Respiratory virus detection during the COVID-19 pandemic in Queensland, Australia

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Abstract

Objective: To determine if non-pharmaceutical interventions (NPIs) impacted on respiratory virus detections in Queensland, Australia, during the COVID-19 pandemic year of 2020.

Methods: We analysed weekly counts of influenza, human metapneumovirus, parainfluenza, respiratory syncytial virus, rhinovirus, and adenovirus available from a Queensland laboratory network for the year 2020. These were compared with averaged counts from 2015 to 2019.

Results: Overall, 686,199 tests were performed. The timing of NPI implementation was associated with a sharp and sustained decline in influenza, where during the typical annual influenza season (weeks 23–40) no cases were detected from 163,296 tests compared with an average of 26.1% (11,844/45,396) of tests positive in 2015–2019. Similar results were observed for human metapneumovirus and parainfluenza. Respiratory syncytial virus detections also declined but increased in weeks 48–52 (5.6%; 562/10,078) to exceed the 2015–2019 average (2.9%; 150/5,018). Rhinovirus detections increased after schools reopened, peaking in weeks 23–27 (57.4%; 36,228/63,115), exceeding the 2017–2019 detections during that period (21.9%; 8,365/38,072).

Conclusions: NPIs implemented to control COVID-19 were associated with altered frequency and proportions of respiratory virus detections.

Implications for public health: NPIs derived from influenza pandemic plans were associated with profound decreases in influenza detections during 2020.

Key words: COVID-19, respiratory viruses, influenza, non-pharmaceutical interventions, SARS-CoV-2

Coronavirus disease 2019 (COVID-19), caused by a lipid-enveloped beta-coronavirus known as severe acute respiratory syndrome coronavirus-2 (SARS-CoV-2), was declared a global pandemic by the World Health Organization on 11 March (Week 11) 2020.[1] Subsequently, many countries, including Australia, implemented public health measures including non-pharmaceutical interventions (NPIs) involving individual- and community-level recommendations to reduce SARS-CoV-2 transmission.[2] The intensity and duration of NPIs implemented in Australia varied by state and territory and included: isolating known cases and quarantining their close contacts; closing state and international borders for non-essential travel, with returned travellers held in hotel quarantine for 14 days; restricting local travel and visitations to hospitals and residential aged and disability care facilities; enforcing physical or social distancing by limiting indoor and outdoor gatherings; reinforcing the use of hand sanitiser and cough hygiene measures; encouraging the wearing of face masks; and issuing stay at home orders.[3]

NPIs introduced to address the COVID-19 pandemic were based upon influenza pandemic planning and would be expected to also have an impact upon other communicable diseases, including those caused by non-influenza respiratory viruses.[4–7] This is because respiratory viruses can be transmitted in respiratory secretions by multiple routes, including direct physical contact, indirectly following contact with contaminated surfaces or objects (fomites) or directly from contact with airborne droplets or aerosols.[8] Indeed, NPIs emphasising physical distancing to minimise each of these potential transmission routes have been associated with decreased virus detections and decreased paediatric respiratory consultations in the United States, Europe and Korea.[4,9–11] In Japan, seasonal influenza cases in children during 2020 were almost halved compared with previous years,[6] while in Australia a 95% decline was seen in routinely collected national influenza surveillance data between March and September 2020 when compared with the previous five years.[12] Respiratory syncytial virus (RSV) detections in children presenting to the Sydney Children's Hospital Network were 94% lower between April and June 2020 than in the same period for 2015–2019.[5] Recent data from PathWest Laboratory Medicine, the sole government-funded diagnostic laboratory in Western Australia, reported a 98–99% reduction in RSV

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and influenza detections during the winter of 2020 compared with 2012–2019.[13] However, when physical distancing and other public health measures were relaxed in the final quarter of 2020, RSV detections in Western Australia increased rapidly within a four-week period from <10 per week to >100 per week.[14]

The aim of this study was to use data from a large private pathology laboratory network in Queensland, Australia, to determine the community-level effects of NPIs introduced in 2020 on respiratory virus detections. We describe the weekly detections of SARS-CoV-2 in 2020 and compare the weekly detections of six respiratory viruses in 2020 with their weekly averages in 2015–2019.

Methods

Setting

Queensland is Australia's second-largest state at 1.85 million km^2 and is located in the north-east of the country. It has a population of 5.2 million, with 70% residing within 200 kilometres of the capital city, Brisbane, in the south-east corner.[15] Queensland has three main climate zones that can influence some respiratory virus seasonality: tropical in the north, subtropical in the south and a hot-arid zone west of the Great Dividing Range.[16–19] Griffith University Human Research Ethics Committee (2021/230) approved the study. All data were de-identified.

Laboratory data

A retrospective analysis was conducted of laboratory data collected prospectively by Sullivan Nicolaides Pathology (SNP) as part of routine surveillance. SNP is a large network of private referral diagnostic laboratories servicing primary healthcare, private hospitals and residential care facilities throughout Queensland and Northern New South Wales; it undertakes about 40% of community laboratory tests in Queensland.[20] Data included the number of weekly tests and weekly positive tests by validated molecular assays.[21] Viruses included on the test panel were influenza A and B, human metapneumovirus (HMPV), parainfluenza viruses 1–3, RSV, rhinoviruses, adenoviruses, and SARS-CoV-2. Weekly counts for the six years from 2015 to 2020 were extracted for all respiratory viruses, except rhinovirus where testing commenced in 2016 (week 37). For this report, the non-SARS-CoV-2 viruses were categorised into six groups: influenza, HMPV, parainfluenza, RSV, rhinoviruses, and adenoviruses.

Statistical analysis

The year 2020 was divided into five periods according to the NPIs mandated by state public health authorities: the 'pre-pandemic' period (weeks 1–11); 'state-wide lockdown' (weeks 12–21); 'easing restriction and reopening of state schools' (weeks 22–31); the 'Greater Brisbane lockdown' (weeks 32–38) and 'continuation of physical distancing and other simple public health measures' (weeks 39–52). The total numbers of virus detections and tests for the five time periods were computed for 2020 and the same calculations were performed for the corresponding periods of the previous five years (2015–2019). The weekly average percentage of positive tests for the years 2015–2019 were compared with 2020 figures in each time period using the chi-square test. Results are presented as absolute frequencies of virus detections and percentages of positive detections.

Results

Non-pharmaceutical interventions

The first Queensland case of COVID-19, an overseas tourist from Wuhan, China, visiting south-east Queensland, was confirmed on 28 January (Week 4) 2020.[22] In response, the Queensland Government implemented a series of NPI public health measures to restrict the transmission of SARS-CoV-2. These included isolating cases and quarantining their contacts, while public health messages focussed on physical distancing, cough and hand hygiene, and staying home and seeking medical advice if unwell using virtual telehealth appointments. By week 12, 319 COVID-19 cases had been notified, prompting state-wide visitor restrictions to hospital and residential care facilities; closures of non-essential business services, including gymnasia, bars, clubs and restaurants; limitations on social gatherings; closures of international and state borders; and strict travel restrictions for Australian citizens and foreign nationals with returning travellers placed in hotel quarantine for 14 days. As cumulative cases approached 700 in week 14, a strict lockdown was imposed with schools closed and residents prohibited from leaving home except for essential work and shopping, exercise and medical reasons. After cumulative cases plateaued around 1,050 in weeks 19–21, restrictions were eased and people could leave home for non-essential reasons, while gymnasia, sporting venues, bars, clubs and restaurants were reopened with restricted numbers, and students returned to school. Interstate borders reopened in week 28, and for the remainder of 2020 borders opened and closed sporadically in response to localised community outbreaks and outbreaks in other states. International borders remained essentially closed to foreign nationals throughout 2020. In the Greater Brisbane region, a further lockdown occurred between weeks 32–38 when 12 community-acquired cases were identified and people living in Greater Brisbane were encouraged to wear face masks in restricted areas.[22,23] Other NPIs continued throughout the year, including physical distancing in public places and at work, and a requirement to self-isolate and be tested for SARS-CoV-2 if symptoms of COVID-19 developed.

Effect of non-pharmaceutical interventions on respiratory viruses

Overall, 686,199 tests were performed by SNP between week 1, 2015, and week 52, 2020. There were 287,819 (41.9%) tests in 2020, a 3.6-fold increase compared with the 2015–2019 average. The number of specimens tested for SARS-CoV-2 during 2020 was 466,931, of which 382 (0.08%) were positive. The total number of specimens tested, and the number testing positive for these viruses during the six years from 2015 to 2020, are detailed in Table 1 and displayed across the five time periods in Supplementary Figures 1 and 2, respectively. The number of detections for each of the six viruses across the five time periods in 2020 that correspond to the public health measures enacted at these times, and the average number for each of these viruses during these same periods for 2015–19, are displayed in Table 2.

Apart from parainfluenza, the weekly percentages of positive tests for the other respiratory viruses in the 2020 pre-pandemic period were similar to the corresponding average values for the previous five years (Figure 1). During the state-wide lockdown period (weeks 12–21) the total number of positive tests decreased markedly, despite the continued increase in laboratory testing (Table 2). The percentage of positive tests remained low for the rest of 2020 for influenza, HMPV and parainfluenza, even after the easing of restrictions. Chi-square analyses demonstrated significant decreases in the percentage of positive tests in 2020 compared with their 2015–2019 average following the introduction of the state-wide lockdown ($p<0.001$), which was sustained for the rest of 2020.

Similarly, the numbers and percentage of positive SARS-CoV-2 tests also decreased markedly after the state-wide lockdown (Figure 1; Supplementary Figure 2).

The annual influenza season in Queensland is typically in winter and early spring from June to September. In the years 2015–2019, it began on average in week 23 (June) and ended in week 40 (September), with the percentage of positive tests peaking in August between weeks 32 and 36 (Figure 1). However, during this period in 2020 (weeks 23–40), no influenza viruses were detected in the 163,296 tests performed, compared to an average of 26.1% (11,844/45,396) of tests being positive for influenza during the 2015–2019 seasons.

A similar pattern was observed for HMPV and parainfluenza, with both having a rapid and sustained decline in the percentage of positive tests following the introduction of the lockdown period (Figure 1). The annual season for HMPV in 2015–2019 peaked in late winter and spring from weeks 31–44 (August–October). During this 14-week peak period in 2020, just 0.04% (28/70,618) of specimens were positive for HMPV, compared with the average detection rate of 4.3% (1,521/35,754) during this same period in 2015–2019. The annual peak season for parainfluenza was also in late winter and spring (weeks 31–44). In 2020, there were no cases of parainfluenza detected in the 70,618 tests performed for these viruses during this period compared with the 4.2% (1,495/35,754) average detection rate in the 2015–2019 seasons.

The average annual RSV season for 2015–19 had a broad peak, ranging from early autumn through to spring (weeks 10–40). However, there was a significant decline in the percentage of positive tests for RSV following the state-wide lockdown (Figure 1). Although there was a rebound in numbers to average seasonal levels in weeks 21–30 after the reopening of schools (Supplementary Figure 2), this was associated with increased testing (Supplementary Figure 1). The percentage of positive tests for RSV remained low after the lockdown was lifted until weeks 48–52, when there was a sudden and non-seasonal increase in RSV detections with the average

Table 1: The total number of tests and positive test results for six respiratory viruses from a private laboratory network during 2015–2020, Queensland, Australia.

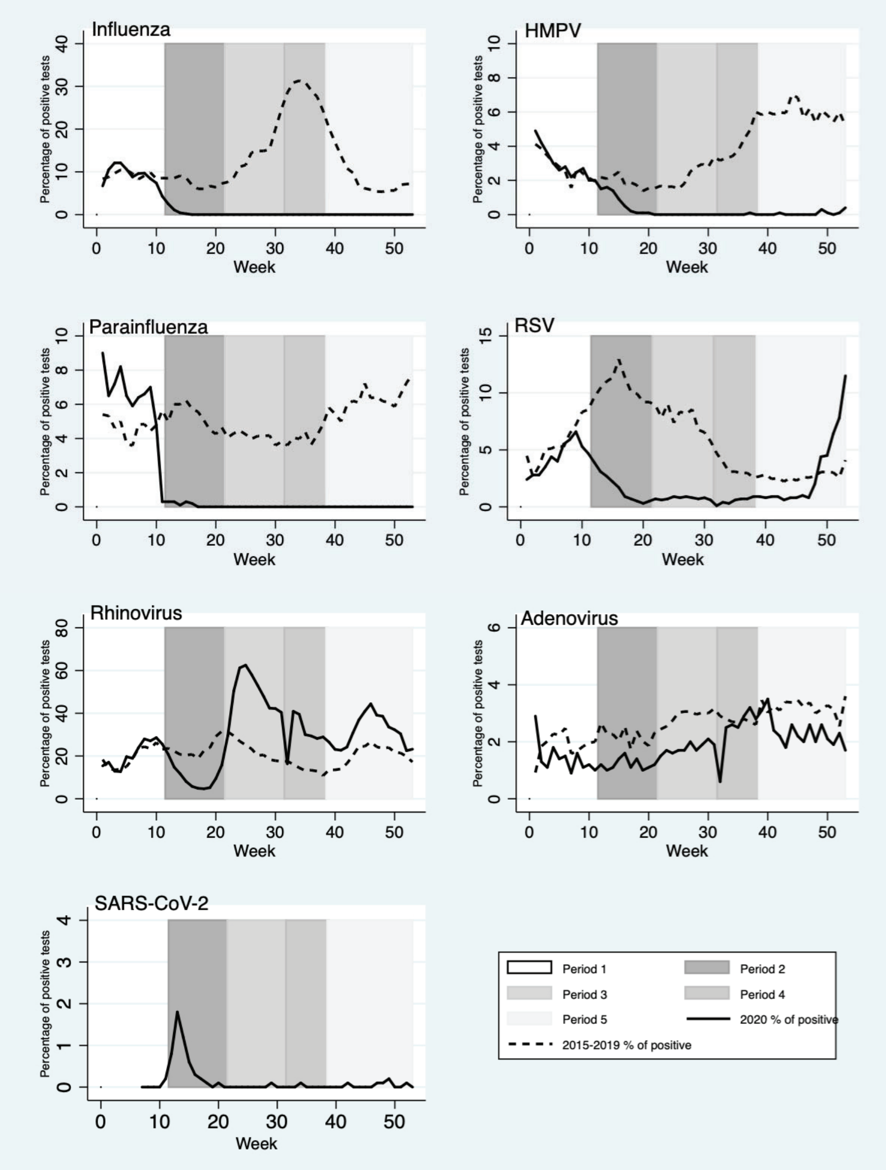
Year	Total tests	Influenza	HMPV	PIV	RSV	RV	ADV
2015	44,215	7,899	1,708	2,312	2,248	na	1,093
2016	53,115	8,205	2,089	3,212	3,161	na	1,569
2017	85,461	21,361	2,547	3,838	3,865	14,274	2,103
2018	75,176	5,765	3,042	4,243	4,526	16,186	2,464
2019	140,413	31,532	4,536	3,893	6,098	25,740	3,625
2020	287,819	2,371	1,083	1,240	4,138	97,369	4,980

Notes:

Total tests for SARS-CoV-2 were 466,931, total positive results were 382 (0.08%).

ADV, adenovirus; HMPV, human metapneumovirus; na, not applicable; PIV, human parainfluenza virus, RV, rhinovirus; RSV, respiratory syncytial virus; SARS-CoV-2, severe acute respiratory syndrome coronavirus 2.

Figure 1: Weekly percentage of positive tests for respiratory viruses in 2020 and the corresponding average values for the previous five years (2015-2019).



Notes:

__Period 1__ (Weeks 1–11): Pre-pandemic; __Period 2__ (Weeks 12–21): State-wide lockdown; __Period 3__ (Weeks 22–31): Easing the restrictions and reopening of state schools; __Period 4__ (Weeks 32–38): Greater Brisbane lockdown; __Period 5__ (Weeks 39–52): continuation of physical distancing and other simple public health measures. Note the differing scales and maximum values on the Y-axes.

positive test rates of 5.6% (562/10,078) exceeding the 2.9% (150/5,018) average for the same period in 2015–2019. Chi-square analyses demonstrated a significant reduction in the percentage of positive tests for RSV in 2020 compared to the 2015–2019 average across all periods (p<0.001), except for period 5 (weeks 39–52; p=0.05).

Although the percentage of positive tests for rhinovirus during the state-wide lockdown was significantly lower than in the same time period for the previous five years (p<0.001), the percentage of rhinovirus positive tests rose sharply in week 22 following the easing of state public health measures, including the reopening of schools, and remained substantially higher than in the years 2017–2019 (Figure 1). From week 23–27 in 2020, the proportion of specimens testing positive for rhinovirus was 57.4% (36,228/63,115) compared with 21.9% (8,365/38,072) for the same period in 2017–2019. The highest percentage of positive tests for rhinovirus was 62.5% in week 25, three weeks after the state schools reopened. The percentage of rhinovirus tests that were positive fell briefly again in week 32 at the time of the Greater Brisbane region lockdown. Overall, from week 22 onwards, the numbers and percentages of positive tests for rhinovirus in 2020 remained significantly higher than for 2017–2019 (p<0.001; Table 2, Supplementary Figure 2).

Adenovirus detections were less impacted by NPIs in 2020 with their lower weekly percentage of detections being already present in the pre-pandemic period (Figure 1). Despite the numbers of adenovirus detections increasing during and after the lockdown, peaking in weeks 22–31 (Supplementary Figure 2), the percentage of positive tests was only 1.8% (2,309/129,389) and lower than during the same 10-week period (3.5%; 676/19,390) in 2015–2019. Chi-square analyses demonstrated significant reductions in the weekly percentage of adenovirus positive tests in 2020 compared to 2015–2019 across each of the five time periods (p≤0.001).

Discussion

In Queensland, the public health response to mitigate the COVID-19 pandemic involving NPIs, including physical separation and an initial strict lockdown period for 10 weeks, was associated with a marked reduction in SARS-CoV-2 detections and a sharp decline in five of the six respiratory viruses tested routinely by a large private laboratory network. As restrictions other than travel were eased and schools reopened, small numbers of SARS-CoV-2 detections continued, primarily from nationals in quarantine who had returned from overseas.[22] However, despite a more than three-fold increase in testing in 2020 after Queenslanders were encouraged to be tested for even mild respiratory symptoms, influenza, HMPV and parainfluenza numbers remained either extremely low or zero. Although RSV detections increased initially as restrictions eased, their percentage of overall tests remained significantly very low, only for an unexpected, non-seasonal sharp rise in RSV detections to occur at the end of 2020. In contrast, both the number of positive rhinovirus detections and percentages rebounded after schools reopened and remained so for the rest of 2020. Meanwhile, weekly adenovirus detection percentages were relatively unaffected and mirrored 2015–2019 patterns, albeit at lower values, which appeared from the first weeks of 2020.

The sustained decline in influenza, HMPV and parainfluenza detections, including throughout their usual annual seasonal epidemics[24-26] and following the cessation of the lockdown periods and further easing of restrictions, was striking. This was especially true for influenza; in Queensland inter-seasonal influenza activity had increased significantly in recent years.[27] In trying to understand the dramatic virus control achieved, it is difficult to disentangle the relative contributions from the various NPIs. Besides the initial lockdown and physical distancing, increased hand hygiene and seasonal influenza vaccination may have made modest contributions to the reduction in influenza detections.[12] A recent Cochrane Systematic Review of 16 trials involving 61,372 participants found that hand hygiene reduced acute respiratory illness episodes by 11% (relative risk 0.89; 95% confidence interval [CI] 0.84, 0.95), although there was a high degree of heterogeneity between the studies and overall low certainty with the evidence.[28] Moreover, when the analysis was limited to laboratory-confirmed influenza (eight trials, 8,332 subjects), hand hygiene appeared to have little effect. The same authors identified a single cluster quasi-randomised controlled trial in two Japanese companies examining the effect of implementing home isolation for employees whose family members developed an influenza-like illness. While there was a

Table 2: Number of detections for six respiratory viruses across five different time periods in 2020 and the average number of detections in the equivalent time period during the five previous years (2015–2019), Queensland, Australia.[a]

	Period 1 (Weeks 1–11)		Period 2 (Weeks 12–21)		Period 3 (Weeks 22–31)		Period 4 (Weeks 32–38)		Period 5 (Weeks 39–52)	
Virus	**2020**	**2015–19**	**2020**	**2015–19**	**2020**	**2015–19**	**2020**	**2015–19**	**2020**	**2015–19**
No. of tests	**26,698**	**7,516**	**61,454**	**10,878**	**129,389**	**19,390**	**39,515**	**23,172**	**30,763**	**18,719**
Influenza	2,061	768	309	991	1	3,950	0	7,152	0	2,090
HMPV	664	183	371	190	23	409	7	891	18	1109
PIV	1,174	344	64	535	2	694	0	872	0	1,053
RSV	1,270	447	983	1,061	975	1,232	175	737	735	500
RV	6,310	1,914[b]	6,683	3,140[b]	63,249	5,353[b]	11,328	3,817[b]	9,799	4,006[c]
ADV	331	199	740	320	2,309	676	872	604	728	568

Notes:

ADV, adenovirus; HMPV, human metapneumovirus; PIV, parainfluenza virus, RV, rhinovirus; RSV, respiratory syncytial virus.

***Period 1** (Weeks 1–11): Pre-pandemic; **Period 2** (Weeks 12–21): State-wide lockdown; **Period 3** (Weeks 22–31): Easing the restrictions and reopening of state schools; **Period 4** (Weeks 32–38): Greater Brisbane lockdown; **Period 5** (Weeks 39–52): continuation of physical distancing and other simple public health measures.*

a: Chi-squared test was used to compare the average percentage of positive tests for the years 2015–2019 with 2020 figures for each time period. "All comparisons are statistically significant (p≤0.001) by chi-square tests except HMPV Period 1 (p=0.79), PIV Period 1 (p=0.50), and RSV Period 5 (p=0.05)".

b: 2017–2019 average.

c: 2016–2019 average.

20% reduction in influenza among the intervention group compared to controls (2.75% vs. 3.18%; hazard ratio 0.80; 95%CI 0.66, 0.97), those workers who stayed at home with ill family members were twice as likely to be infected.[29]

Queensland is a popular national and international tourist destination, and genomic sequencing has identified each year that there are multiple incursions by global influenza virus populations into Australia, with a rapid spread between cities and states.[30] The severe reduction in international travel into Australia combined with mandatory 14-day hotel quarantine on arrival, which exceeds the incubation period and duration of most respiratory viral infections, is likely to have played an important role in the sustained decline in influenza detections in Queensland and elsewhere in Australia. This is especially likely given the decline of influenza virus activity reported in other Australian states[11,12] and internationally.[6,31,32]

In 2020, 18 million doses of influenza vaccine were distributed to Australian healthcare providers.[33] Unfortunately, data from the Australian Immunisation Register are incomplete, with just nine million doses recorded. While 44% of children aged six months to <5 years and 64% of adults aged ≥65 years received at least one dose of influenza vaccine between March and August 2020, compared with 40% and 59% in 2019, respectively, these increases may have resulted in part from improved reporting rather than increased coverage.[34] Nevertheless, it is unlikely that such modest increases in vaccine uptake compared to 2019, where large numbers of influenza cases were recorded in the laboratory database, would have had such a profound effect on reducing influenza spread within Queensland. Taken together, it is uncertain what this sustained decline in influenza means for future seasonal influenza activity as population immunity declines and new incursions are expected when international borders reopen without travellers having to quarantine.

Consistent with observations in other Australian states,[14,35] RSV detections were lower than expected after the introduction of NPIs, which coincided with the annual seasonal RSV peak in Queensland.[17,18] However, RSV detections increased unexpectedly at the end of the year, well outside the usual seasonal period for this virus. The increased number of older children observed with positive RSV detections[14] combined with presumed waning population immunity and relaxing of COVID-19 restrictions may explain this surge in numbers, which in Queensland continued into January and February of 2021 (data not shown). Such RSV outbreaks were predicted in late 2020 by modellers in the northern hemisphere.[36]

The increased detection of rhinoviruses was likely influenced by changing testing behaviour. After the state-wide lockdown was relaxed, community members were encouraged to present for COVID-19 (and other respiratory virus) testing for even minor respiratory symptoms. It is possible such people would not have been tested previously and rhinovirus causing mild illnesses would not have been identified. Such biased sampling may have resulted in a higher proportion of all tests being positive despite no change in the underlying virus epidemiology. Nevertheless, there are other possibilities for the increased detection of rhinovirus seen in Queensland in 2020. Children are seen as key reservoirs of rhinovirus spread and primary drivers of adult infection.[7,37] Increased rhinovirus activity was reported previously in Australia[38] and North America[39] when children returned to school from vacation, and more recently in New South Wales, Western Australia, New Zealand, the United Kingdom and Europe following the easing of COVID-19 restrictions.[5,7,12,35,40,41] In addition to being transmitted directly and indirectly by respiratory secretions, rhinoviruses can also be shed in stools.[42] Moreover, it is a non-enveloped virus, which is less susceptible to alcohol-gel based hand sanitisers recommended during the COVID-19 pandemic and it survives on surfaces for prolonged periods.[43] Furthermore, face masks do not prevent the transmission of rhinovirus-containing droplets and aerosols.[44] Finally, in the absence of influenza and other virus competition and potential viral interference,[45] rhinoviruses may have filled an empty ecological niche and circulated more freely within the community.[46,47] Consequently, besides strict lockdown measures, NPIs may only have a limited impact upon rhinovirus transmission.

Despite the increased number of adenovirus detections in 2020 resulting from increased testing, it was the respiratory virus least affected by NPIs. Like rhinoviruses, adenoviruses are non-enveloped and can be transmitted directly and indirectly by respiratory secretions and the faecal-oral route. Adenoviruses survive for prolonged periods on environmental surfaces and are not inactivated by many disinfectants, including alcohol-hand gel.[48] We speculate that for these reasons NPIs had less impact upon adenovirus detections throughout 2020.

The strengths of our study are its state-wide coverage with a strong community focus that includes primary healthcare, private hospitals and residential care facilities. It uses a large dataset that is collected prospectively, includes six of the most prevalent non-COVID-19 respiratory viruses and encompasses six years of weekly testing data (from 2015 to 2020). The limitations are the lack of sociodemographic and clinical information and that it does not include data from Queensland government-funded hospitals, where more severe cases are likely to be managed.

Implications for public health

The NPIs introduced in Queensland as public health measures to mitigate transmission of SARS-CoV-2 were derived from prior pandemic influenza planning.[49] This provided an opportunity to determine their effects upon other respiratory viruses. Decreased detection of influenza, HMPV and parainfluenza following a 10-week lockdown period was sustained, while as NPI restrictions eased, RSV detections increased several months later, possibly from waning immunity, and rhinovirus and adenovirus detections increased as schools reopened and testing thresholds were lowered. These data inform pandemic planning in Queensland, as although confidence will be renewed with implementing NPIs while waiting for vaccine development for future novel influenza outbreaks, not all viruses are suppressed for a sustained period. The findings we present here should prompt further investigations to determine the relative contribution of individual NPIs on the successful suppression of respiratory virus transmission, as well as which interventions are sustainable for future primary prevention, considering the different physicochemical properties of viruses and their multiple routes of transmission.

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Supporting Information

Additional supporting information may be found in the online version of this article:

Supplementary Figure 1: A: Weekly number of specimens tested for respiratory viruses in 2020 and the corresponding average values for the previous 5-years (2015–2019). B: Weekly number of specimens tested for SARS-CoV-2.

Supplementary Figure 2: Weekly number of positive tests for respiratory viruses in 2020 and the corresponding average values for the previous 5-years (2015-2019).