





ORIGINAL RESEARCH

Impact of COVID-19 pandemic on emergency department patient volume and flow: Two countries, two hospitals

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Abstract

Objectives: COVID-19 greatly disrupted the provision of emergency care across the globe. ED service delivery was urgently redesigned as human and material resources were mobilised, and patients with respiratory symptoms were isolated. This study aimed to compare ED patient volume and flow metrics before and during the COVID-19 pandemic.

Methods: An observational study was conducted in two large urban EDs in Brisbane, Australia and Seoul, Republic of Korea. Patient volume and flow were quantified using ED presentation numbers and service times, respectively. Daily case numbers, waiting, treatment and admission delay times were compared between 2019 and 2020/2021 using time series plots. Outcomes were further classified by triage category and age group. Trends were examined alongside a timeline of health service and government policies.

Results: There were reductions in daily presentations for the least urgent triage categories during the early phase of the pandemic. The caseloads for the most urgent triage categories were unaffected. The

trends were similar in both EDs. A reduction in waiting and admission delay times but not treatment times coincided with reduced presentations in Brisbane. This pattern gradually reversed as presentations returned to baseline. In Seoul, admission delay times returned to pre-pandemic levels despite a persistent reduction in presentation numbers.

Conclusions: Total daily presentations varied considerably according to government mandated social restrictions and testing requirements in both EDs. The reductions in waiting and admission delay times corresponded with improvements in hospital capacity.

Key words: *Australia, coronavirus, COVID-19, emergency, South Korea.*

Introduction

Coronavirus disease 2019 (COVID-19) caused by the severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) was declared a pandemic by the World Health Organization on 11 March 2020.¹ Across the globe, the provision of emergency care was greatly disrupted with EDs urgently redesigning services and mobilising both

Key findings

- ED presentations of lower triage categories were reduced at the start of the pandemic.
- Reductions in ED waiting and delay-to-admission times corresponded with improvements in hospital capacity.
- Treatment times at RBWH were unchanged, suggesting an adaptable patient flow model.

human and material resources.²⁻⁶ The core challenge for EDs, during this time, was to respond to unfamiliar and rapidly evolving external pressures while maintaining a well-functioning service.

Brisbane, Australia and Seoul, Republic of Korea, are two cities in developed countries with different experiences and responses to the COVID-19 pandemic. In Queensland, the first patient diagnosed with COVID-19 was in late January 2020.⁷ Case numbers rose and plateaued in mid-April, reaching a cumulative total of over 1300 across a state of 5 million people by January 2021. In South Korea, the first case of COVID-19 was diagnosed at end of January 2020 in a person from Wuhan, China,⁸ and the first outbreak occurred by end of February at a religious assembly at a local metropolis. During the first months of the pandemic in Seoul, new case numbers were somewhat constant at approximately 10 per day. However by mid-August 2020, a large outbreak resulted in a cumulative total (at that

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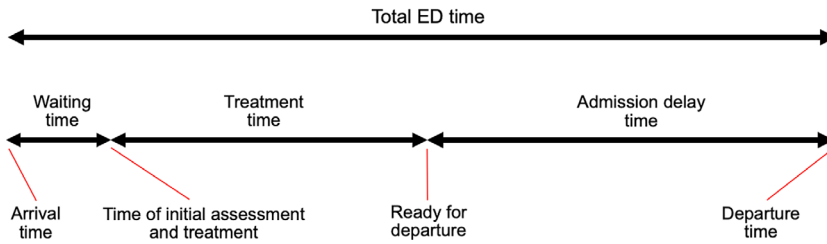


Figure 1. Definition of total ED time.

TABLE 1. Characteristics of the study hospitals

| | Royal Brisbane and Women's Hospital | Severance Hospital |
|------------------|--|---|
| Location | Brisbane, Australia (city of 2.3 million) | Seoul, Republic of Korea (city of 9.8 million) |
| Type | Tertiary/quaternary referral university hospital Level-six ED (highest level) | Tertiary referral university hospital Mid-level (out of three levels) ED |
| Size | 1000 hospital beds 44 ED beds | 2400 beds 52 ED beds |
| Annual ED census | 85 000 per year | 100 000 per year |

time) of approximately 3000 COVID-19-positive patients.⁹

While studies of the number of ED presentations during the COVID-19 pandemic have provided insight into the demand pressures faced by EDs, they have revealed little about ED performance.^{10–13} An examination of ED patient flow measures such as total ED time and its component waiting, treatment and admission delay times (Fig. 1)¹⁴ would provide a better understanding of how well an ED was functioning in a pandemic setting.

The aim of this study was to compare ED patient census and flow metrics before and during the COVID-19 pandemic. The results in two large urban EDs in different countries were contrasted for insights into the pandemic response.

Methods

An observational study was conducted using routinely collected ED

data from 1 January 2019 to 30 June 2021 at the Royal Brisbane and Women's Hospital (RBWH) in Brisbane, Australia and the Severance Hospital (SH) in Seoul, Republic of Korea. The two hospitals along with their initial responses to the pandemic are summarised in Tables 1 and 2. An exemption from ethical review was granted by the RBWH Human Research Ethics Committee, and approval granted by the Ethical Review Board at SH.

Data, extracted from information systems at both hospitals, included patient demographics, 'time of arrival to ED', 'time of initial assessment and treatment', 'time ready for departure', 'time of departure from ED' and triage category.¹⁴ Total presentation numbers along with presentations to the COVID clinic (RBWH) and isolation areas were also retrieved. The Australasian Triage Scale (ATS)¹⁵ and Korean Triage and Acuity Scale (KTAS)¹⁶ are five-level ordinal scales with '1' being assigned to the most urgent patients.

Waiting time ('initial assessment and treatment time' minus 'arrival time'), treatment time ('departure ready time' minus 'initial assessment and treatment time') and total ED time ('departure time' minus 'arrival time') were calculated (Fig. 1). Admission delay time ('departure time' minus 'departure ready time') was also calculated for admitted patients. At SH, the 'time of initial assessment and treatment' was not recorded, therefore separate waiting and treatment times could not be calculated.

The study outcomes were ED patient volume and flow. Patient volume was quantified as the number of patients per day and reported using a 7-day moving average. Trends in patient volumes were depicted using time-series plots with presentation numbers stratified by triage category and age groups. ED flow was measured using waiting, treatment, and total ED times. Trends in flow were similarly depicted using time-series plots. Descriptive statistics and time series plots were calculated and drawn using Stata 16.1 (College Station, TX, USA).

Results

The pre-pandemic annual ED census was higher at SH compared with RBWH (100 000 vs 85 000). SH also had a relatively larger proportion of category 4 triages. Trends in census stratified by triage category are shown in Figure 2. At RBWH, ATS 1 presentations remained stable over 2019–2021, whereas ATS 2–5 presentations fell sharply in March 2020, not returning to pre-pandemic levels until September 2020. Similarly at SH, KTAS 3–5 presentations declined in March 2020. The reduced presentations continued through to December 2020, punctuated by a large reduction in September.

ED census at RBWH excluded COVID clinic attendances. ED census at SH included all attendances screened for COVID without a separate testing clinic. Presentations to RBWH COVID clinic increased to an initial peak (200/day) in mid-March, with a decline towards the annual nadir by May (Fig. S1). From there, daily numbers increased with intermittent

TABLE 2. Operational approaches to the pandemic

| Royal Brisbane and Women's Hospital (RBWH) | Severence Hospital |
|---|---|
| (Changes implemented from 27 March 2020) | (Changes implemented from 24 February 2020) |
| Reconfiguration of pre-existing ED footprint with a 10-bed isolation area for suspected or confirmed COVID patients, and an attached donning and doffing area | 15 existing ED beds with partitions between each bed designated as a treatment area for potentially infected patients |
| Separate COVID testing clinic in an external marquee beside ED entrance† | Separate screening area within ED comprised of two negative pressure rooms, one consultation room, and a waiting room‡ |
| Increased staffing to cover isolation beds and COVID clinic | Increased staffing to cover COVID clinic |
| Patients transferred to inpatient wards once decision for admission had been made by the ED consultant, i.e. patients were reviewed by inpatient units on the wards and not in ED | Same as RBWH |
| Patients admitted from the ED isolation area were transferred to infectious disease isolation ward | Patients who were confirmed with COVID-19 as a result of the PCR test were transferred to infectious disease isolation ward |
| Daily update on ED operational procedures including infection control protocols via an intradepartmental online platform | Notification of infection control protocols update and real-time assignment of primary care physicians and isolation wards for individual COVID-19 confirmed patients using group chat room messenger in which people from related departments participate (Department of Emergency Medicine, Department of Infectious Diseases, Department for Diagnostic laboratory medicine, and infection control office) |
| Cancellation of ED education activities | Transition to online education |
| Cancellation of elective surgery | No intervention in elective surgery and admission schedule |
| Interhospital transfers to RBWH require strict inpatient consultant approval | The hospital transfer in and out process of ED was operated the same as before‡, but COVID-19 confirmed patients had to be assigned a transfer hospital through the public health centre |
| Telehealth for outpatient consultations | Telehealth was not implemented |

†At both EDs, patients presenting for COVID testing with mild symptoms were discharged, and unwell patients could be diverted to isolation beds within the ED. ‡The emergency physician had the authority to allow transfer to Severence Hospital, but the hospitalisation case was discussed with the relevant department before decision.

peaks in August (600), September (700), December (780) and January 2021 (800). From pandemic onset, approximately 1 in 20 patients at RBWH were initially triaged to the isolation area (Fig. S2). Over the same period, 1 in 3 patients at SH were treated through its isolation area.

In 2019, children comprised a sizable proportion of SH attendances and negligible proportion at RBWH, which had a relatively larger proportion of 55–74-year-olds. Trends in

ED census stratified by age group are shown in Figure 3. The drop in census involved all age groups during March 2020. At RBWH, the drop was disproportionately represented in the 15–34-year-olds. At SH, paediatric attendances were most affected, with >74-year-olds least affected.

Before COVID, mean total ED time was much higher at SH than RBWH (approximately 12 vs 4 h). Trends in service times are shown in Figure 4. With emergence of

COVID in March and plummeting presentations, waiting time was reduced. By August, waiting time was increasing and within 2 months had stabilised to 2019 levels. Treatment time was stable throughout 2019–2021. In contrast, total ED time was substantially shortened during March–July before lengthening to and above pre-pandemic levels. This was due to a marked reduction in admission delay time for admitted patients (Fig. 3). At

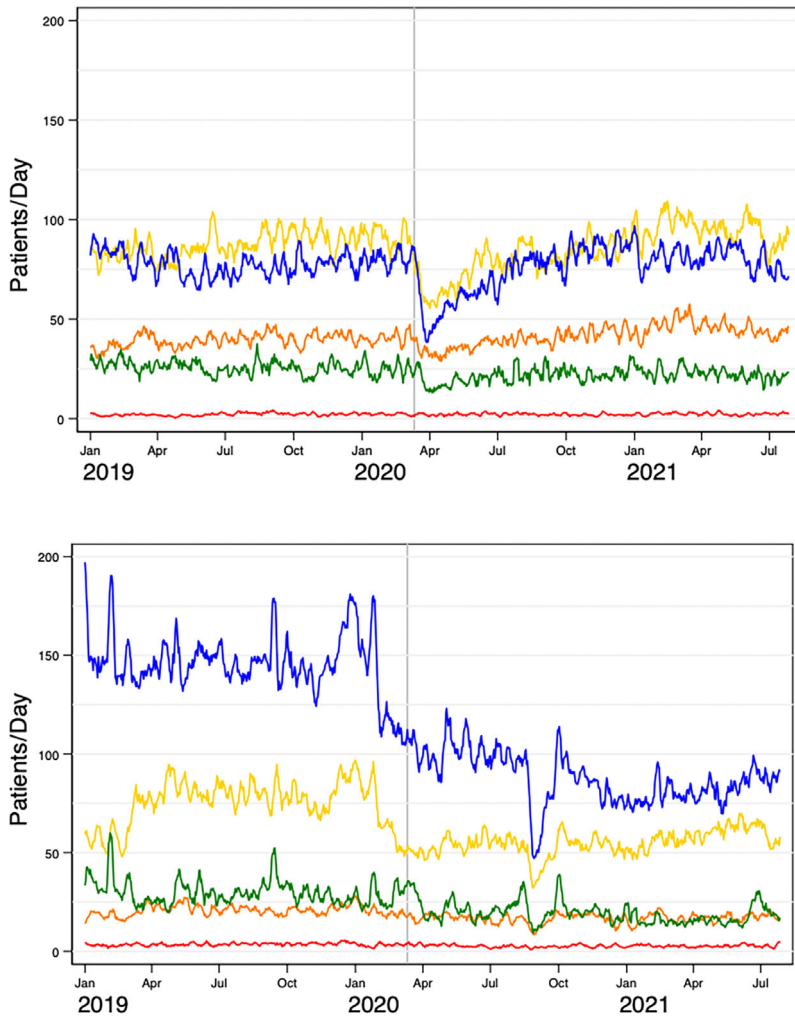


Figure 2. Daily ED census by triage category (7-day moving average). (a) Royal Brisbane and Women's Hospital, Australia. (—) ATS 1; (—) ATS 2; (—) ATS 3; (—) ATS 4; (—) ATS 5. (b) Severence Hospital, Republic of Korea. (—) KTAS 1; (—) KTAS 2; (—) KTAS 3; (—) KTAS 4; (—) KTAS 5. ATS, Australasian Triage Scale; KTAS, Korean Triage and Acuity Scale; Vertical line: 11 March 2020 (World Health Organization declared COVID-19 as a pandemic).

SH, separate waiting and treatment times were unavailable. The combined waiting and treatment times appeared stable over 2019–2021. The total ED time, like RBWH, reduced in the months following pandemic onset.

Discussion

The effect of the pandemic on ED volume was remarkably similar between RBWH and SH despite obvious differences between the two EDs. Australia and South Korea have different healthcare systems, although

both are OECD (Organisation for Economic Co-operation and Development) member countries with high-income economies. Each country had different public health approaches, and each hospital had different internal processes to respond to the pandemic.

This study has several key findings. First, the reduction in presentations only occurred in the least urgent triage categories for both health systems. Second, the reduced waiting times at RBWH and the steady waiting and treatment times at SH corresponded with a

reduction in presentations. Third, treatment time (recorded at RBWH only) remained steady compared with pre-pandemic levels. Finally, total ED times were markedly reduced immediately following pandemic onset.

Our findings should be viewed in the context of a pandemic in its early phases when COVID-zero strategies were pursued and characterised by frequent lockdowns and low COVID numbers. Ideally, these findings should also be contextualised with knowledge of the proportion of patients meeting the suspected COVID criteria¹¹ and proportion with confirmed COVID, which could impact on the timeliness of care. This information was not available from our information systems. Our systems, however, did record the number of presentations to the isolation area which could be viewed as a proxy for suspected COVID. We also visualised the trends in time-series plots without a formal time-series analysis.¹⁷ Again, ideally a comparison should be made between the observed and predicted census and flow metrics based on modelling. This is a limitation of ours and other papers of this nature. That said, we can place our findings in the context of the existing literature.

Previous studies on the impact of COVID have focused on ED volume and departmental operations. Discussions regarding flow have been extrapolative rather than measured.^{10–13} Australian and Korean EDs have been burdened by testing and isolation requirements in different ways. The Australian COVID-19 ED (COVED) project,^{11,18–20} found that 20% of ED presentations were tested for COVID.¹⁸ The overall burden of suspected COVID cases was 11.4%.

That both EDs in our study experienced fewer presentations during the pandemic is consistent with current literature. There was a 37.3% reduction in presentations affecting all triage categories in two Melbourne EDs.¹⁰ South Korean EDs demonstrated reductions of 46.4–58.1% and 76.9% in paediatric and adult presentations, respectively.^{13,21}

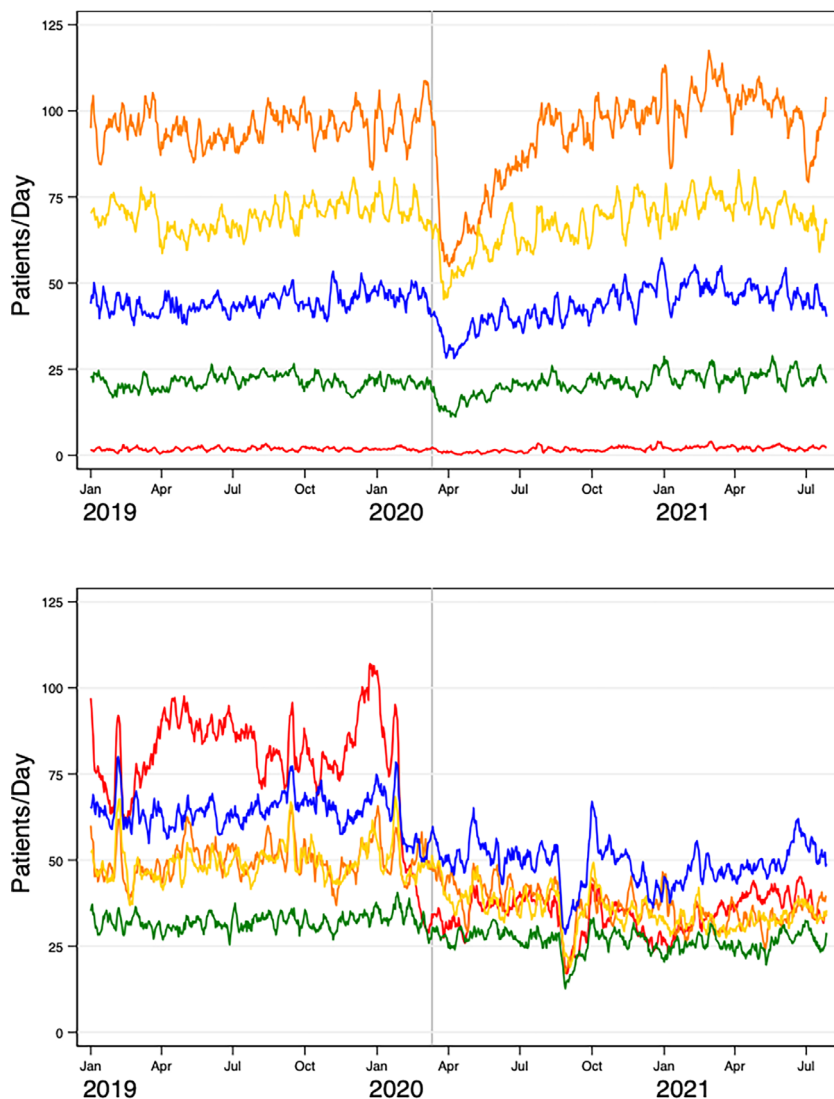


Figure 3. Daily ED census by age group (7-day moving average). (a) Royal Brisbane and Women's Hospital, Australia. (b) Severence Hospital, Republic of Korea. Vertical line: 11 March 2020 (World Health Organization declared COVID-19 as a pandemic). (—) 0–15 years; (—) 15–35 years; (—) 35–55 years; (—) 55–75 years; (—) >75 years.

Of note, reductions in presentations have occurred regardless of the incidence of positive COVID cases (Fig. S5). In the COVED study, positive cases were 2% (14/702) of those tested.¹⁹ An Australian tertiary children's hospital found positive cases in 0.9% (4/433) over 30 days in March–April 2020.²² Even in such low prevalence settings, resources may be strained because EDs must manage unfiltered patients rather than solely confirmed cases.²³ A

South Korean study measured an increase in ED lengths of stay during the pandemic despite a reduction in daily census, coinciding with process changes to viral testing, X-rays, and triage.¹³

Census

The decline in 2020 ATS 3–5 presentations occurred when the Australian federal government declared a Human Biosecurity Emergency (18 March, see

timeline, Fig. S4). It also coincided with the national travel ban on non-citizen international arrivals (20 March) and Queensland's introduction of \$13 000 fines for suspected cases failing to isolate. Presentation numbers drifted back towards just shy of baseline around the time of Queensland's further easing of social restrictions (3 July).

Two spikes in RBWH COVID clinic presentations were evident around the turn of the year (Fig. S1). The first, on 22 December 2020, coincided with Queensland declaring Greater Sydney a hotspot, and directing all travellers returning from the area to be tested. On 2 January 2021, visitors from Victoria were mandated to be tested following an outbreak in Melbourne. Presentations numbers to the rest of the ED were unaffected. The Queensland government imposed a 3-day lockdown from 8 January 2021 which had little impact on testing numbers.

The number of daily ATS/KTAS 1–2 presentations were comparable during 2019 to 2020 (Fig. 2). Furthermore, in 2020, ATS/KTAS 1–2 presentations did not fluctuate in association with the pandemic timeline in the same way that categories 3–5 did. This would suggest that numbers of critical illness cases were unaffected by social restrictions in Queensland and Seoul – a hypothesis supported by reduced presentations in the younger, but not older and typically more co-morbid age groups. In Brisbane, there were a limited number of critically ill patients diagnosed with COVID-19. (The peak number of intensive care unit patients across the health service at any one time totalled 5).²⁴

In Korea, foreign visitors were not blocked from entry, and self-isolation began on 1 April 2020 for 2 weeks from the date of entry. Although regional infections continued in Korea, the Korean government did not close national borders or enforce strong lockdown policies. The recommendation to wear a mask became mandatory from 24 August 2020, but

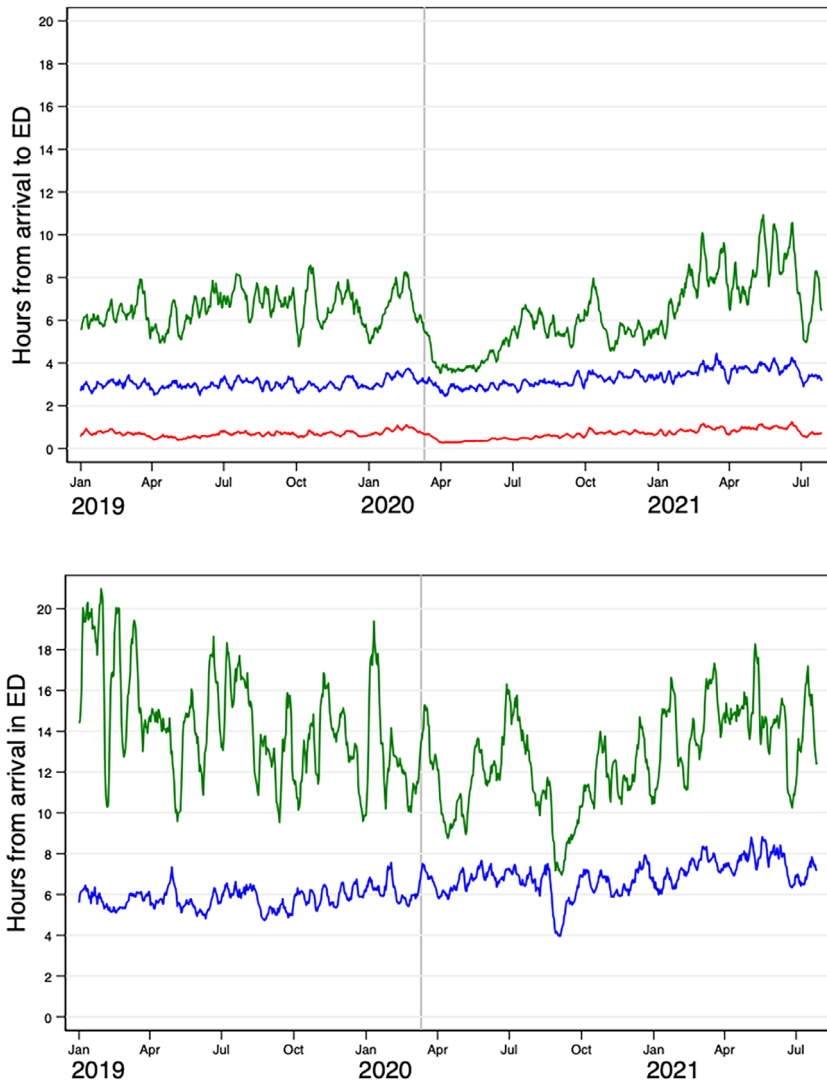


Figure 4. Daily mean service times for admitted patients (7-day moving average). (a) Royal Brisbane and Women's Hospital, Australia. (—) Initial assess and treat; (—) ready for departure; (—) departure from ED. (b) Severence Hospital, Republic of Korea. (—) Ready for departure; (—) departure from ED. Vertical line: 11 March 2020 (World Health Organization declared COVID-19 as a pandemic).

no fine was imposed. The decrease in the number of visiting patients may have been influenced by the fear of getting COVID in the ED and social mood that mildly unwell patients should refrain from visiting EDs in large hospitals to provide capacity to treat infected patients. The sustained decline in paediatric patients may be because of the reduced incidence of respiratory tract infection and other communicable disease. The reduction in KTAS 1–3 patients in September 2020 is explained by a workforce

strike action by trainee doctors in training hospitals.

Service times

That such rapidly changing external pressures together with a large and well-resourced whole-of-hospital intervention had no effect on RBWH ED treatment times suggests that the usual model of ED patient flow that was in place at RBWH²⁵ is robust. Any increase in treatment times for patients who entered isolation²⁶ are

unlikely to have affected the mean treatment times for the department because of their low numbers. Of note, however, ATS 1–2 patients admitted from ED isolation had significant delays transferring to the ward (Figs S6,S7), likely because of the additional care and bed management procedures required for isolated patients.²⁶ The reduction in mean waiting (RBWH) and admission delay (RBWH, SH) times occurring in March 2020 may be attributed to multiple factors. A drop in the absolute numbers of presentations could be expected to have reduced overcrowding, improving efficiency. Changes in health policy and local infrastructure may have also contributed.

At SH, the pandemic onset and associated system-wide response had no appreciable effect on the combined treatment and waiting times. As neither of these was measured directly, interpretation is limited. However, the following observations could be attributed to differences in the patient flow model at SH as compared with RBWH. First, at the time of reduced daily presentations (Fig. 5) there was a corresponding reduction in admission delay time but not waiting/treatment time. This is consistent with a whole-of-hospital pandemic response but limited capacity of the ED itself. Second, despite presentation numbers (SH) remaining reduced throughout most of 2021, waiting/treatment time continued to gradually rise for admitted patients (Figs 4b and 5).

There are several additional limitations to this analysis. There were no data collected about departmental and hospital-wide staffing levels (medical, nursing, allied health, patient support officers, security and administration) at either hospital. We did not collect any data about supplies of medications, mechanical ventilators, personal protective equipment (PPE), or other devices and consumables, so cannot draw any inferences about potential contribution of supply shortages to patient flow. However, any impact of medical supply shortages on ED patient flow in Australia is likely to be small given

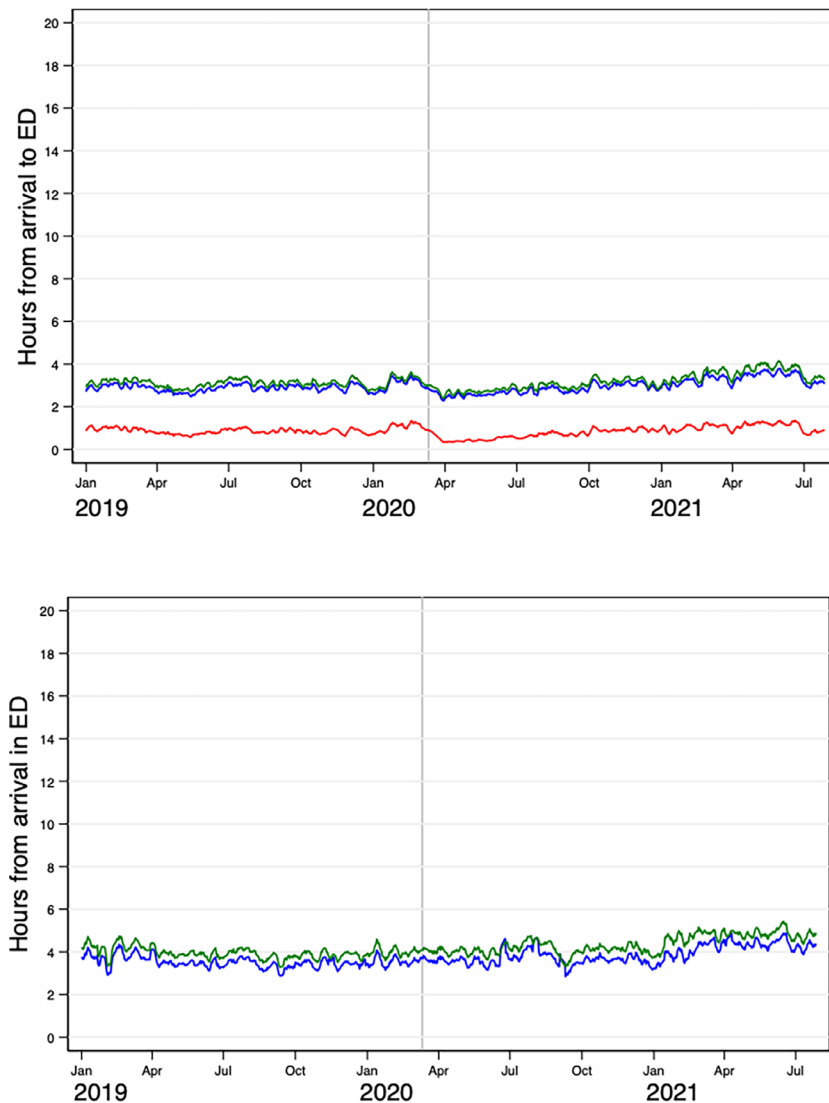


Figure 5. Daily mean services times for discharged patients (7-day moving average). (a) Royal Brisbane and Women's Hospital, Australia. (—) Initial assess and treat; (—) ready for departure; (—) departure from ED. (b) Severence Hospital, Republic of Korea. (—) Ready for departure; (—) departure from ED. Vertical line: 11 March 2020 (World Health Organization declared COVID-19 as a pandemic).

the relatively small number of ED patients with COVID-19. Given the multiple number of shifting variables (positive COVID-19 cases, social lockdown measures, government-imposed fines, travel restrictions, health district capacity changes) it is difficult to definitively conclude that any one measure or factor was instrumental.

Conclusion

The COVID-19 pandemic was associated with an initial

reduction in total daily ED presentations that coincided with increased COVID-19 case numbers as well as social restrictions implemented by government. These reduced presentation numbers were only for triage categories of lower urgency. This pattern of presentations occurred in both the Australian and Korean hospitals. The reductions in ED waiting and delay to admission times corresponded to improvements in hospital capacity, whereas treatment times were unchanged. This suggests the

flow model in place at RBWH is adaptable.

Competing interests

KC is a section editor for *Emergency Medicine Australasia* and was excluded from the peer-review process and all editorial decisions related to the acceptance and publication of this article. Peer-review was handled independently by members of the Editorial Board to minimise bias.

Data availability statement

The data that support the findings of this study are available from the corresponding author upon reasonable request.

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Supporting information

Additional supporting information may be found in the online version of this article at the publisher's web site:

Figure S1. Daily presentations to COVID clinic (RBWH, Australia).

Figure S2. Daily presentations to isolation areas (RBWH and SH).

Figure S3. Service times for ATS 1–2 patients (RBWH, Australia). (a) Admitted, (b) discharged.

Figure S4. Timeline of COVID-19 pandemic responses.

Figure S5. Daily totals of new COVID-19 cases. (a) Regional, (b) national.

Figure S6. Service times for ATS 1–2 admitted patients. (a) Isolation area, (b) non-isolation area.

Figure S7. Service times for ATS 1–2 discharged patients. (a) Isolation area, (b) non-isolation area.