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ORIGINAL ARTICLE

Effects of COVID-19 pandemic restrictions on an Australian neonatal and paediatric retrieval service

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Aim: The COVID-19 pandemic and associated travel and social distancing restrictions have reduced paediatric intensive care unit admissions for respiratory illnesses. The effects on retrieval (transport) services remain unquantified. Our study examined the utility of statistical process control in assessing the impact of the COVID-19 pandemic on the number of neonatal and paediatric transfers in an Australian retrieval service.

Methods: Data collected prospectively from the SA Ambulance Service MedSTAR Emergency Retrieval database in South Australia were analysed from January 2015 to June 2021. Statistical process control methodology, a combination of a time series analysis and assessment for common and special cause variation, was used to assess the impact of the COVID-19 pandemic on retrieval workload (primary outcome of interest).

Results: A total of 5659 neonatal and paediatric transfers occurred during the study period and were included. A significant decrease in paediatric transfers occurred after the initial lockdown measures in March 2020 were announced in South Australia (special cause variation). However, a similar reduction was not observed for neonatal transfers (common cause variation).

Conclusion: Our study demonstrates that statistical process control may be effectively used to understand the effects of external events and processes on usual activity patterns in the retrieval setting. We found a reduction in retrieval numbers for paediatric transfers but no effect on neonatal transfer numbers. The decline in paediatric transfers was primarily attributed to reduced respiratory cases.

Key words: COVID-19; emergency medicine; infant; newborn; paediatrics.

What is already known on this topic

1 The COVID-19 pandemic and its resultant restrictions have reduced paediatric intensive care unit admissions for respiratory illnesses.
2 The effects on neonatal and paediatric retrieval services remain unquantified.

What this paper adds

1 Our study found a reduction in retrieval numbers for paediatric transfers but no effect on neonatal transfers.
2 The decline in paediatric transfers was primarily attributed to reduced respiratory cases, although overall paediatric transfers also declined.

Reports world-wide across 2020 found that the number of paediatric intensive care unit (PICU) admissions with respiratory syncytial virus and influenza did not undergo the usual winter increase. In South America, there were 83% fewer PICU admissions for lower respiratory tract infections compared to the 2018–2019 average over the same period.[1] Centres in the USA, Italy, Scotland and Australia had similar findings.[2–5] While it would seem logical that a similar effect would occur in retrieval services, this has not yet been examined to our knowledge.

Statistical process control (SPC) is a statistical methodology based on the theory of variation that makes sense of any process or outcome measured over time. It combines a time series analysis with a graphical presentation of data to provide early insights into data for varied audiences.[6] The two key concepts in SPC are common and special cause variation. Common cause variation implies that the observed variation reflects random fluctuations, signifying that the process is in control and is 'business as usual'. When the process is not in control, there is more variation than expected by chance alone. This variation is due to external processes or events and is termed special cause variation.[7]

The objective of our study was to evaluate the utility of SPC methodology in understanding the impact of the COVID-19 pandemic across our neonatal and paediatric retrieval workload.

Methods

We utilised a time series analysis using prospectively collected data across January 2015 to June 2021. The study was undertaken at

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Conflict of interest: None declared.

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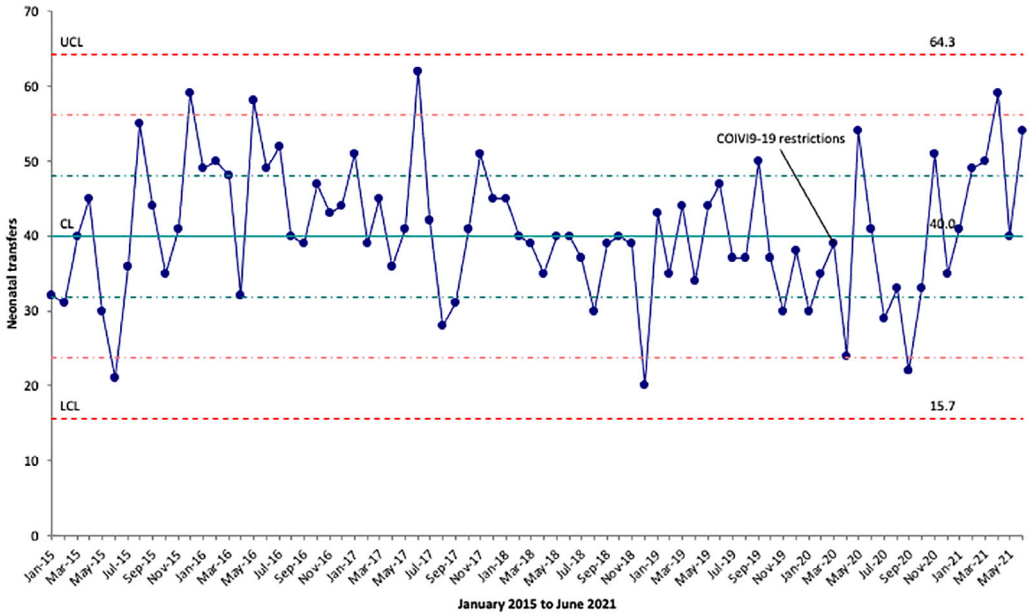

Fig. 1 Monthly neonatal transfers (X chart) from January 2015 to June 2021. Explanation: No special cause variation seen. CL, centreline (average); U/LCL, upper and lower control limits. (—●—), Neonatal transfers; (- - - - -), UCL; (· · · · · ·), +2 sigma; (- - - - -), +1 sigma; (——), average; (- - - - -), −1 sigma; (· · · · · ·), −2 sigma; (- - - - -), LCL.

SA Ambulance Service MedSTAR Emergency Medical Retrieval, which provides critical care transport throughout South Australia, parts of the Northern Territory and New South Wales. All neonatal and paediatric patients transferred during the study period were included. De-identified data on numbers of neonatal (<28 days old) and paediatric (4 weeks to <18 years old) transfers were sourced from the MedSTAR Air Maestro (V3.2.20314.1 © 2020 Avinet Pty. Ltd) database.

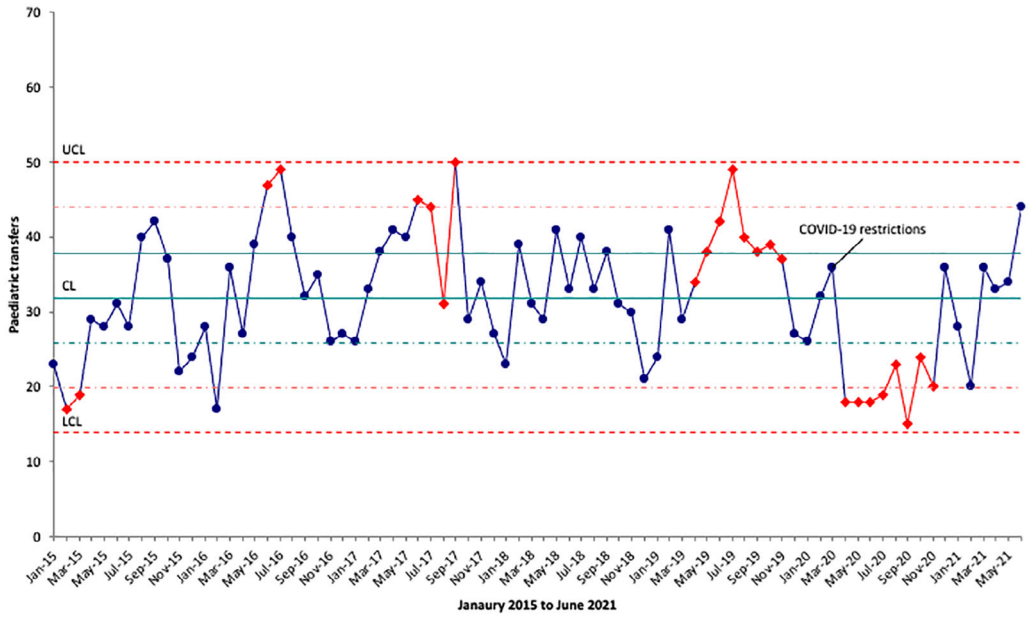

Fig. 2 Monthly paediatric transfers (X chart) from January 2015 to June 2021. Explanation: Special cause variation (red dots) observed across multiple periods correlating with late autumn–winter–early spring respiratory illness peak (seasonal variation). CL, centreline (average); U/LCL, upper and lower control limits. (—●—), Paediatric transfers; (- - - - -), UCL; (· · · · · ·), +2 sigma; (——), +1 sigma; (——), average; (- - - - -), −1 sigma; (· · · · · ·), −2 sigma; (- - - - -), LCL.

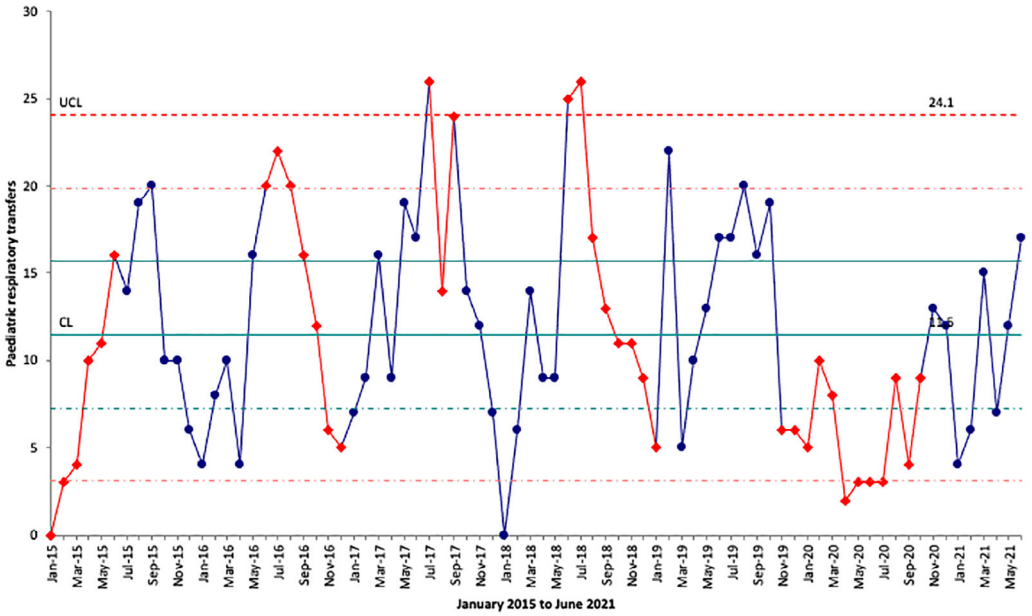

Fig. 3 Monthly paediatric respiratory transfers (X chart) from January 2015 to June 2021. Explanation: Special cause variation (red dots) observed across multiple periods correlating with late autumn-winter-early spring respiratory illness peak (seasonal variation). CL, centreline (average); U/LCL, upper and lower control limits. (—●—), Respiratory transfers; (- - - -), UCL; (- - - -), +2 sigma; (——), +1 sigma; (——), median; (- - - -), −1 sigma; (- - - -), −2 sigma; (- - - -), LCL.

SPC methodology was the primary analysis used. Analysis was undertaken using the QI Macros package in Microsoft Excel Version 16.49 (KnowWare International Inc., Denver, CO, USA). Centreline (mean) and control limits were calculated using SPC methods to conform to the primary assumptions of the relevant control chart. Special cause was defined as a single point outside the control limits; eight or more consecutive points above or below the centre line; six consecutive points increasing or

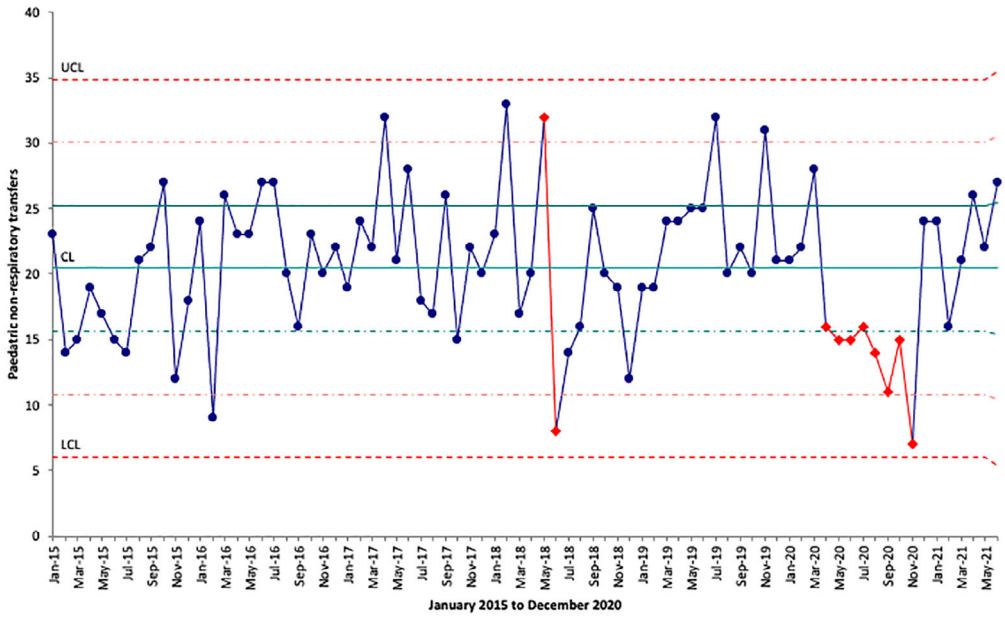

Fig. 4 Monthly paediatric non-respiratory transfers (X chart) from January 2015 to June 2021. Explanation: Special cause variation (red dots) observed from March to November 2020. CL, centreline (average); U/LCL, upper and lower control limits. (—●—), Non-respiratory transfers; (- - - -), UCL; (- - - -), +2 sigma; (——), +1 sigma; (——), average; (- - - -), −1 sigma; (- - - -), −2 sigma; (- - - -), LCL.

decreasing; two out of three consecutive points near a control limit (outer 1/3); and/or 15 consecutive points around the centreline (inner 1/3).[8] Special cause variation was deemed present if any of these rules were met. The probability of any one of the rules occurring is <0.05.

A one-way analysis of variance (ANOVA) test was used to determine whether the mean monthly numbers of paediatric transfers varied significantly within respiratory and non-respiratory transfer groups. We defined seasonal variation as a visually recognisable pattern of similar periodic processes seen in each year combined with the ANOVA test showing significant month to month variation.

Results

From January 2015 to June 2021, SA Ambulance Service MedSTAR Emergency Retrieval transferred 3171 neonatal and 2488 paediatric patients. An average of 40 neonatal transfers occurred each month (range: 20–62) (Fig. 1). No special cause variation was seen for neonatal transfer numbers, with a stable baseline observed (common cause variation). A monthly average of 32 paediatric transfers (range: 5–50) was found (Fig. 2).

We observed seasonal variation in monthly numbers of paediatric transfers across 2015–2019 (Fig. 2). Disaggregation into respiratory (Fig. 3) and non-respiratory transfers (Fig. 4) revealed this variation to be due to the respiratory transfers. The presence of seasonal variation was further supported by the one-way ANOVA test finding the mean number of paediatric respiratory transfers was significantly different for at least 1 month (F-value = 9.79, $P < 0.001$). No differences were found for the mean numbers of non-respiratory transfers (F-value = 0.37, $P = 0.963$).

Declines in the numbers of monthly paediatric and respiratory transfers were observed (Fig. 3) across the COVID-19 lockdown period in South Australia (March to November 2020). Special cause variation was observed across this period indicating a change in the numbers of anticipated respiratory transfers. Figure 5 shows the difference from average monthly paediatric respiratory transfers consistent with a process change due to external factors.

Ethical approval was provided by the Women's and Children's Hospital Human Research Ethics Committee (Audit 1185A/08/2023).

Discussion

The COVID-19 restrictions in South Australia impacted our paediatric transfer workload, with no effect on neonatal transfer numbers. Our analysis supports the hypothesis that the COVID-19 pandemic influenced only paediatric transfer numbers, primarily in a decrease in paediatric respiratory transfers, consistent with the available literature.[1–5]

On 15 March 2020, a public health emergency was declared in South Australia concerning COVID-19. Compared with international rates, Australia has maintained low population and case-fatality rates.[9] The public health measures placed early in the pandemic to control the spread of COVID-19 included a national lockdown and physical distancing (Appendix S1, Supporting Information). These measures positively impacted the rates of respiratory syncytial virus and influenza circulating in the community. As a result, the anticipated "winter peak" of paediatric respiratory patients did not occur in 2020 (Figs 3,5). However, as restrictions eased across South Australia in 2020 and into 2021, it is anticipated that paediatric respiratory cases will increase again. It is worth noting that overall numbers of paediatric retrievals decreased, and this may have been related to less movement, including less socialising

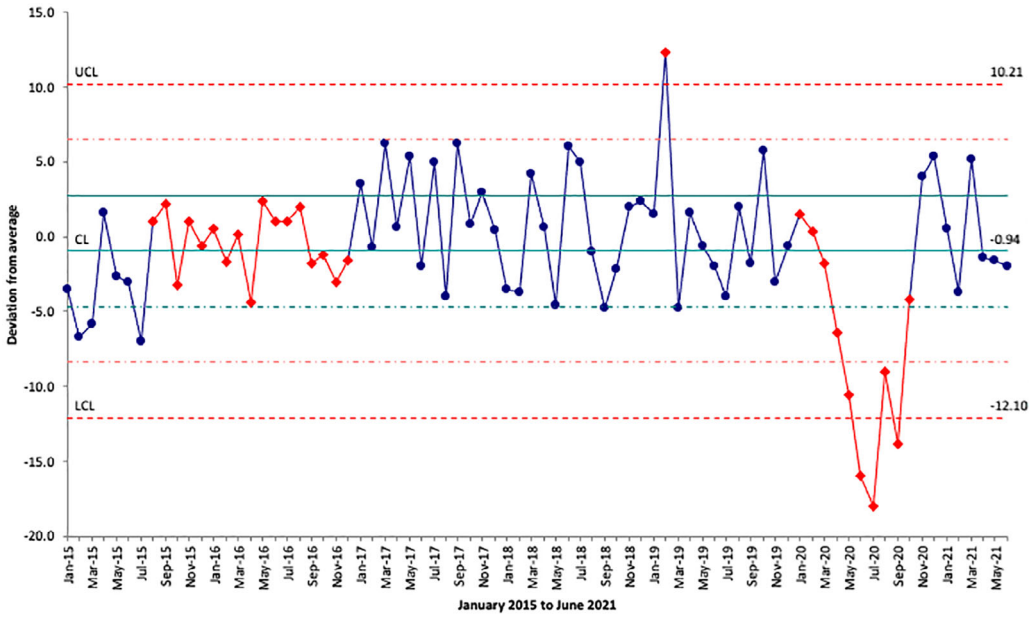

Fig. 5 Differences in average monthly paediatric respiratory transfers. Explanation: Special cause variation (red dots) observed across two time periods, one consistent with significant decreases in deviation from the average numbers of monthly respiratory transfers across 2020. CL, centreline (average); U/LCL, upper and lower control limits. (—●—), Deviation from average; (-----), UCL; (-----), +2 sigma; (——), +1 sigma; (——), average; (-----), −1 sigma; (-----), −2 sigma; (-----), LCL.

and outdoor activities, further reducing trauma and other types of non-infective cases. The numbers of neonatal transfers remained steady, despite the lockdown, suggesting no association between neonatal transfers and the lockdown measures. As more data becomes available nationally over time, it will be interesting to understand the potential impact of pandemic restrictions, birth rates and possible effects on prematurity rates.

Conclusion

Rather than performing potentially complicated pre–post analyses with their inherent limitations, the use of SPC methodology allowed us to assess the impact of COVID-19 restrictions on our service in a simple time-series graphical form.[10] Although used in some healthcare settings, primarily in the USA and more commonly in anaesthesia,[11] its use is limited beyond these settings. It may have benefits that are not yet fully realised.

Statistical process control is a practical methodology to understand the effects of external events on a retrieval service. It has broader implications for use in retrieval settings beyond evaluating the impact of COVID-19.

Acknowledgements

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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:

Appendix S1. Summary of COVID-19 related public health measures in Australia.