ORIGINAL ARTICLE

Respirology · APSR · WILEY

Official Journal of the Asian Pacific Society of Respirology

Impact of COVID-19 pandemic restrictions on the cardio-respiratory health of New Zealanders

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Funding information
Waikato Medical Research Foundation

Associate Editor: Marcos Restrepo; **Senior Editor:** Paul King

Abstract

Background and objective: The COVID-19 pandemic has caused disruption to health, social interaction, travel and economies worldwide. In New Zealand, the government closed the border to non-residents and required all arrivals to quarantine for 14 days. They also implemented a strict contact-restriction system to eliminate COVID-19 from the community. These measures also reduced the circulation of other respiratory viruses such as influenza and respiratory syncytial virus. We assessed the impact of these measures on hospital admissions for respiratory and cardiac diseases.

Methods: National data on hospital admissions for each week of 2020 were compared to admissions for the previous 5 years. Analyses were curtailed after week 33, when a COVID-19 outbreak in Auckland led to different levels of pandemic restrictions making national data difficult to interpret.

Results: The numbers of acute infectious respiratory admissions were similar to previous years before the introduction of COVID-19 restrictions, but then fell lower and remained low after the pandemic restrictions were eased. The usual winter peak in respiratory admissions was not seen in 2020. Other than small reductions during the period of the strictest contact restrictions, non-infectious respiratory and cardiac admissions were similar to previous years and the usual winter peak in heart failure admissions was observed.

Conclusion: The observed patterns of hospital admissions in 2020 are compatible with the hypothesis that circulating respiratory viruses drive the normal seasonal trends in respiratory admissions. By contrast, these findings suggest that respiratory viruses do not drive the winter peak in heart failure.

KEYWORDS
congestive heart failure, coronavirus disease, COVID-19, myocardial infarction, pandemic restrictions, respiratory admission, respiratory virus, SARS CoV-2, winter peak

INTRODUCTION

The coronavirus disease (COVID-19) pandemic caused by the novel severe acute respiratory syndrome coronavirus 2 (SARS-CoV-2) has caused disruption in health, social functioning, travel and economies worldwide.

The New Zealand government attempted to limit the introduction of COVID-19 by asking people arriving from overseas from 15 March to self-isolate for 14 days. Following the first 28 identified cases of COVID-19 in New Zealand, the international border was closed on 19 March 2020: only New Zealand residents and a very select group of essential

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SUMMARY AT A GLANCE

COVID-19 pandemic restrictions in New Zealand led to marked reductions in circulating respiratory viruses and winter infectious respiratory admissions. There was little change in cardiac admissions, suggesting that respiratory viruses play a central role in seasonal respiratory admissions but not the winter peak in heart failure.

workers were allowed to enter the country after this date.[1] From 10 April, all returnees were required to enter a government-managed quarantine facility for 14 days. On 8 June, further measures included tests COVID-19 tests on day 3 and 12 of their quarantine stay.[1] Those with COVID-19 or positive tests were managed in an isolation facility.

Within New Zealand, the government introduced a four-level alert system to manage the outbreak and rapidly went to the highest level of pandemic restriction—moving to level 2 on 21 March, level 3 on 23 March and on level 4 on 25 March.[2] At level 4, residents were only allowed to leave their homes for groceries, healthcare, exercise within their local neighbourhood and other services deemed by the government to be essential. People were asked to stay at least 2 m away from others when doing these activities. Only essential workers were permitted to leave home to go to work. Social contacts were limited to people living in the same household to further reduce person–person transmission. The only exception was that two households were permitted to form a 'bubble' to allow for vulnerable people to be cared for. The government began to lift restrictions when it was clear that community transmission had been contained. Levels 3 (27 April) and 2 (13 May) progressively allowed a return to normal person–person interactions by increasing the numbers permitted to attend social gatherings, allowing retail and hospitality sectors to operate, and non-essential workers to return to work places. At level 1 (8 June), New Zealanders were expected to record their outings using a NZ COVID tracer smartphone app, but were largely able to return to normal life.[1]

After 102 days without community transmission of COVID-19, a new community outbreak was detected in Auckland and consequently Auckland moved back to level 3 and the rest of the country moved to level 2 on 12 August 2020.

Thus, New Zealand experienced a unique situation with closed borders, quarantine of all arrivals from overseas, and a period of strict contact restrictions for the resident population. This not only eliminated the community transmission of SARS-CoV-2, but also impaired the transmission of other circulating viruses within the New Zealand population, and prevented the introduction of new seasonal viral strains from overseas. This created an unanticipated benefit of a reduction in other circulating respiratory viruses that normally peak during winter months: viruses such as influenza and respiratory syncytial virus (RSV) have been effectively eliminated by the pandemic restrictions.[3,4] Anecdotally, this led to a noticeable reduction in respiratory infections over the winter.

However, the benefits of this reduction in respiratory infections may extend beyond respiratory health. There is a
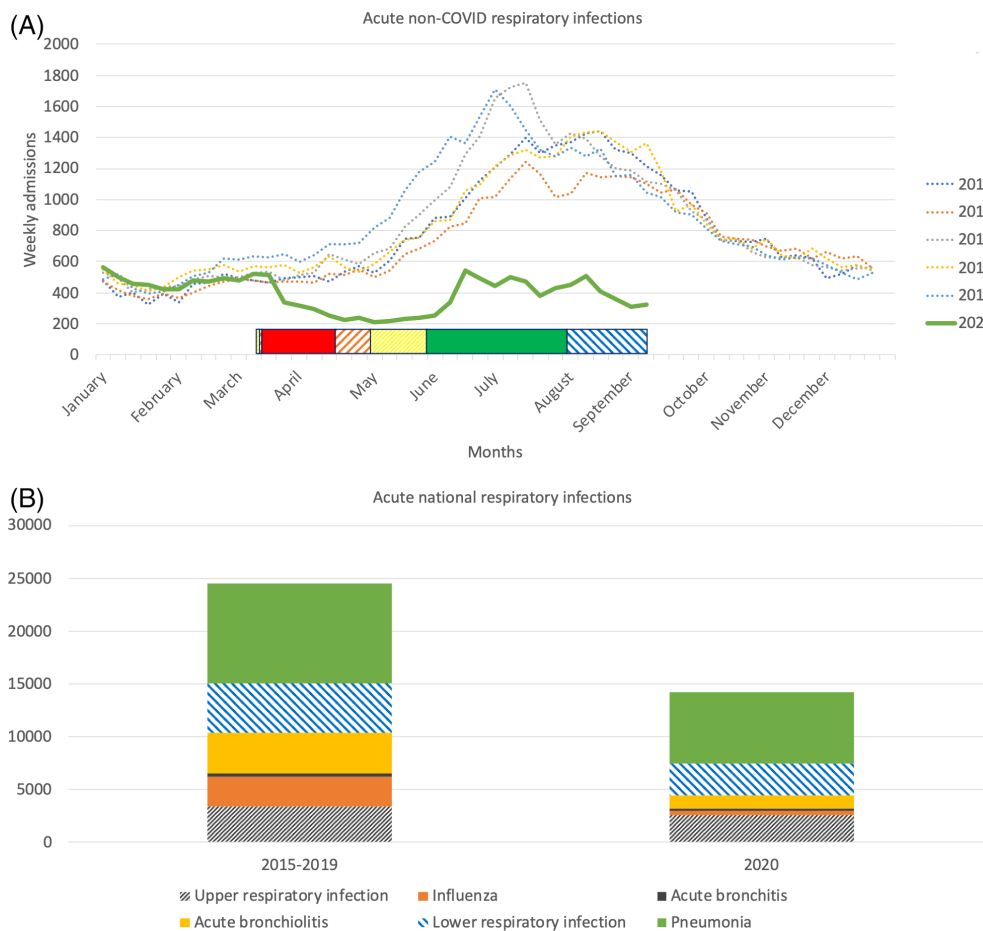

FIGURE 1 Weekly acute respiratory infectious admissions in New Zealand in the years 2015–2020: Including all pneumonias, all influenzas, acute bronchitis, acute bronchiolitis and acute upper respiratory infections of multiple and unspecified sites and unspecified acute lower respiratory infection. The coloured bar represents the level of the New Zealand government's restrictions in place during 2020: red = level 4; orange lined = level 3; yellow lined = level 2; green = level 1. The blue-lined bar represents when the Auckland region and the rest of the country experienced different restriction levels. Panel (B) shows common acute respiratory infection-related admissions for the first 37 weeks of the year. For the years 2015–2019, the mean numbers of admissions are shown

well-recognized, but poorly understood, winter peak in admissions to hospital for congestive heart failure (CHF) and acute coronary syndromes (ACS).[5,6] Severe respiratory infections are known to be associated with acute cardiac disease and the spread of respiratory viruses is one of the putative mechanisms put forward to explain the rise in cardiac admissions during winter.[7–10]

During the COVID-19 pandemic, some countries observed reductions in hospitalisations for acute cardiovascular diseases, but it is unknown if these were due to genuine reductions in disease incidence or behavioural changes, such as a reluctance to seek health-care.[11–13] The New Zealand COVID-19 response and reduction in circulating winter viruses provide a rare opportunity to explore the effect of contact restrictions on the respiratory and cardiovascular health of New Zealanders and to test the following hypotheses:

1. That the reduction in circulating respiratory viruses will be associated with reductions in infection-related respiratory hospitalisations but not in non-infection-related respiratory hospitalisations.
2. That the reduction in acute respiratory infections will be associated with reductions in admissions for cardiac failure and ACS.

METHODS

The New Zealand Ministry of Health provided data on all coded national admissions for the years 2015–2020. The first 37 weeks of 2020 were provided, which includes the time up to the second pandemic restrictions in August. Diagnostic codes were combined into categories of Acute Respiratory Admissions (associated with infection); Admissions for exacerbations of Chronic Respiratory Disease; Cardiovascular Admissions; and Admissions related to Respiratory Malignancies (Table S1 in the Supporting Information). Admissions due to COVID-19 were excluded. The numbers of admissions for each week of 2020 were compared with those for each year from 2015 to 2019. No formal statistical testing of the differences was undertaken.

Local virus data

Detailed, week-by-week, viral detection data were available for the Waikato region for 2019 and 2020. Population coverage (all virus testing for ~360,000 people), test algorithms and laboratory methods were comparable for both years. This information is used here to illustrate the epidemiology
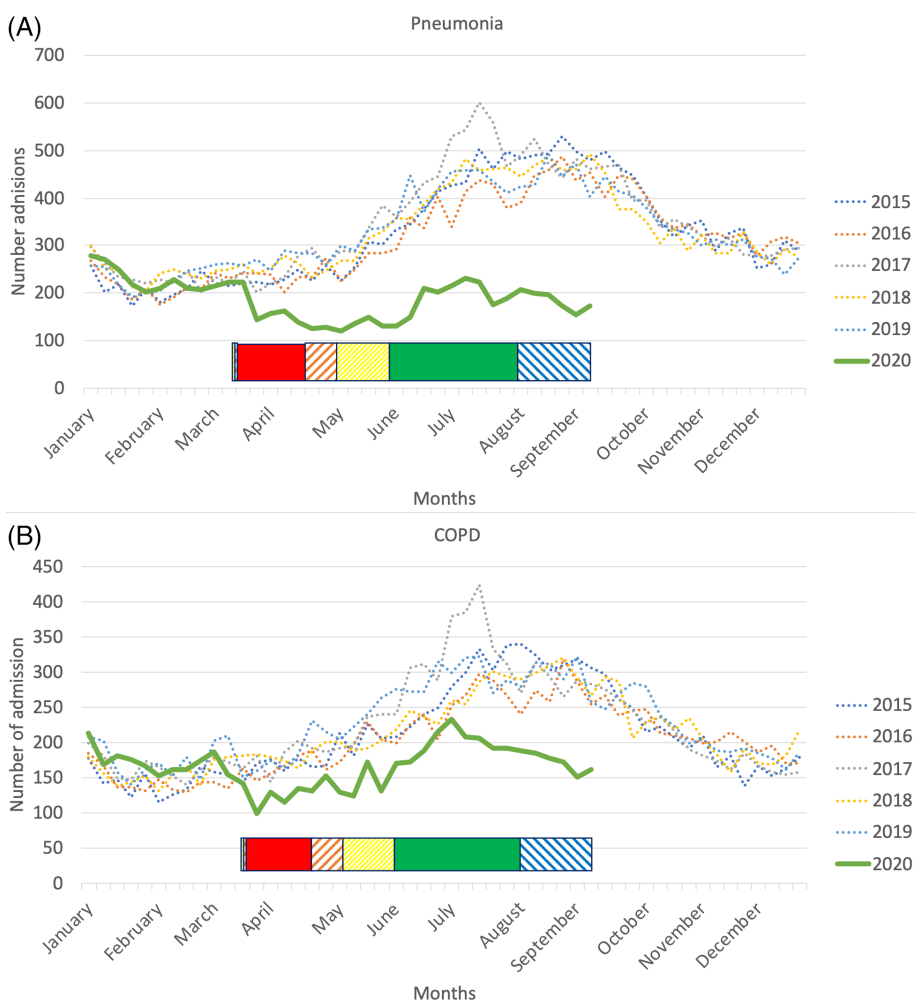

FIGURE 2 Weekly pneumonia and COPD admissions in New Zealand in the years 2015–2020. The coloured bar represents the level of the New Zealand government's restrictions in place during 2020: red = level 4; orange lined = level 3; yellow lined = level 2; green = level 1. The blue-lined bar represents when the Auckland region and the rest of the country experienced different restriction levels

of predominant virus groups in a representative region of New Zealand. Influenza and RSV detection were performed by a laboratory-developed PCR test following the 2009 CDC Influenza RT PCR protocol, using nasopharyngeal, flocked swabs, in virus transport media, determined by local availability. Samples were primarily from children admitted to Waikato Hospital with respiratory illness. Rhinoviruses and enteroviruses, seasonal coronaviruses, parainfluenza viruses and adenoviruses were detected in 2019, using the FTD™ Respiratory Pathogen 21 kit (Fast Track Diagnostics Luxembourg) and, in 2020 the QIAstat-Dx® Respiratory Panel (QIAGEN GmbH Hilden). These samples were primarily from immunosuppressed adults, ICU patients and selected paediatric patients, admitted to Waikato Hospital with respiratory illness. The Waikato Hospital microbiology laboratory is accredited by International Accreditation New Zealand and participates in the Royal College of Pathologists or Australasia Quality Assurance Program, with satisfactory results for both years.

RESULTS

Acute respiratory admissions were lower overall in 2020 compared to previous years with a notable absence of the usual winter peak. This persisted following easing of the pandemic restrictions (Figure 1A). When admissions were divided into individual diagnoses they were proportionally similar, with the exception of influenza-related admissions, which were much lower in 2020 compared to previous years (Figure 1B). Pneumonia and chronic obstructive pulmonary disease (COPD) admissions followed a similar trend to the total acute respiratory illness with markedly fewer admissions over the winter of 2020 (Figure 2A,B). Asthma admissions were lower during pandemic restrictions, rapidly rose to the normal winter volumes following easing of contact restrictions, but fell again as the year progressed (Figure 3A).

Numbers of non-infectious respiratory admissions in 2020 such as; malignant neoplasm of bronchus and lung (Figure 4A), pulmonary embolism (Figure 4B) and pneumothorax (Figure 4C) were not different to previous years.
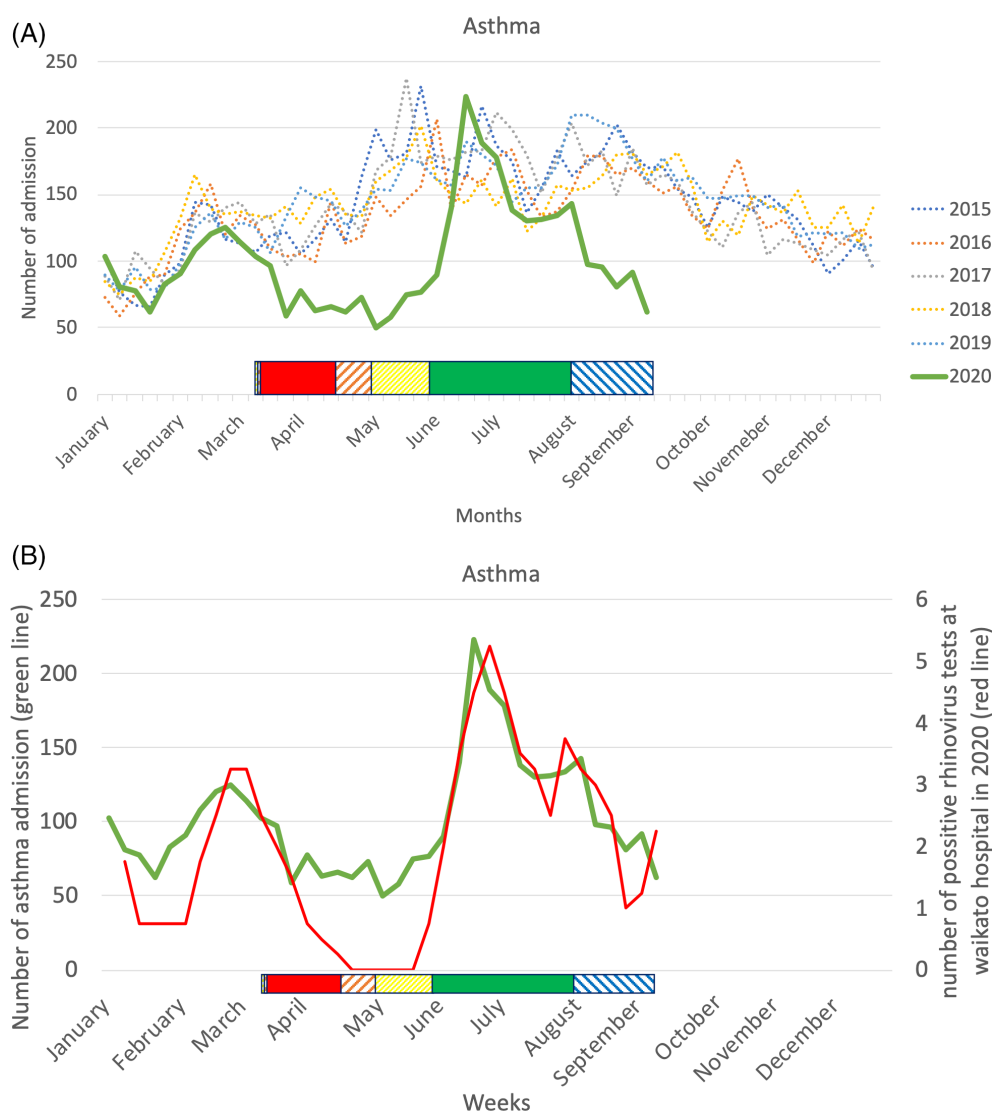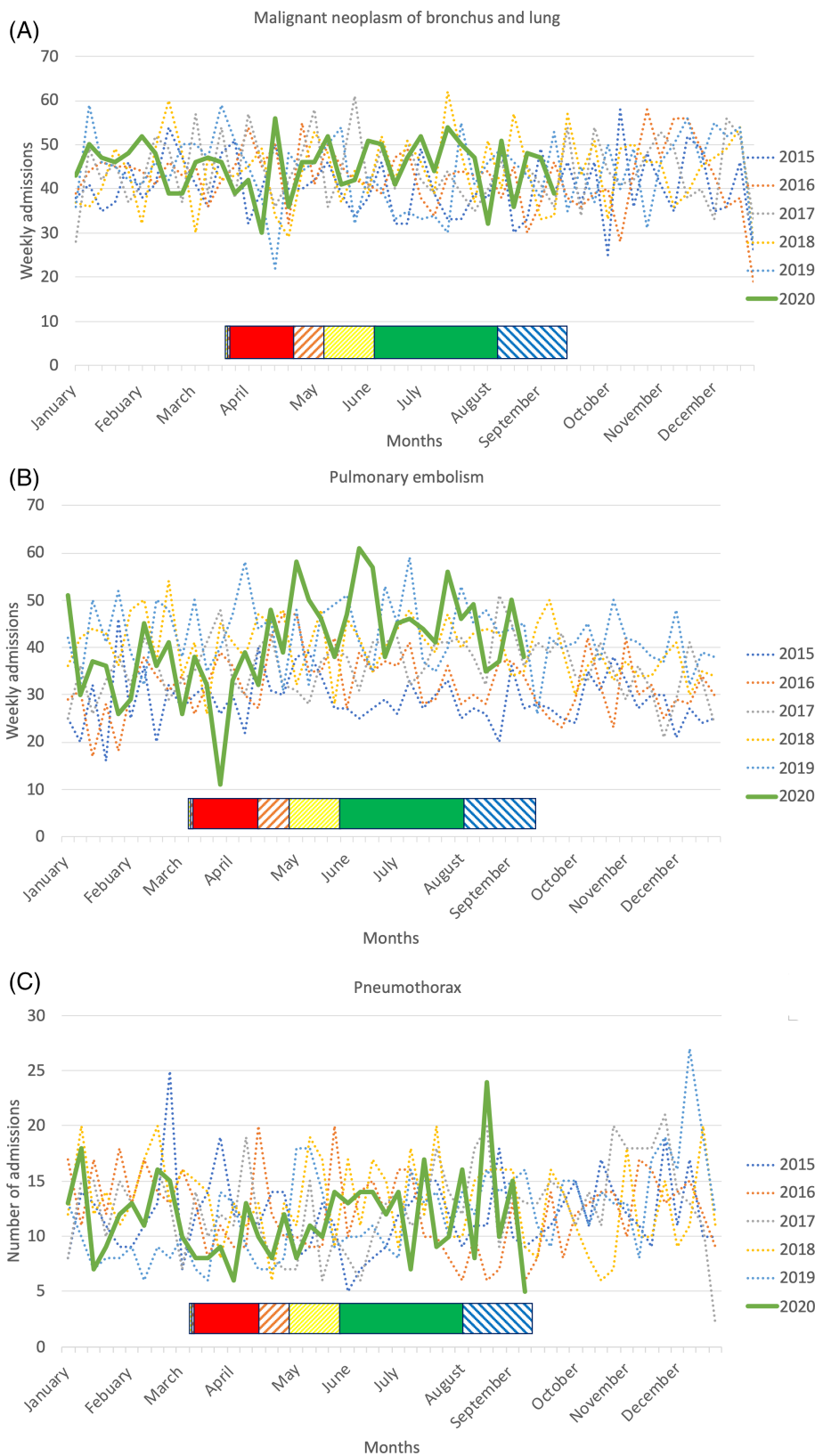

(A)

(B)

FIGURE 3 Weekly asthma admissions in New Zealand in the years 2015–2020 and rhinovirus detection in the Waikato region. The coloured bar represents the level of the New Zealand government's restrictions in place during 2020: red = level 4; orange lined = level 3; yellow lined = level 2; green = level 1. The blue-lined bar represents when the Auckland region and the rest of the country experienced different restriction levels. The red line indicates the number of positive rhinovirus tests

FIGURE 4 Non-infectious respiratory admissions in New Zealand in the years 2015–2020 including malignant neoplasm of bronchus and lung (A), pulmonary embolism (B) and pneumothorax (C). The coloured bar represents the level of the New Zealand government's restrictions in place during 2020: red = level 4; orange lined = level 3; yellow lined = level 2; green = level 1. The blue-lined bar represents when the Auckland region and the rest of the country experienced different restriction levels

Acute coronary syndrome admissions appeared to be lower during the level 4 pandemic restrictions but then returned to levels that were similar to other years when the restrictions were eased (Figure 5A). There was little change in the pattern of admissions for CHF in 2020 compared to previous years with the usual increase in admissions over winter, (Figure 5B).
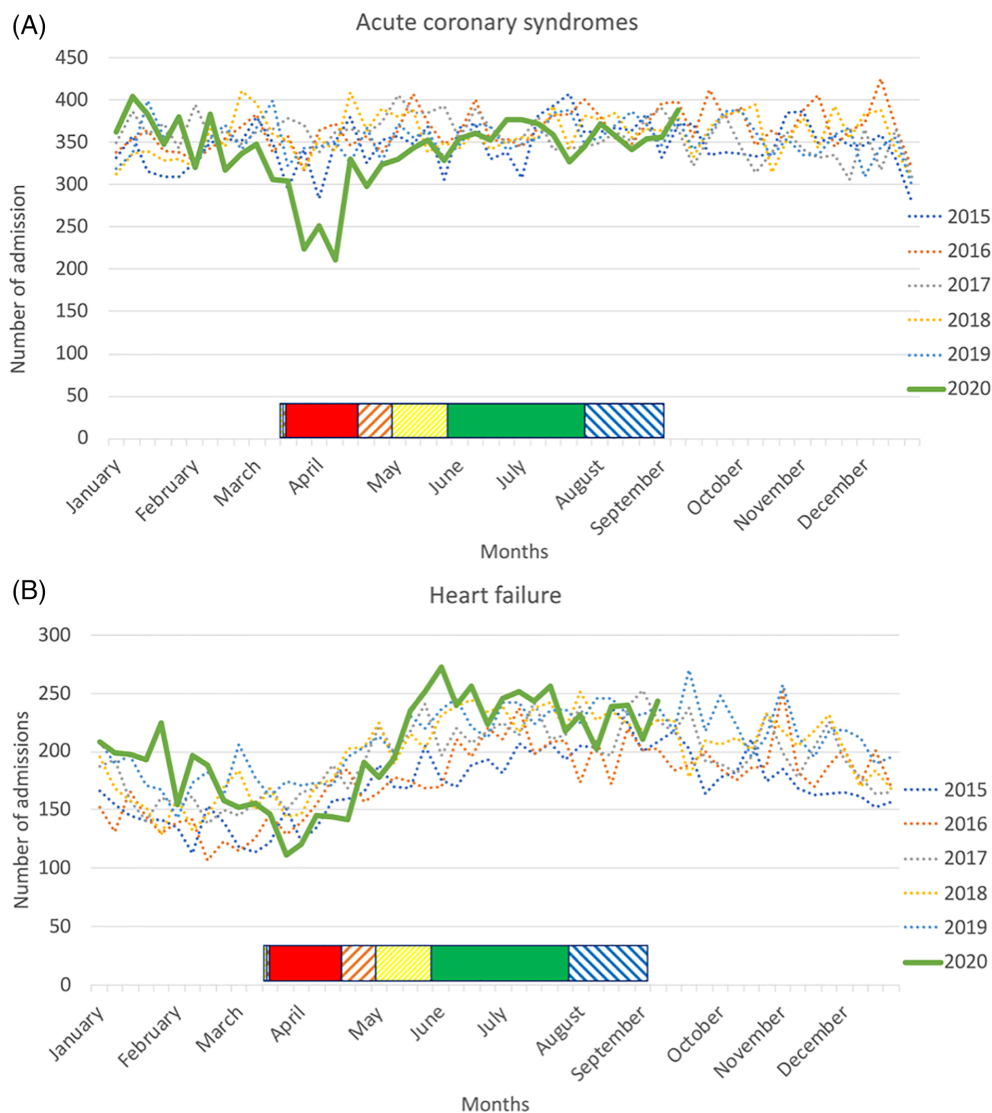
(A)

(B)

FIGURE 5 Acute cardiac admissions in New Zealand in the years 2015–2020 including acute coronary syndrome (A) and heart failure (B). Acute coronary syndromes include admissions for myocardial infarction and angina. The coloured bar represents the level of the New Zealand government's restrictions in place during 2020: red = level 4; orange lined = level 3; yellow lined = level 2; green = level 1. The blue-lined bar represents when the Auckland region and the rest of the country experienced different restriction levels

DISCUSSION

In New Zealand, the pandemic restrictions and strict border control have successfully controlled COVID-19 but also created a closed system whereby the introduction and spread of several other winter viruses has been substantially reduced or eliminated. This has been associated with a marked reduction in acute respiratory admissions with a loss of the usual winter peak. Infectious respiratory admissions stayed low despite contact restrictions lifting (Figure 1).

The reduction in acute infectious respiratory admissions, including pneumonia, COPD and lower respiratory tract infections (Figure 2) are compatible with the hypothesis that the normal seasonal trends in admissions are driven by circulating respiratory viruses. The observation that infectious respiratory admissions remained low after pandemic restrictions within New Zealand were lifted, whereas non-infectious admissions appeared to be at normal levels, indicates that the reduction in admissions is unlikely to be explained by changes in health-care seeking behaviour.

Nationally, New Zealand saw reductions in the numbers of all major groups of respiratory viruses detected in 2020, relative to rates for 2015 to 2019: Influenza (99.9%), RSV (98%), rhinovirus (74.6%), enterovirus (82.2%), adenovirus (81.4%), hMPV (92.2%) and PIV (80.1%).[3] Thus, although it is thought that bacterial infections cause most pneumonia admissions, these data suggest that viruses may contribute more than previously thought.[14] However, it is also plausible that viral infections precipitate secondary bacterial infections or that that the pandemic restrictions also reduced the spread of pathogenic bacteria.

It is unsurprising that measures designed to halt the spread of SARS-CoV-2 have also impacted on the prevalence of other respiratory viruses. Substantial reductions in influenza and RSV illnesses following pandemic restrictions were clearly seen.[3,4] Detection of other common respiratory viruses also fell and most of these remained very low after restrictions were eased. These reductions are likely to be due to the strict level 4 lockdown reducing the chances for viruses to circulate, encouraging all those with viral-like

symptoms to self-isolate, and preventing re-introduction of viruses from overseas by requiring all returning travellers to quarantine for 14 days. Other measures, such as improved hand hygiene, may have played a role in reducing virus transmission. During the period of observation, facial coverings were not required, except for domestic air travel, and were infrequently used in New Zealand. Rhinovirus detection also fell to low levels during the strict (level 4) pandemic restrictions, but unlike other viruses, it peaked in June to August 2020 after the restrictions were relaxed before falling again.[3] The reasons for this peak and subsequent fall in rhinovirus are uncertain.

Asthma admissions were low during the strict pandemic restrictions but rebounded quickly following their relaxation to normal levels in June–July of 2020 but then fell again to lower than normal levels (Figure 3A). There are several possible mechanisms to explain this trend, but it seems most likely that the rapid return of rhinoviruses in the community led to the peak in asthma admissions. Rhinoviruses are strongly associated with asthma exacerbations,[15,16] and the peak in asthma admissions coincided with the national re-emergence of rhinovirus in June (Figure 3B).[3] Both rhinovirus isolates and asthma admissions subsequently fell. While local rhinovirus data are presented here, this closely mirrors rhinovirus activity recorded elsewhere in the SHIVERS II project and GP sentinel sites.[3] These observations of the close relationship between rhinovirus detection and asthma hospitalisations suggest that rhinovirus may play an even bigger role in asthma exacerbations than previously recognized. However, it is also possible that re-exposure to allergens outside of the home could explain the rise in asthma admissions in June–July, although this would not explain the subsequent reduction. It is also possible that people did not pick up their usual inhalers during pandemic restrictions and were unable to prevent or treat subsequent acute exacerbations.

Apart from a brief reduction in ACS during the level 4 pandemic restrictions, there was a little discernible effect on cardiac admissions (Figure 5A,B). Hence, these observations do not provide an explanation for the seasonal winter peak in CHF admissions.[5] Exposure to respiratory viral infections, such as influenza, has been proposed as one of several putative mechanisms for this winter peak.[17,18] Our observations suggest that this is not the case, otherwise we would have expected CHF admissions to stay low during the winter in keeping with the lower rates of respiratory infections and the reduction in circulating viruses. These findings are consistent with a large meta-analysis that found that influenza vaccination does not reduce mortality or hospitalisations in heart failure patients.[19] Other mechanisms for the winter rise in heart failure admissions have been proposed including temperature variation and exposure to pollution and these need further investigation.[20,21]

Acute respiratory tract infections caused by viruses such as RSV and influenza, as well as pneumonia and exacerbations of COPD, have previously been linked with episodes of ACS.[22–25] However, we observed that the number of admissions for ACS stayed within normal limits apart from a small decline during the 4 weeks of very strict restrictions, during which people were expected to stay home as much as possible. This pattern of admissions does not support the hypothesis that common circulating respiratory viruses precipitate substantial numbers of these events because the lower levels of ACS did not persist after pandemic restrictions were eased, even though admissions for respiratory tract infections remained low and there were few viruses in circulation.[3,4] The initial decline in ACS admissions could be due to changes health-seeking behaviours with a reluctance to seek medical attention during the pandemic restrictions. Alternatively, the enforced changes in lifestyle during the strict pandemic restrictions may have led to a genuine reduction in the incidence of ACS.

Strengths of this study include the use of national admission data from all New Zealand hospitals during a time when the entire population experienced the same levels of restriction with very few COVID-19 infections confounding the admission trends. A limitation is that only the first 33 weeks of 2020 can be compared nationally because of a second outbreak of COVID-19 in Auckland leading this region (approximately one third of the population of New Zealand) to having different restrictions from the rest of the country. Further follow up of the national respiratory viral landscape may provide insights into how respiratory viruses interact with seasonal and environmental factors to influence respiratory health.

Although we cannot prove cause-and-effect with these observational data, the apparent impact of pandemic restrictions on acute infectious respiratory admissions has been substantial. For example, the total number of admissions for pneumonia in the first 37 weeks of 2020 (including before the pandemic restrictions) was 6957, which is about 42% lower than the mean number of admissions over the same period for the previous 5 years of just over 12,000. Whether these reductions will be sustained over the rest of the year remains to be seen, but such reductions indicate the potential benefits that could be achieved if the spread of common respiratory viruses could be prevented without pandemic restrictions. Recently Kung et al. showed that New Zealand had lower national mortality in 2020 compared to previous years.[26] The reduction in infection-related respiratory admissions offers a plausible mechanism for this reduction in total mortality.

In summary, these unique ecologic data from the unusual circumstances brought about by nationwide COVID-related restrictions demonstrate that reductions in circulating respiratory viruses to very low levels are associated with a marked reduction in acute respiratory admissions for pneumonia, COPD, asthma and lower respiratory infections. With the possible exception of asthma, these restrictions eliminated the expected winter peak in these admissions. There was little impact on acute cardiac admissions indicating that the usual winter peak in heart failure admissions is probably not driven by respiratory viral infections.

AUTHOR CONTRIBUTIONS

Sarah Fairweather: Data curation; formal analysis; investigation; methodology; project administration; writing - original draft; writing-review & editing. **Catherina Chang:** Conceptualization; data curation; formal analysis; funding acquisition; investigation; methodology; project administration; resources; supervision; validation; visualization; writing - original draft; writing-review & editing. **Chris Mansell:** Conceptualization; data curation; formal analysis; methodology; writing - original draft; writing-review & editing. **Eskandarain Shafuddin:** Conceptualization; funding acquisition; methodology; writing-review & editing. **Bob Hancox:** Conceptualization; data curation; formal analysis; methodology; supervision; validation; writing - original draft; writing-review & editing.

CONFLICT OF INTEREST

None declared.

ETHICS STATEMENT

Formal ethics approval was deemed not required for this study after consultation with the Health and Disability Ethics Committees of New Zealand, as the data used do not contain any personal identifying information.

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.