

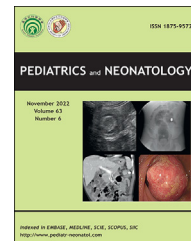


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Original Article

COVID-19 vaccination-related attendance at a pediatric emergency department in Singapore among 12- to 18-year old adolescents



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Key Words

BNT162b2 vaccine;
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post-vaccination
phenomenon

Background: Singapore was one of the first countries to begin COVID-19 vaccination with the BNT162b2 vaccine for adolescents aged 12–18 years. This study evaluates the incidence of COVID-19 vaccine related attendances to a Pediatric Emergency Department (PED) to understand post-vaccination health behaviors among adolescents.

Methods: This was a retrospective review of electronic medical records over a 4 month period, from the start of the adolescent vaccination drive to when more than 85% of this group had been fully vaccinated.

Results: The incidence of COVID-19 vaccination-related presentations to our PED was 3.1% over 4 months (291 of 9387 PED attendances), with a peak daily incidence of 15.4% (14 of 91 attendances). Presentations were characterized by severity into: severe (3.4%), moderate (7.9%) or mild (88.7%) based on predefined criteria. The most common presenting complaints were chest pain (58.8%), dyspnea (28.2%) and palpitations (22.6%). Hospitalization was required in only 6.2% of attendances. Patients with moderate-severe presentations were 0.7 years older ($p = 0.030$), more likely to have underlying drug allergies ($p = 0.048$) and had higher rates of hospitalization ($p < 0.005$) compared to mild presentations. Despite concerns of cardiac inflammation, chest pain related attendances were less likely to be severe ($p < 0.005$) with reduced hospitalization need ($p = 0.043$) compared to other presentations. Investigations beyond clinical assessment comprised 91% of attendances, but abnormalities were only found in 6.4% cases.

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Conclusion: Our study supports current evidence that COVID-19 vaccination is safe amongst adolescents. We highlight the health behaviors among adolescents post-vaccination, which is partly driven by media reports on vaccine side effects and an element of anxiety. While most of the presentations were mild, these can have implications on health resource utilization, particularly in an ongoing pandemic. As healthcare workers, we have an ongoing role to ensure accurate information on vaccine safety is communicated effectively to the public.

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1. Introduction

The coronavirus disease 2019 (COVID-19) pandemic caused by the SARS-CoV-2 virus has continued to spread rampantly across the globe. At the time of writing, the virus has infected more than 265 million individuals and caused more than 5.26 million deaths globally.¹ In an attempt to control the pandemic and reduce morbidity and mortality rates, various vaccines targeting the SARS-CoV-2 virus have been developed and tested. While many of these vaccines were originally authorized for those above 16 years of age, over time, with the persisting pandemic and continued emergence of new variants, many countries have begun authorizing immunization against COVID-19 for those 12–16 years.

The drive to vaccinate school-going children is well intentioned, particularly since this group contributes not insignificantly to viral transmission.^{2,3} Vaccinating school children against COVID-19 would theoretically contribute to herd immunity and eventually allow for in-person learning in schools, which is important for these children. Importantly, despite children and adolescents generally having milder COVID-19 infections compared to adults, severe illness can still occur in this group, particularly for those with underlying chronic conditions.⁴ This group is also at risk of the multisystem inflammatory syndrome in children (MIS-C), also known as paediatric inflammatory multisystem syndrome (PIMS) after infection with the SARS-CoV-2 virus, adding weight to the consideration for vaccination.⁵

Singapore was one of the first countries in the world to implement the COVID-19 vaccination for those aged 12–18 years. The vaccination drive was started for this age group from 3rd June 2021 with the messenger RNA vaccine BNT162b2 (Pfizer-BioNTech). This vaccination drive had begun shortly after the United States Food and Drug Administration authorized the Pfizer-BioNTech COVID-19 vaccine for children 12–15 years.⁶ Eligible patients would receive two doses of 30 µg of the BNT162b2 vaccine 21 days apart. At that time, data supporting vaccine efficacy and safety in adolescents had already been demonstrated in a large multinational randomized controlled trial, which had shown that out of 1131 adolescents receiving the BNT162b2 vaccine, none had experienced vaccine-related serious adverse events.⁷ Despite the scientific evidence demonstrating vaccine safety and efficacy, there continues to be substantial hesitancy and heightened anxiety pertaining to the COVID-19 vaccination globally.^{8–10} These phenomena are in part driven by numerous anti-vaccine campaigns and streams of misinformation circulating through social media,

which not only have an influence on vaccine acceptance among the general public, but may potentially affect post-vaccination behaviors.

With that in mind, we set out to study COVID-19 vaccination related attendances to the Pediatric Emergency Department (PED) for adolescents in our hospital. The objective of our study was to evaluate the incidence of COVID-19 vaccine related attendance to the PED and to understand the health behaviors of adolescents post-vaccination. We believe that such a study would provide valuable information to support vaccine safety, and would complement data from the COVID-19 vaccine adverse effects reporting platform, as it would capture not only serious adverse events, but also reflect health-seeking behaviors motivated by anxiety related to COVID-19 vaccination. More importantly, it will give us deeper insight into the healthcare utilization for post-vaccination care, a hidden economical factor that may not have been apparent to many.

2. Methods

This is a retrospective review of electronic medical records for all patients aged 12–18 years who attended the PED at the National University Hospital in Singapore from 3rd June to 30th September 2021. The period of data collection coincided with the start of the COVID-19 vaccination drive for children aged 12–18 years, and lasted until at least 85% of Singapore's eligible population had completed 2 doses of the COVID-19 vaccinations, which was the threshold the country had set for easing of pandemic-related restrictions.¹¹ Our hospital houses one of only two main PEDs serving Singapore, with an annual attendance rate of 40,000 to 45,000 attendances per annum. Ethics approval for this study was obtained from the National Healthcare Group Domain Specific Review Board (NHG DSRB 2021/00755).

We systematically screened through the list of all PED attendances within the period of data collection. Medical records of patients aged 12–18 years were scrutinized for suitable cases. The inclusion criteria for "cases" included: (1) Attending the PED with a COVID-19 vaccine related complaint and (2) Age group 12–18 years old. Demographic, clinical and COVID-19 vaccine related information were collected for all cases in a standard data collection template designed prior to data access. The clinical presentations were categorized into "mild", "moderate" or "severe" based on criteria defined *a priori* by the study team. "Severe" presentations were based on local clinical

guidelines on serious adverse events after the BNT162b2 vaccine and include the following: (1) immune (anaphylaxis, vasculitis, systemic inflammatory response), (2) neurological (Bell's palsy, encephalitis, myelitis, Guillain-Barre syndrome, other neuropathies), (3) cardiac (pericarditis, myocarditis or arrhythmias), or (4) hematological (thrombocytopenia: platelet $<100,000$ per microliter). "Moderate" presentations were defined by the authors as the following: not meeting criteria for "severe presentation" but with (1) symptoms concerning enough for the physician to recommend in-patient observation, (2) physician decision that subsequent doses of the vaccine would be contraindicated, (3) prolonged symptoms beyond 2 weeks, (4) physician recommendation for "off duty" or rest above 2 weeks. Presentations not meeting the "severe" or "moderate" criteria would automatically be categorized as mild. At least 3 senior authors had deliberated the cases for consensus on the categorization of all the presentations. For patients who had severe presentations, additional information on the clinical course, laboratory investigations and prognosis were summarized. In addition, we collected data on the number of hospital admissions and number of patients with multiple PED attendances for COVID-19 vaccine-related complaints.

The baseline characteristics of the study participants were tabulated. We also compared the characteristics of patients with moderate or severe presentations against those who had mild presentations, and compared those presenting with chest pain against other presentations. For the comparative data, statistical analysis was performed using the STATA BE Version 17 software from StataCorp LLC.

3. Results

The incidence of COVID-19 vaccine-related PED attendance was 3.1% over 4 months (291 of 9387 PED attendances), with a weekly incidence ranging from 0.5% to 8.5%. The peak daily incidence for vaccine-related complaint to our PED occurred in July, reaching 15.4% (14 of 91 attendances). This had coincided with media reports of a local case of vaccine-induced myocarditis in a teenage patient.¹² (Fig. 1) In parallel to that, we observed that the most common presenting complaints were chest pain (58.8%), followed by dyspnea (28.2%) and palpitations (22.6%). The incidences of attendance related to commonly encountered post-vaccination symptoms such as fever, injection site pain or myalgia were relatively low in our cohort, occurring in only 11.7%, 5.9% and 3.0% of cases respectively. Twenty (6.9%) of the attendances were classified as "reattendance", which meant that the same individual had visited the PED more than once for a COVID-19 vaccine related complaint.

Amongst the COVID-19 vaccine-related attendances, 10 (3.4%) were categorized as severe, 23 (7.9%) were moderate while the remaining 258 (88.7%) were mild. The severe presentations included anaphylaxis ($n = 3$) and pericarditis ($n = 3$), and single cases of erythema multiforme major, myocarditis, multifocal atrial tachycardia and Bell's palsy respectively (Table 1). There were no vaccine-related mortalities. Seven (2.4%) of the presentations were associated with a possible allergic reaction to the BNT162b2

vaccine, with presentations ranging from angioedema (eye or lip swelling), rashes to full manifestation of anaphylaxis.

The mean age of patients in our cohort was 14.6 years (S.D. 1.6), with a higher proportion of males. The majority of patients were Chinese, reflective of the baseline demographics of Singapore. Within our cohort, 27.1% of the cases had underlying chronic medical conditions, the most common being atopic diseases and obesity. In addition, 8.2% of cases had a previously diagnosed psychiatric diagnoses. There were 8.9% of attendances associated with a previous history of drug allergy. Eighteen (6.2%) of the 291 attendances required hospitalization, with a duration ranging from 1 to 8 days, and mean hospital stay of 3.3 days (Table 2).

Two-hundred sixty-five (91.0%) cases received further investigations beyond basic clinical assessment with history and physical examination. The most frequent investigation was the electrocardiogram, which was performed in 249 (85.5%) attendances. One hundred eighty-five (64.3%) attendances had additional blood investigations beyond a point-of-care capillary blood glucose. Despite the high number of additional investigations done, clinically significant abnormalities were only found in 6.4% cases, while the majority of the results were normal.

We compared the characteristics of the severe presentations against those with mild or moderate presentations. Those with moderate or severe presentations were older by 0.7 years ($p = 0.030$), and were more likely to have underlying drug allergies ($p = 0.048$) compared to those with mild presentations. Additionally, the moderate or severe presentations were more significantly associated with the first dose of vaccine compared to the mild presentations ($p = 0.041$). Unsurprisingly, there was a significantly higher rate of hospital admission for those with moderate or severe presentations ($p < 0.001$) (Table 3). Chest pain being the most prevalent presenting symptom was of interest to us, particularly with specific clinical protocols to detect peri-myocarditis, which was a concern with the BNT162b2 vaccine. Interestingly, chest pain related attendances were associated with 1.9 days longer onset of symptoms compared to other attendances ($p = 0.014$). Despite concerns of underlying cardiac inflammation, chest pain related attendances were associated with less severe presentations ($p < 0.001$) and reduced need for hospitalization ($p = 0.043$) compared to other presentations (Table 4).

Of the 152 presentations which were related to the first vaccine dose, in only 8 (5.3%) cases where there was a recommendation by the physician to withhold or postpone subsequent COVID-19 vaccine doses. All patients had complete recovery of symptoms with no permanent or residual dysfunction.

4. Discussion

As the world continues to be crippled by the ongoing COVID-19 pandemic, vaccination has been adopted as a key strategy to tackle this long-drawn health crisis. With increasing numbers of COVID-19 infection in children and the risk of MIS-C that follows, there has been much discussion about the inclusion of children in vaccination

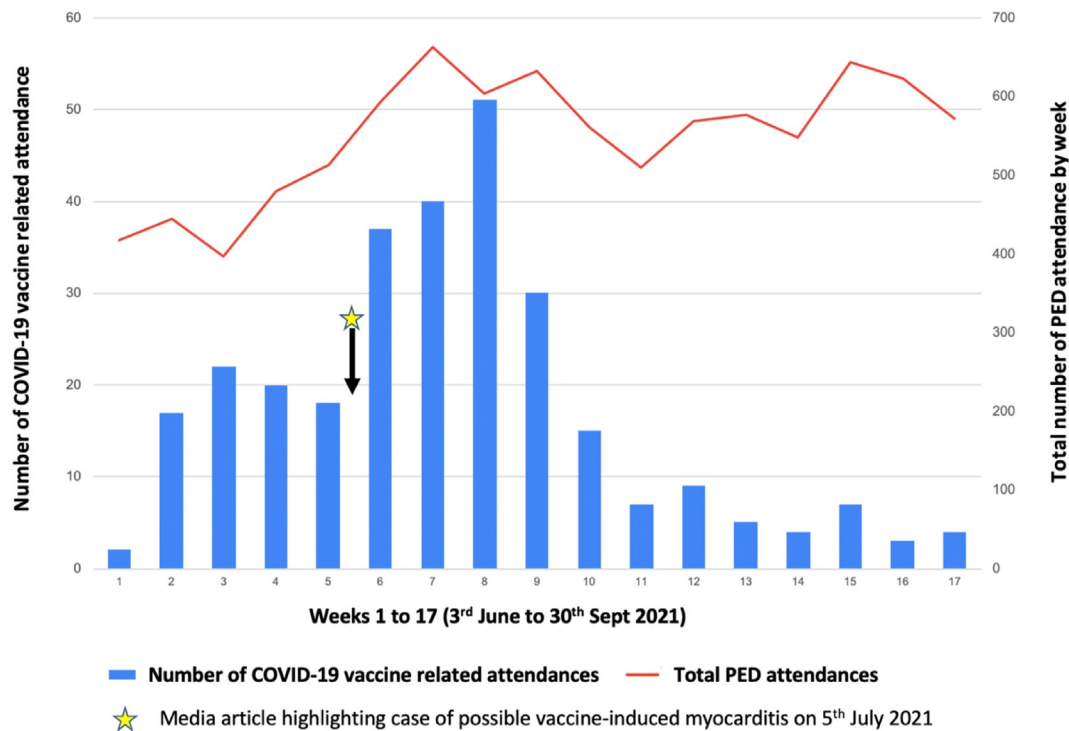


Figure 1 COVID-19 vaccination related attendances to the PED (by week). The initial surge in PED attendances relate to the rise in COVID-19 vaccine related attendances. From week 14, the high total PED attendance reflects the beginning of the Delta variant COVID-19 infection wave in Singapore.

programs.^{13,14} Like Singapore, many countries have already included adolescents aged 12 and above in their vaccination programs. Consistent with available literature, our study has demonstrated that the BNT162b2 vaccine is safe for adolescents with low prevalence of severe side effects.^{7,15} Our data supports available information on the safety of the BNT162b2 vaccine in the 12–18 years age group, of which the most commonly reported side effects include rash, angioedema, dyspnea, palpitations, chest tightness, fever, light-headedness and syncope.¹⁵ Interestingly, there were relatively lower incidences of the common expected post-vaccination symptoms, such as fever, headaches, myalgia and injection site pain presenting to our PED. We hypothesize that this may be related to the information on commonly encountered post-vaccination symptoms that were made readily available to patients and highlighted at the vaccination centers during the time of inoculation.

We demonstrated how post-vaccine attendances related to cardiopulmonary symptoms such as chest pain, palpitations and dyspnea peaked in our PED following media reports of cardiovascular collapse in a 16 year old male with possible post-vaccine myocarditis.¹² Our data reflects the concerns of the general public of the risk of developing post-vaccine peri-myocarditis following the news release. In our cohort, there was only 1 case of myocarditis and 3 cases of pericarditis respectively, all occurring in males. This rare adverse effect of the messenger RNA COVID-19 vaccine is known to be more prevalent in young males. Indeed in an Israeli study, the estimated incidence of myocarditis after the BNT-162b2 vaccine was reported to be

2.13 cases per 100,000 persons, with the highest incidence among male subjects between ages 16 and 29 years.¹⁶ Fortunately, the severity for these cases of myocarditis have been reported to be mild or moderate, with a very low mortality rate, similar to our reported experience. Despite the low incidences of myocarditis and the positive outcomes for those affected, our PED decided to develop a clinical protocol for screening suspected cases of post-vaccine peri-myocarditis. This was in response to considerable public concerns, the need for early detection of cardiac inflammation and to allow standardization of practice across clinicians. We had a low threshold for evaluation of peri-myocarditis in all attendees presenting with either chest pain, dyspnea or palpitations post-vaccine. The investigations undertaken consisted of: electrocardiogram, chest x-ray, cardiac enzymes (creatinine kinase (CK), CK-MB and troponin-I), full blood count, electrolyte panel, erythrocyte sedimentation rate and C-reactive protein. Reassuringly, the majority of the tests performed were normal.

Our study underscores the “post-vaccine phenomenon”, a term coined by the authors to describe the influx of post-vaccine complaints to the PED, whereby the individual experiences various mild non-specific symptoms following the COVID-19 vaccine, related to an element of anxiety, which self-resolve spontaneously. With the heightened media attention and propagated misinformation regarding side effects of the COVID-19 vaccines, post-vaccine phenomenon is not unexpected. Our experience highlights eloquently the temporal relationship between media releases and incidences of post-vaccine attendances to the

Table 1 Clinical characteristics of patients with “severe” presentations related to the COVID-19 vaccination.

Case	Diagnosis	Demographics	Clinical Course	Patient Outcome
1	Anaphylaxis	16 year old Male PMH: none NKDA	<ul style="list-style-type: none"> Presented with dyspnea, throat tightness and rashes a few minutes after the first vaccine; haemodynamics stable IM adrenaline not given as symptoms rapidly resolved Treatment received: antihistamines for rash 	Symptoms completely resolved within 2 h Recommended against second vaccine dose
2	Anaphylaxis	16 year old Female PMH: asthma NKDA	<ul style="list-style-type: none"> Presented with pre-syncope, globus sensation, rash and hypotension shortly after the second vaccine Received intramuscular adrenaline at vaccination center 	Admitted for 24 h due to persistent dizziness, subsequently resolved Recommended against second vaccine dose
3	Anaphylaxis	16 year old Female PMH: rosacea NKA	<ul style="list-style-type: none"> Presented with lip swelling, dizziness, facial flushing and dyspnea 6 h after second vaccine. Haemodynamics stable Symptoms resolved with antihistamines Did not require IM adrenaline 	Symptoms spontaneously improved
4	Erythema multiforme (EM) major	17 year old Female	<ul style="list-style-type: none"> Presented with diffuse urticarial rashes over whole body 20 days after first vaccine taken Associated with fever and respiratory symptoms Rash rapidly worsened with some mucosal involvement Skin biopsy histology consistent with EM Extensive evaluation for infective causes done but all returned negative Treated with oral and topical steroids 	Rashes gradually improved with treatment. Considerations on triggers included underlying infection vs. vaccine. In view of temporarily, decision made to advise against second dose
5	Pericarditis	15 year old Male PMH: asthma NKDA	<ul style="list-style-type: none"> Presented with pleuritic chest pain 2 days after first vaccine associated with dyspnea and fever. Haemodynamics stable ECG: diffuse ST segment elevation Blood investigations: cardiac enzymes normal 2DE: bright and thickened pericardium posterior and lateral to the left ventricle; normal biventricular function Treatment received: Indomethacin 	Symptoms resolved within 48 h of treatment ECG changes and 2DE resolved within 2 weeks Second dose of COVID vaccine delayed but eventually given and tolerated well
6	Pericarditis	15 year old Male PMH: nil NKDA	<ul style="list-style-type: none"> Had chest pain 2 weeks after first vaccine but did not seek medical attention, presented 5 days after second dose due to worsening pleuritic chest pain and dyspnea Pericardial rub heard on auscultation ECG: saddle shaped ST elevations with occasional premature ventricular complex Cardiac enzymes and 2DE normal Treatment received: indomethacin 	Symptoms gradually improved over 3 weeks
7	Pericarditis	18 year old Male PMH: nil NKDA	<ul style="list-style-type: none"> Presented with chest pain and dyspnea 4 days after second vaccine ECG show ST elevation in chest leads CK 1571 U/L (NR 30–350); CK-MB and troponin-I normal 2DE: mild pericarditis Treatment received: Arcoxia 	Admitted to hospital for 48 h observation Symptoms improved with treatment and completely resolved within 5 days

(continued on next page)

Table 1 (continued)

Case	Diagnosis	Demographics	Clinical Course	Patient Outcome
8	Myocarditis (Mild, subacute)	15 year old Male PMH: nil NKDA	<ul style="list-style-type: none"> Presented with palpitations and exertional dyspnea 11 days after first dose of vaccine Tachycardia noted with pulse 110/minute; blood pressure normal ECG normal, troponin-I 67.6 (NR < 17.4) ng/L; CK-MB and CK normal ZDE normal No specific treatment required 	Serial troponin-I returned to normal within 48 h Second dose of vaccine held off
9	Multifocal atrial tachycardia	16 year old Male PMH: none NKDA	<ul style="list-style-type: none"> Presented with acute onset irregular palpitations at rest, not associated with chest pain or dyspnea 1 month after second vaccine dose Systemic review unremarkable No recent drug ingestions Haemodynamics stable ECG showing multifocal atrial tachycardia with 3 distinct morphologies of p wave in a single lead; cardiac monitoring showing irregular heart rate from 50 to 140 ZDE normal Electrolytes, thyroid function and blood count normal Treatment received: oral bisoprolol 	Chemical conversion with oral bisoprolol (**this presentation was not deemed to be due to the COVID-19 vaccine but in view of the temporality with the vaccine exposure, we have included this in our list)
10	Bell's palsy	14 year old Female PMH: none Allergic to acetylcysteine	<ul style="list-style-type: none"> Presented with left facial droop and blurring of vision 3 days after first dose of vaccine Examination confirmed isolated left lower motor neuron facial nerve palsy; exposure keratopathy noted on ophthalmic assessment. Treatment received: valaciclovir and prednisolone 	Complete recovery of left facial nerve function within 2 months. Second dose of vaccine received 3 months later and was well tolerated

Table abbreviations: PMH- past medical history; NKDA-no known drug allergies; IM-intramuscular; ECG-electrocardiogram; ZDE-two-dimensional echocardiogram; NR- normal range

PED. This phenomenon is not unique to our local setting. In the United Kingdom, emergency departments had similarly reported a surge in attendances for mild side effects towards the AstraZeneca COVID-19 vaccination after media coverage of risk of blood clots.¹⁷ The Centers for Disease Control and Prevention (United States) has in fact reported on anxiety-related symptoms after the COVID-19 vaccination.¹⁸ This anxiety may in part contributed by the masses of information circulating through social media, many of which may not be scientifically substantiated.^{19,20}

Media influence aside, another factor that may drive post-vaccination health-seeking behaviors include the financial compensation programs for COVID-19 vaccine-related injuries that are available in some countries. In Singapore, the Vaccine Injury Financial Assistance Program (VIFAP) for COVID-19 vaccination provides a one-time goodwill financial assistance for individuals who have experienced serious side effects requiring hospitalization, resulting in persistent incapacity or disability, or death as a result of the COVID-19 vaccine.²¹ To qualify for this, the

serious side effect has to be certified by a doctor to be related to the vaccination. While our study did not directly assess the role of the VIFAP in mediating post-vaccine related PED attendances, we believe that this may have contributed to the health-seeking behaviors that we have observed to some extent. Philosophically though, much of what we have observed on post-vaccine health-seeking behaviors can be linked back to the psychological theories that form the Health Behavior Model, whereby an individual's course of action is deemed to be dependent on the individual's perceptions of the benefits and barriers related to health behavior.²²

Healthcare resource utilization for post-vaccine care is an important aspect that needs to be considered in any vaccination program, particularly in countries where rates of COVID-19 infections continue to be high. The surges in post-vaccine related complaints to emergency departments may coincide with surges in actual cases of COVID-19 infection, leading to a strain in emergency resources. Fortunately for us, the surge in post-vaccine attendances

Table 2 Characteristics of patients attending the PED with COVID-19 vaccination related complaints.

Patient Characteristics	Number (Percentages unless otherwise specified)
Mean Age (SD), years	14.6 (1.6)
Gender	
• Male	164 (56.4)
• Female	127 (43.6)
Ethnicity	
• Chinese	171 (58.8)
• Malay	44 (15.1)
• Indian	39 (13.4)
• Others	37 (12.7)
Number of attendances with underlying chronic disease	79 (27.1)
Two most commonly documented pre-existing chronic diseases (excluding psychiatric conditions)	
• Atopy: Asthma, allergic rhinitis, eczema	45 (15.5)
• Obesity	15 (5.2)
Number of attendances with previous psychiatric morbidity	24 (8.2)
Number of attendances with previous known drug or vaccine allergies	Drug allergies 26 (8.9) Vaccine allergies 0 (0)
First vs. second dose of COVID-19 vaccine	First dose: 152 (52.2) Second dose: 136 (46.7) Not documented: 3 (1.0)
Mean duration from vaccination to onset of symptoms (SD), days	8.2 (12.6)
Seven most commonly reported symptoms at presentation	
• Chest pain/chest tightness	171 (58.8)
• Shortness of breath	82 (28.2)
• Palpitations	66 (22.6)
• Headache	41 (14.1)
• Syncope/presyncope/ lightheadedness	36 (12.4)
• Fever	34 (11.7)
• Rashes	12 (4.1)
Severity of presentations	
• Mild	258 (88.6)
• Moderate	23 (7.9)
• Severe	10 (3.4)
Requiring investigations	
• ECG only	249 (85.6)
• Including blood tests	185 (63.6)

Table 3 Comparison based on severity of presentations: mild against moderate-severe presentations.

Characteristics	Mild presentations (n = 258)	Moderate or severe presentations (n = 33)	p value
Mean age with 95% CI (years)	14.5 (14.3–14.7)	15.2 (14.5–15.8)	0.030 ^a
Gender			0.551*
• Female (%)	43.0	48.5	
• Male (%)	57.0	51.5	
Pre-existing chronic disease (%)	26.7	30.3	0.665*
Pre-existing drug allergy (%)	7.8	18.1	0.048*
Mean duration from vaccination to onset of symptoms, with 95% CI (days)	4.2 (3.4–5.0)	3.5 (1.4–5.6)	0.547 ^a
Vaccine			0.041*
• First (%)	50.2	72.7	
• Second (%)	49.8	27.3	
Requirement for admission (%)	0.7	45.5	<0.005*

^a Two sample t test, *Chi squared test.

Table 4 Comparison between cases who presented with chest pain against other presentations.

Characteristics	Chest pain (n = 171)	Non-chest pain related (n = 120)	p value
Mean age with 95% CI (years)	14.7 (14.4–14.9)	14.4 (14.2–14.7)	0.230 ^a
Gender			0.520*
• Female (%)	42.1	45.8	
• Male (%)	57.9	54.2	
Pre-existing psychiatric disease, including ADHD (%)	8.8	7.5	0.698*
Mean duration from vaccination to onset of symptoms with 95% CI (days)	4.9 (3.9–5.9)	3.0 (2.0–4.0)	0.014 ^a
Vaccine			0.044*
• First dose (%)	47.1	61.0	
• Second dose (%)	53.9	39.0	
Severe presentations (%)	2.3	5.8	<0.005*
Requirement for admission (%)	3.5	9.2	0.043*

^a Two sample t test, *Chi squared test.

occurred when daily COVID-19 infection rates had remained low in Singapore, ranging from 4 to 219 cases per day.²³ Within several weeks of this surge, Singapore had experienced the COVID-19 Delta variant infection wave, and this had coincided at a time when post-vaccine attendances had

already declined. Emergency department visits aside, the costs for investigations, follow up visits and loss of productivity associated with post-vaccine symptoms are additional financial burdens that contribute towards vaccine

economics. Nonetheless, we believe that it is important to support individuals who experience symptoms post-vaccination, as this can improve overall confidence in the vaccination program, which is an important aspect in our fight against this pandemic. Perhaps this service may need to be decentralized from the emergency departments, particularly for mild or moderate symptoms, where community clinics may be a more appropriate facility to shoulder this responsibility, if given the appropriate resources.

To the best of our knowledge, this is the first study describing the COVID-19 vaccination related attendances to an emergency department. This study is crucial in several aspects: (1) Complements data on vaccine safety published in clinical trials and vaccine adverse effects databases, (2) Provides real world evidence of healthcare utilization related to post-vaccination symptoms, (3) Highlights various health-seeking behaviors pertaining to the COVID-19 vaccine. With this information, we are better able to understand and anticipate behaviors of the general public, which at the present moment has mainly been focused on vaccine acceptance or hesitancy. It is important to realize that even for those who eventually receive the vaccine, there can be various health-seeking behaviors pertaining to the post-vaccination effects.

This study has several limitations. Firstly, it represents the experience of a single center, which may not be generalizable to all healthcare settings. In addition, the retrospective nature of our study invariably involved some inconsistencies in the data quality, which was dependent on the documentation done during the consultation. That said, the key data required for this study could be easily obtained from the electronic database, with insignificant missing data. While we have included data on the adverse effects of the COVID-19 vaccine, our aim was not to provide comprehensive incidences of COVID-19 vaccine-related side effects, which would already be captured prospectively in the vaccine adverse events reporting databases available in many countries. This study adds value through the use of our PED experience as a model to demonstrate healthcare utilization and health behaviors among adolescents pertaining to COVID vaccination, particularly pertaining to "post-vaccination phenomenon".

In conclusion, while we have observed a significant incidence of post-vaccination attendance to the PED, most of these have been mild, and even the severe presentations were all self-limiting with no permanent loss of function. This supports current available evidence that the COVID-19 vaccine is safe among adolescents. Most of the PED attendances related to vaccination may be related to an element of anxiety pertaining to the adverse effects of the COVID-19 vaccine, which in part is driven by the media. Despite the mild nature of these complaints, they can add considerably to healthcare resource utilization, which can have a sizable economic impact during a prolonged pandemic. As healthcare professionals, we have an ongoing duty to ensure that accurate information on vaccine efficacy and safety is effectively communicated to the general public.

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Declaration of competing interest

All authors have no conflicts of interest to disclose.

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