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Threat of COVID-19 impacting on a quaternary healthcare service: a retrospective cohort study of administrative data

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ABSTRACT

Objectives The threat of a pandemic, over and above the disease itself, may have significant and broad effects on a healthcare system. We aimed to describe the impact of the SARS-CoV-2 pandemic (during a relatively low transmission period) and associated societal restrictions on presentations, admissions and outpatient visits.

Design We compared hospital activity in 2020 with the preceding 5 years, 2015–2019, using a retrospective cohort study design.

Setting Quaternary hospital in Melbourne, Australia.

Participants Emergency department presentations, hospital admissions and outpatient visits from 1 January 2015 to 30 June 2020, n=896 934 episodes of care.

Intervention In Australia, the initial peak COVID-19 phase was March–April.

Primary and secondary outcome measures Separate linear regression models were fitted to estimate the impact of the pandemic on the number, type and severity of emergency presentations, hospital admissions and outpatient visits.

Results During the peak COVID-19 phase (March and April 2020), there were marked reductions in emergency presentations (10 389 observed vs 14 678 expected; 29% reduction; p<0.05) and hospital admissions (5972 observed vs 8368 expected; 28% reduction; p<0.05). Stroke (114 observed vs 177 expected; 35% reduction; p<0.05) and trauma (1336 observed vs 1764 expected; 24% reduction; p<0.05) presentations decreased; acute myocardial infarctions were unchanged. There was an increase in the proportion of hospital admissions requiring intensive care (7.0% observed vs 6.0% expected; p<0.05) or resulting in death (2.2% observed vs 1.5% expected; p<0.05). Outpatient attendances remained similar (30 267 observed vs 31 980 expected; 5% reduction; not significant) but telephone/telehealth consultations increased from 2.5% to 45% (p<0.05) of total consultations.

Conclusions Although case numbers of COVID-19 were relatively low in Australia during the first 6 months of 2020, the impact on hospital activity was profound.

Strengths and limitations of this study

- The impact of the threat of COVID-19 in 2020 was observed at a quaternary referral hospital in Victoria across three settings: the emergency department, hospital admissions and hospital outpatient visits and compared with the preceding 5 years, totalling 896 934 episodes of care.
- Modelling patient data over the last 5 years, rather than last year alone, provides a stronger prediction of what the numbers in 2020 should have been.
- Not only were the changes in number and type of presentations explored, but also the impact on vulnerable populations.
- We explored whether admitted patients were more unwell during the peak of COVID-19.
- It is not known if patients who avoided presenting to the Royal Melbourne Hospital during the COVID-19 outbreak sought care elsewhere, such as community general practitioners or local hospitals.

INTRODUCTION

The COVID-19 pandemic has affected hospitals in varied ways. The usual business of providing care to patients without COVID-19 has altered, and the pattern of presentations and admissions has changed. For instance, as the number of COVID-19 cases rose, a decrease in overall number of emergency presentations has been reported, ranging from 49% in the UK to 88% in Italy.[1–4] Unanticipated and indirect impacts on hospital services occurred even in regions with relatively few reported COVID-19 cases.

Before July 2020, Australia had been relatively spared. As of 30 June 2020, there had been 8023 COVID-19 cases and 104 deaths among a population of 25 million. In the second-largest jurisdiction, Victoria, there

had been 2159 cases. The Victorian government declared a state of emergency on March 16 and shut down all non-essential activities. Health services were instructed to suspend non-urgent surgery to maintain surge capacity. The federal government introduced widened criteria for telehealth consultation rebates to encourage the use of telehealth.

The Australian context provides a unique opportunity to examine the effects of the threat of COVID-19 on healthcare utilisation. Using hospital administrative data from the Royal Melbourne Hospital, one of Victoria's largest hospitals and designated hospital for treating patients with COVID-19, we determined changes in the number, type and severity of emergency presentations, hospital admissions and hospital outpatient visits, during the first half of 2020 compared with the preceding 5 years, 2015–2019. An understanding of changes can improve planning, public health messaging and resource management for future surges.

METHODS

Study design and population

The Royal Melbourne Hospital is a major metropolitan, quaternary referral and teaching hospital, operating approximately 800 beds. It is one of two major trauma referral centres in Victoria and one of Australia's leading public hospitals. Patients are transferred to the Royal Melbourne Hospital from tertiary organisations across Victoria and Tasmania. Commencing 1 March 2020, the hospital opened a fever clinic for the screening of patients for SARS-CoV-2 and became a designated hospital for treating patients with COVID-19 .

Administrative data are collected on all patients and can be accessed through an integrated data warehouse, which links data from source systems including the patient administration system, electronic health records and official diagnostic coding data. We obtained episode level data on all emergency department (ED) presentations and hospital outpatient visits from 1 January 2015 to 30 June 2020. Admissions data were collected from 1 January 2015 to 31 May 2020 (June was excluded as discharge coding for admissions was incomplete at the time of data acquisition on 15 July 2020). Data fields included demographics, ED discharge coding of diagnoses, principal International Classification of Diseases-10 diagnosis at hospital discharge, length of stay, intensive care unit (ICU) stay, triage category according to the Australasian Triage Scale (ATS, range 1–5, where 1 is most critical), COVID-19 diagnosis, in-hospital mortality; and for outpatient visits the modality of visit (in person, telephone, telehealth). We accessed publicly available data on Victorian COVID-19 notifications.

Patient and public involvement

No patient was involved. The study includes deidentified patient data from the Royal Melbourne Hospital, Australia. It was not appropriate or possible to involve patients or the public in the design, or conduct, or reporting, or dissemination plans of our research.

Statistical analysis

To determine whether there were changes in the number of different hospital cases in 2020 compared with the preceding 5 years, we used linear regression models to test the null hypothesis that there was no difference in the number between the prepandemic (2015–2019) and postpandemic (2020) periods. Separate linear regression models were fitted to the number of (1) 'emergency presentations', excluding the dedicated COVID-19 fever clinic; (2) 'admissions' including healthcare provided in the home, that is, intravenous treatment for patients with pneumonia, but excluding single day admissions, statistical separations (cessation of an episode of patient care), organ procurement, maternity and birth episodes; (3) 'outpatient visits', excluding missed appointments; (4) patients with one of eight primary diagnoses: 'pneumonia', 'trauma', 'mental health or substance abuse', 'acute coronary syndrome', 'stroke', 'appendicitis' or 'cellulitis' (expressed as a total number for the 1 or 2-month period) (see online supplemental eTables 1–7 for categorisation codes). These eight diagnoses were prespecified for detailed analyses as they were hypothesised to change in numbers of presentations during the pandemic and each comprised a significant proportion of all presentations; (5) patients within each 'triage category' (ATS 1–3=high acuity, 4–5=low to moderate); (6) 'ICU admissions' (number of patients admitted to ICU expressed as a percentage of admitted patients); (7) 'deaths' (number of admitted patients who died, expressed as a percentage of admitted patients); (8) patients from different suburbs across Melbourne (expressed as a proportion of admitted patients) as well as (9) 'length of stay' (excluding short-term stay ≤24 hours and presented as the average duration in hours for all patients), against 'year of admission' (prepandemic/postpandemic) and 'date of admission' (dd/mm/year) to adjust for seasonality. The number of 'ICU admissions', 'number of deaths' and 'length of stay' were adjusted for 'age' and 'gender' in addition to 'year of admission' and 'date of admission' since we expected these outcomes to vary depending on the patient demographic presenting to the hospital, that is, an older cohort of patients in 2020 may explain a rise in deaths and therefore, may not be associated with the pandemic. All other dependent variables were used to represent healthcare utilisation, regardless of the patient demographic; they were not adjusted for age and gender.

To calculate the mean difference (and 95% CI) between expected and observed numbers for 2020, we fitted a linear regression model of case numbers against 2015–2019 and predicted numbers for 2020 and compared these with actual numbers for 2020. We used Gaussian regression models for continuous variables and Poisson regression models for all count variables. A conservative approach was used to check for statistical differences ($p<0.05$) based on whether the 95% CIs of the difference

overlapped with zero. We used the same models to observe the pandemic's effects from January to February, March to April and June to July. These 2-month windows represented the pandemic's pre, peak and transition phases, respectively, and were compared with the same periods in 2015–2019. Only the January–June period was considered because this is the available data for 2020 and it captured the first wave of the COVID-19 outbreak when it posed more of a threat to overwhelming the health service than a reality.

The regression models showed little autocorrelation as indicated by the Durbin-Watson test and the residuals showed only minor deviations from normality when using the univariate kernel density estimation. Overdispersion was not detected in any analysis as indicated by the Pearson χ^2 dispersion statistic. Because this is an exploratory study and not a study that would lead to a change in clinical practice, we did not correct for multiple-hypothesis testing. All analyses were conducted using Stata V.16 (StataCorp, Texas, USA) and R V.4.0.2 (R Project for Statistical Computing).

RESULTS

Observations during January–Jun 2020

From 1 January to 30 June 2020 there were 2159 positive SARS-CoV-2 notifications in Victoria, Australia, of which 138 were diagnosed and 28 admitted at the Royal Melbourne Hospital. From 1 January to 30 June 2020 there were 47 609 emergency presentations (36 188 excluding fever clinic), 16 867 admissions (excluding June) and 96 722 outpatient visits. Notifications for SARS-CoV-2 peaked in Victoria in early April, and a coincident reduction in ED presentations to the Royal Melbourne Hospital occurred in March and April (figure 1A). A concomitant increase in patients screened in the fever clinic was observed in March and April and peaked in the third week of March, 2 weeks before the peak in COVID-19 cases. Emergency presentations remained below pre-COVID-19 activity in May and June.

Similarly, both emergency and elective hospital admissions were considerably reduced during the peak COVID-19 period compared with the pre-COVID period and began to recover in May (figure 1B). Outpatient appointments dropped for 1 week during the peak COVID-19 period but quickly recovered (figure 1C). Telehealth and telephone appointments increased during the peak COVID-19 period to compensate for the decrease in face-to-face appointments. They continued to represent a large proportion of appointments in May and June.

ED episodes

From 2015 to 2019, there was a year-on-year increase in caseload for all ED presentations (figure 2). During March–April 2020 when COVID-19 cases peaked, there was a marked reduction in ED presentations (10 389 observed vs 14 678 expected; 29% reduction, p<0.05) (table 1). There were fewer trauma (major and minor)

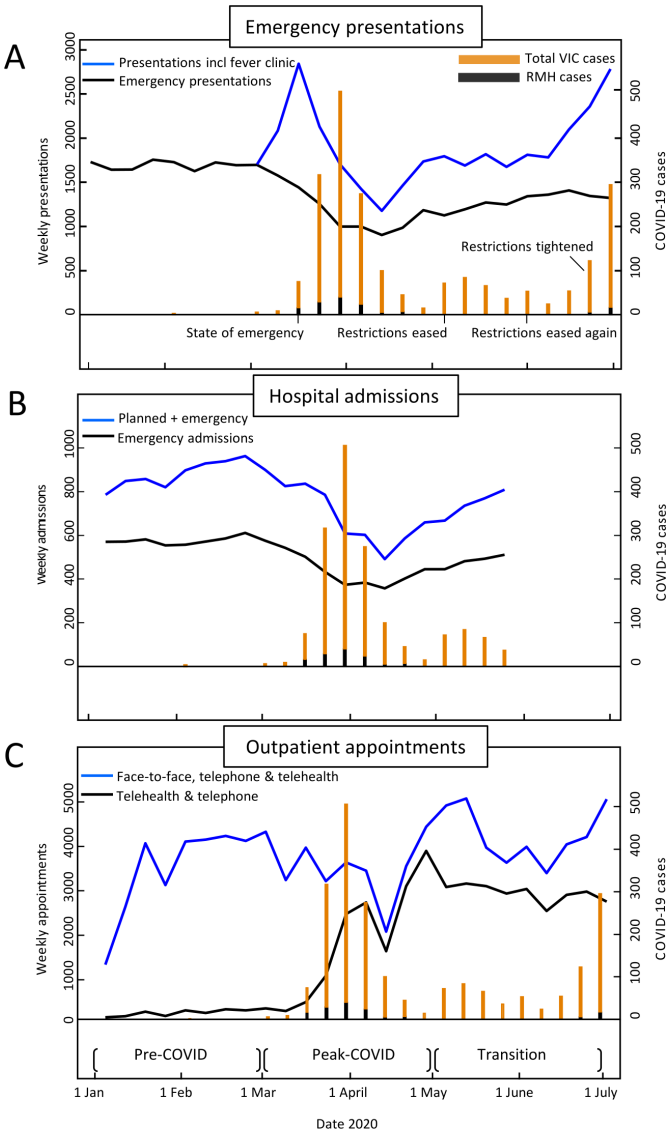

Figure 1 Weekly number of positive COVID-19 cases in VIC and treated at the RMH and the corresponding changes in number of ED presentations (A), hospital admissions (B) and outpatient appointments (C) from 1 January to 30 June 2020. Complete hospital admission data are available till 30 May 2020. ED, emergency department; RMH, Royal Melbourne Hospital; VIC, Victoria.

cases (1336 observed vs 1764 expected; 24% reduction, p<0.05), stroke cases (114 observed vs 177 expected; 36% reduction, p<0.05), mental health and substance abuse cases (221 observed vs 267 expected; 20% reduction, p<0.05) and appendicitis cases (54 observed vs 76 expected; 29% reduction, p<0.05) but an increase in cellulitis cases (89 observed vs 69 expected; 29% increase, p<0.05). There was no difference in the actual versus expected number of acute myocardial infarction or pneumonia cases.

As Victorian COVID-19 cases began to decline during the May–June transition phase, the ED continued to observe fewer overall presentations (11 298 observed vs 13 729 expected; 18% reduction, p<0.05), and there were fewer high acuity cases (63.9% observed vs 65% expected;

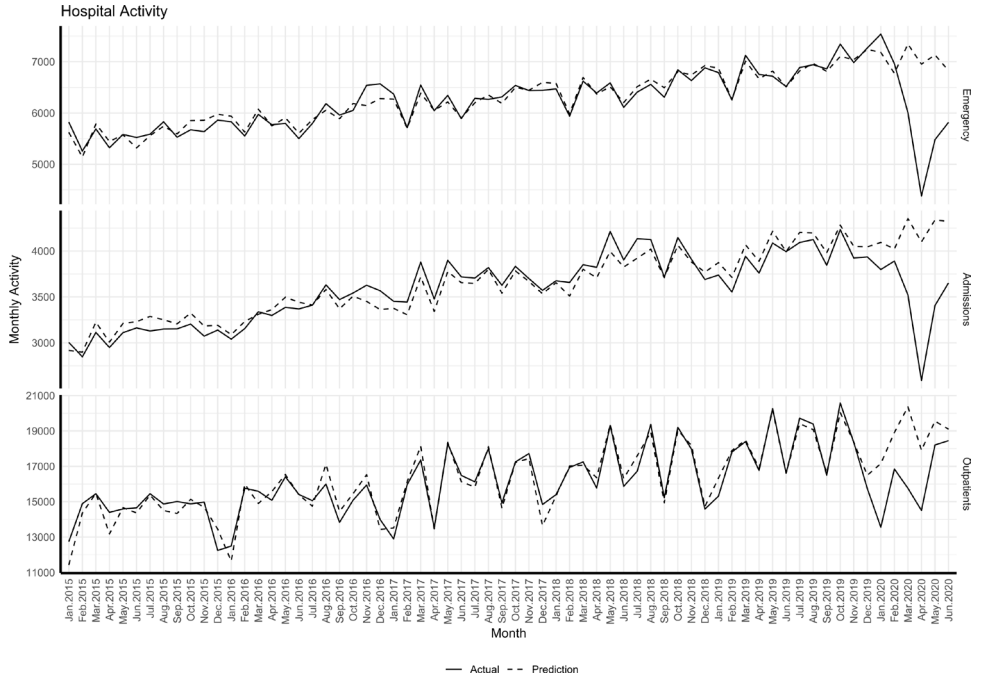

Figure 2 Time series of the monthly number of presentations to emergency, inpatient admissions and outpatient appointments to the Royal Melbourne Hospital from January 2015 to June 2020. The solid line shows the actual numbers recorded for the month, while the hashed line indicates the predicted numbers based on the underlying trend. Year-by-year trend shows the case loads are increasing, except in 2020, where in March and April the numbers decreased dramatically and deviate from the predicted line.

p<0.05) (table 1, online supplemental table). Fewer cases of pneumonia (32 observed vs 52 expected; 39% reduction, p<0.05), trauma (1419 observed vs 1564 expected; 9% reduction, p<0.05), appendicitis (36 observed vs 59 expected; 39% reduction, p<0.05) were detected, but an increase in cellulitis (131 observed vs 99 expected; 32% increase, p<0.05) and mental health and substance abuse cases (260 observed vs 220 expected; 18% increase, p<0.05) was found but no difference in stroke or acute myocardial infarction cases.

The residential postcode of ED arrivals changed significantly from March to June compared with the pre-COVID-19 period (travel for medical attention was an exemption during lockdown). Proportionally fewer people arrived from outer suburbs compared with patients from suburbs situated closer to the hospital (p<0.05) (online supplemental etables 8–10). A smaller proportion was born outside of Australia (p<0.05).

Inpatient episodes

From 2015–2019, the yearly number of admissions increased (figure 2). During the peak of COVID-19 cases in March–April 2020, there were fewer admissions (5972 observed vs 8368 expected; 28% reduction, p<0.05), both emergency and planned, to the Royal Melbourne Hospital compared with the equivalent period in 2015–2019 (table 2). This included fewer stroke (134 observed vs 177 expected; 24% reduction, p<0.05), trauma (624 observed vs 900 expected; 31% reduction, p<0.05), mental health and substance abuse cases (93 observed vs 166 expected; 19% reduction, p<0.05), cellulitis cases (43 observed vs 88 expected; 51% reduction, p<0.05), and appendicitis cases (56 observed vs 75 expected; 25% reduction, p<0.05) but an increase in the number of pneumonia cases (138 observed vs 95 expected; 45% increase, p<0.05), 12 of whom tested positive for COVID-19. The number of admissions with acute myocardial infarction were not different from predicted. A higher proportion of admissions required time in ICU (7% observed vs 6% expected; 17% increase, p<0.05) or died in hospital (2.2% observed vs 1.5% expected; 47% increase, p<0.05). There was no difference in the average length of stay.

The transition phase in May continued to show fewer admissions (3343 observed vs 4616 expected; 28% reduction, p<0.05) and more patients arriving from ED required time in ICU (9% observed vs 7.7% expected; 17% increase, p<0.05) (table 2 and online supplemental eTables 11–13). As with the peak COVID-19 period, the number of deaths was higher from expected (2.1% observed vs 1.5% expected; 40% increase, p<0.05).

Outpatient episodes

Monthly outpatient appointments gradually increased from 2015 to 2019 (figure 2) and showed no significant change in the total number of appointments during the COVID-19 peak (30 267 observed vs 31 980 expected; 5% reduction, not significant) and transition phase (36 656 observed vs 36 878 expected; 6% reduction, not significant). During the peak COVID-19 period, telehealth and telephone appointments made up 45% of all appointments (45% observed vs 9% expected; p<0.05), and in the transition phase 56% (56% observed vs 3.4% expected;

Table 1 Characteristics of people presenting to the emergency department at the Royal Melbourne Hospital from 1 March to 30 April 2015–2020

	March–April						Mean difference between predicted and observed in 2020 (95% CI)		
	2015	2016	2017	2018	2019	2020	March–April Peak COVID-19	January–February Pre-COVID-19	May–June transition
Presentations, N	11 011	11 746	12 590	13 012	13 878	10 389	−4289 (−3700 to −4880)*	680 (431 to 929)*	−2431 (−2680 to −2180)*
ATS, %									
High acuity, ATS 1–3	56.7	56.0	58.4	59.3	62.0	62.6	0.7 (−0.9 to 2.3)	−2.5 (−3.3 to −1.7)*	−1.1 (−1.8 to −0.3)*
Low to moderate acuity, ATS 4–5	43.3	44.0	41.6	40.7	38.0	37.4	−0.7 (−2.3 to 1.9)	4.2 (1.7 to 3.3)*	1.1 (0.3 to 1.8)*
Conditions presenting, N									
Stroke	82	109	110	113	167	114	−63 (−84 to −42)*	19 (−2 to 40)	3 (−30 to 24)
Acute myocardial infarction	80	54	73	62	92	83	1 (−15 to 15)	21 (3 to 39)*	15 (−31 to 1)
Pneumonia	55	34	31	38	41	40	7 (−6 to 20)	17 (1 to 33)*	−20 (−32 to −8)*
Cellulitis	74	82	96	76	62	89	20 (1 to 40)*	60 (37 to 83)*	32 (12 to 52)*
Mental health/substance abuse	197	229	231	243	249	211	−56 (−87 to −27)*	−17 (−50 to 16)	40 (7 to 74)*
Appendicitis	69	56	76	75	71	54	−22 (−38 to −6)*	−11 (−8 to 31)	−23 (−36 to −10)*
Trauma	1591	1655	1689	1830	1644	1336	−428 (−527 to −329)*	36 (158 to 316)*	−145 (−216 to −74)*

Percentages=(number/daily total) ×100 for the 2-month period. Numbers exclude attendees to the fever clinic in March–April (n=5471) and May–June (n=5925). Additional information is available in online supplemental tables. Two-month differences between observed versus predicted emergency presentations are provided for March and April 2020 (peak COVID-19), January–February (pre-COVID-19) and May–June (transition period).
*Regression analysis: significance based on 95% CI (p<0.05).
ATS, Australasian Triage Scale.

p<0.05) (table 3 and online supplemental eTables 14–16). Those attending outpatients in the peak COVID-19 period were younger than expected, and the proportion of patients born outside of Australia decreased (online supplemental etables 14–16). The transition from face-to-face to telehealth was also observed in potentially vulnerable groups, such as the elderly and those born outside of Australia (making up 44%–61% of all appointments from March to June, p<0.05).

DISCUSSION

During an initial mild wave of COVID-19 in Victoria, there was a marked reduction in the use of hospital services at a major quaternary, level 1 trauma hospital. We have provided a broad overview of the changes that occurred across the hospital services of ED care, hospital admissions (planned and emergency) and ambulatory outpatient clinics. Some of these changes were planned and predictable (eg, deferral of non-urgent elective surgery cases), some surprising (eg, considerable reductions in emergency presentations and admissions) and others forced but timely adaptations (eg, increased use of telehealth).

We observed a 29% reduction in ED presentations during March and April 2020 compared with predicted presentations modelled on data from the previous 5 years. A similar phenomenon has been reported from countries with high levels of COVID-19 infection rates[4–7] and emerging data suggest this may also have occurred in settings with a low burden of COVID-19.[8] With less social interaction, community surveillance data demonstrated historically low levels of influenza-like symptoms in Victoria,[9] which may have resulted in fewer presentations with influenza-like illnesses and also fewer viral exacerbations of chronic conditions. Psychological components may have also been an important factor. Analysis from previous pandemics has demonstrated that fear of contracting disease in hospital or concern that hospital resources are overwhelmed can lead to avoidance of seeking medical care for patients with non-pandemic-related illnesses.[10 11]

There was an apparent reduction in trauma presentations, probably related to less population mobility including fewer cars on the roads, cancellation of sporting activities and reduced industrial activities. There were also fewer stroke presentations, a trend observed elsewhere.[5 12 13] In contrast to other settings, but similar to another major Melbourne hospital, we noted no change in presentations of acute myocardial infarction.[14–16]

The proportion of people presenting to the ED who were born outside of Australia, significantly reduced during March–June 2020. It is concerning that this group of patients has been accessing less hospital care during the COVID-19 pandemic, given the health vulnerabilities of some subsets of the culturally and linguistically diverse population[17] and that approximately 30% of people living near the hospital have a non-English-speaking

Table 2 Characteristics of patients admitted to the Royal Melbourne Hospital from 1 March to 30 April 2015–2020

	March–April						Mean difference between predicted and observed in 2020 (95% CI)		
	2015	2016	2017	2018	2019	2020	March–April Peak COVID-19	January–February Pre-COVID-19	May transition period
Admissions, N	5888	6505	7246	7550	7565	5972	−2396 (−2810 to −1981)*	−533 (−929 to −135)*	−1273 (−1570 to −976)*
Emergency admission, N (%)	3970 (67.4)	4253 (65.4)	4604 (63.5)	4840 (64.1)	4921 (65.1)	3801 (63.7)	−1511 (−1709 to −1314)*	−222 (−347 to −98)*	−627 (−717 to −536)*
Planned admission, N (%)	1918 (32.6)	2252 (34.6)	2642 (36.5)	2710 (35.9)	2664 (34.9)	2171 (36.4)	−888 (−1183 to −592)*	−318 (−635 to −2)*	−648 (−876 to −420)*
Length of stay, hours mean (SD)									
Any admission	150.2 (236.0)	149.3 (242.9)	137.7 (239.5)	133.7 (233.4)	144.9 (287.8)	133.5 (211.6)	−1.6 (−8.6 to 5.5)	−6.0 (−11 to −1.0)*	1.0 (−6.4 to 8.4)
Emergency admission	126.7 (195.9)	124.4 (180.0)	119.7 (197.9)	114.3 (175.5)	122.8 (210.1)	110.9 (164.5)	−6.0 (−0.3 to 12.2)	−4.6 (−9.1 to −0.1)*	3.4 (−4.0 to 10.9)
Planned admission	198.8 (296.8)	196.3 (325.5)	169.1 (295.7)	168.3 (308.2)	186.0 (390.3)	173.2 (271.0)	19.7 (3.1 to 36.2)*	12.3 (−1.2 to 25.9)	12.5 (−4.6 to 29.7)
Requiring ICU (%)									
Any admission	5.7	5.3	5.8	6.3	5.6	7.0	1.0 (0.5 to 1.6)*	−0.2 (−0.7 to 0.4)	0.8 (−0.1 to 1.6)
Emergency admission	6.0	5.9	6.7	7.6	6.6	8.1	0.5 (−0.1 to 1.0)	−0.5 (−1.0 to 0.1)	1.3 (0.4 to 2.2)*
Planned admission	5.2	4.0	4.2	4.1	3.7	5.0	0.6 (0.2 to 0.9)*	0.3 (0.0 to 0.6)	−0.5 (−0.9 to −0.2)*
Died (%)									
Any admission	1.9	1.6	1.8	1.4	1.6	2.2	0.7 (0.3 to 1.0)*	0.0 (−0.3 to 0.3)	0.6 (0.2 to 1.0)*
Emergency admission	2.4	2.1	2.0	1.7	2.0	2.3	0.4 (0.1 to 0.7)*	0.0 (−0.3 to 0.2)	0.5 (0.1 to 0.9)*
Planned admission	0.7	0.8	1.4	0.9	0.9	2.0	2.3 (2.1 to 2.5)*	0.0 (−0.1 to 0.1)	0.1 (−0.1 to 0.3)
Conditions presenting, N									
Stroke	74	132	157	118	154	134	−43 (−64 to −22)*	9 (−19 to 37)	−5 (−25 to 16)
Acute myocardial infarction	106	80	89	101	104	96	−5.5 (−22 to 11)	6 (−12 to 25)	−3.6 (−17 to 9)
Pneumonia	88	74	97	84	95	138	43 (20 to 66)*	18 (0 to 38)	−34 (−44 to −23)*
Cellulitis	16	63	75	46	71	43	−45 (−58 to −32)*	−43 (−59 to −27)*	−47 (−55 to −39)*
Mental health/substance abuse	63	111	96	108	96	93	−23 (−36 to −8)*	−22 (−42 to −1)*	−11 (−24 to 1.8)
Appendicitis	43	55	57	60	68	56	−19 (−32 to −6)*	1 (−15 to 17)	−18 (−25 to −11)*
Trauma	683	799	786	880	815	624	−276 (−333 to −220)*	−60 (−118 to 0)	−117 (−159 to −74)*

Percentages=(number/daily total) × 100 for the 2-month period. Additional information is available in online supplemental tables.
Differences between observed versus predicted admissions are provided for March and April 2020 (peak COVID-19), January–February (pre-COVID-19) and May (transition period).
*Significance based on 95% confidence interval (p<0.05).

Table 3 Characteristics of patients attending outpatient appointments at the Royal Melbourne Hospital from 1 March to 30 April 2015–2020

	March–April						Mean difference between predicted and observed in 2020 (95% CI)		
	2015	2016	2017	2018	2019	2020	March–April Peak COVID-19	January–February Pre-COVID-19	May–June transition
Attended appointments	29 851	30 666	30 890	33 025	35 160	30 267	−1713 (−6483 to 3055)	−4609 (−10 135 to 917)	−222 (−5897 to 5421)
Face-to-face, N (%)	29 851 (100)	30 666 (100)	30 190 (97.8)	31 536 (95.5)	33 276 (94.6)	16 532 (54.6)	−13,219 (−17 068 to −9370)*	3871 (−9137 to 1395)	−18 292 (−21 093 to −15 492)*
Telephone, N (%)	–	–	628 (2.0)	1370 (4.2)	1664 (4.7)	8586 (28.4)	5876 (3448 to 8305)*	−2558 (−2,863 to −2253)*	7815 (5739 to 9890)*
Telehealth, N (%)	–	–	72 (0.2)	119 (0.4)	220 (0.6)	5157 (17.0)	6029 (4366 to 7694)*	−160 (−299 to −23)*	7596 (6176 to 9015)*
Age (years) mean (SD)	53.4 (18.4)	53.4 (18.6)	53.1 (18.6)	52.9 (18.6)	53.1 (18.4)	50.7 (18.3)	−3.7 (−5.1 to −2.3)*	0.0 (−1.6 to 2.1)	−1.7 (−3.4 to 0.1)
Born in Australia, %	55.6	56.0	56.6	57.9	59.3	64.1	4.8 (0.6 to 8.9)*	5.9 (0.2 to 11.6)*	9.2 (5.7 to 12.7)*
Age≥65 years, N	9660	9899	9675	10 165	10 939	8011	−1250 (−2157 to −344)*	−1258 (−2688 to 172)	−2276 (−3543 to −989)*
Face-to-face, %	100	100	98.0	96.1	96.0	54.3	−36.0 (−45.2 to −26.9)*	1.2 (0.5 to 1.9)*	−45.6 (−52.6 to −38.6)*
Telephone, %	–	–	1.9	3.6	3.5	32.6	24.0 (17.2 to 30.7)*	−0.5 (−1.4 to 0.4)	33.3 (27.9 to 38.6)*
Telehealth, %	–	–	0.1	0.3	0.5	13.0	12.1 (9.3 to 14.8)*	0.0 (−0.1 to 0.1)	12.3 (10.4 to 14.3)*

Two-month differences between observed versus predicted outpatient appointments are provided for March and April 2020 (peak COVID-19), January–February (pre-COVID-19) and May–June (transition period). Additional information is available in online supplemental tables.
*Significance based on 95% CI (p<0.05).

background.[18] This highlights the importance of public health messaging that hospitals continue to be operational and are safe places to access necessary care.[19]

During March–May, while the total number of admissions decreased, we observed significant increased mortality or need for ICU support among both planned and emergency admissions. These findings suggest that the patients presenting to the hospital during the threat of COVID-19 and immediately after were more unwell than before the pandemic began.[16] Local and international data suggest a delay in seeking medical care during the COVID-19 outbreak,[3 20–22] resulting in more severe pathology at presentation. In Victoria, there was a 2%–3% increase in the number of people dying in the community during May compared with other months.[23] Although further examination is required, it broadly supports our assertion that people were avoiding or delaying care during this time. An overwhelming influx of COVID-19 cases, as seen elsewhere,[24] can be discounted as a reason for worse outcomes at the Royal Melbourne Hospital. The underlying causes merit further exploration.

Admissions with pneumonia increased from March to April, which could not be explained by the 12 cases of COVID-19. We were surprised by this increase as there was less community transmission of influenza in Victoria during the stay-at-home order period. It is possible that pneumonia cases, that might have otherwise been treated in the community, were instead managed in the hospital due to concern of a COVID-19 diagnosis.

There was a remarkable and rapid increase in telehealth and telephone outpatient appointments during the peak March–April period, with changes persisting after the threat of COVID-19 had diminished. Patients accessing telehealth appointments appeared to be younger and less likely to be born outside of Australia. Using the telephone or computer was not a significant barrier for 44%–61% of older patients, including those born outside Australia, who used these options instead of face-to-face appointments. The severity of illness of the older patients who used telehealth is unknown, nor is it known what their motivation was for using it. While it is likely they feared contracting COVID-19 at the hospital, we cannot discount their shift in behaviour was simply because the clinicians promoted it. A recent survey of clinicians and patients from the Royal Melbourne Hospital reported that the standard of outpatient care was not compromised by using telehealth compared with on-site appointments.[25] Although access to care mostly continued during the pandemic, it will be important to ensure that services cater to any disadvantaged patient groups.

Our study has some limitations. Coding lags for inpatient admissions resulted in only 1 month of data to represent the transition period after the initial peak of COVID-19. Although the Royal Melbourne Hospital is one of the largest hospitals state-wide, our data are restricted to a single site. Future studies could explore linking datasets between hospitals, general practice and community health databases to examine whether there

is an overall reduction of care-seeking behaviour across all services or if the drop is limited to specific hospital services. Although changes in the population of the primary catchment area of the Royal Melbourne Hospital could influence the caseload, these are unlikely to entirely explain the observed decreased numbers during 2020. Occupied bed days increased from a mean of 650 in 2015 to a mean of 780 early 2020 and was reflected in the regression models that demonstrated an increase in activity from 2015 to early 2020. The population of the primary catchment area also increased by 2.5% per annum from 2015 to 2020.[26] On the other hand, there would have been fewer people inhabiting the local suburbs due to restricted international travel, difficulties in residents returning home from overseas, fewer international students and a decline in tourist numbers. This may also explain, in part, why fewer people born outside Australia presented to the hospital during 2020. Nevertheless, it is likely that multiple factors associated with the pandemic contributed to the abrupt changes in health service utilisation, and it is beyond the scope of this paper to explore these in detail. Other explanations cited in the literature for a decrease in patients without COVID -19 in countries overwhelmed by positive infections do not apply to our study, where we examine a unique time when COVID-19 was only a threat. For instance, there was no general hospital policy to shorten hospital stay or to keep beds free in case of an influx of patients with COVID-19 or to divert ambulances. Nor was the Royal Melbourne Hospital overwhelmed by furloughed or redeployed staff at this stage of the pandemic.[27]

Our findings raise concern that during the initial threat of COVID-19, and even after it abated, there has been a marked reduction in hospital presentations and indicators of increased severity in those presenting. It will be imperative for public health authorities to improve community messaging regarding the importance of seeking timely care. Targeting vulnerable groups who already have barriers to accessing care will be especially important. This may require increased investment in interpreting and community-based outreach services. Hospitals should prepare for a potential increase in workload, not only from patients who had elective procedures deferred but from patients who avoided care during the initial threat of COVID-19. At the time of writing, Victoria is experiencing a second surge in COVID-19 cases. Ongoing monitoring and analysis of health outcomes will help inform responses to this and future COVID-19 upsurges or other pandemics.

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