2,050.7	47.0	2,263.0	41.9
Other	3,474.9	58.6	2,440.3	52.3	2,313.7	53.0	3,139.6	58.1
χ^2 (p-value)	-	-	-	215.89 (<0.0001)	-	238.24 (<0.0001)	-	2.31 (0.129)
Mode of Referral	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	6,137.7	100.0	4,821.6	100.0	4,604.2	100.0	5,726.4	100.0
GP/GP OOH Referral	2,309.4	37.6	1,498.8	31.1	1,392.0	30.2	1,908.3	33.3
Self-Referral	3,029.9	49.4	2,684.5	55.7	2,608.6	56.7	3,084.0	53.9
Other	798.4	13.0	638.3	13.2	603.6	13.1	734.1	12.8
χ^2 (p-value)	-	-	-	274.04 (<0.0001)	-	504.61 (<0.0001)	-	201.63 (<0.0001)
Triage Category	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	4,938.5	100.0	3,860.0	100.0	3,665.5	100.0	4,551.5	100.0
Immediate/V urgent	2,122.4	43.0	1,696.0	43.9	1,510.4	41.2	1,794.9	39.4
Urgent N	2,403.8	48.7	1,844.5	47.8	1,865.0	50.9	2,364.3	52.0
Standard/Non-Urgent	412.3	8.3	319.5	8.3	290.1	7.9	392.3	8.6
χ^2 (p-value)	-	-	-	4.25 (0.119)	-	30.36 (<0.0001)	-	92.63 (<0.0001)
Age Group	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	6,303.0	100.0	4,953.2	100.0	4,721.8	100.0	5,841.7	100.0
Age 0–14	778.8	12.4	549.8	11.1	388.4	8.2	471.9	8.1
Age 15–44	1,416.1	22.5	1,149.8	23.2	982.1	20.8	1,251.0	21.4
Age 45–64	1,370.8	21.7	1,142.8	23.1	1,185.1	25.1	1,418.4	24.3
Age 65–79	1,575.9	25.0	1,241.8	25.1	1,286.3	27.3	1,588.3	27.2
Age 80+	1,161.4	18.4	869.0	17.5	879.9	18.6	1,112.1	19.0
χ^2 (p-value)	-	-	-	39.56 (<0.0001)	-	479.30 (<0.0001)	-	516.61 (<0.0001)
Gender	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Weekly Average	6,302.9	100.0	4,953.6	100.0	4,722.0	100.0	5,842.0	100.0
Males	3,155.0	50.1	2,561.8	51.7	2,440.1	51.7	2,956.7	50.6
Females	3,147.9	49.9	2,391.8	48.3	2,281.9	48.3	2,885.3	49.4
χ^2 (p-value)	-	-	-	15.67 (<0.0001)	-	20.95 (<0.0001)	-	2.78 (0.095)

admission types including elective, emergency, maternity and newborn admissions (Figure 8).

Trends in elective and emergency admissions for selected diagnostic groups are shown in Table 7. Comparing elective admissions in Periods 2–4 2020 to what would have been expected based on Period 1 2020, there were particularly large reductions in cancer (36,120 fewer episodes of admission, -33.8%), gastroenterology (26,895 fewer episodes of admission, -56.1%), dermatology (12,180 fewer episodes of admission, -66.8%), respiratory (8,021 fewer episodes of admission, -65.8%) and cardiovascular (6,637 fewer episodes of admission, -58.5%) admissions. Further analysis of emergency admissions with specific selected 'tracer diagnoses' showed reductions

Table 6. Predictors of admission from ED in 2020.

Variables in Logistic Regression Model	Total ED Presentations		Admitted		Not Admitted		Adjusted OR	95% CI lower, upper	p-value
Time Period	**N**	**%**	**N**	**%**	**N**	**%**			
Period 1 2020*	188,272	100.0	50,424	26.8	137,848	73.2	1.00	-	-
Period 2 2020	70,294	100.0	19,814	28.2	50,480	71.8	1.04	1.01, 1.07	0.005
Period 3 2020	113,459	100.0	33,054	29.1	80,405	70.9	1.10	1.07, 1.12	<0.0001
Period 4 2020	148,569	100.0	40,894	27.5	107,675	72.5	1.06	1.04,1.08	<0.0001
Age Category									
Age 0–14*	94,383	100.0	14,451	15.3	79,932	84.7	1.00	-	-
Age 15–44	181,178	100.0	31,560	17.4	149,618	82.6	1.08	1.05, 1.11	<0.0001
Age 45–64	117,068	100.0	33,762	28.8	83,306	71.2	1.89	1.84, 1.94	<0.0001
Age 65–79	82,354	100.0	37,696	45.8	44,658	54.2	3.57	3.47, 3.67	<0.0001
Age 80+	45,418	100.0	26,711	58.8	18,707	41.2	5.00	4.84, 5.17	<0.0001
Triage Category									
Standard/Non-Urgent*	110,092	100.0	9,353	8.5	100,739	91.5	1.00	-	-
Immediate/Very Urgent	89,739	100.0	46,900	52.3	42,839	47.7	8.88	8.64, 9.13	<0.0001
Urgent	209,769	100.0	56,213	26.8	153,556	73.2	3.19	3.11, 3.28	<0.0001
Mode of Referral									
Self-Referral*	289,266	100.0	74,825	25.9	214,441	74.1	1.00	-	-
GP/GP OOH Referral	165,372	100.0	47,572	28.8	117,800	71.2	1.51	1.48,1.54	<0.0001
Other Mode of Referral	53,458	100.0	18,304	34.2	35,154	65.8	1.37	1.33,1.41	<0.0001
Mode of Arrival									
Mode of Arrival Other Mode of Arrival*	363,776	100.0	75,733	20.8	288,043	79.2	1.00	-	-
Arrival by Ambulance/ Helicopter	111,487	100.0	58,702	52.7	52,785	47.3	2.16	2.12, 2.21	<0.0001
Gender									
Male*	263,231	100.0	73,265	27.8	189,966	72.2	1.00	-	-
Female	257,348	100.0	70,920	27.6	186,428	72.4	1.00	0.99, 1.02	0.805
Total N 375,822	**Nagelkerke R^2 28.6%**			**χ^2 83184.65 (p-value <0.0001)**			**Degrees of Freedom 13**		

***Reference Category**

in admissions with stroke and transient ischaemic attack (TIA) (411 fewer episodes of admission, -12.1%) and acute myocardial infarction (AMI) (395 fewer episodes of admission, -14.7%) in Periods 2–4 2020 compared to expected based on Period 1 2020. There were also reductions in emergency admission with injury (2,059 fewer episodes of admission, -21.4%) and post-road traffic accident (RTA) (182 fewer episodes of admission, -24.4%) in Periods 2 and 3 2020 compared to expected based on Period 1 (Table 8).

For all non-COVID-19 hospital admission types there was a small overall increase in in-hospital mortality in Period 3 compared to Period 1 (0.9% vs. 0.6%, p-value 0.004) and a higher proportion of patients discharged in Periods 2–4 had a Charlson co-morbidity index (CCI)[30] score of over 10 compared to Period 1 (19.9% vs. 13.5%, p-value <0.0001). Patients experiencing an emergency admission are generally more acutely unwell compared to other admission types. These observed differences in outcomes were no longer statistically significant

Table 7. **Weekly average non-COVID-19 elective and emergency admissions by CCS-IM 2020.**

	Period 1 (Ref) Week 1–8		Period 2 Week 9–12		Period 3 Week 13–19		Period 4 Week 20–26	
Total Admission	**Elective**	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**
Weekly Average Count	22,534.6	8,171.5	16,193.8	6,007.3	9,665.3	5,789.9	14,214.6	7,375.6
Weekly Average Rate*	473.2	171.6	340.1	126.2	203.0	121.6	298.5	154.9
Count Difference	-	-	-6,340.8	-2,164.2	-12,869.3	-2,381.6	-8,320.0	-795.9
Rate Difference (95% CI)	-	-	-133.1 (-141.2, -125.1)	-45.4 (-50.4, -40.6)	-270.2 (-277.6, -262.9)	-50.0 (-54.9, -45.2)	-174.7 (-182.6, -166.8)	-16.7 (-21.8, 11.6)
Rate Ratio (95% CI)	-	-	0.72 (0.70, 0.73)	0.74 (0.71, 0.76)	0.43 (0.42, 0.44)	0.71 (0.69, 0.73)	0.63 (0.62, 0.64)	0.90 (0.87, 0.93)
χ^2 (p-value)	-	-	1,042 (<0.0001)	330.80 (<0.0001)	5,161 (<0.0001)	406.90 (<0.0001)	1,891 (<0.0001)	40.81 (<0.0001)
Cancer Admission	**Period 1**		**Period 2**		**Period 3**		**Period 4**	
	Elective	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**
Weekly Average Count	5,931.4	268.4	4,691.3	193.3	3,226.4	209.3	4,185.1	249.6
Weekly Average Rate	124.6	5.6	98.5	4.1	67.8	4.4	87.9	5.2
Count Difference	-	-	-1,240.1	-75.1	-2,705.0	-59.1	-1,746.3	-18.8
Rate Difference (95% CI)	-	-	-26.1 (-30.3, -21.8)	-1.5 (-2.5, -0.7)	-56.8 (-60.7, -52.9)	-1.2 (-2.1, -0.3)	-36.7 (-40.8, -32.5)	-0.4 (-1.3, 0.5)
Rate Ratio (95% CI)	-	-	0.79 (0.76, 0.82)	0.72 (0.59, 0.87)	0.54 (0.52, 0.57)	0.78 (0.65, 0.93)	0.71 (0.68, 0.73)	0.93 (0.78, 1.11)
χ^2 (p-value)	-	-	144.90 (<0.0001)	12.23 (0.001)	799.70 (<0.0001)	7.31 (0.007)	301.70 (<0.0001)	0.68 (0.409)
Cardiovascular Admission	**Period 1**		**Period 2**		**Period 3**		**Period 4**	
	Elective	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**
Weekly Average Count	630.3	1,416.3	384.5	980.3	155.0	1,145.1	297.9	1,431.3
Weekly Average Rate	13.2	29.7	8.1	20.6	3.3	24.0	6.3	30.1
Count Difference	-	-	-245.8	-436.0	-475.3	-271.2	-332.4	15.0
Rate Difference (95% CI)	-	-	-5.1 (-6.5, -3.9)	-9.1 (-11.2, -7.1)	-9.9 (-11.1, -8.8)	-5.7 (-7.8, -3.6)	-6.9 (-8.2, -5.7)	0.4 (-1.9, 2.5)
Rate Ratio (95% CI)	-	-	0.61 (0.54, 0.69)	0.69 (0.64, 0.75)	0.25 (0.21, 0.29)	0.81 (0.75, 0.87)	0.47 (0.41, 0.54)	1.01 (0.94, 1.09)
χ^2 (p-value)	-	-	59.52 (<0.0001)	79.34 (<0.0001)	287.70 (<0.0001)	28.70 (<0.0001)	119.10 (<0.0001)	0.08 (0.778)

Gastroenterology Admission	Period 1		Period 2		Period 3		Period 4	
	Elective	Emergency	Elective	Emergency	Elective	Emergency	Elective	Emergency
Weekly Average Count	2,662.9	940.8	1,623.0	694.0	644.3	743.3	1,433.6	928.4
Weekly Average Rate	55.9	19.8	34.1	14.6	13.5	15.6	30.1	19.5
Count Difference	-	-	-1,039.9	-246.8	-2,018.6	-197.5	-1,229.3	-12.4
Rate Difference (95% CI)	-	-	-21.8 (-24.5, -19.1)	-5.2 (-6.9, -3.5)	-42.4 (-44.8, -40.0)	-4.2 (-5.8, -2.5)	-25.8 (-28.4, -23.2)	-0.3 (-0.2, 1.5)
Rate Ratio (95% CI)	-	-	0.61 (0.57, 0.65)	0.74 (0.67, 0.81)	0.24 (0.22, 0.26)	0.79 (0.72, 0.87)	0.54 (0.50, 0.57)	0.99 (0.90, 1.08)
χ^2 (p-value)	-	-	252.41 (<0.0001)	37.25 (<0.0001)	1,233 (<0.0001)	23.16 (<0.0001)	369.12 (<0.0001)	0.08 (0.776)
Mental Health Admission	**Period 1**		**Period 2**		**Period 3**		**Period 4**	
	Elective	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**
Weekly Average Count	16.5	136.9	10.8	94.3	4.0	130.4	6.6	175.6
Weekly Average Rate	0.3	2.9	0.2	2.0	0.1	2.7	0.1	3.7
Count Difference	-	-	-5.7	-42.6	-12.5	-6.5	-9.9	38.7
Rate Difference (95% CI)	-	-	-0.1 (-0.3, -0.1)	-0.9 (-1.5, -0.3)	-0.2 (-0.5, -0.1)	-0.2 (-0.1, 0.5)	-0.2 (-0.4, -0.01)	0.8 (0.1, 1.5)
Rate Ratio (95% CI)	-	-	0.65 (0.30, 1.41)	0.69 (0.53, 0.89)	0.24 (0.08, 0.72)	0.95 (0.75, 1.21)	0.39 (0.16, 0.98)	1.28 (1.03, 1.60)
χ^2 (p-value)	-	-	1.21 (0.2718)	7.86 (0.005)	7.62 (0.0058)	0.16 (0.690)	4.27 (0.0387)	4.79 (0.028)
Respiratory Admission	**Period 1**		**Period 2**		**Period 3**		**Period 4**	
	Elective	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**
Weekly Average Count	677.6	1,549.8	426.3	1,261.3	125.0	773.9	228.0	769.9
Weekly Average Rate	14.2	32.5	9.0	26.5	2.6	16.3	4.8	16.2
Count Difference	-	-	-251.3	-288.5	-552.6	-775.9	-449.6	-779.9
Rate Difference (95% CI)	-	-	-5.2 (-6.7, -3.9)	-6.0 (-8.2, -3.9)	-11.6 (-12.8, -10.4)	-16.2 (-18.3, -14.3)	-9.4 (-10.7, -8.2)	-16.3 (-18.4, -14.4)
Rate Ratio (95% CI)	-	-	0.63 (0.56, 0.71)	0.81 (0.76, 0.88)	0.18 (0.15, 0.22)	0.49 (0.46, 0.54)	0.34 (0.28, 0.39)	0.49 (0.46, 0.54)
χ^2 (p-value)	-	-	57.25 (<0.0001)	29.62 (<0.0001)	380.51 (<0.0001)	259.10 (<0.0001)	223.31 (<0.0001)	262.30 (<0.0001)

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Infection Admission	Period 1		Period 2		Period 3		Period 4	
	Elective	Emergency	Elective	Emergency	Elective	Emergency	Elective	Emergency
Weekly Average Count	229.9	145.3	118.8	119.8	16.9	91.4	48.6	104.9
Weekly Average Rate	4.8	3.1	2.5	2.5	0.4	1.9	1.0	2.2
Count Difference	-	-	-111.1	-25.5	-213.0	-53.9	-181.3	-40.4
Rate Difference	-	-	-2.3 (-3.1, -1.6)	-0.6 (-1.2, 0.1)	-4.4 (-5.1, -3.8)	-1.2 (-1.8, -0.5)	-3.8 (-4.5, -3.1)	-0.9 (-1.5, -0.2)
Rate Difference (95% CI)	-	-	0.52 (0.41, 0.64)	0.82 (0.65, 1.05)	0.07 (0.04, 0.12)	0.63 (0.48, 0.82)	0.21 (0.15. 0.29)	0.72 (0.56. 0.93)
χ^2 (p-value)	-	-	35.43 (<0.0001)	2.45 (0.117)	183.90 (<0.0001)	12.24 (<0.0001)	118.10 (<0.0001)	6.52 (0.011)
Injury & Poisoning Admission	**Period 1**		**Period 2**		**Period 3**		**Period 4**	
	Elective	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**
Weekly Average Count	245.4	1,012.3	205.0	799.5	116.1	782.1	184.3	1,043.1
Weekly Average Rate	5.2	21.3	4.3	16.8	2.4	16.4	3.9	21.9
Count Difference	-	-	-40.4	-212.8	-129.3	-230.2	-61.1	30.8
Rate Difference (95% CI)	-	-	-0.9 (-1.7, 0.03)	-4.5 (-6.2, -2.7)	-2.8 (-3.5, -1.9)	-4.9 (-6.6, -3.1)	-1.3 (-2.1, -0.4)	0.6 (-1.2, 2.5)
Rate Ratio (95% CI)	-	-	0.84 (0.69, 1.01)	0.79 (0.72, 0.87)	0.47 (0.38, 0.59)	0.77 (0.70, 0.85)	0.75 (0.62, 0.91)	1.03 (0.95, 1.12)
χ^2 (p-value)	-	-	3.62 (0.0571)	24.99 (<0.0001)	46.20 (<0.0001)	29.51 (<0.0001)	8.69 (0.003)	0.46 (0.496)
Dermatology Admission	**Period 1**		**Period 2**		**Period 3**		**Period 4**	
	Elective	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**	**Elective**	**Emergency**
Weekly Average Count	1,013.1	206.6	560.8	136.3	125.0	131.3	419.6	184.9
Weekly Average Rate	21.3	4.3	11.8	2.9	2.6	2.8	8.8	3.9
Count Difference	-	-	-452.3	-70.3	-888.1	-75.3	-593.5	-21.7
Rate Difference (95% CI)	-	-	-9.5 (-11.1, -7.9)	-1.4 (-2.2, -0.7)	-18.7 (-20.0, -17.3)	-1.5 (-2.3, -0.8)	-12.5 (14.0, -10.9)	-0.4 (-1.3, 0.4)
Rate Ratio (95% CI)	-	-	0.55 (0.49, 0.61)	0.66 (0.53, 0.82)	0.12 (0.10, 0.15)	0.64 (0.51, 0.79)	0.41 (0.37, 0.46)	0.89 (0.73, 1.09)
χ^2 (p-value)	-	-	129.91 (<0.0001)	14.45 (0.0001)	693.10 (<0.0001)	16.80 (<0.0001)	245.91 (<0.0001)	1.21 (0.272)

*All Rates per 100,000 Population

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Table 8. **Emergency admission with a tracer condition 2020.**

Stroke/TIA Admission	**Period 1 (Reference)**	**Period 2**	**Period 3**	**Period 4**
Total N=4,503	**Week 1–8**	**Week 9–12**	**Week 13–19**	**Week 20–26**
Weekly Average Count	189.0	147.0	154.3	189.0
Weekly Average Rate*	4.0	3.1	3.2	4.0
Count Difference	-	-42.0	-34.7	0.0
Rate Difference (95% CI)	-	-0.9 (-1.6, -1.3)	-0.8 (-1.5, 0.03)	0.0 (-0.8, 0.8)
Rate Ratio (95% CI)	-	0.78 (0.63, 0.96)	0.82 (0.66, 1.01)	1.00 (0.82, 1.22)
χ2 (p-value)	-	5.25 (0.022)	3.51 (0.061)	0.00 (0.999)
AMI Admission	**Period 1 (Reference)**	**Period 2**	**Period 3**	**Period 4**
Total N=3,492	**Week 1–8**	**Week 9–12**	**Week 13–19**	**Week 20–26**
Weekly Average Count	149.5	116.8	124.4	136.9
Weekly Average Rate*	3.1	2.5	2.6	2.9
Count Difference	-	-32.7	-25.1	-12.6
Rate Difference (95% CI)	-	-0.6 (-1.3, -0.02)	-0.5 (-1.2, 0.2)	-0.2 (-0.9, 0.4)
Rate Ratio (95% CI)	-	0.78 (0.61, 0.99)	0.83 (0.66, 1.06)	0.92 (0.73, 1.16)
χ2 (p-value)	-	4.02 (0.045)	2.30 (0.129)	0.55 (0.457)
Alcohol Admission	**Period 1 (Reference)**	**Period 2**	**Period 3**	**Period 4**
Total N=7,150	**Week 1–8**	**Week 9–12**	**Week 13–19**	**Week 20–26**
Weekly Average Count	269.6	207.5	266.0	328.7
Weekly Average Rate*	5.7	4.4	5.6	6.9
Count Difference	-	-62.1	-3.6	59.1
Rate Difference (95% CI)	-	-1.3 (-2.2, -0.4)	-0.1 (-1.0, 0.9)	1.2 (0.2, 2.3)
Rate Ratio (95% CI)	-	0.77 (0.64, 0.92)	0.98 (0.83, 1.17)	1.22 (1.03, 1.43)
χ2 (p-value)	-	8.08 (0.005)	0.02 (0.876)	5.84 (0.016)
Self-Harm Admission	**Period 1 (Reference)**	**Period 2**	**Period 3**	**Period 4**
Total N=1,903	**Week 1–8**	**Week 9–12**	**Week 13–19**	**Week 20–26**
Weekly Average Count	64.8	74.5	65.3	90.0
Weekly Average Rate*	1.4	1.6	1.4	1.9
Count Difference	-	9.7	0.5	25.2
Rate Difference (95% CI)	-	0.2 (-0.3, 0.7)	0.0 (-0.5, 0.5)	0.5 (0.17, 1.04)
Rate Ratio (95% CI)	-	1.15 (0.82, 1.60)	1.01 (0.71, 1.42)	1.39 (1.01, 1.91)
χ2 (p-value)	-	0.68 (0.411)	0.002 (0.960)	4.10 (0.043)
RTA Admission	**Period 1 (Reference)**	**Period 2**	**Period 3**	**Period 4**
Total N=1,719	**Week 1–8**	**Week 9–12**	**Week 13–19**	**Week 20–26**
Weekly Average Count	67.8	50.0	52.0	87.6
Weekly Average Rate*	1.4	1.1	1.1	1.8
Count Difference	-	-17.8	-15.8	19.8
Rate Difference (95% CI)	-	-0.3 (-8.2, 0.1)	-0.3 (-0.8, 0.1)	0.4 (-0.1, 0.9)
Rate Ratio (95% CI)	-	0.74 (0.51, 1.06)	0.77 (0.53, 1.10)	1.29 (0.94, 1.78)
χ2 (p-value)	-	2.68 (0.102)	2.07 (0.150)	2.54 (0.111)

Injury Admission	Period 1 (Reference)	Period 2	Period 3	Period 4
Total N=21,119	**Week 1–8**	**Week 9–12**	**Week 13–19**	**Week 20–26**
Weekly Average Count	875.0	675.3	695.0	936.1
Weekly Average Rate*	18.4	14.2	14.6	19.7
Count Difference	-	-199.7	-180.0	61.1
Rate Difference (95% CI)	-	-4.2 (-5.8, -2.6)	-3.8 (5.4, -2.2)	1.3 (-0.5, 3.0)
Rate Ratio (95% CI)	-	0.77 (0.70. 0.85)	0.79 (0.72, 0.88)	1.07 (0.98, 1.17)
χ2 (p-value)	-	25.73 (<0.0001)	20.64 (<0.0001)	2.06 (0.151)

*All Rates per 100,000 Population

when analysis was limited to emergency admissions only. In-hospital mortality for emergency admissions was 2.5% in Period 3 vs. 2.4% in Period 1 (p-value 0.888), while the proportion of those with a CCI score of over 10 was 12.2% vs. 11.7% (p-value 0.627) (Table 9) Analysis of specific emergency tracer diagnoses also showed no difference in severity as measured with CCI and in-hospital mortality.

In Period 4, HIPE analysis found that the rates of non-COVID-19 hospital admission remained below expected levels for all age groups compared to Period 1 (Rate Ratio 0.72, 95% CI 0.71, 0.73, p-value <0.0001) (Figure 7). There was less recovery for elective admissions (Rate Ratio 0.63, 95% CI 0.62, 0.64, p-value <0.0001) compared to emergency admissions (Rate Ratio 0.90, 95% CI 0.87, 0.93, p-value <0.0001). During Period 4, there were increases in emergency mental health admissions (Rate Ratio 1.28, 95% CI 1.03, 1.60, p-value 0.028) (Table 7), emergency alcohol-related admissions (Rate Ratio 1.22, 95% CI 1.03, 1.43, p-value 0.016) and emergency admissions with self-harm (Rate Ratio 1.39, 95% CI 1.01, 1.91, p-value 0.043) (Table 8).

Discussion

Summary of key findings

This study reports on the changes in healthcare utilisation in acute hospitals in Ireland during the first wave of the COVID-19 pandemic in 2020. There was reduced healthcare utilisation for elective and emergency acute public hospital care. This reduction began in early March 2020, following the beginning of the first wave (Period 2), and overall persisted for the duration of this study which included the time period when society reopened and public health restrictions were eased; up to 5th July 2020 (Period 4). During this period, population rates of elective non-COVID-19 care did not recover. In contrast, there was greater recovery of emergency healthcare utilisation rates, however, activity still remained below pre-COVID-19 levels, particularly among younger age groups. In particular, this study finds evidence of increased emergency alcohol and emergency mental health related admissions following the reopening of society (Period 4) which began on 18th May 2020,

Those who presented to ED during the first wave of the COVID-19 pandemic had an increased likelihood of admission which may suggest increased severity of illness[27]. However, this finding may be explained by reverse association and there is no evidence of an immediate increase in in-hospital mortality or an increase in co-morbidity on discharge. The full consequences of the impact of changes due to delayed or missed care on population health may only become apparent over time.

Comparison with other studies

The findings of this study are consistent with other published reports and literature describing disruption to healthcare services during the first wave of the COVID-19 pandemic in multiple countries[5,31–33]. In particular, reductions in ED presentations and hospital admissions which persisted following the easing of restrictions are reported[32–34]. While a proportion of these reductions were likely due to decreased incidence of certain conditions related to population-level restrictions, some necessary care was not accessed for acute medical emergencies (e.g., stroke and AMI)[3–5,32,35]. The greatest reductions in presentations were reported among vulnerable groups such as lower socioeconomic groups, those at extremes of age and ethnic minorities[5,36].

This study found no evidence of immediate harm related to delayed or lost presentations. This is in contrast to other studies, which reported evidence of increased morbidity and mortality associated with changes in healthcare utilisation[4,5,37]. This impact may only become fully apparent over time and through examination of wider health information datasets.

Reasons for changes in acute hospital utilisation

The reasons for the changes in healthcare utilisation during the study period are likely multifactorial. The COVID-19 pandemic highlighted well-established weaknesses in the Irish health system that pre-date the COVID-19 pandemic. These include the absence of universal healthcare, acute hospital capacity deficits and a service configuration with overreliance on the acute hospital system to provide scheduled as well as unscheduled care due to poor orientation to primary and community care[7,10,11,38,39]. In order to create capacity to manage acute COVID-19 and non-COVID-19 illness, it was necessary to postpone elective care in the acute hospitals[38]. While some time-critical elective care was diverted to private hospitals[40], analysis of clinical patterns of elective admissions in this study suggest that there are large backlogs in care. This finding

Table 9. Comparison of the characteristics of emergency non-COVID-19 admissions period 2–4 2020 vs. period 1 2020.

Emergency Admissions	Period 1 2020 (Reference)		Period 2 2020		Period 3 2020		Period 4 2020	
	Week 1–8		Week 9–12		Week 13–19		Week 20–26	
Admission Source (N=182,106)	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Admissions	8,173.6	100.0	6,009.0	100.0	5,796.6	100.0	7,443.6	100.0
Home	7,613.0	93.1	5,572.1	92.7	5,413.9	93.4	6,969.2	93.7
Another Hospital	340.1	4.2	277.8	4.6	255.4	4.4	307.3	4.1
RCF	209.1	2.6	149.8	2.5	118.4	2.0	158.4	2.1
Other	11.4	0.1	9.3	0.2	8.9	0.2	8.7	0.1
χ2 (p-value)	-	-	-	1.90 (0.593)	-	4.52 (0.211)	-	3.29 (0.348)
Discharge Destination (N=180,664*)	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Discharges	8,108.3	100.0	5,963.3	100.0	5,743.2	100.0	7,391.8	100.0
Home	6,882.8	84.9	5,066.8	85.0	4,849.1	84.4	6,339.0	85.8
RCF	524.0	6.4	314.0	5.3	233.0	4.1	351.1	4.8
Died	200.3	2.5	148.5	2.5	144.2	2.5	147.4	2.0
Another Hospital	415.6	5.1	353.5	5.9	422.9	7.4	439.7	5.9
Other	85.6	1.1	80.5	1.3	94.0	1.6	114.6	1.5
χ2 (p-value)	-	-	-	14.93 (0.005)	-	72.01 (<0.0001)	-	36.40 (<0.0001)
Discharge Outcome (N=182,106)	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Discharges	8,173.6	100.0	6,009.0	100.0	5,796.6	100.0	7,443.6	100.0
Dead	200.2	2.4	148.5	2.5	144.3	2.5	147.4	2.0
Alive	7,973.4	97.6	5,860.5	97.5	5,652.3	97.5	7,296.2	98.0
χ2 (p-value)	-	-	-	0.02 (0.903)	-	0.02 (0.888)	-	3.99 (0.05)
Gender (N=182,106)	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Admissions	8,173.6	100.0	6,009.0	100.0	5,796.6	100.0	7,443.6	100.0
Female	4,073.6	49.8	2,896.8	48.2	2,792.9	48.2	3,641.3	48.9
Male	4,100	50.2	3,112.2	51.8	3003.7	51.8	3,802.3	51.1
χ2 (p-value)	-	-	-	3.68 (0.055)	-	3.74 (0.053)	-	1.33 (0.249)
CCI (N=182,106)	**N**	**%**	**N**	**%**	**N**	**%**	**N**	**%**
Total Admissions	8,173.6	100.0	6,009.0	100.0	5,796.6	100.0	7,443.6	100.0
<1	6,152.7	75.3	4,579.3	76.2	4,310.3	74.3	5,575.2	74.9
1–3	534.5	6.5	391.9	6.5	406.4	7.0	527.9	7.1
4–6	232.0	2.9	171.3	2.9	155.1	2.7	187.6	2.5
7–9	297.0	3.6	204.5	3.4	219.1	3.8	271.0	3.6
10+	957.4	11.7	662.0	11.0	705.7	12.2	881.9	11.9
χ2 (p-value)	-	-	-	2.33 (0.676)	-	2.60 (0.627)	-	3.28 (0.513)

Emergency Admissions	Period 1 2020 (Reference)		Period 2 2020		Period 3 2020		Period 4 2020	
	Week 1–8		Week 9–12		Week 13–19		Week 20–26	
Age Group (N=182,106)	N	%	N	%	N	%	N	%
Total	8,173.6	100.0	6,009.0	100.0	5,796.6	100.0	7,443.6	100.0
Age 0–14	948.8	11.6	689.3	11.5	491.6	8.5	594.4	8.0
Age 15–44	1,775.1	21.7	1,359.0	22.6	1,202.4	20.8	1,573.7	21.1
Age 45–64	1,905.1	23.3	1,438.2	23.9	1,508.4	26.0	1,882.1	25.3
Age 65–79	2,099.5	25.7	1,534.2	25.5	1,595.9	27.5	2,034.5	27.3
Age 80+	1,445.1	17.7	988.3	16.5	998.3	17.2	1,358.9	18.3
$\chi 2$ (p-value)	-	-	-	5.03 (0.284)	-	48.54 (<0.0001)	-	63.49 (<0.0001)

*N=1,142 missing for discharge destination and discharge outcome variables

is supported by the increases in waiting lists for elective care that occurred during this time period, suggesting that the demand for elective care was not fully met by the private sector[41]. In the period following the first wave of the COVID-19 pandemic in 2020, when society reopened, ongoing capacity restrictions in healthcare settings and the need to provide care for those with COVID-19 infection meant that it was not possible to resume elective activity at pre-COVID-19 levels or to provide the level of services required to fully address backlogs in elective care[42,43]. For emergency care, the reduction may have been due to reduced incidence of some medical conditions, e.g., injuries and non-COVID-19 infections, due to population-level restrictions and/or due to a reduction in unnecessary emergency attendances[26,35,44–49]. However, the scale of the reductions shown in this study and reduction in presentations for conditions such as stroke/TIA and AMI which are non-discretionary and time-sensitive suggest that necessary care was avoided or delayed. This may have been due to a fear of exposure to COVID-19 in hospital[50,51]. Deaths due to untreated acute medical emergencies may have also contributed to the lack of 'rebound' admissions observed following the reopening of society, Increased utilisation of acute health services for emergency alcohol and self-harm admissions in the period immediately following wave 1 suggests that the pandemic, and associated restrictions, are negatively impacting population health and wellbeing. This finding is consistent with published data reporting increased mental distress and increased utilisation of secondary mental health services due to the COVID-19 pandemic[52–55]. This burden of unmet need is likely greatest among vulnerable groups most affected by COVID-19 such as those living in poverty, ethnic minority groups and older people[2,24,56–58].

Implications for health policy and health system reform in Ireland

Harnessing the COVID-19 shock to manifest health system change. COVID-19 is a shock to the health system[59]. However, despite the challenges, the system has responded and shown innovation and flexibility in work practices and delivery of services, which demonstrate capacity and readiness to reform[11,38]. Lessons must be learned from COVID-19 to build health system resilience and increase preparedness for the future, including future pandemic preparedness[59,60]. In the long-term, further strategic reform aligned with Sláintecare should be progressed building on this innovation and change capability shown during the COVID-19 pandemic. Internationally, there have been calls to 'build back better' and also to 'build back fairer' to achieve sustainable, resilient health systems and deliver universal healthcare. Such an endeavour will require political leadership, human and financial resources and investment in information technology (IT) infrastructure and public health expertise[11,61–65]. In Ireland, this will need to include addressing now well-acknowledged public health service capacity investment deficits[66], which were partially relieved on a temporary basis through bespoke pandemic-specific arrangements with private hospitals. The findings of this study were disseminated nationally to the director of Sláintecare and to the national leads for Integrated Care, the Acute Hospitals and Mental Health. This study quantified the changes in healthcare utilisation during the first wave of the COVID-19 pandemic and identified key clinical areas to focus on for population health recovery. The findings are important in the context of the ongoing reform of the Irish health system and the findings of this study informed the HSE National Service Plan for 2022 which has a focus on scheduled care recovery[67].

Public health should be core to health reform. Public health has been frontline in confronting initial waves of COVID-19 in Ireland. With the development and arrival of the COVID-19 vaccination in 2021, Ireland has entered a new phase of the COVID-19 pandemic. However, COVID-19 and its associated consequences will continue to impact population health and the health system for many years. Therefore, strong public health leadership and advocacy are required to seize the opportunity to control COVID-19 infection, to guide population health recovery from COVID-19 and to progress health system reform in Ireland

Limitations of this study

Due to the data available at the time of analysis, this study focuses only on the first wave of COVID-19. While the patterns observed in this study may predict healthcare utilisation in subsequent waves, there are likely differences as some lessons learned from the first wave may have been acted on. PET and HIPE datasets do not allow for identification of repeat episodes of care which may overestimate population rates of healthcare utilisation. However, such an overestimate is likely to be minimal due to the large size of the datasets. During the first wave of the COVID-19 pandemic, some time-sensitive elective care was provided in the private hospitals, these data were not available for this study. Therefore, the reduction in elective hospital activity may be overestimated. Data on GP utilisation were not analysed in this study, changes in provision of GP care may explain some of the changes reported. Hospital outpatient department (OPD) activity was also not examined, this may underestimate need for services as there are backlogs for OPD appointments. PET does not contain clinical information therefore the impact on non-COVID-19 care was not quantified. HIPE reports data on patients discharged from acute hospitals. Therefore, patients who remained in hospital at the end of the study period are not included in this study. As those who are more unwell may have longer admissions with poorer outcomes, co-morbidity and in-hospital mortality may have been underestimated.

Conclusion

This study quantifies and describes changes in acute hospital care utilisation during the first wave of the COVID-19 pandemic in Ireland. The results show that there are large backlogs in elective care, and evidence of delayed and lost emergency care. These backlogs in care must be managed with urgency. The consequences of delayed and lost care will only become fully apparent over time. The results also demonstrate increased population need and demand for mental health and alcohol services triggered by the pandemic. The population health impacts of COVID-19 and associated restrictions, particularly in relation to mental health and alcohol, need to be addressed through strong public health and health systems responses including the adoption of a pandemic recovery plan, especially targeting the most vulnerable. COVID-19 highlights inherent weakness in the Irish health system. However, the system shock is an opportunity to progress strategic reform of the Irish health system towards a universal, high-quality, sustainable and resilient health system, capable of meeting population health needs and responding to future pandemics.

Data availability

Underlying data

Open Science Framework. The public health and health system implications of changes in the utilisation of acute hospital care in Ireland during the first wave of COVID-19: Lessons for recovery planning. DOI: https://doi.org/10.17605/OSF.IO/D56SZ[68]

This project contains the following underlying data:

- The public health and health system implications of changes in the utilisation of acute hospital care_Supplementary Tables.pdf
- The public health and health system implications of changes in the utilisation of acute hospital care_RECORD Checklist.pdf

The datasets processed for this study were derived from special categories of personal data concerning health. The datasets are controlled by the HSE, not the authors, and so the authors cannot determine requests for data access. Further information on HSE data protection policy can be located at hse.ie/eng/gdpr/hse-data-protection-policy/. Reasonable requests to access the two datasets used in this study, HIPE and PET, can be directed to the data controller by contacting the HSE Healthcare Pricing Office (https://hpo.ie/) in the case of HIPE and to the HSE Special Delivery Unit https://www.hse.ie/eng/about/who/acute-hospitals-division/special-delivery-unit/ in the case of PET.

Reporting guideline

OSF registries. RECORD guideline checklist, extended from the STROBE statement. DOI: https://doi.org/10.17605/OSF.IO/D56SZ[68]

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Open Peer Review

Current Peer Review Status: ? ✓ ✓

Version 3

Reviewer Report 13 October 2022

https://doi.org/10.21956/hrbopenres.14914.r33021

✓ **Akke Vellinga**
School of Public Health, Physiotherapy and Sports Science, University College Dublin, Dublin, Ireland

I am satisfied with the changes.

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Epidemiology, infectious disease, general practice, statistics, prescribing, antibiotics, AMR, data, data dashboards

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 2

Reviewer Report 26 September 2022

https://doi.org/10.21956/hrbopenres.14826.r32823

? **Akke Vellinga**
School of Public Health, Physiotherapy and Sports Science, University College Dublin, Dublin, Ireland

This is an interesting study showing some of the impacts of the pandemic on the Irish Health

System. Whereas the authors have already addressed many issues raised by the other reviewers, an overall lack of context remains. The data sets used are from public hospitals only. One positive outcome of the pandemic was the use of private hospitals. They took over much of the elective and non-covid hospital care from the public hospitals. Whereas there is a mention in the limitations of the study, it should be better reflected in the whole manuscript. Reductions in non-covid admissions in the data may just be because these admissions happened in the private hospitals, not necessarily because they did not happen. This should be discussed in the results. It is now presented as if there just is a reduction due to the pandemic, which is true, but not the whole story. The reduction of 35% in non-covid admissions may be entirely explained by redirecting these to private hospitals.

The term recovery period is not appropriate. By July 2020 there was no recovery, in either healthcare use, the pandemic or otherwise. Please choose a better term throughout (or just stick with period 4).

Admission to hospitals changed radically during the pandemic, and most likely those who were sicker were more likely to be admitted. These people were sicker in general when they presented and therefore more likely to be admitted. What was not clear to me is if the fewer admissions were compared to the same period the previous year (which would be because of less presentations) or if this is a subset of the presentations. I suspect it is the first. If so, the figures should present the admissions as a subset of the total presentations, which could show that admissions from ED are actually higher.

The tracer conditions are of interest, as also pointed out by the other reviewers. In particular their rise in period 4. Whereas this is an interesting paper, the focus of the discussion is only on the reductions during period 2-3, while the tracer conditions and the potential of the health system to use private hospitals as part of a public system seem to be the main lessons from this paper/the pandemic. I would suggest refocusing the discussion.

The expected 'rebound' of the admissions in period 4 may not be seen due to death from covid or the condition for which they did not present (AMI, cancer, other). This should be discussed.

Some of the variables showing significance in the logistic regression can also be explained by reverse association. Please add to the discussion.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?

Yes

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Epidemiology, infectious disease, general practice, statistics, prescribing, antibiotics, AMR, data, data dashboards

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 04 Oct 2022

Louise Marron, Dr Steevens' Hospital, Dublin 8, Ireland

Comment 1: This is an interesting study showing some of the impacts of the pandemic on the Irish Health System. Whereas the authors have already addressed many issues raised by the other reviewers, an overall lack of context remains. The data sets used are from public hospitals only. One positive outcome of the pandemic was the use of private hospitals. They took over much of the elective and non-covid hospital care from the public hospitals. Whereas there is a mention in the limitations of the study, it should be better reflected in the whole manuscript. Reductions in non-covid admissions in the data may just be because these admissions happened in the private hospitals, not necessarily because they did not happen. This should be discussed in the results. It is now presented as if there just is a reduction due to the pandemic, which is true, but not the whole story. The reduction of 35% in non-covid admissions may be entirely explained by redirecting these to private hospitals.

Reply 1: Many thanks for this comment. This study examined healthcare utilisation in public hospitals. Data on private hospital activity during the first wave of the COVID-19 pandemic were not available for this study. This has now been stated more clearly in the methods. In the limitations, this paper also states that *during the first wave of the COVID-19 pandemic, some time-sensitive elective care was provided in the private hospitals, these data were not available for this study*. *Therefore, the reduction in elective hospital activity may be overestimated* .

During 2020, waiting lists for elective care increased despite private hospital activity and during the time period for this study in 2020, the National Public Health Emergency Team (NPHET) recommended the cancellation of non-essential care. There is no evidence suggesting that all the need for elective care was met in the private sector during the first wave of COVID-19 and this has been evident from the increase in waiting lists for elective care nationally. This is now stated more clearly in the discussion with an additional reference added for a recently published paper by Mercille et al., 2022.

Comment 2: The term recovery period is not appropriate. By July 2020 there was no

recovery, in either healthcare use, the pandemic or otherwise. Please choose a better term throughout (or just stick with period 4).

Reply 2: Many thanks for your comment about the use of the term recovery period for Period 4. The rationale for the study time periods is outlined in Table 1. The time periods were defined based on the epidemiology of COVID-19 and the recommended public health measures during the study time period. The term recovery period for Period 4 was used to reflect the reopening of society and the easing of public health restrictions and the significant reduction in notified COVID-19 cases during this time period. When this study was conducted in 2020, the future course of the COVID-19 pandemic was unknown. The term recovery period has now been replaced with the terms reopening of society, easing of public health restrictions and Period 4 in the paper.

Comment 3: Admission to hospitals changed radically during the pandemic, and most likely those who were sicker were more likely to be admitted. These people were sicker in general when they presented and therefore more likely to be admitted. What was not clear to me is if the fewer admissions were compared to the same period the previous year (which would be because of less presentations) or if this is a subset of the presentations. I suspect it is the first. If so, the figures should present the admissions as a subset of the total presentations, which could show that admissions from ED are actually higher

Reply 3: Thank you for this comment. This paper presents the population rates of Emergency Department (ED) presentations, admissions from ED and the population rates of non-COVID-19 hospital admission (elective and emergency) using two datasets; PET and HIPE As part of the methodology, two reference periods were used; the same time periods in 2019 and also Period 1 of 2020 (pre-COVID-19) to compare population healthcare utilisation trends during pre- and post-COVID-19 time periods. Population rates for each outcome were calculated using Census 2016 as the denominator. The changes in the trends in healthcare utilisation including hospital admission following presentation to ED and non-COVID-19 hospital admissions were the same overall for each reference period. Data from the internal comparison within 2020 are presented in this paper. It is clear from this analysis that overall, the population rates of emergency admissions reduced comparing pre- and post-COVID-19 time periods. The results presented show the findings from the analysis that aligns with the study aims and objectives and methodology used to describe changes in healthcare utilisation during the first wave of the COVID-19 pandemic in Ireland.

Comment 4: The tracer conditions are of interest, as also pointed out by the other reviewers. In particular their rise in period 4. Whereas this is an interesting paper, the focus of the discussion is only on the reductions during period 2-3, while the tracer conditions and the potential of the health system to use private hospitals as part of a public system seem to be the main lessons from this paper/the pandemic. I would suggest refocusing the discussion.

Reply 4: Many thanks for this comment about the tracer conditions. The significant increases in emergency admissions for self-harm, alcohol and acute mental health in Period

4 were key findings of this study and this is emphasised in the discussion. The reduction in key tracer conditions such as stroke and acute myocardial infarction are were also significant findings from a clinical and public health perspective and are included in the discussion. The section in the discussion *Harnessing the COVID-19 shock to manifest health system change* has been expanded to include more discussion about the role of the private hospitals. The Irish Government Economic and Evaluation Service Spending Review 2021 has been included as a reference in addition to the other reference also added to the discussion from Mercille *et al.,* 2022.

Comment 5: The expected 'rebound' of the admissions in period 4 may not be seen due to death from covid or the condition for which they did not present (AMI, cancer, other). This should be discussed.

Reply 5: Thank you for this comment that rebound admissions may not be seen due to deaths from COVID-19 or from delayed/lost emergency care. This has been added to the discussion.

Comment 6 Some of the variables showing significance in the logistic regression can also be explained by reverse association. Please add to the discussion.

Reply 6: Many thanks for this comment about reverse association. This has been added to the paper.

Many thanks for taking the time to review this paper and for your comments.

Competing Interests: No competing interests were disclosed.

Reviewer Report 23 June 2022

https://doi.org/10.21956/hrbopenres.14826.r32279

Therese McDonnell
IRIS Centre, School of Nursing, Midwifery and Health Systems, University College Dublin, Dublin, Ireland

Thank you for the revisions made in response to my comments. The title and methods now better reflect the content of the paper. Other alterations noted.

Is the work clearly and accurately presented and does it cite the current literature?

Partly

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
Partly

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Health economics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard.

Version 1

Reviewer Report 12 May 2022

https://doi.org/10.21956/hrbopenres.14487.r31956

?

Therese McDonnell
IRIS Centre, School of Nursing, Midwifery and Health Systems, University College Dublin, Dublin, Ireland

This is an interesting paper using high quality national data on ED attendance and admissions at public hospitals in Ireland to identify how attendance/admissions altered over the initial weeks of the onset of COVID-19 in 2020.

Specific comments:

- There is mention within the paper and in the abstract of interrupted time-trend analysis. I don't see this in the Results, so this reference needs to be amended.

- Table 1: the date range for Period 4 needs to be amended.
- Selecting the tracer diagnoses is valuable, perhaps this can be better motivated in the *Outcomes* section.
- The logistic regression (Table 6) gives little insight on how predictors altered the likelihood of admission after Period 1. Consider re-focusing this regression – perhaps through this use of interactions, comparison with prior years, or a multinomial logit.
- I think the discussion needs to better reflect the results. The most impactful finding of this paper is the lack of a rebound in hospital admissions for elective procedures in Period 4. While this is discussed in the *Reasons for change in acute hospital utilisation* section, it should also be clearly mentioned in the first paragraph of the Discussion: *Summary of findings.* This first paragraph also makes a statement suggesting evidence of increased severity in Periods 2 - 4, however the triage classifications in the ED tables suggest little change in severity. Ambulance usage may have increased due to the restrictions on movement (lack of transport) and due to some individuals seeking guidance from paramedics on the need to attend hospital. Age may not be directly related to severity, an increase in the age of admissions may also be linked to a greater usage of ambulance. The *Reasons for change in acute hospital utilisation* section notes COVID-19 has highlighted the weaknesses in the Irish health system, and a number of references are given. I would recommend reviewing these references – a number pre-date COVID-19 and not all support that COVID-19 highlighted the shortcomings of the system. Perhaps rewording is needed here.
- I would suggest reframing the title to match what the paper actually achieved. I don't feel the paper delivers on the title as currently stated, and I'm unsure what lessons derive directly from this analysis, for example I don't see the relationship with universal healthcare.
- Overall, I think this is a good paper that presents a national picture that makes a valuable contribution to the literature.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Yes

Are sufficient details of methods and analysis provided to allow replication by others?
Yes

If applicable, is the statistical analysis and its interpretation appropriate?
Yes

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Health economics

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 30 May 2022

Louise Marron, Dr Steevens' Hospital, Dublin 8, Ireland

Many thanks for your comments and feedback and for taking the time to review this paper.

Comment 1:

There is mention within the paper and in the abstract of interrupted time-trend analysis. I don't see this in the results so this reference needs to be amended.

Reply 1:

Thank you for your comment. This study was a comparison of population rates of healthcare utilisation during different time periods in the first wave of COVID-19 infection in Ireland in 2020; the time periods were defined based on the epidemiology of the first wave and the associated population level restrictions. It was described in the paper as an interrupted time-trend analysis. I have removed this term from the paper and abstract and I have updated the manuscript and described the study as a retrospective, population-based observational study which more accurately reflects the methodology.

Comment 2:

Table 1: the date range for Period 4 needs to be amended.

Reply 2:

Many thanks for flagging this error. I have amended this.

Comment 3:

Selecting the tracer diagnoses is valuable, perhaps this can be better motivated in the Outcomes section.

Reply 3:

Many thanks for this comment. I have added further information and detail to the outcomes

section further explaining the purpose of selecting the tracer conditions, how the tracer conditions were selected and the rationale for their selection.

Comment 4:

The logistic regression (Table 6) gives little insight on how predictors altered the likelihood of admission after Period 1. Consider re-focusing this regression – perhaps through the use of interactions, comparison with prior years or a multinomial logit.

Reply 4:

Thank you for your comment. The purpose of the binary logistic regression analysis was to assess if presentation to ED within the specific time periods in the study was associated with an increased likelihood of admission from ED. The main finding was that independent of all other factors collected as part of PET data that may influence admission, there was an increased likelihood of being admitted to hospital following ED presentation in Periods 2–4 compared to Period 1, which was most marked in Period 3 (the peak of restrictions). Increased admissions from ED may suggest increased severity of illness on presentation (I have included a reference for this) and this was also in keeping with the clinical experience reported to the authors by clinicians at the time. I have edited the methods and the findings to more accurately reflect the purpose of the regression which has a limited impact on the overall findings of this paper.

Comment 5:

I think the discussion needs to better reflect the results. The most impactful finding of this paper is the lack of a rebound in hospital admissions for elective procedures in Period 4. While this is discussed in the *Reasons for change in acute hospitalisation* section, it should also be clearly mentioned in the first paragraph of the *Discussion: Summary of findings*. This first paragraph also makes a statement suggesting evidence of increased severity on Periods 2-4, however the triage classifications in the ED tables suggest little change in severity. Ambulance usage may have increased due to the restrictions on movement (lack of transport) and due to some individuals seeking guidance from paramedics on the need to attend hospital. Age may not be directly related to severity, an increase in the age of admissions may also be linked to a greater usage of ambulance. The Reasons for change in healthcare utilisation section notes that COVID-19 has highlighted the weaknesses in the Irish health system, and a number of references are given. I would recommend reviewing these references – a number pre-date COVID-19 and not all support that COVID-19 highlighted the shortcomings of the system. Perhaps rewording is needed here.

Reply 5:

Thank you for your comments and insights into the findings of this paper. I have added that in particular, rates of elective non-COVID-19 care did not recover following the first wave to the *summary of key findings section* in the discussion. I have also discussed this further in the *reasons for changes in acute hospital utilisation* section. Specifically, I have noted that this lack of recovery in elective care was due to ongoing capacity restrictions in healthcare settings

and the ongoing need to direct resources to the provision of COVID-19 care. I have referenced the 2020 Winter Plan and the 2021 HSE service plan. In the summary of key findings section, I have taken out mention of the greater proportion that arrived by ambulance and the older age groups as findings which may suggest increased severity of illness. I have noted that there was increased likelihood of admission from ED which may suggest increased severity of illness and noted no evidence of increase in in-hospital mortality or increase in co-morbidity on discharge. I have reworded the *reasons for changes in acute hospital utilisation section* to more clearly make the point that the weakness in the Irish health system that I mention and reference did pre-date COVID-19 and as a result these weaknesses impacted the COVID-19 response.

Comment 6:

I would suggest reframing the title to match what the paper actually achieved. I don't feel the paper delivers on the title as currently stated, and I'm unsure what lessons derive directly from this analysis, for example I don't see the relationship with universal healthcare.

Reply 6:

Many thanks for your comment. I have changed the title of the paper to Changes in the utilisation of acute hospital care in Ireland during the first wave of the COVID-19 pandemic in 2020 which is an accurate reflection of what the paper reports.

Comment 7:

Overall, I think this is a good paper that presents a national picture that makes a valuable contribution to the literature

Reply 7:

Many thanks for your comments and feedback and for taking the time to review this paper.

Competing Interests: I have no competing interests to declare.

Reviewer Report 13 December 2021

https://doi.org/10.21956/hrbopenres.14487.r30817

?

Kednapa Thavorn
Clinical Epidemiology Program, Ottawa Hospital Research Institute, Ottawa, ON, Canada

This population-based study described the utilization of acute hospital services during the first wave of the COVID-19 pandemic in Ireland. The study was based on two national databases; ED attendances were obtained from Patient Experience Time (PET), while acute hospital discharge data were derived from Hospital In-Patient Enquiry (HIPE). Descriptive statistics and regression analysis were used to compare presentation to and admission from ED and acute hospital admission of any type for a non-COVID-19 illness across the four study periods, representing the epidemiology and public health management of COVID-19 in Ireland. This study shows that the first wave of COVID-19 was associated with decreased ED presentations, fewer admissions from ED, and non-COVID-19 hospital admissions.

- The study's title does not directly align with the study findings and is misleading. The study assessed the impact of the pandemic and the public health and health system measures on health care utilization; it did not fully describe how changes in health care utilization may affect public health or the health care system.

- There are some inconsistencies across the manuscript. In the abstract, the authors indicated that they used an interrupted time-series (ITS) analysis, but this methodology was not mentioned or used in the main texts. Instead, logistic regression was used. Please verify and ensure consistency. Additionally, the results section compared outcomes between four exposure periods and historical periods. The historical period was not defined or described in the method section. It is unclear why the first period (06/01/2020–01/03/2020) and the historical period (2017-19 or 2019) were used interchangeably as a reference group.

- What was the purpose of the inclusion of tracer diagnoses? Please provide further descriptions.

- The result section provides primarily descriptive results, which are difficult to interpret due to the potential impact of seasonal and trend patterns. If the authors did not use an ITS, they should focus on the results of multiple logistic regression analyses, as this method helped adjust for some confounding factors. The adjusted results would be more informative and more appropriate to compare against the existing literature.

- How were Figures 3 – 7 generated? Were they based on multiple regression analyses? If they were, shouldn't the y-axis be shown as adjusted odd ratios instead of rate ratios? There were three study outcomes? Why were only the regression results of ED admission reported in the manuscript (Table 6)?

- The discussion on health policy and health system implications was too broad; it is unclear how the study findings led to these policy recommendations.

Is the work clearly and accurately presented and does it cite the current literature?
Yes

Is the study design appropriate and is the work technically sound?
Partly

Are sufficient details of methods and analysis provided to allow replication by others?
No

If applicable, is the statistical analysis and its interpretation appropriate?
Partly

Are all the source data underlying the results available to ensure full reproducibility?
Partly

Are the conclusions drawn adequately supported by the results?
Partly

Competing Interests: No competing interests were disclosed.

Reviewer Expertise: Health services research

I confirm that I have read this submission and believe that I have an appropriate level of expertise to confirm that it is of an acceptable scientific standard, however I have significant reservations, as outlined above.

Author Response 30 May 2022

Louise Marron, Dr Steevens' Hospital, Dublin 8, Ireland

Many thanks for your comments and feedback and for taking the time to review this paper.

Comment 1:

The study's title does not directly align with the study findings and is misleading. The study assessed the impact of the pandemic and the public health and health system measures on health care utilization; it did not fully describe how changes in health care utilization may affect public health or the health care system.

Reply 1:

Thank you for your comment, I have changed the title of the paper to 'Changes in the utilisation of acute hospital care in Ireland during the first wave of the COVID-19 pandemic in 2020' which is an accurate reflection of what the study reports.

Comment 2:

There are some inconsistencies across the manuscript. In the abstract, the authors indicated that they used an interrupted time-series (ITS) analysis, but this methodology was not mentioned or used in the main texts. Instead, logistic regression was used. Please verify and ensure consistency. Additionally, the results section compared outcomes between four exposure periods and historical periods. The historical period was not defined or described in the method section. It is unclear why the first period (06/01/2020–01/03/2020) and the historical period (2017-19 or 2019) were used interchangeably as a reference group.

Reply 2:

Thank you for your comment. This was not an interrupted time series analysis and this term was not used in the manuscript. This study was a comparison of population rates of healthcare utilisation during different time periods in the first wave of COVID-19 infection in Ireland in 2020; the time periods were defined based on the epidemiology of the first wave and the associated population level restrictions. It was described in the paper as an interrupted time-trend analysis. On reflection, I agree that the term is unclear. Therefore, I have removed this term and I have described the study as a retrospective, population-based observational study which more accurately reflects the methodology. Thank you also for your comment regarding the need for more clarity about the historical reference periods and the reference period within 2020. I have included further details about this in the methodology and results sections. I have defined the time periods in the methods section and explained that both reference periods were used and the trends and associated public health implications were found to be similar so the paper primarily focuses on the internal comparison within 2020. The two comparisons showing similar trends also suggests that the variation observed within 2020 was not related only to seasonal differences in healthcare utilisation trends.

Comment 3:

What was the purpose of the inclusion of tracer diagnoses? Please provide further descriptions

Reply 3:

Thank you for your comment. I have provided further detail in the updated manuscript. The purpose of selecting the 'tracer diagnoses' was to explore healthcare utilisation trends in key clinical areas where changes in healthcare utilisation had been observed. These conditions were chosen following a review of the literature and from discussions with the national HSE Lead for Integrated Care, the Lead for the Acute Hospitals and for Mental Health who were clinicians providing frontline care during the COVID-19 pandemic in Ireland. Inclusion of the tracer diagnoses allowed us to better delineate more specific implications for key clinical conditions to inform recovery planning. I have included further detail on this in the outcomes section of the methods section.

Comment 4:

The result section provides primarily descriptive results, which are difficult to interpret due to the potential impact of seasonal and trend patterns. If the authors did not use an ITS, they should focus on the results of multiple logistic regression analyses, as this method helped adjust for some confounding factors. The adjusted results would be more informative and more appropriate to compare against the existing literature.

Reply 4:

Thank you for your comment. The results primarily focus on the absolute and relative differences in rates of healthcare utilisation in pre and post COVID-19 time periods. The

purpose of including two reference periods was to assess if population trends in healthcare utilisation were similar for both periods, the historic (pre-2020) comparison allowed delineation of seasonal effects. Unfortunately, the logistic regression analysis could only be carried out for PET data as the HIPE data are aggregate data. I have stated this more clearly in the methods and I have included further detail on the logistic regression analysis. As outlined in the data sources section of the paper, HIPE is a well-established, quality-assured health information system that is the primary source of episode-based clinical, demographic and administrative data on discharges from acute public hospitals in Ireland. HIPE data are aggregate data that are used nationally to inform healthcare planning, management and activity-based funding. For this study the HIPE data provided details of non-COVID-19 admissions to the acute hospitals, it identified changes in trends for all non-COVID-19 admissions and in particular changes for elective and emergency admissions and differences in the changes observed between elective and emergency admissions.

Comment 5:

How were Figures 3 – 7 generated? Were they based on multiple regression analyses? If they were, shouldn't the y-axis be shown as adjusted odd ratios instead of rate ratios? There were three study outcomes? Why were only the regression results of ED admission reported in the manuscript (Table 6)?

Reply 5:

Thank you for your comment. Figures 3 to 7 show the population rates of healthcare utilisation presented as weekly rates (Figures 3 and 4) and rate ratios (Figures 5, 6 and 7). These figures were not generated from regression analysis but from calculation of population rates of healthcare utilisation and comparison between pre- and post-COVID-19 time periods. I have clarified this further in the methods and the axes of the figures are labelled to reflect what is shown. There were three study outcomes, outcome was a non-COVID-19 hospital admission. This outcome is reported in the results, the rate difference and rate ratio per 100,000 population. However, as the reductions in non-COVID-19 hospital admissions were predominantly for elective and emergency admissions and as there were notable differences in the patterns and trends observed between elective and emergency admissions, these are presented separately in Figures 3, 4 5 and 7. I have clarified this in the results section. Regression analysis was only possible for PET data which are individual level data while the HIPE data are episode based and are aggregate data. I have updated the data sources section of the paper to more clearly state this. The purpose of the regression analysis was to identify factors, including time period, on the likelihood of admission from ED following presentation to ED. I have amended the methods section to more accurately reflect the purpose of the regression analysis reported in Table 6.

Comment 6:

The discussion on health policy and health system implications was too broad; it is unclear how the study findings led to these policy recommendations.

Reply 6:

Thank you for your comment. I have changed the title of the paper. I have also updated the discussion to include that the findings of this study were disseminated nationally to the director of Sláintecare and to the national leads for integrated care, the acute hospitals and mental health. I have added that this study quantified the changes in healthcare utilisation during the first wave of the COVID-19 pandemic and identified key clinical areas to focus on for population health recovery which are important in the context of the ongoing reform of the Irish health system. I have also added that the findings of this study informed the HSE National Service Plan for 2022 which has a focus on scheduled care recovery with an included reference to the plan.

Competing Interests: I have no competing interests to declare.