

The Impact of COVID-19 Pandemic on the Health-Seeking Behaviour of an Asian Population with Acute Respiratory Infections in a Densely Populated Community

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Abstract

Background

The COVID-19 pandemic led to the implementation of various non-pharmaceutical interventions (NPI) as the Singapore government escalated containment efforts from DORSCON Orange to Circuit Breaker. NPI include mandatory mask wearing, hand hygiene, social distancing, and closure of schools and workplaces. Considering the similar mode of transmission of COVID-19 and other pathogens related to acute respiratory infections (ARI), the effects of NPI are postulated to decrease ARI attendances in the community. The uptake of respiratory-related vaccinations are surrogate indicators of the health-seeking behaviour amidst the pandemic. This study primarily aims to determine the effect of Singapore's NPI on ARI attendances across a cluster of polyclinics. The secondary aim is to determine the impact of COVID-19 outbreak on the uptake of influenza and pneumococcal vaccinations.

Methods

The effect of the nation-wide measures on the health-seeking behaviour of the study population was examined over three periods: (1) 9 weeks prior to the start of Circuit Breaker (DORSCON Orange period), (2) 8 weeks during the Circuit Breaker, and (3) 9 weeks after easing of Circuit Breaker. Data on ARI attendances and respiratory-related vaccinations uptake for the corresponding periods in 2019 were also extracted for comparison and to assess the seasonal variations of ARI. The average weekly workday ARI attendances were compared with those of the preceding week using Wilcoxon signed rank test.

Results

ARI attendances dropped steadily throughout the study period and were 50%-80% lower than in 2019 since Circuit Breaker. They remained low even after Circuit Breaker ended. Positivity rate for influenza-like illnesses samples in the community was 0.0% from the last week of Circuit Breaker to end of study period. Respiratory vaccinations uptake was higher in 2020 than 2019.

Conclusions

NPI and public education measures during DORSCON Orange and Circuit Breaker periods appear to be associated with the health-seeking behaviour of the public. Changing levels of perceived susceptibility, severity, benefits and barriers, and widespread visual cues based on the Health Belief Model may account for this change. Understanding the impact of NPI and shifts in the public's health-seeking behaviour can aid in the planning of future pandemic responses.

Background

The novel coronavirus 2 (SARS-CoV-2) or COVID-19 infection was declared a pandemic by the World Health Organization (WHO) on 11 March 2020, and has infected more than 45 million people globally as of end October 2020.¹ Current evidence shows that the COVID-19 virus is mainly transmitted via

respiratory droplets and contact routes.²⁻⁶ Preventive measures to reduce its transmission include wearing of face masks, good hand hygiene and isolation of infected persons.⁶⁻⁷ The escalation of the pandemic has resulted in many nations enacting emergency health policies and national-wide measures to decelerate the spread of the virus.

The COVID-19 pandemic led to the establishment of a multi-ministry taskforce by the Singapore government to manage the local outbreak. The taskforce leverages on the Disease Outbreak Response System Condition (DORSCON) to guide the implementation plan.⁸ It raised the DORSCON to Yellow on 21 January 2020 and to Orange level on 7 February 2020. A set of preventive measures was mandated as a "Circuit Breaker" (CB) to curb the transmission of COVID-19 within the community⁹. These CB measures were implemented from 7 April to 1 June 2020, and COVID-19 (Temporary Measures) Act 2020 was gazetted to ensure strict enforcement of the measures.¹⁰ The CB measures include social distancing, working from home for employees, and full home-based learning for students. Free reusable masks were distributed to all residents. Recreation venues, attractions and places of worship were closed, and older persons were advised to stay home. Members of the public were advised to be socially responsible by practising good hand hygiene, wearing masks when going out, and consult a doctor if they were sick. Violation of these measures were subjected to penalties. People with symptoms of Acute Respiratory Infections (ARI) were given mandatory five-day sick leave to recover at home, and were not allowed to leave their homes except to seek medical attention. Those who failed to comply were liable to a fine of up to \$10,000, or imprisonment up to six months, or both, under the Infectious Diseases Act.¹¹

Singapore reported its first case of COVID-19 on 23 January 2020, and has more than 50,000 cases as of 31 October 2020.¹² It is densely populated with 5.7 million people living on the 721.5 square kilometres tropical island-state. Over 70% of its multi-ethnic Asian population live in close proximity within public high-rise housing estates.¹³ Pathogens such as influenza, parainfluenza, pneumococcus causing ARI are endemic. Like the COVID-19 virus, they are similarly transmitted from person-to-person via respiratory droplets, direct contact and fomites.¹⁴

These ARIs are commonly managed by primary healthcare providers in Singapore. The 20 public primary care clinics (polyclinics) and about 1700 private general practitioner (GP) clinics are the major local primary healthcare providers.¹⁵ Data from the Singapore Ministry of Health (MOH) showed over 153,000 ARI attendances in the polyclinics annually over the past three years from 2017 to 2019 respectively.¹⁶ ARIs are among the top 4 conditions seen at the polyclinics, making up 8.6-9.4% of polyclinic attendances in the past three years.¹⁷

Strict enforcement of nation-wide measures to contain the COVID-19 outbreak are postulated to affect the incidences of ARI. Non-pharmaceutical interventions (NPI) in the community, such as social distancing, have shown to be effective in reducing influenza transmission in East Asia.¹⁸⁻²¹ Preventive measures such as up-to-date influenza vaccinations will also mitigate the ARI risk in the community. Soo RJJ et al reported that influenza activity had declined in Singapore in the current year 2020 based on routine

sentinel surveillance data on influenza-like infections from a national network of primary care clinics and the National Public Health Laboratory, suggesting that the measures taken for COVID-19 were effective in reducing the local spread of other respiratory diseases.²² Considering the similar mode of transmission of COVID-19 and other pathogens related to ARI, the effect of NPI and collective CB measures are postulated to decrease the ARI attendances in the community in Singapore. The uptake of influenza and pneumococcal vaccinations are also surrogate indicators of their health-seeking behaviour amidst the pandemic.

Study Aims

This study primarily aims to determine the effect of Singapore's NPI on the ARI attendances across a cluster of polyclinics. The secondary aim of the study is to determine the impact of COVID-19 outbreak on the uptake of respiratory-related vaccinations, namely influenza and pneumococcal vaccinations.

Method

Study site

SingHealth Polyclinics (SHP) serve an estimated 1.3 million residents, which constitutes 23% of Singapore's 5.7 million population, living in the eastern region of the island state.¹⁵ These polyclinics serve as "one-stop" healthcare centres providing accessible and affordable primary healthcare services to the local residents, including influenza and pneumococcal vaccinations. SHP manage about 6,400 patients daily during each workday in its network of 8 polyclinics.²³ In 2019, an average of 5471 patients attended these polyclinics for ARI per week based on disease coding in the electronic medical records system.²⁴

Study period

The effect of the nation-wide measures on the health-seeking behaviour of the study population was examined over three periods: (1) 9 weeks prior to the start of Circuit Breaker (corresponding to DORSCON Orange period), (2) 8 weeks during the Circuit Breaker (7 April to 1 June 2020), and (3) 9 weeks after easing of Circuit Breaker (2 June to 1 August 2020). The public was allowed to seek medical attention, including ARI, throughout the observation period. Data for the corresponding periods in the preceding year was also extracted for comparison and to assess the seasonal variations of ARI.

Study population

The study population consisted of all patients who attended SHP for ARI during the observation period. This included Singapore citizens, permanent residents and non-residents of all ages who may either walk-in or make a prior appointment to be seen at any of the SHP clinics. Patients may self-present or be referred by medical practitioners in both public and private practice.

Definition of case

ARI attendance was defined as a visit by a patient to any branch of SHP for the diagnoses of acute bronchitis, influenza-like illness (ILI), upper respiratory tract infection (URTI) and pneumonia. These diagnoses were coded by the attending doctor into the SHP electronic medical records system, Sunrise Clinical Manager (SCM). The codes originate from the International Classification of Diseases (ICD-10) codes J20.9, J10.1, J06.9 and J18.9 respectively.

De-identified aggregated data on influenza and pneumococcal vaccinations were extracted for the observation period in 2020 and the corresponding periods in the preceding year (2019). These were based on the service codes entered by SHP nurses who administered the vaccinations into an electronic operational system, Outpatient Administration System (OAS). The service codes used for influenza, adult and child pneumococcal conjugate (PCV13) and pneumococcal polysaccharide (PPSV23) vaccines were PINF2, PPVNIH, PPVNI, and PPNV respectively. Instead of attendances, the headcounts of the recipients are computed for each type of vaccine, regardless of the multiplicity of the vaccine doses.

Database and data extraction

The clinical information and records documented by the polyclinic staff in the SCM and OAS are channelled into the institution's data warehouse, Enterprise Health Intelligence System (eHIntS). eHIntS is an enterprise business intelligence repository integrating clinical information, business workload and finance for reporting and healthcare analysis. The study data was extracted from eHIntS based on the four stipulated ARI diagnoses tagged to their corresponding ICD-10 codes and the service codes of the vaccinations within the observation period.

Data

Three main datasets were extracted: (1) the total weekly ARI attendances at the 8 polyclinics, which were grouped according to age, gender, ethnicity and respective clinic; (2) the total weekly attendances for each of the 4 ARI diagnoses, and (3) monthly uptake for influenza and pneumococcal vaccinations at all 8 SHP clinics. The age groups were specified as child (0-16 years old), adult (17-64 years old) and older adult (≥ 65 years old). This was performed by setting filters in eHIntS for time periods, diagnosis codes, age limits, race, and gender. The polyclinics are operational for half a day on Saturdays and close on Sundays and public holidays. The average weekly ARI attendances were computed based on number of workdays for the specific week.

Data management

The data was extracted and processed by the Health Information Department. The Principal Investigator documented the data extraction algorithm to allow for data re-examination if necessary. The data was recorded in Microsoft Excel spreadsheets by the PI and backup copies maintained by the co-investigators in password-protected computers. Data would be archived for 7 years as per local research ethics guidelines and policy.

Statistical analysis

The average weekly workday ARI attendances were presented in Figure 1, and were compared with those of the preceding week using Wilcoxon signed rank test. The rate of change of average weekly workday attendance was derived from taking $[\text{Attendances in Week } n - \text{Attendances in Week } (n-1)] / \text{Attendance in Week } (n-1)$. All analyses and charts were performed and plotted using IBM SPSS 25.0 and Tableau Desktop 2019.1, and Excel. A p-value of less than 0.05 is considered statistically significant.

Results

The results are presented chronologically across the three stipulated periods.

a) Average Workday Total ARI Attendances Per Week

DORSCON Orange

The ARI attendances were generally higher in early 2020 than 2019. There was a significant peak just before the start of DORSCON Orange with an average workday attendances of 1624 per week. It reflected the greatest rate of increase of 29.0% from the preceding week. This was followed by a steep decline of 19.9% from the first week of DORSCON Orange period. Henceforth, there was a steady decline of average weekly workday attendances and also when compared to 2019, reaching a lowest average weekly workday attendances of 685 at week 14. There was a brief period of statistically significant rise of 11.3% in ARI attendances from week 12 to 13.

Circuit Breaker

CB period saw a further decline in the ARI attendances. There was a significant drop in average workday ARI attendances per week by 26.6% after the first week of CB, and by 22.5% after the second week of CB.

Compared to the corresponding period in 2019, which had a consistent average workday attendance per week of 1061, the same period in year 2020 saw a steady weekly drop in ARI attendances from a weekly workday average of 504 in week 15 (start of CB) to a lowest of 186 in week 21. Towards the end of CB, there was a gradual rise in the ARI attendances, from an average of 186 in week 21 to 283 in week 23. This was reflected as a significant increase of 10.3% at week 23, which corresponded to the end of CB.

End of Circuit Breaker

The only statistically significant increase in average weekly workday ARI attendances of 23.4% was seen in the first week after the end of CB. This was then followed by a 4-week period of non-statistically significant decline in ARI attendances. Week 30 showed a statistically significant decline in ARI attendances of 20.4%.

The corresponding period in 2019 showed much higher ARI attendances. The average workday ARI attendances per week in 2019 showed a continuous increase with the only exceptions being weeks 28

and 31 having statistically significant declines of 0.3% and 8% respectively.

Our findings corroborated with national data from Singapore's MOH which reported weekly polyclinic attendances for ARI. Mean weekly national polyclinics attendances for ARI dropped by 31.3% from epidemiological weeks 1-5 to epidemiological weeks 6-14 during DORSCON Orange, and plunged by a further 69.5% for epidemiological weeks 15-22 during CB. It dropped further to 1.9% at the end of our study period. The overall positivity rate for influenza among ILI samples in the community was 0.0% during the last 4 weeks of our study period.¹⁶

b) Average Workday ARI Attendances Per Week By Age Groups

The decrease in average workday ARI attendances per week was seen in all 3 age groups during the CB period, with the greatest drop seen amongst the children, from an average of 247 in 2019 to 121 in 2020.

Paediatric ARI attendances

Prior to DORSCON Orange, an average 295 and 262 workday paediatric attendances for ARI for 2019 and 2020 respectively were observed. However, when DORSCON Orange measures were implemented, such attendances declined steadily to 177 in 2020 compared to 249 in 2019. During the CB, the attendances declined significantly further to an average weekly workday attendance of 26 compared to 254 in 2019. This attendance increased slightly with easing of CB measures from week 23 to 54, but was still lower than the mean attendances of 230 in 2019.

Adult ARI attendances

For epidemiological weeks 1-5, the average workday adult ARI attendances per week in 2020 was higher at 847 compared to 754 in 2019. During the DORSCON Orange period, the average workday child ARI attendances for adults were comparable, at 620 in 2020 compared to 624 in 2019. During the CB, the average workday adult ARI attendance per week in 2020 declined to 207 compared to 660 in 2019 during epidemiological weeks 15-22. This reflected an approximate 70% reduction in attendance.

Older Adult ARI attendances

For older adults, the average workday attendances per week in 2020 declined by half (51%) during the DORSCON Orange period and by a further 53% to 47 during the CB. This was in contrast to 2019 when the average workday attendance per week remained fairly constant at approximately 150.

c) Average Workday ARI Attendances Per Week By Diagnosis

Bronchitis

Average workday bronchitis attendances per week showed a steady decline throughout DORSCON Orange period. The rate of decline was steepest during DORSCON Orange, as reflected by a drop of 66.7% during this period. Subsequently, the attendances generally levelled off at this low level during CB period.

When CB period ended, the average weekly attendances decreased by 69.0%, as compared to the corresponding period in 2019.

ILI

Average workday ILI attendances per week showed 2 peaks in attendances in 2020. The first peak occurred at epidemiological week 2, which coincided with one of the bimodal increases in influenza incidence from November to January in Singapore. It corresponded approximately to the influenza season in the Northern hemisphere. The second peak in average workday ILI attendances per week was unexpected. It occurred approximately 6 weeks after DORSCON Orange was declared. The increase of 86.7% in 2020 was higher than the peak in 2019.

Pneumonia

Prior to DORSCON Orange period, the average weekly attendances for pneumonia in 2020 was higher than similar period in 2019. There was an average weekly attendance of 15 in the first 5 weeks of 2020 compared to 8 in 2019. The sharpest decline for pneumonia related attendances was noted during DORSCON Orange and levelled off during CB. Subsequently there was a gentle decline in the post Circuit Breaker period, which was a contrast to the increase in attendances seen in 2019 for this period.

URTI

There was a spike in average weekly attendances just before the implementation of DORSCON Orange in 2020, as compared to the same period in 2019. This was followed by a decline of 27.9% during the first half of DORSCON Orange period. URTI attendances continued to drop further during the CB period, accounting for an average decline of 74% during this period. It remained at this low level even after the CB period ended.

d) Influenza Vaccination Uptake

Uptake of influenza vaccination in Singapore demonstrated two peaks which corresponded to winter in Southern and Northern hemispheres. The uptake of Influenza vaccination generally increased across all age groups in Singapore in 2020. This was most apparent for the months of January to April 2020 when compared to the corresponding months in the preceding year. There was a total of 2965 Influenza vaccinations in January 2020, compared to 1683 in January 2019, which indicated an increase of 76.2%.

The uptake of Influenza vaccination increased even further after the implementation of DORSCON Orange. February 2020 registered a total of 1483 Influenza vaccinations, marking an increase of 144.3% from 607 in February 2019. In March 2020, the polyclinics administered a total of 4430 Influenza vaccinations, which was a marked increase of 198.7%, compared to February 2020. As we progressed to CB, there were 3629 Influenza vaccinations in April 2020, which was a drop of 18.1% from the preceding month. The uptake continued to decline by 16.6% at 3027 vaccinations in May 2020. After the end of the CB period, a sharp increase in vaccinations by 34.2% in June 2020 but decreased in July 2020 by 28.0%.

e) Pneumococcal Conjugate (PCV13) Vaccination Uptake

The uptake of PCV13 vaccination was fairly constant from the end of 2019 to January 2020. A slight dip of 9.4% was observed when DORSCON Orange was implemented in February 2020, which rose by 33.0% in March 2020 but reduced by 15.3% in April 2020 when CB commenced. There was a decrease of 17.6% in May 2020. The uptake rose by 25.8% to 1892 vaccinations in June 2020 after the CB, and another 1.6% to 1922 in July 2020.

f) Pneumococcal Polysaccharide (PPSV23) Vaccination Uptake

The PCV13 vaccination uptake was constant from the last few months of 2019 to January 2020. The vaccination decreased by 19.3% from 455 in January 2020 to 367 in February 2020 when DORSCON Orange was implemented. It was elevated by 45.2% to 533 in March 2020, then declined by 24.0% to 405 in April 2020 when the CB began. The uptake rose sharply by 65.8% to 673 in June 2020 upon easing of the CB, and by a further 9.5% to 737 in July 2020.

Discussion

The average weekly workday ARI attendances showed a steady decline throughout both DORSCON Orange and CB periods, but with a slight transient increase of around 10-24% at the end of each period. Even after easing of CB, the ARI attendances remained lower than those in 2019 by 62.6-81.5%. This could be attributed to the continuation of NPI introduced during CB which resulted in decreased ARI transmission in the community. Other factors such as heightened awareness of mode of transmission and deliberate avoidance of high risk places such as polyclinics likely also contributed to this decline.

Individual NPI such as mandatory mask wearing, hand hygiene and respiratory vaccinations have been associated with decreased ARI attendances throughout and post CB. However in a systematic review by Wang et al²⁵, it was found that surgical mask usage had a non-significant protective effect in reducing the risk of ARI among asymptomatic individuals in non-healthcare settings. This contrasts with a review by Jefferson et al²⁶, which found face mask to be the best performing intervention compared with other physical NPI studied across different population and settings. Another systematic review by Cowling et al²⁷ found that there was some evidence to support the wearing of masks or respirators during illness to protect others, and public health emphasis on mask wearing during illness may help to reduce influenza virus transmission. Chou et al²⁸ reported that evidence on mask effectiveness for respiratory infection prevention was stronger in healthcare than community settings. Factors affecting the efficacy of face masks include proper usage, type of masks, compliance, droplet or aerosol transmission, and healthcare or community setting. Thus its efficacy can be highly variable.

The evidence for hand hygiene, another individual NPI in curbing ARI transmission is equivocal. In a systematic review performed by Warren-Gash et al²⁹, it was found that the greatest effect of hand hygiene was seen in two studies in low to middle-income settings, which may partly be explained by

differences in access to soap and hand-washing equipment. In higher-income settings, smaller effects were seen, which tended to be in institutions such as childcare centres and schools. Similarly, a population-based study in Sweden by Merk et al³⁰ suggests that increases in what adult laymen perceive as being adequate hand-washing may not significantly reduce the risk of ARIs. Hence the efficacy of hand hygiene is dependent on the adequacy of hand hygiene techniques, use of appropriate soap, and extent of exposure. Another key factor is the different transmission routes of ARI. Hand hygiene has a greater effect in cases of droplet transmission versus aerosol transmission.

The United States Centres for Disease Control and Prevention (CDC) started tracking the effectiveness of the influenza vaccine since 2003. Since then, its effectiveness has varied from year to year, from a low of 10% in 2004-05 to a high of 60% in 2010-11.³¹ Influenza vaccination appeared to reduce the risk of severe disease of those infected despite vaccination^{32,33}, provided moderate protection against influenza-associated hospitalisations in adults³³ and reduced intensive care admissions.³⁴ The attenuation of disease severity could explain the decreased ARI attendances in our study as people could self-medicate or recuperate at home instead of seek medical attention. The decline in and sustained low ARI attendances coincided with an increase in uptake of influenza vaccination.

Various community NPI were implemented during the study period such as home confinement through Work From Home (WFH) and Home Based Learning (HBL) for school-going children. Social distancing interventions during CB included restricting visitations and gatherings amongst individuals of different households, closing of mass religious gatherings and cancellation of mass events. Safe distancing measures such as keeping 1-metre distance from other individuals continued even after CB period. A systematic review by Rashid et al³⁵ suggested that school closure seemed to be moderately effective in reducing the transmission of influenza and in delaying the peak of an epidemic. Work place-related interventions like work closure and home working are also modestly effective. Internal mobility restriction is effective only if prohibitively high (50% of travel) restrictions are applied and mass gatherings occurring within 10 days before the epidemic peak are likely to increase the risk of transmission of influenza. Ajelli et al³⁶ found that school closure over the weekends contributed to decrease the effective reproduction number of about 8% and significantly affected the pattern of transmission. These results highlight the pivotal role played by schools in the transmission of the 2009 H1N1 influenza. Using data from 2009 H1N1 pandemic influenza outbreak in Pennsylvania, Cauchemez et al³⁷ also reported strong association between-place interactions with back- and-forth waves of transmission between the school, the community, and the households. School-aged individuals facilitated the introduction and spread of influenza in households, but most cases were not infected by school-aged household members.

The fast evolution of COVID-19 into a worldwide pandemic seems to be associated with the shifts in health-seeking behaviour of the local population. The Health Belief Model provides a plausible framework for this behaviour change.

In line with the Health Belief Model^{38,39}, the escalation to DORSCON Orange and CB likely increased the public's Perceived Susceptibility and Perceived Severity of COVID-19 in the community, and also served

as Cues to Action to practise social distancing measures such as staying home as much as possible. Stricter social distancing measures were explicit visual cues when they were implemented at the end of week 13 such as closure of all entertainment venues, ensuring of sufficient separation of dine-in areas in food and beverage outlets, limiting gatherings outside of work and school to a maximum 10 persons, cancellation of all religious gatherings and closure of all enrichment centres. The government also made it a legal requirement for patients to be issued with sick leave for ARI for stay-home convalescence during the duration of the sick leave. The above measures could have contributed to both decreased community transmission of ARIs and avoidance of clinic visits due to perceived risk of COVID-19 transmission in healthcare establishments.

The public's "Perceived Barriers" to seeking medical attention for mild ARI could have outweighed their Perceived Benefits of visiting a healthcare establishment. Perceived Barriers such as risk of transmission of COVID-19 when out of their homes, issuance of mandatory 5-day sick leave and fear of having to undergo a COVID-19 nasopharyngeal swab test greatly outweighed the Perceived Benefits of a medical attendance. Mild ARI could easily be self-medicated at home. Closure of non-essential workplaces and all schools negated the need to obtain sick leave when unwell.

There was however a single disruption in the steady decline of ARI attendances during DORSCON Orange period. Week 12 to 13 saw a brief period of statistically significant rise in ARI attendances of 11.3%. This corresponded to the start of Malaysia's Movement Control Order (MCO) and implementation of safe-distancing measures in Singapore. Singapore has a substantial workforce from Malaysia. These Malaysian workers commute to and from Singapore daily. Malaysia's MCO comprised of closure of its borders to all, and required returning residents to undergo mandatory health checks and 14-day quarantine upon return. It could be possible that those who wanted to return to Malaysia contributed to this rise as they wanted to find out if they were medically fit to travel back to Malaysia.

Safe-distancing measures initiated in Singapore included 1-metre distancing in public venues, limiting of number of shoppers within stores, suspension of all events and gatherings with 250 or more participants and launch of a new mobile application TraceTogether to facilitate contact tracing. Week 12 also saw a ballooning of number of local COVID-19 cases from fewer than 100 cases in the preceding weeks to 226 cases at the start of week 12. The safe-distancing measures and escalation in the number of local positive cases could have heightened the public's awareness of COVID-19's symptoms, signs and the government's containment efforts. These would serve as Cues to Action in promoting health-seeking behaviour should any ARI symptom be encountered.

The first 2 weeks of CB saw the steepest decline in ARI attendances for the whole CB period, and also for the year 2020. This coincided with a political leader's public address to detail the even stricter CB measures such as school closures with full HBL, closure of non-essential workplace premises, no dine-in service at food and beverage establishments, closure of recreation venues and places of worship, setting up of an inter-agency task force to manage the growing issue of COVID-19 transmission in foreign workers' dormitories, declaration of 8 foreign workers' dormitories as isolation areas under the Infectious

Diseases Act, and precautionary mandatory Stay Home Notice (SHN) for all work permit and S-pass holders in the construction industry. It was also during these 2 weeks that the government made it mandatory for all to wear masks when out of home and distributed free reusable masks to all residents.

Influenza vaccination uptake generally increased since the start of 2020 as compared to 2019. This could be due to increased patient education and advice given by healthcare workers to older adults in view of the higher morbidity and mortality risks associated with advanced age.

The statistically significant rise in weekly average workday ARI attendances in the last week of CB likely coincided with the public's eager anticipation of the end of CB. The only statistically significant rise in ARI attendances occurred in the first week after the end of CB. Both observations were more likely to be attributed to increased health-seeking behaviour rather than an actual increase in ARI transmission as it was too short a duration post CB. Workers employed in certain workplaces such as educational institutions had to undergo a COVID-19 swab test prior to returning to work. With the reopening of schools and some workplaces, there was also a need to obtain sick leave when unfit for school or work. There could also be moral obligation to be checked for COVID-19 when having ARI to avoid transmission to others upon return to school or work.

The evolving data from a cluster of polyclinics which serve at least a third of the Singapore population constitutes a strength in the study. Our study was based on aggregated attendances from all ages and demographics within the study period, thereby minimising sample bias. Data was compared among the various phases of pandemic containment in 2020, as well as year-on-year with the preceding year, to minimise effect of seasonal variation. Implementation and compliance with NPI of this extent is not common, but was largely achievable during our study period due to the communitarian culture and trust in the leadership of the nation. The study hence provided a rare opportunity to evaluate the impact of a large array of NPI implemented as part of nationwide pandemic containment efforts by the government.

The study is limited to attendances in public primary care clinics. ARI attendances at the private GP clinics were excluded. The data were confined to 9 weeks of ARI attendances before and after the lockdown in 2020 and 2019. However, these were deemed to be sufficient to account for normal variations in weekly ARI attendances. Data on ARI attendances by individuals despite prior influenza and pneumococcal vaccinations were not available in this study.

This study highlighted the association of community NPI, respiratory vaccinations, and shifts in the public's health-seeking behaviour on decreasing ARI attendances during a respiratory infectious disease pandemic. This was congruent with a study by Noh et al⁴⁰ who reported the association of extensive application of NPI in response to COVID-19 and reduced influenza epidemic in South Korea. By engaging and educating the community across all age groups on the modes of transmission and methods to decrease ARI transmission from now onwards, the public's knowledge of and compliance with NPI and appropriate vaccinations are expected to improve. Such measures should be integrated as key components in any emerging infectious disease outbreak preparedness action plan.

Conclusion

NPI and public education measures during DORSCON Orange and CB periods appear to be associated with the health-seeking behaviour of the public and contributing to decreased ARI transmission. This translated to overall decreased ARI attendances in primary care clinics during the stipulated observation period. Changing levels of perceived susceptibility, severity, benefits and barriers, and widespread visual cues based on the Health Belief Model may account for the change in health-seeking behaviour. Understanding the impact of NPI on shifts in the public's health-seeking behaviour and ARI transmission can aid in the planning of future pandemic responses.

Abbreviations

ARI	Acute Respiratory Infections
CB	Circuit Breaker
CDC	Centres for Disease Control and Prevention
CIRB	SingHealth Centralised Institutional Review Board
DORSCON	Disease Outbreak Response System Condition
eHIntS	Enterprise Health Intelligence System
GP	General Practitioner
HBL	Home Based Learning
MCO	Movement Control Order
MOH	Ministry of Health
NPI	Non-pharmaceutical interventions
OAS	Outpatient Administration System
PCV13	pneumococcal conjugate vaccine
PPSV23	pneumococcal polysaccharide vaccine
SCM	Sunrise Clinical Manager
SHN	Stay Home Notice
SHP	SingHealth Polyclinics

URTI	upper respiratory tract infection
WFH	Work From Home
WHO	World Health Organisation

Declarations

Ethics approval and consent to participate

SingHealth Centralised Institutional Review Board (CIRB) approved a waiver of consent for this study (CIRB reference number: 2020/2570). Consent to participate was not applicable.

Consent for publication

Not applicable.

Availability of data and materials

The datasets generated and/or analysed during the study are not publicly available but are available from the corresponding author on reasonable request.

Competing interests

No competing interests to declare.

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No funding was received.

Authors' contributions

THMJ, TNC, CZY, TKT and TMS contributed to the conceptual design, data analysis and interpretation of the results. THMJ, CZY, TKT and TMS reviewed the literature. SL extracted the data, which were analysed by EK. Charts were prepared by EK and SL. THMJ, CZY, TKT, TMS drafted the manuscript. TNC, AE, DN and WH reviewed the draft and recommended amendments. THMJ and TNC revised the manuscript. All authors reviewed and approved the final manuscript before journal submission.

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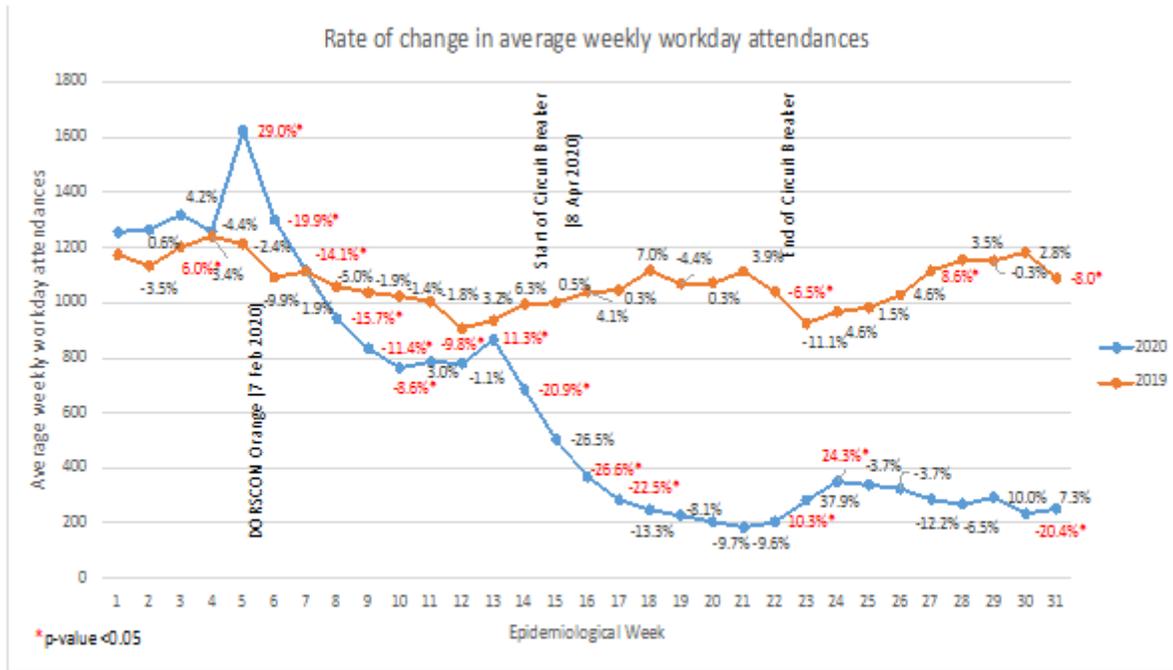
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Figures



Note: Epidemiological Week 1 is from 29 Dec 2019 to 4 Jan 2020

Figure 1

Rate of change in average weekly workday attendances

Rate of change in average weekly workday attendances

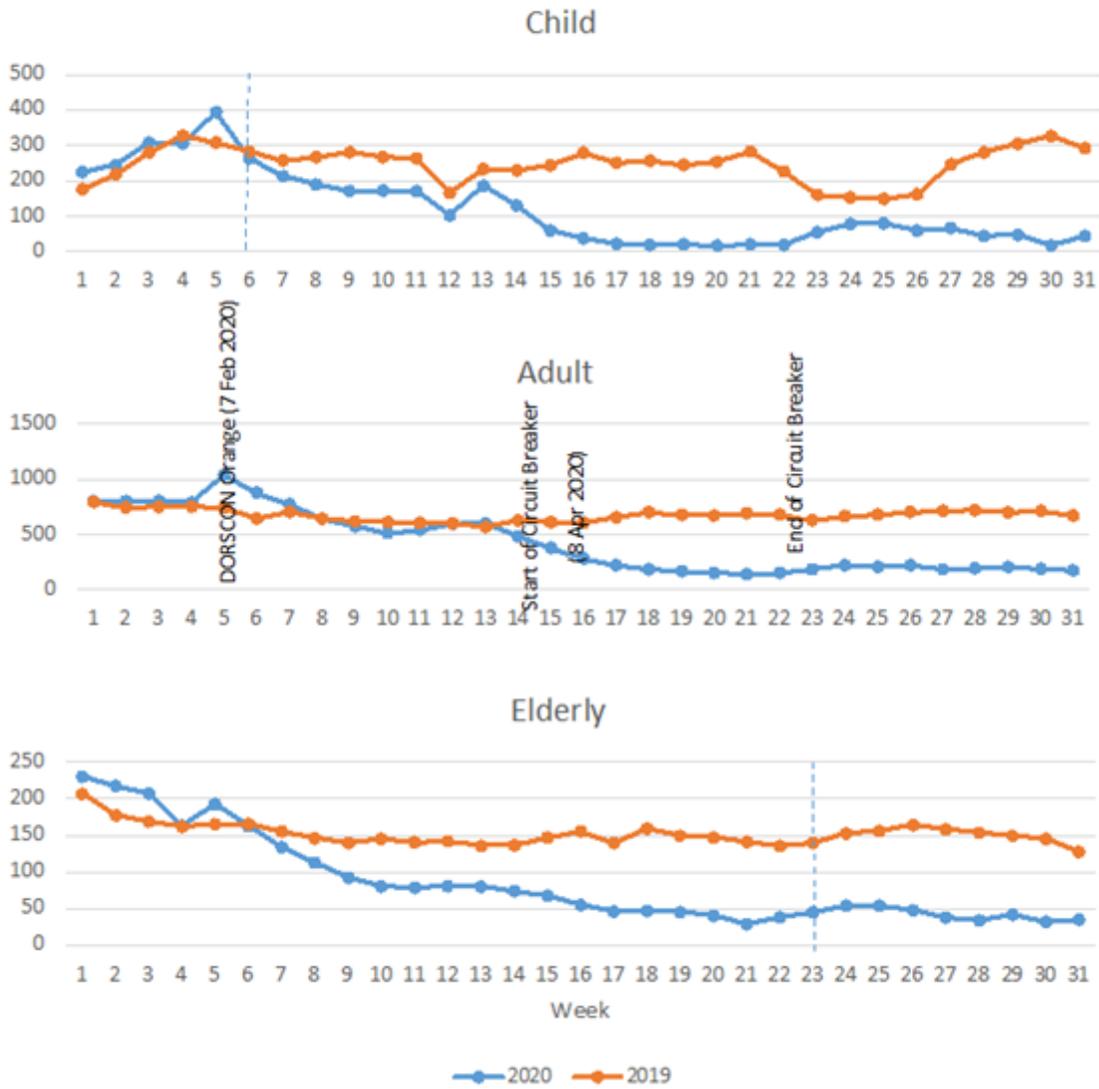
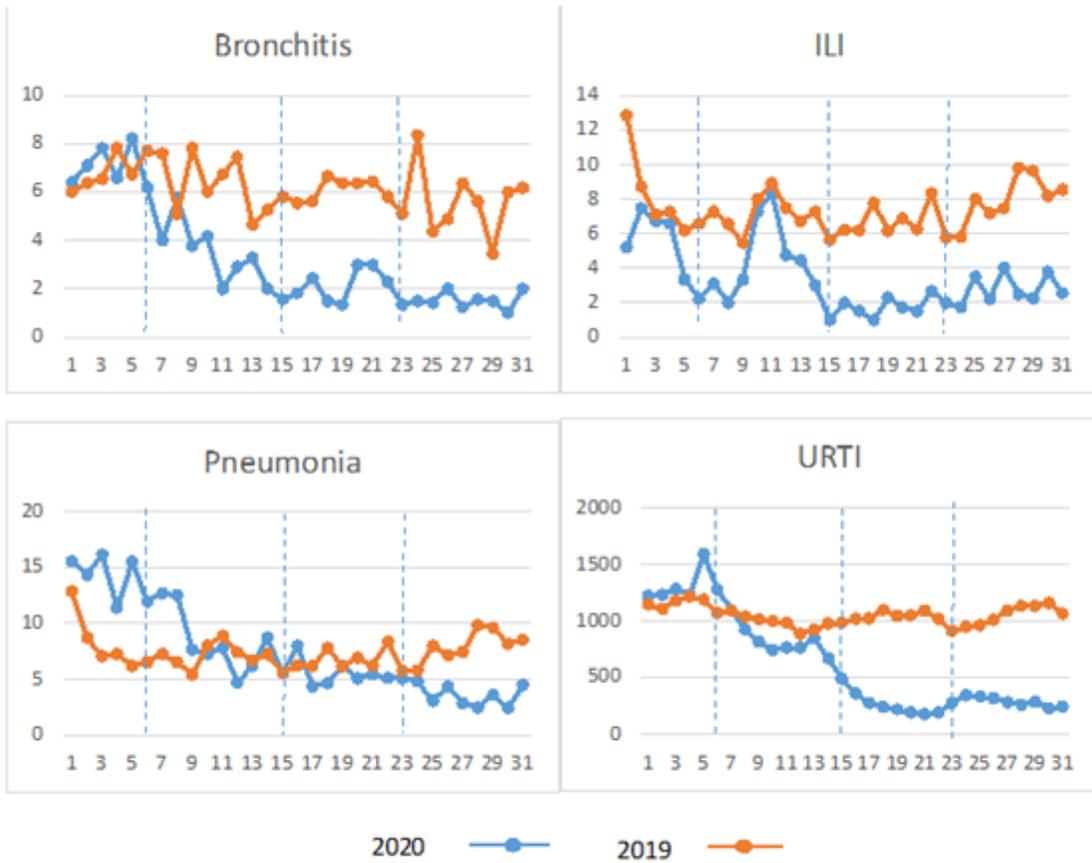


Figure 2

Rate of change in average weekly workday attendances by age groups

Rate of change in average weekly workday attendances



Notes:

1. Epidemiological Week 1 starts from 29 Dec 2019 to 4 Jan 2020
2. Epidemiological Week 6 – start of DORSCON Orange, Week 15 – Start of Circuit Breaker, Week 23 – End of Circuit Breaker

Figure 3

Rate of change in average weekly workday attendances by diagnosis

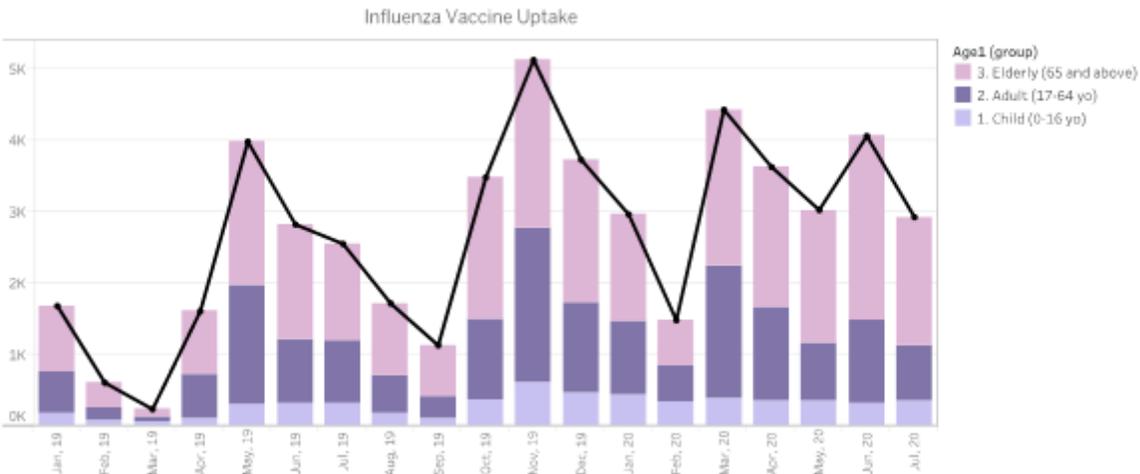


Figure 4

Influenza vaccination uptake

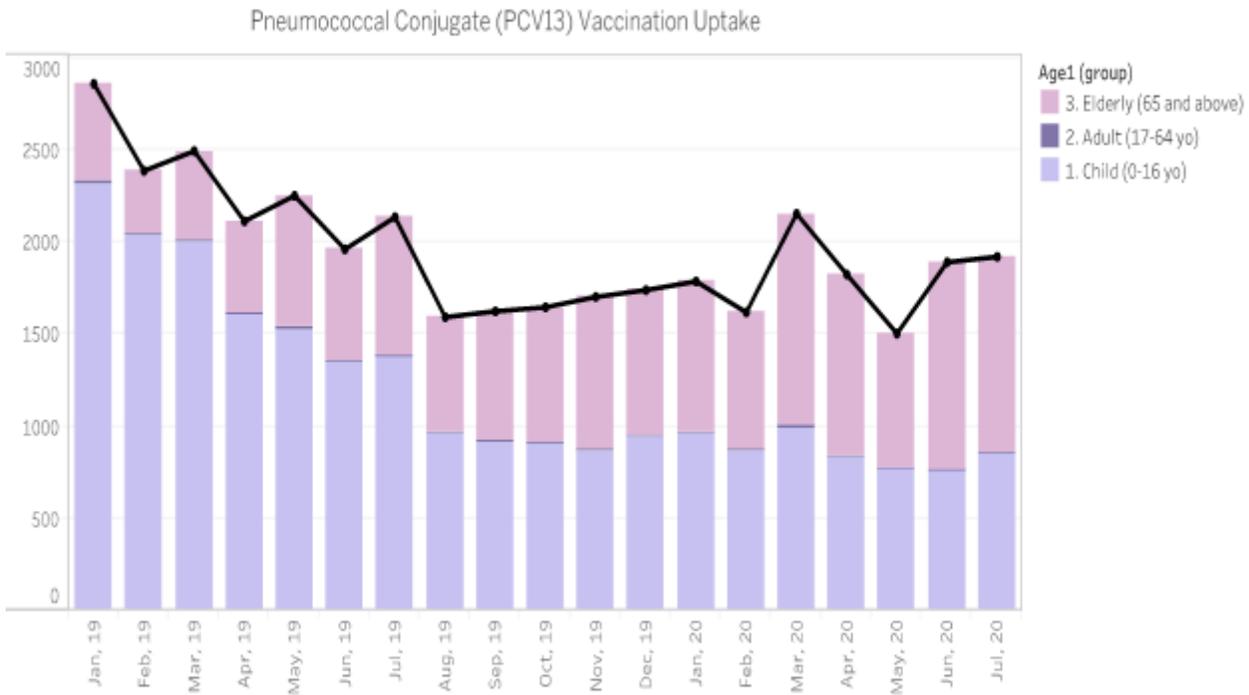


Figure 5

PCV13 vaccination uptake

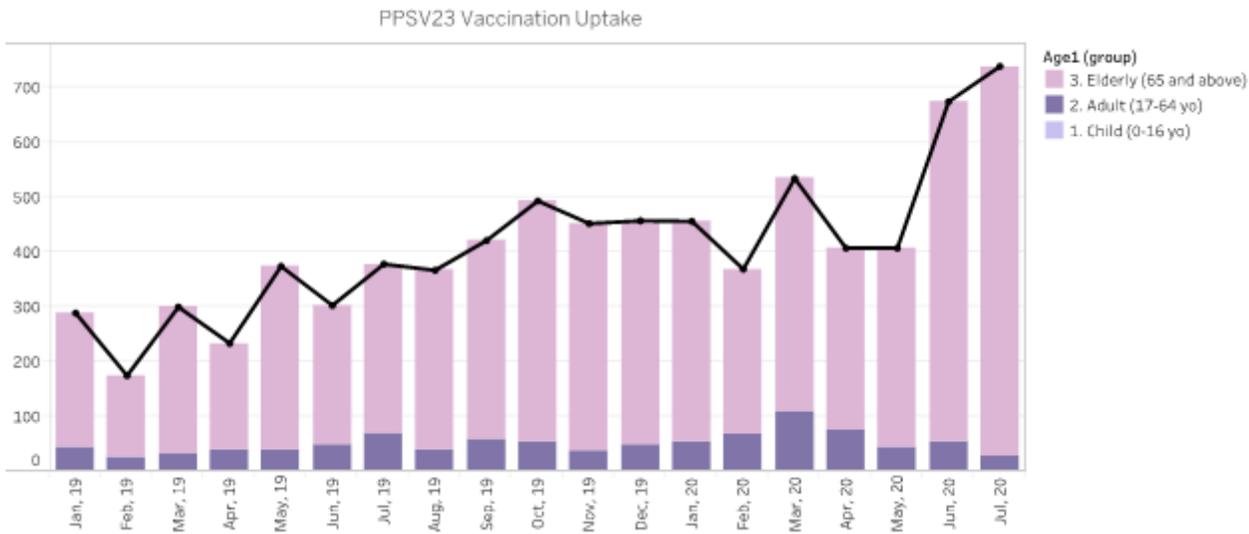


Figure 6

PPSV23 vaccination uptake

The Health Belief Model

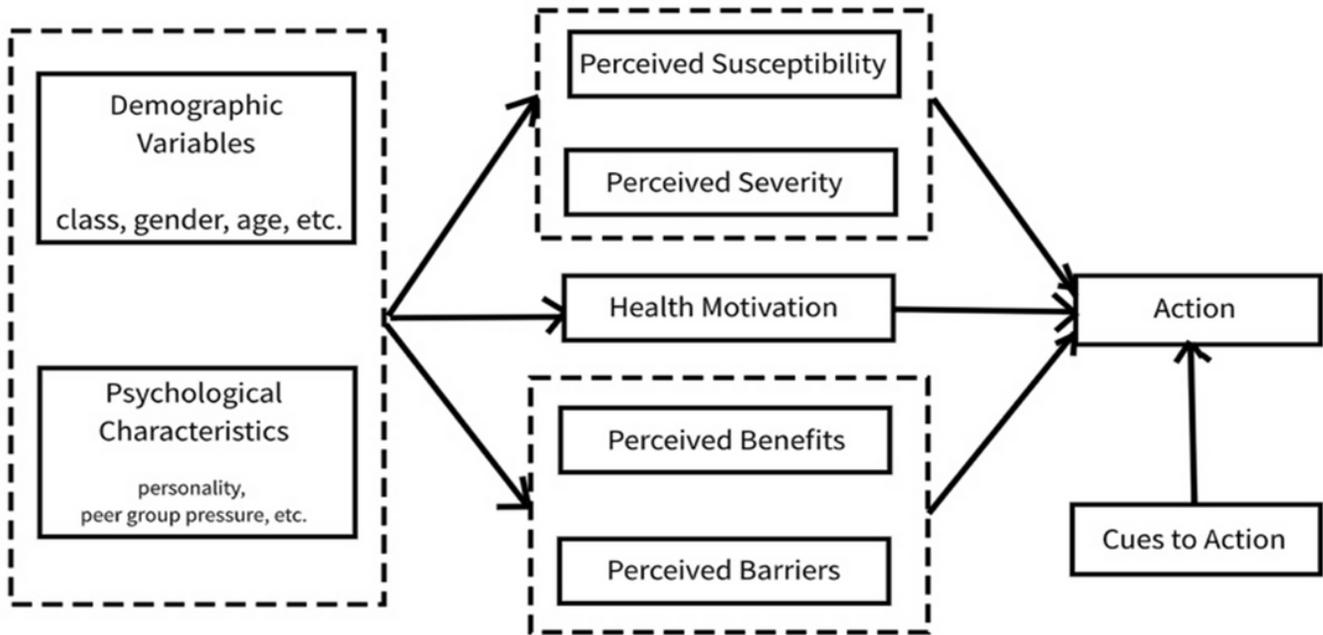


Figure 7

Health Belief Model