Adverse reactions and safety profile of the mRNA COVID-19 vaccines among Asian military personnel

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ABSTRACT

Introduction: The use of novel mRNA platforms for COVID-19 vaccines raised concern about vaccine safety, especially in Asian populations that made up less than 10% of study populations in the pivotal vaccine trials used for emergency use authorisation. Vaccine safety issues also remain a concern in assessing the clinical risks and benefits of vaccine boosters, particularly in specific age groups or segments of the population. This study describes a vaccination exercise involving Asian military personnel, and the adverse reactions and safety events observed.

Methods: Minor adverse reactions, hospitalisations and adverse events of special interest were monitored as part of the organisation's protocol for safety monitoring of COVID-19 vaccinations. All vaccine recipients were invited to complete an online adverse reaction questionnaire. Medical consults at the military's primary healthcare facilities were monitored for vaccine-related presentations. All hospitalisations involving vaccine recipients were analysed. Adverse reaction rates between doses, vaccines and age groups were compared.

Results: A total of 127,081 mRNA vaccine doses were administered to 64,661 individuals up to 24 July 2021. Common minor adverse reactions included fever/chills, body aches and injection site pain. These were more common after dose 2. Younger individuals experienced minor adverse reactions more frequently. Rare cases of anaphylaxis, Bell's palsy and myocarditis/pericarditis were observed. No deaths occurred.

Conclusion: Minor adverse reactions were less common than reported in other studies, and rates of anaphylaxis, Bell's palsy and myocarditis/pericarditis were comparable. Our study supports the favourable safety profile of mRNA COVID-19 vaccines, which may help guide decisions about booster doses if required.

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INTRODUCTION

The COVID-19 pandemic has led to significant changes in the way of life for many around the world.^{1,2} After more than a year, many countries continue to struggle with rising infection rates, and economic and social impact of the pandemic.³⁻⁵ COVID-19 vaccines have become available since the end of 2020, and are a critical part of the multipronged approach towards the resumption of international travel and trade, as well as the easing of societal restrictions. Singapore was one

of the first countries to roll out COVID-19 vaccinations, beginning on 30 December 2020 with healthcare workers, using the mRNA COVID-19 vaccine manufactured by Pfizer-BioNTech, and subsequently adding the Moderna vaccine.

Although mRNA vaccines have been under study for many years,⁶ none had undergone clinical trials for infectious diseases until the COVID-19 pandemic. Interim analyses of phase 3 clinical trials assessing the efficacy, safety and tolerability of the Pfizer-BioNTech⁷

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CLINICAL IMPACT

What is New

- Findings from this cohort of military personnel support the overall safety of the mRNA COVID-19 vaccines among young individuals, mostly between the ages of 20 and 30.
- Adverse reactions are mostly minor and are within the reported ranges in the literature.

Clinical Implications

- Our study supports the favourable safety profile of the mRNA COVID-19 vaccines for young individuals in Singapore and provides reassuring data to support rapid rollout of mass vaccination to other Asian populations in this age category.

and Moderna⁸ COVID-19 vaccines were published in December 2020 and February 2021, respectively. Since then, many health authorities including the US Food and Drug Administration, European Medicines Agency, and Singapore's Health Sciences Authority have authorised these 2 mRNA vaccines for emergency use.

However, studies and trials involving the mRNA COVID-19 vaccines thus far have had limited representation by Asian ethnicities. In the pivotal trials for the Pfizer-BioNTech and Moderna vaccines, Asians only comprised 4.3%⁷ and 4.6%⁸ of participants, respectively. Real-world effectiveness and pharmacovigilance studies of mRNA vaccines from Asian and military populations are similarly limited, with most studies being conducted in non-Asian countries.^{9–11} As mRNA vaccine use has increased outside controlled clinical research settings, pharmacovigilance monitoring has identified rarer adverse events such as myocarditis and pericarditis,^{11,12} which were not observed in the phase 3 clinical trials involving smaller cohorts. Multiple studies suggest that a paucity of safety data for specific subgroups, including Asians, contributes to vaccine hesitancy,^{13,14} with many concerned about side effects.^{15,16} Given that booster doses may be needed in future to tackle waning vaccine efficacy and the emergence of new SARS-CoV-2 variants,¹⁷ it is useful to describe the safety profile and adverse reactions of mRNA COVID-19 vaccines in Asians, so as to contribute to the medical literature and address such reservations.^{18,19} We describe here the safety and adverse event profile in a multiethnic Asian cohort in the Singapore military who received at least 1 dose of an mRNA COVID-19 vaccine.

METHODS

We prospectively monitored post-vaccination adverse reactions in a cohort of Singapore military personnel who have received at least 1 dose of either the Pfizer-BioNTech or Moderna COVID-19 vaccine. Data were collected from vaccine recipients, military doctors and existing force health surveillance frameworks. Firstly, all recipients received an automated text message 7 days after the first dose, requesting them to complete a 1-minute online questionnaire, with another automated reminder sent 10 days after the same dose. This was repeated for the second dose. Respondents were asked to indicate the adverse reactions that they had experienced following vaccination from a list of adverse reactions. (Questionnaire of Supplementary Appendix in online version of this article.) Cardiac-related symptoms such as abnormal sensation of heart beat, chest tightness and difficulty breathing were added to the list on 14 June 2021 due to reports of myocarditis and pericarditis following mRNA COVID-19 vaccination in the global press and literature. Free-text entries for reports prior to 14 June 2021 were analysed for cardiac-related symptoms and were included in the analysis for these symptoms where relevant. Secondly, military doctors who reviewed individuals seeking medical attention for post-vaccination adverse reactions were instructed to assign a specific disease code on the electronic medical record (EMR). Lastly, we utilised existing force health surveillance frameworks for adverse reaction monitoring. This included a reporting system whereby all hospitalisations involving military personnel were reported to the military's Biodefence Centre. Adverse reaction data collected via these 3 methods were compiled into a single database for analysis. All the authors vouch for the completeness of the data and the accuracy of the analysis.

Sex and ethnicity records were retrieved from the EMR; sex was self-reported via institution-wide human resource channels, and ethnicity was classified using Singapore's census protocols.²⁰ For each reaction, we calculated incidence rates and rate ratios after dose 2 versus dose 1 for both mRNA vaccines together and separately, with 95% confidence intervals (CI). Incidence rates between doses, vaccines and age groups were compared using multivariate logistic regression, adjusting for vaccine administered, dose, age, sex and ethnic group where appropriate. A 2-sided *P* value of <0.05 was considered statistically significant. Descriptive analyses were performed for rarer events including hospitalisations, cases of allergic reactions, anaphylaxis, Bell's palsy and myocarditis/pericarditis.

Analyses were performed using R version 4.1.0. As data were collected as part of COVID-19 vaccination safety monitoring, ethics board approval was not required.

RESULTS

The COVID-19 vaccination exercise in Singapore's military commenced on 14 January 2021 using mRNA COVID-19 vaccines. Second doses were administered between 21 and 56 days after first doses, using the same vaccine that was administered for the first dose. Adverse reaction reports received up to 3 August 2021 were analysed. This corresponds to vaccinations administered up to 24 July 2021.

Vaccination progress and demographics

A total of 127,081 mRNA COVID-19 vaccine doses were administered to 64,661 individuals up to 24 July 2021. Of these, 62,420 individuals (96.5%) have been fully vaccinated with 2 doses of a mRNA vaccine, comprising more than 90% of all military personnel²¹ (Fig. 1). The cohort of vaccine recipients was predominantly young (median age 22 years, interquartile range 20–30), male (92.1%) and of Chinese ethnicity (Chinese 79.3%, Malay 7.4%, Indian 8.4%, others 2.4% and unknown 2.4%). In the cohort, 37,367 individuals (57.8%) received at least 1 dose of the Pfizer-BioNTech vaccine, while 27,294 (42.2%) received at least 1 dose of the Moderna vaccine (Table 1).

A total of 70,905 responses from 45,582 individuals (55.8% of vaccine doses) were analysed. Age, sex and ethnic distributions of individuals with adverse reaction reports were similar to those of the general cohort of vaccine recipients (median age 22 years, 93.7% male, 82.0% Chinese). Distribution of vaccine administered was similar to the general cohort of vaccine recipients (60.3% Pfizer-BioNTech vaccine). Of the total responses, 39,154 were received after dose 1 and 31,751 were received after dose 2 (Table 1).

A decreasing response rate was observed over time from the start of vaccination campaign until the cut-off date, from a monthly average of 72.5% in January to 52.6% in July. In contrast, the proportion of adverse reaction reports that indicated at least 1 adverse reaction increased over time, from a monthly average of 41.9% in January to 62.2% in July (Fig. 2).

Minor adverse reactions

Injection site pain (18.4%), body aches (10.9%) and fatigue (10.8%) were the most common adverse reactions after dose 1 (Fig. 3). Fever/chills (32.6%), body aches (20.9%) and fatigue (14.1%) represented the most common adverse reactions after dose 2. (Table S1 in online Supplementary Appendix.)

In general, adverse reactions were more common after dose 2 versus dose 1 (59.4% vs 44.4%, adjusted rate ratio [RR] 1.34, 95% CI 1.32–1.36). Specifically, the highest adjusted RRs were observed for fever/chills

Fig. 1. Progress of vaccinations over time. (See online article for colour version.)

Table 1. Demographics of vaccine recipients and recipients with adverse reaction reports

	All recipients (n = 64,661)		Pfizer-BioNTech vaccine recipients (n = 37,367)		Moderna vaccine recipients (n = 27,294)		Recipients with adverse reaction reports (n = 45,582)
	Received at least 1 dose (n = 64,661)	Received 2 doses (n = 62,420)	Received at least 1 dose (n = 37,367)	Received 2 doses (n = 37,162)	Received at least 1 dose (n = 27,294)	Received 2 doses (n = 25,258)	
Age, years							
Median (IQR)	22 (20–30)	22 (20–30)	25 (21–36)	24 (21–36)	21 (19–23)	21 (19–23)	22 (20–31)
Range	15–73	15–73	15–73	15–73	17–67	17–67	15–67
Age group, no. (%)							
Under 20 years	12,075 (18.7)	11,424 (18.3)	4,115 (11.0)	4,085 (11.0)	7,960 (29.2)	7,339 (29.1)	8,394 (18.4)
20–29 years	35,669 (55.2)	34,373 (55.1)	19,846 (53.1)	19,765 (53.2)	15,823 (58.0)	14,608 (57.8)	24,524 (53.8)
30–39 years	8,478 (13.1)	8,281 (13.3)	6,204 (16.6)	6,154 (16.6)	2,274 (8.3)	2,127 (8.4)	6,047 (13.3)
40–49 years	5,642 (8.7)	5,563 (8.9)	4,706 (12.6)	4,672 (12.6)	936 (3.4)	891 (3.5)	4,384 (9.6)
50–59 years	2,389 (3.7)	2,371 (3.8)	2,107 (5.6)	2,097 (5.6)	282 (1.0)	274 (1.1)	1,922 (4.2)
60 years and above	408 (0.6)	408 (0.7)	389 (1.0)	389 (1.0)	19 (0.1)	19 (0.1)	311 (0.7)
Sex, no. (%)							
Male	59,574 (92.1)	57,476 (92.1)	33,913 (90.8)	33,766 (90.9)	25,661 (94.0)	23,710 (93.9)	42,715 (93.7)
Female	4,929 (7.6)	4,793 (7.7)	3,430 (9.2)	3,372 (9.1)	1,499 (5.5)	1,421 (5.6)	2,867 (6.3)
Others	17 (0.0)	14 (0.0)	1 (0.0)	1 (0.0)	16 (0.1)	13 (0.1)	0
Unknown	141 (0.2)	137 (0.2)	23 (0.1)	23 (0.1)	118 (0.4)	114 (0.5)	0
Ethnic group, no. (%)							
Chinese	51,288 (79.3)	49,627 (79.5)	30,886 (82.7)	30,736 (82.7)	20,402 (74.7)	18,891 (74.8)	37,392 (82.0)
Malay	4,800 (7.4)	4,567 (7.3)	1,978 (5.3)	1,969 (5.3)	2,822 (10.3)	2,598 (10.3)	3,228 (7.1)
Indian	5,459 (8.4)	5,253 (8.4)	3,115 (8.3)	3,096 (8.3)	2,344 (8.6)	2,157 (8.5)	3,804 (8.3)
Others	1,538 (2.4)	1,478 (2.4)	739 (2.0)	736 (2.0)	799 (2.9)	742 (2.9)	1,059 (2.3)
Unknown	1,576 (2.4)	1,495 (2.4)	649 (1.7)	625 (1.7)	927 (3.4)	870 (3.4)	99 (0.2)

Table 1. Demographics of vaccine recipients and recipients with adverse reaction reports (Cont'd)

	All recipients (n = 64,661)		Pfizer-BioNTech vaccine recipients (n = 37,367)		Moderna vaccine recipients (n = 27,294)		Recipients with adverse reaction reports (n = 45,582)
	Received at least 1 dose (n = 64,661)	Received 2 doses (n = 62,420)	Received at least 1 dose (n = 37,367)	Received 2 doses (n = 37,162)	Received at least 1 dose (n = 27,294)	Received 2 doses (n = 25,258)	
Received at least 1 dose, no. (%)	64,661 (100)	–	37,367 (100)	–	27,294 (100)	–	–
Received 2 doses, no. (%)	62,420 (96.5)	–	37,162 (99.5)	–	25,258 (92.5)	–	–
Received Pfizer-BioNTech vaccine, no. (%)	37,367 (57.8)	37,162 (59.5)	–	–	–	–	27,481 (60.3)
Received Moderna vaccine, no. (%)	27,294 (42.2)	25,258 (40.5)	–	–	–	–	18,101 (39.7)
Total responses	–	–	–	–	–	–	70,905
Responses after dose 1	–	–	–	–	–	–	39,154
Responses after dose 2	–	–	–	–	–	–	31,751
IQR: interquartile range							

(RR 6.26, 95% CI 6.00–6.54) and chest discomfort (RR 3.05, 95% CI 2.27–4.11). Among adverse reactions that were less common after dose 2, injection site pain (RR 0.57, 95% CI 0.55–0.59) and muscle aches (RR 0.67, 95% CI 0.62–0.72) had the lowest adjusted RRs (Fig. 3). Trends for the more common adverse reactions remained consistent when analysed separately for each vaccine, except for fever/chills which was much more common in Moderna recipients (Tables S2–S4 in online Supplementary Appendix).

A smaller proportion of older recipients were observed to have experienced at least 1 adverse reaction, as compared to younger recipients (RR 0.62, 95% CI 0.56–0.69 for ≥ 60 years compared to 20–29 years). This trend was consistent for body aches, fever/chills, headache and muscle aches (Fig. 4 and Table S5 in online Supplementary Appendix).

Hospitalisations and deaths

The median follow-up period was 119 days after dose 1, and 104 days after dose 2. There was a total of 79 reports of hospitalisations, out of which 45 (57.0%) occurred within 30 days of dose administration, 52 (65.8%) within 42 days, and 61 (77.2%) within 60 days. Case details of hospitalisations can be found in Table S6 of online Supplementary Appendix. Besides hospitalisations for perimyocarditis and chest pain with normal troponins, the number of hospitalisations for all other causes during our study period was similar to that during the same period in 2020. There were more hospitalisations for perimyocarditis and chest pain with normal troponins during our study period as compared to the same period in 2020. There were no reports of deaths following COVID-19 vaccination.

Allergic reactions and anaphylaxis

Fifty-eight recipients (45.6 per 100,000 doses) were diagnosed with allergic reactions due to the mRNA COVID-19 vaccine after seeking medical attention for their adverse reactions. Thirty-four were diagnosed after dose 1, and 24 were diagnosed after dose 2.

Of the 58, 2 were diagnosed with anaphylaxis due to the COVID-19 vaccine, both after dose 1 (rate: 1.6 per 100,000 doses).

The first case of anaphylaxis involves a 25-year-old female with no known allergies. She reported chest tightness, shortness of breath, sensation of lip fullness, and hoarseness of voice 40 minutes after receiving her first dose. There were no abnormalities during the physical examination, including no observable lip

Fig. 2. Proportion of recipients with adverse reaction reports over time (red line) compared to proportion of adverse reaction reports with at least one adverse reaction over time (blue line). (See online article for colour version.)

Red crosses and blue triangles represent individual data points for each day during the vaccination exercise. Lines represent the line of best fit derived using a linear model. Grey areas represent 95% confidence intervals.

Red crosses: proportion of recipients with adverse reaction report for each day.

Blue triangles: proportion of adverse reaction reports with at least one adverse reaction for each day.

swelling. Her vital parameters were stable. Intramuscular adrenaline and intravenous hydrocortisone were administered, with subsequent improvement in her symptoms. She was monitored and discharged after a few hours.

The second case involves a 22-year-old male with a history of rash after seafood consumption. He reported rashes and giddiness within 30 minutes after his first dose, and subsequently developed nausea, diarrhoea, lethargy, shortness of breath, a globus sensation in his throat, and voice changes. He was given intravenous diphenhydramine and hydrocortisone, with symptomatic improvement. He was monitored and discharged after several hours.

Bell's palsy

One recipient was diagnosed with Bell's palsy after receiving dose 1 of the mRNA COVID-19 vaccine (rate: 0.8 per 100,000 doses). He is a 38-year-old male with no past medical history. He developed left-sided facial numbness, hypogeusia, an asymmetrical smile, and drooling from the left side of his mouth 10

hours after vaccination. He was given a short course of prednisolone, and recovered fully after a few months.

Myocarditis and pericarditis

Three recipients were diagnosed with myocarditis/pericarditis, all after receiving dose 2 of the mRNA COVID-19 vaccine (rate: 2.4 per 100,000 doses). All 3 had no history of cardiac conditions.

The first case involves an 18-year-old male who reported non-exertional chest discomfort and fever 1 day after his second dose. Electrocardiogram (ECG) showed pericarditic changes. Serum troponin was elevated. A transthoracic echocardiogram showed a preserved ejection fraction (EF) with no abnormalities or evidence of pericardial effusion. He was given a short course of colchicine and ibuprofen, and his symptoms had resolved completely.

The second case involves a 21-year-old male who reported worsening of pre-existing back discomfort with radiation to his chest, lethargy, and fever 4 days after his second dose. ECG showed pericarditic changes and serum troponin was elevated. Magnetic resonance

Table 2. Details of cases of anaphylaxis, Bell's palsy and myocarditis/pericarditis

Age at dose 1	Sex	Ethnic group	Past medical/allergic history	Vaccine	Dose	Clinical features	Time/Day of symptom onset	Outcome	Received dose 2
Anaphylaxis									
25 years	Female	Chinese	No significant history	Pfizer-BioNTech	1	Chest tightness, shortness of breath, subjective lip fullness	40 minutes	Alive; fully recovered	No
22 years	Male	Chinese	Seafood allergy	Moderna	1	Generalised pruritus, rash, nausea, diarrhoea, lethargy, giddiness, shortness of breath, globus sensation in throat, change in voice	Within 30 minutes	Alive; fully recovered	No
Bell's palsy									
38 years	Male	Chinese	No significant history	Pfizer-BioNTech	1	Left-sided facial numbness, tongue tingling, reduced taste sensation Left eye unable to close completely, asymmetrical smile, drooling from left side of mouth	9 hours	Alive; fully recovered	No
Myocarditis/Pericarditis									
18 years	Male	Chinese	No significant history	Moderna	2	Non-exertional chest discomfort, fever	1 day	Alive; fully recovered	Not applicable
21 years	Male	Chinese	No significant history	Moderna	2	Non-exertional chest discomfort, fever, lethargy	4 days	Alive; fully recovered	Not applicable
18 years	Male	Chinese	No significant history	Moderna	2	Central, non-radiating chest discomfort, shortness of breath	3 days	Alive; fully recovered	Not applicable

imaging (MRI) of his heart revealed findings meeting the Lake Louise criteria for myocarditis, with a preserved EF and no pericardial involvement. He was given a short course of colchicine and ibuprofen, and his symptoms had resolved completely.

The third case involves an 18-year-old male who reported chest tightness and shortness of breath 4 days after his second dose. ECG did not show significant abnormalities and serum troponin was elevated. MRI findings did not meet the criteria for myocarditis. His EF was preserved, and there was no pericardial involvement. He was diagnosed with perimyocarditis clinically. He was given a short course of colchicine and ibuprofen, and his symptoms had since resolved completely.

Details of the aforementioned cases can be found in Table 2.

DISCUSSION

The COVID-19 vaccination exercise began in the Singapore military on 14 January 2021. An organisation-wide vaccination exercise was carried out, with several vaccination centres set up in various parts of Singapore. This enabled the achievement of a vaccination rate above 90% by July 2021.²¹ As COVID-19 vaccination was and remains voluntary, there has been a concerted push from the start of the vaccination exercise to educate all personnel on the rationale, known side effects and safety profile of the mRNA COVID-19 vaccines. The intent was to answer any queries early, to address possible sources of vaccine hesitancy. Additionally, both active and passive surveillance systems were implemented to monitor the adverse reaction profile of the vaccines post-vaccination, to facilitate more comprehensive ascertainment of the spectrum of adverse reactions.

Fig. 3. Adverse reactions after dose 1 compared to dose 2. Adverse reactions are sorted by the proportion of dose 1 adverse reaction reports that reported the specified adverse reaction. (See online article for colour version.)

Fig. 4. Adverse reactions by age group. Adverse reactions are sorted by the proportion of respondents aged 20–29 years that reported the specified adverse reaction. (See online article for colour version.)

The adverse reaction report response rate decreased with time, possibly due to increased familiarity with the vaccines and disinclination to provide nil returns. The proportion of reports with at least 1 adverse reaction increased over time, indicating that recipients with adverse reactions were reporting their reactions through the easily accessible reporting system. It is also possible that pervasive media messaging with the national vaccine rollout was raising awareness in vaccine recipients of adverse events from vaccination. While this suggests significant utility in a questionnaire-based self-reporting surveillance system, continued efforts to encourage questionnaire submission by vaccine recipients without adverse reactions are important to reduce non-response bias.

In our cohort of 64,661 individuals, the mRNA COVID-19 vaccines appear safe and well-tolerated. Post-vaccination adverse events were common: 44.4% and 59.4% of reports indicated at least 1 adverse reaction after dose 1 and dose 2, respectively. There were more adverse reactions reported after dose 2, consistent with higher reactogenicity. Our observations are comparable to phase 3 clinical trials of the mRNA COVID-19 vaccines, with body aches, fatigue, fever/chills and injection site pain among the most common adverse reactions.^{7,8} We observed a generally lower rate of minor adverse reactions compared to those from studies conducted in the US, other countries and other populations.^{7,8,22,23} This was surprising as our cohort includes a larger proportion of younger individuals, for whom higher reactogenicity is expected.²² Indeed, this trend is also seen in this study's subgroup analyses among the various age groups. Possible explanations for the lower rate in our study include differences in ethnicity, sex, health-seeking behaviour between study populations, and cultural differences in the perception and reporting of vaccine adverse reactions.^{24,25}

Additionally, we observed a trend towards higher rates of minor adverse reactions among Moderna vaccine recipients as compared to Pfizer-BioNTech vaccine recipients. This has also been observed in other studies,²⁶ and may possibly reflect a stronger immune response produced by the vaccine. This hypothesis may be supported by recent studies observing higher effectiveness of the Moderna vaccine as compared to the Pfizer-BioNTech vaccine at 6 months after vaccination.²⁷⁻²⁹ Policymakers making decisions on the choice of a mRNA vaccine for vaccination exercises may need to weigh the possibly increased effectiveness of the Moderna vaccine needs against its possible increased risk of minor adverse reactions and reactogenicity.

There is a baseline incidence of medical events requiring hospital admissions, even in the absence of COVID-19 vaccination campaigns. The observed increase in hospitalisations for chest pain with normal troponins is likely due to a lower threshold for hospital referrals, with an increased awareness of post-vaccination myocarditis among the general public and healthcare professionals. It is otherwise reassuring that the number of hospitalisations for other conditions were similar to that during the same period in 2020. The rates of anaphylaxis and myocarditis/pericarditis in our study are comparable to those reported in studies from other countries³⁰⁻³³ while our observed rate of Bell's palsy is lower.^{7,8} While these observations are reassuring and continue to support a favourable safety profile in favour of vaccinations for Asians, continued monitoring and pharmacovigilance is necessary in order to detect very low-frequency adverse events that may occur.³⁴

This study has several strengths. Firstly, it provides useful and comprehensive data on adverse reactions in an Asian cohort that is predominantly male and relatively younger. Secondly, the large sample size, high questionnaire response rate, and comprehensive surveillance system for hospital admissions facilitated comprehensive capture of the full spectrum of adverse reactions.

The study also had several limitations. Firstly, there may be recall and non-response bias with passively collected self-reported data. Although the demographics of recipients with adverse reaction reports and the larger cohort of all recipients are similar, suggesting that non-response bias may be limited, factors not related to demographics may affect an individual's response. Secondly, participants could have altered their responses based on the perception that their military superiors might have access to this information, despite reassurances laid out in the survey. Thirdly, use of cross-sectional data collection may also miss events occurring after questionnaire submission. However, the overall vaccination safety monitoring system would capture later events if they were clinically significant. No such events were reported. Lastly, there are no data available for baseline rates of hospitalisation in a matched cohort, limiting the interpretation of our study's observed hospitalisation rates.

CONCLUSION

Our findings fill data gaps regarding the safety of the mRNA COVID-19 vaccines in Asians, and in young males. Most adverse reactions are mild, further emphasising the favourable safety profile of both the

Pfizer-BioNTech and Moderna vaccines, regardless of ethnicity. Reliable information on vaccine safety in different settings and groups will continue to address vaccine hesitancy and guide organisations with vaccination rollouts, both in terms of primary courses and further doses if needed, so as to mitigate the economic, societal and health impact of COVID-19.

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