LETTER TO THE EDITOR

Impact of lockdowns on paediatric asthma hospital presentations over three waves of COVID-19 pandemic

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Abstract

Public health measures to mitigate the COVID-19 pandemic have altered health care for chronic conditions. The impact of the COVID-19 pandemic on paediatric asthma, the most common chronic respiratory cause of childhood hospitalisation, in Australia, remains unknown. In a multicentre study, we examined the impact of three waves of COVID-19 on paediatric asthma in New South Wales Australia. Time series analysis was performed to determine trends in asthma hospital presentations in children aged 2–17 years before (2015–2019) and during the COVID-19 pandemic (2020–2021) using emergency department and hospital admission datasets from two large tertiary paediatric hospitals.

In this first report from Australia, we observed a significant decrease in asthma hospital presentations during lockdown periods including April (68.85%), May (69.46%), December (49.00%) of 2020 and August (66.59%) of 2021 compared to pre-pandemic predictions.

The decrease in asthma hospital presentations coincided with the lockdown periods during first, second and third waves of the COVID-19 pandemic and was potentially due to reduced transmission of other common respiratory viruses from restricted movement.

Keywords: COVID-19, Lockdowns, Paediatric asthma

Background

Asthma is one of the most common chronic respiratory conditions of childhood affecting almost 14% of children worldwide [1]. Children with asthma are at risk of frequent hospital presentations due to acute asthma attacks often caused by viral respiratory infections and exposures to increased levels of pollen and air pollution [2–4]. Some reports have indicated a decrease in paediatric asthma hospital presentation associated with the initial wave of the COVID-19 pandemic [5]. Several factors have been linked to this observed decrease including a decrease in transmission of respiratory infection due to school closures and less exposure to outdoor air pollution from staying at home [6]. However these reports have been based on single centre and captured the initial wave of the pandemic.

In New South Wales (NSW) Australia, which is the most densely populated state of the country, as of September 2021, we have experienced three waves of the COVID-19 pandemic. The first wave of the COVID-19 pandemic in New South Wales (NSW) Australia was during February–March 2020 which prompted a state-wide lockdown from March 2020...
including border and school closures and stay at home orders. Schools returned to face-to-face learning from mid-May in NSW but restrictions on social gatherings were still in place. There was a resurgence of COVID-19 cases during October and December of 2020 which again resulted in restricted movement within greater NSW and introduction of mask mandates in indoor settings and on public transportation. The third wave of the COVID-19 pandemic in NSW due to the emergence of the Delta variant of SARS-CoV-2 resulted in wider lockdowns in greater Sydney on 26th June 2020, with mandatory mask use in indoor settings and on public transport and with schools going back to remote learning. Additionally, in an effort to contain the highly transmissible Delta strain, some areas in Sydney with increasing number of cases went under curfew effective between 9 pm and 5am from 23rd August 2021. Mandatory mask use while in outdoor settings was also put in place in NSW from the same date. As of September 30, 2021, greater Sydney remained in lockdowns, with easing of curfew and stay-at-home order to be lifted from 11 October and schools resuming face-to-face learning from end of October 2021.

The COVID-19 lockdowns led to generalised decrease in healthcare resource utilisation for common chronic conditions. The impact of COVID-19 lockdowns on paediatric asthma in Australia remains unclear. We aimed to examine the impact of lockdowns associated with three waves of the COVID-19 pandemic on paediatric asthma hospital presentations in NSW, Australia.

### Methods

In this multicentre study, we analysed data from the Sydney Children's Hospitals Network (SCHN) in NSW, the largest provider of tertiary paediatric services in Australia, comprising two large hospitals including the Sydney Children's Hospital at Randwick and the Children's Hospital at Westmead. We included the SCHN’s electronic medical records from 1st January 2015 to 31st August 2021. Data were extracted from two routinely collected datasets including hospital admission and emergency department (ED) attendance data for hospital presentations associated with asthma (predominantly allergic asthma J45.0, non-allergic asthma J45.1, mixed asthma J45.8, asthma unspecified J45.9 and status asthmaticus J46) in children aged 2–17 years, using International Classification of Diseases 10th revision Australian Modification for hospital admissions and Systemised Nomenclature of Medicine Clinical Terms for ED attendances. We included children aged ≥ 2 years of age as asthma diagnosis is challenging in younger children.

We compared asthma hospital presentations (inpatient admissions and ED attendances) in the pandemic period (1st January 2020–31st August 2021) with the pre-pandemic period (1st January 2015–31st December 2019) and plotted counts of asthma hospital presentation by months and performed time series analysis to predict frequencies and their 95% confidence intervals (CIs) in 2020–2021 based on pre-pandemic years, using autocorrelation error and autoregressive integrated moving average (ARIMA) models. We estimated the percentage difference between the observed and the

### Table 1

| Year of presentation | 2015 | 2016 | 2017 | 2018 | 2019 | 2015–2019 | 2020 | 2021 (up to 31st August) |
|----------------------|------|------|------|------|------|-----------|------|-------------------------|
| Any diagnosis        |      |      |      |      |      |           |      |                         |
| 2–17 years (Total)   | 96,431 | 100 | 97,961 | 100 | 98,091 | 100 | 95,439 | 100 | 104,940 | 100 | 492,863 | 100 | 93,818 | 100 | 69,703 | 100 |
| 2–5 years           | 40,860 | 42.37 | 41,431 | 42.29 | 40,230 | 41.01 | 38,909 | 40.76 | 43,269 | 41.23 | 204,700 | 41.53 | 36,490 | 38.89 | 28,675 | 41.3 |
| 6–12 years          | 39,202 | 40.65 | 39,737 | 40.56 | 40,325 | 41.10 | 38,903 | 40.76 | 42,596 | 40.59 | 200,763 | 40.73 | 37,469 | 39.94 | 26,785 | 38.42 |
| 13–17 years         | 16,369 | 16.97 | 16,793 | 17.14 | 17,536 | 17.87 | 17,627 | 18.46 | 19,075 | 18.17 | 19,859 | 17.73 | 19,859 | 21.17 | 14,243 | 20.04 |
| Asthma hospital presentations |      |      |      |      |      |           |      |                         |
| 2–17 years (Total)   | 3078 | 3.19 | 2665 | 2.72 | 2540 | 2.58 | 2295 | 2.40 | 2582 | 2.46 | 13,160 | 2.67 | 1912 | 2.03 | 1452 | 2.08 |
| 2–5 years           | 1640 | 53.28 | 1262 | 47.35 | 967 | 38.07 | 878 | 38.25 | 848 | 32.84 | 5595 | 42.51 | 601 | 31.43 | 440 | 30.30 |
| 6–12 years          | 1238 | 40.22 | 1158 | 43.45 | 1234 | 48.58 | 1062 | 46.27 | 1262 | 48.87 | 5954 | 45.24 | 977 | 51.09 | 737 | 50.75 |
| 13–17 years         | 200 | 6.49 | 245 | 9.19 | 339 | 13.34 | 355 | 15.46 | 472 | 18.28 | 1611 | 12.24 | 334 | 17.46 | 275 | 18.93 |
| Month      | Number of inpatient admissions and ED attendances | Year 2020 | Year 2021 (up to 31st August) |
|------------|--------------------------------------------------|-----------|-------------------------------|
|            | Observed number (95% CI) | Predicted number | Percentage difference from predicted number (%) (95% CI) | Observed number (95% CI) | Predicted number | Percentage difference from predicted number (%) (95% CI) |
| All children aged 2–17 years | | | | |
| All year | 1912 | 2223.4 (1230.58, 3216.22) | −14.01 (−40.55, 55.37) | 1452 | 2087.2 (940.79, 3233.61) | −30.43 (−55.1, 126.8) |
| JAN       | 124  | 139.88 (53.63, 226.14)   | −11.35 (−45.17, 131.23) | 73  | 143.27 (32.14, 254.41)   | −49.05 (−127.14, 152.14) |
| FEB       | 227  | 267.78 (181.48, 354.07)  | −15.23 (−35.89, 25.08)  | 234 | 240.59 (129.35, 351.83)  | −2.74 (−33.49, 80.91) |
| MAR       | 244  | 245.44 (159.11, 331.78)  | −0.59 (−26.46, 53.35)   | 254 | 223.34 (111.99, 334.68)  | 13.73 (−24.11, 126.8) |
| APR       | 60   | 192.61 (106.23, 278.98)  | −68.85 (−78.49, 43.52)  | 186 | 182.83 (71.38, 294.28)   | 1.73 (−36.79, 160.59) |
| MAY       | 76   | 248.82 (162.41, 335.24)  | −69.46 (−77.33, 53.2)   | 337 | 225.48 (113.92, 337.04)  | 49.46 (−0.01, 195.82) |
| JUN       | 211  | 199.03 (112.58, 285.49)  | 6.01 (−26.09, 87.43)    | 216 | 187.29 (75.63, 298.96)   | 15.33 (−27.75, 185.61) |
| JUL       | 165  | 137.81 (51.31, 224.31)   | 19.73 (−26.44, 211.56)  | 79  | 140.39 (28.61, 252.16)   | −43.73 (−68.67, 176.12) |
| AUG       | 198  | 240.54 (154, 327.08)     | −17.69 (−39.46, 28.57)  | 73  | 218.51 (106.62, 330.4)   | −66.59 (−77.91, 31.53) *** |
| SEP       | 163  | 189.23 (102.65, 275.81)  | −13.86 (−40.9, 58.8)    |       |      |                           |
| OCT       | 134  | 153.17 (66.54, 239.8)    | −12.52 (−44.12, 101.37) |       |      |                           |
| NOV       | 208  | 210.91 (124.24, 297.58)  | −1.38 (−30.1, 67.42)    |       |      |                           |
| DEC       | 102  | 200.01 (113.3, 286.73)   | −49 (−64.43, 9.97)      |       |      |                           |
| Children aged 2–5 years | | | | |
| All year | 601  | 528.6 (−119.32, 1176.52) | −               | 440 | 331.8 (−416.35, 1079.95) | −               |
| JAN       | 41   | 38.39 (−11.82, 88.59)    | −               | 16  | 26.5 (−36.29, 89.29)     | −               |
| FEB       | 68   | 82.93 (32.7, 133.17)     | −18.01 (−48.94, 107.96) | 83  | 56.89 (−5.98, 119.76)    | −               |
| MAR       | 90   | 68.66 (18.39, 118.92)    | 31.09 (−24.32, 389.37) | 88  | 46.57 (−16.37, 109.52)   | −               |
| APR       | 9    | 55.07 (4.77, 105.37)     | −83.66 (−91.46, 88.85) | 65  | 36.74 (−26.29, 99.76)    | −               |
| MAY       | 8    | 57.4 (7.07, 107.73)      | −86.05 (−92.57, 13.08) | 101 | 37.91 (−25.19, 101.02)   | −               |
| JUN       | 70   | 40.36 (−10, 90.72)       | −               | 61  | 25.68 (−37.51, 88.87)    | −               |
| JUL       | 51   | 27.46 (−22.93, 77.86)    | −               | 12  | 16.32 (−46.95, 79.59)    | −               |
| AUG       | 59   | 72.7 (22.28, 123.13)     | −18.85 (−52.08, 164.83) | 14  | 47.19 (−16.16, 110.55)   | −               |
| SEP       | 49   | 46.66 (−3.8, 97.12)      | −               |       |      |                           |
| OCT       | 62   | 33.77 (−16.73, 84.26)    | −               |       |      |                           |
| NOV       | 67   | 44.4 (−6.12, 94.93)      | −               |       |      |                           |
| DEC       | 27   | 52.27 (1.71, 102.84)     | −48.35 (−73.74, 147.79) |       |      |                           |
Table 2 (continued)

| Month | Number of inpatient admissions and ED attendances |  |
|-------|-------------------------------------------------|---|
|       | Number of inpatient admissions | Predicted number (95%CI) | Percentage difference from predicted number (%) (95% CI) | Number of inpatient admissions | Predicted number (95%CI) | Percentage difference from predicted number (%) (95% CI) |
|       | Observed number | Predicted number | Observed number | Predicted number | Observed number | Predicted number |
|-------|----------------|----------------|----------------|----------------|----------------|----------------|
|       | 977 | 1176.4 (742.15, 1610.65) | −16.95 (−39.34, 31.64) | 737 | 1171.6 (670.17, 1673.03) | −37.09 (−55.95, 9.97) |
|       | JAN | 50 | 68.3 (17.98, 118.62) | −26.79 (−57.85, 178.11) | 39 | 79.32 (16.95, 141.68) | −50.83 (−72.47, 130.06) |
|       | FEB | 123 | 133 (82.64, 183.35) | −7.52 (−32.91, 48.83) | 113 | 122.92 (60.48, 185.36) | −8.07 (−39.04, 86.85) |
|       | MAR | 114 | 124.24 (73.86, 174.62) | −8.24 (−34.71, 54.35) | 131 | 117.02 (54.5, 179.54) | 11.95 (−27.04, 140.37) |
|       | APR | 30 | 96.61 (46.2, 147.02) | −68.95 (−79.6, −35.06) | 87 | 98.41 (35.81, 161.01) | −11.59 (−45.97, 142.98) |
|       | MAY | 50 | 128.29 (77.84, 178.73) | −61.02 (−72.03, −35.77) | 178 | 119.76 (57.07, 182.44) | 48.64 (−2.43, 211.87) |
|       | JUN | 110 | 334 | 518.4 (401.75, 635.05) | −35.57 (−47.41, −16.86) | 275 | 583.8 (449.11, 718.49) | −52.89 (−61.73, −38.77) |
|       | JUL | 79 | 112.12 (61.64, 162.59) | −1.89 (−32.35, 78.46) | 116 | 108.66 (46.1, 171.62) | 5.56 (−32.41, 151.63) |
|       | AUG | 110 | 77.08 (26.57, 127.59) | 2.49 (−38.08, 197.35) | 39 | 85.25 (22.41, 148.1) | 15.95 (−27.04, 140.37) |
|       | SEP | 33 | 113.47 (62.93, 164.01) | −3.06 (−32.93, 74.8) | 34 | 109.78 (46.85, 172.71) | −69.03 (−80.31, −27.43) |
|       | OCT | 36 | 39.61 (27.34, 51.88) | −16.68 (−45.05, 70.58) | 18 | 45.92 (32.27, 61.57) | −60.8 (−69.78, −44.22) |
|       | NOV | 40 | 42.63 (30.35, 54.92) | −15.56 (−34.45, 18.62) | 38 | 47.38 (33.65, 61.12) | −28.25 (−44.37, 1.04) |
|       | DEC | 40 | 44.48 (32.18, 56.78) | −10.08 (−29.55, 24.29) | 35 | 48.39 (34.68, 62.09) | −27.67 (−43.63, 0.92) |
|       | 18 | 41.22 (28.91, 53.54) | −49.06 (−60.77, −27.37) | 240 | 47.38 (33.65, 61.12) | −28.25 (−44.37, 1.04) |
|       | 18 | 50.53 (38.21, 62.86) | −64.38 (−71.37, −52.89) | 34 | 51.32 (37.55, 65.08) | 13.02 (−10.88, 54.46) |
|       | 31 | 44.13 (31.79, 56.48) | −29.76 (−45.11, −2.49) | 39 | 49.08 (35.28, 62.88) | −20.54 (−37.97, 10.53) |
|       | 35 | 40.48 (28.13, 52.84) | −13.55 (−33.76, 24.43) | 28 | 47.92 (34.1, 61.75) | −41.57 (−54.66, −17.88) |
|       | 29 | 46.65 (34.28, 59.02) | −37.84 (−50.87, −15.4) | 25 | 50.62 (36.76, 64.48) | −50.61 (−61.23, −32) |

The numbers in bold highlight significant differences *p < 0.05  
**p < 0.01  
***p < 0.001
predicted frequencies in 2020 and 2021 compared to pre-pandemic years and stratified the analysis by age groups: 2–5 years, 6–12 years and 13–17 years. This study was approved by the SCHN Human Research Ethics Committee (2020/ETH01432).

Results
In the pre-pandemic years (2015–2019) there were in total 492,863 hospital presentations in children aged 2–17 years, of these 13,160 (2.67%) were due to asthma and in pandemic years (2020–2021) there were 163,521 hospital presentations of which 3364 (2.05%) were due to asthma (Table 1).

In 2020–2021, the overall percentage difference in the annual observed number of asthma hospital presentations were not different compared with pre-pandemic years. However, the observed frequency of asthma hospital presentations in April, May and December of 2020 and August 2021 were significantly lower than predicted numbers based on the trend of these months observed in 2015–19 (68.85% reduction in April, 69.46% in May and 49% in December of 2020 and 66.59% in August of 2021; p < 0.05) (Table 2). The reduction in asthma hospital presentation in April–May of 2020 and August 2021 was observed across all the age-groups excluding children aged 2–5 years which could have been due to very small numbers of observed hospital presentations in this age-group.

Discussion
In this first report from Australia, we have shown significant reductions in paediatric asthma hospital presentations during April, May and December of 2020 and August of 2021 which coincided with the periods of restricted movement within NSW due to measures implemented to mitigate the three waves of the COVID-19 pandemic in NSW. We observed a reduction of 50–70% in paediatric asthma hospital presentations which is comparable to reductions observed during the lockdowns implemented in the initial stages of the pandemic in other parts of the world [5].

There are several possible explanations for this observed pattern. Firstly a reduction in paediatric hospital presentations associated with viral respiratory infections was also observed during April and May 2020 in NSW [7]. Viral respiratory infections are common triggers for asthma attacks. Restrictions on face-to-face learning during the lockdown periods may have reduced transmission of respiratory viruses within school settings. Indeed peaks in asthma hospital presentations in children are associated with return to school [8].

The observed reduced number of asthma hospital presentations during April, May of 2020 and August 2021 could also be linked to reduced exposure to outdoor air pollution from stay-at home orders and children staying indoors. There is evidence that general outdoor air quality in NSW improved during the lockdown period [9]. Additionally October–December coincides with major grass pollen peaks in NSW and limited outdoor movement during the second wave of the COVID-19 pandemic could help explain the reduced asthma hospital presentations during these months in children aged 12–17 years who generally have higher mobility compared to younger children.

In response to disruptions to health services due to lockdowns, the Australian government enhanced telehealth to enable access to routine healthcare services via telephone or videoconferencing. It is also possible that general fear within community residents about contracting COVID-19 which may have led to reduced physical visits to hospitals and opting for telehealth services. We could not look into adherence to asthma medications during lockdown periods. There are reports of increased purchase of asthma inhaler medications during lockdown period which may lead to improved self-management of asthma symptoms [10].

Our data demonstrated that during the three waves of the COVID-19 pandemic in NSW so far, measures to contain the pandemic including lockdowns, mask mandates and restricted outdoor movement may have led to a reduction in paediatric asthma hospital presentations. Chronic conditions constitute a major burden on the health system. Healthcare utilisation associated with chronic conditions declined globally during the pandemic. While this decline has been associated with lockdowns, such an approach is not feasible or sustainable in the absence of an infectious disease outbreak. Therefore further research to determine the positive factors associated with this observed pattern could help develop strategies to mitigate the burden of chronic conditions such as asthma on the health system.

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Author contributions
NH, RL and AJ conceived and designed the study, NH drafted the manuscript, NHu conducted the statistical analysis, LO, CH, GM, PNB and HS all provided technical input in design of the study. All authors provided critical feedback to the drafting of the manuscript. All authors read and approved the final manuscript.

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Data availability
The data that support the findings of this study is available upon appropriate ethics approval.
Declarations

Ethics approval and consent to participate
This study was based on administrative datasets and did not require individual patient consent. The study was approved by the SCHN Human Research Ethics Committee (2020/ETH01432).

Competing interests
The authors have no competing interests to declare.

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