COVID-19
Vaccine Updates

Number 52, 21st July 2022

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Introduction

This document summarises the vaccine efficacy and effectiveness, the vaccine specifications, the vaccine development pipeline, and the timeline for World Health Organization (WHO) review of the various COVID-19 vaccines in late phase development. This document is updated weekly.

- Vaccine efficacy refers to the performance of a vaccine in a controlled clinical trial (study) situation
- Vaccine effectiveness refers to the performance of a vaccine in a population under real-world conditions

Key messages

- COVID-19 vaccine efficacy results from different trials cannot be directly compared against each other. They must be interpreted in the context of study designs (including case definitions, clinical endpoints, access to testing), target populations, and COVID-19 epidemiologic conditions (the variants circulating at the time of the study). All efficacy studies were conducted prior to Omicron predominance and most prior to Delta.
- All COVID-19 vaccines in late phase development report high vaccine efficacy against severe COVID-19 and favourable safety profiles
- Most vaccines have low effectiveness against Omicron infection but maintain moderate to high effectiveness against severe disease, especially post booster.
- The Pfizer/BioNTech vaccine has been authorised in children ≥6 months by the US FDA and EU EMA; and in those ≥5 years by Health Canada, Australian TGA, NZ Medsafe and UK MHRA. The Moderna vaccine has been authorised in children ≥6 months by the US FDA, Health Canada and Australian TGA; in those ≥6 years by the EU EMA and UK MHRA; and in those ≥12 years by NZ Medsafe.
- WHO SAGE recommends that boosters should be administered 4-6 months after the primary series in high-priority groups, including older adults and health workers. [1] ATAGI has recommended that immunocompromised persons in Australia receive a third dose as part of the primary series and booster doses of Pfizer/BioNTech or Moderna be offered to all adults irrespective of the primary COVID-19 vaccine given.[2,3] First booster doses are recommended for individuals ≥5years of age in US; and 12-15 for certain vulnerable groups and ≥16 years in Australia, the UK and the EU. Second booster doses are recommended for the elderly and vulnerable in the UK, EU and USA; in those ≥18 years in Canada; and in those ≥30 years in Australia; [4,5].
- Mixed vaccine schedules (i.e., delivering different types of vaccine for the first and second dose) generally provide good protection against infection and severe disease
- Seven intranasal vaccines are in development (6 live-attenuated viruses or virus-vectored vaccines; 1 protein subunit[6].These may be beneficial in preventing transmission
- A very rare clotting disorder with low platelets (Thrombosis with Thrombocytopaenia Syndrome – TTS) has been associated with the AstraZeneca and Johnson & Johnson vaccines. [7–9] The majority of cases fully recover with adequate treatment. The risk following the first dose of AstraZeneca vaccine has been estimated by the EMA as 1 in 100,000 and by the Australian Technical Advisory Group on Immunisation (ATAGI) as 1 in 50,000.10,11 Risk of TTS is much lower following the second dose of AstraZeneca vaccine: estimate in the UK is 1 in 1.5 million second doses[1010].
- The risk of TTS following the first dose of Johnson & Johnson vaccine has been estimated as 1 in 319,000 in the USA[11]
- The risk of myocarditis/pericarditis is increased following the second dose of Pfizer/BioNTech and Moderna vaccines, particularly in younger males, occurring in >1 in 20,000 males under 25 years of age. [12] Highest rate in males 16-17 years of age following Pfizer/BioNTech vaccine but no clear difference in risk between Moderna and Pfizer/BioNTech. [12] Highest rate in males 16-17 years of age following Pfizer/BioNTech vaccine but no clear difference in risk between Moderna and Pfizer/BioNTech.[13] There is a small increase in risk of myocarditis in females <30 and males >50 years of age. Data from Ontario, Canada, and the UK suggest higher rates following Moderna than Pfizer/BioNTech vaccine. ATAGI in Australia continue to review the data.
- Appropriate communication on the benefit-risk profile of COVID-19 vaccines remains crucial to maintain confidence in immunisation programmes and to avoid vaccine hesitancy. suggest higher rates following Moderna than Pfizer/BioNTech vaccine. TGA in Australia continue to review the data.

New updates

Key updates include *(also highlighted in yellow text in the document)*

- Relative effectiveness of a Pfizer/BioNTech booster (3rd dose) versus no booster (2 doses), following AstraZeneca or Pfizer/BioNTech primary series, against hospitalisation or death from Omicron among adults in Australia. (Page 19,40,42) This has not yet been peer reviewed.
  - 65% (61-69%)
- Effectiveness of AstraZeneca and mRNA vaccines against symptomatic infection, hospitalisation, and death with Omicron variant in the UK (updated 7th July 2022)
  - Symptomatic infection:
    - AstraZeneca 2 doses (2-4 weeks): 45-50%
    - AstraZeneca 2 doses: No effect beyond 25 weeks
    - Pfizer or Moderna 2 doses (2-4 weeks): 65-70%
    - Pfizer or Moderna 2 doses (≥ 25 weeks): 15%
    - Pfizer or Moderna booster dose (2-4 weeks): 60-75%
    - Pfizer or Moderna booster dose: No effect beyond 20 weeks
  - Hospitalisation
    - AstraZeneca or Pfizer booster dose among 18-64 years (2- 4 weeks): 82.4%
    - AstraZeneca or Pfizer booster dose among 18-64 years old (≥15 weeks): 53.6%
    - AstraZeneca or Pfizer booster dose among 65+ years (2-4 weeks): 92.4%
    - AstraZeneca or Pfizer booster dose among 65+ years old (≥15 weeks): 76.9%
  - Death
    - AstraZeneca, Pfizer or Moderna 2 doses (≥ 25 weeks): 50%
    - Pfizer or Moderna booster following AstraZeneca, Pfizer or Moderna primary series: 2-4 weeks: 93.6%; ≥10 weeks: 87.6%
- Meta-analysis of studies assessed mean decrease in effectiveness of primary series and booster doses of Pfizer/BioNTech, AstraZeneca, Sinovac, Moderna, and Johnson & Johnson against symptomatic infection and severe COVID-19 for Omicron and pre-Omicron variants between 1 and 6 months post-vaccination among adults[26]

  Primary series:
  - Decrease in effectiveness from 1-6 months against symptomatic infection:
    - Omicron variant: 47.6% (36.6-60.2)
    - Pre-omicron variant: 24.9% (13.4-41.6)
  - Decrease in effectiveness from 1-6 months against severe COVID-19
    - Omicron variant: 1.0% (-3.9-6.6)
    - Pre-omicron variant: 10.0% (6.1-15.4)

  Booster dose:
  - Decrease in effectiveness from 1-4months
    - Symptomatic infection: 24.3% (19.9-29.1)
    - Hospitalisation: 28.5% (18.3-40.5)
  - Decrease in effectiveness from 1-6 months:
    - Symptomatic infection: 5.3% (2.4-8.7)
    - Hospitalisation: 8.2% (3.7-14.3)
- Effectiveness of third dose of Pfizer/BioNTech against hospitalisation with Omicron among adults in USA (Page 22, 52)
  - Immunocompetent
    - <3 months since third dose: 55% (17-75)
    - ≥3 months since third dose: 25% (-40-60)
  - Immunocompromised
    - <3 months since third dose: 55% (17-75)
    - ≥3 months since third dose: 25% (-40-60)

- Odds ratios for COVID-19 outcomes among unvaccinated compared to vaccinated adults after primary series of Sinovac in Brazil between 17 January to 14 December 2021 (Page 47)
    - Symptomatic infection
        - OR: 1.38 (1.24-1.45) at 42-69 days
        - OR: 1.92 (1.43-2.58) at 154-181 days
    - Hospitalisation
        - OR: 1.25 (1.04-1.51) at 70-97 days
        - OR: 1.94(1.41-2.67) at ≥182 days
- Effectiveness of Pfizer/BioNTech and natural immunity (prior infection) against symptomatic infection with Omicron in adults in Qatar suggests hybrid immunity provides additional protection with 3 doses + previous infection providing the highest protection (Page 18,41)
    - Three doses of Pfizer/BioNTech
        - Following previous infection: 77.3% (72.4-81.4)
        - No previous infection: 52.2% (48.1-55.9)
    - Two doses of Pfizer/BioNTech
        - Following previous infection: 55.1% (50.9-58.9)
        - No previous infection: -1.1% (-7.1-4.6)
    - Previous infection and no vaccination
        - 46.1% (39.5-51.9)
- A Swedish study reported a higher serological response after Omicron infection among vaccinated individuals with no history of previous infection with COVID-19 compared to vaccinated individuals with previous infection[14]
- The immune response was found to be higher among adults who received a single dose of Pfizer/BioNTech, Astra Zeneca or Sinovac and were previously infected with COVID-19 in Thailand compared to those who had no evidence of prior infection[15]
- Effectiveness of maternal vaccination with two doses of Pfizer/BioNTech or Moderna against hospitalisation with Omicron in infants < 6 months old (Page 24)
    - Overall: 38% (8-58)
    - During 20 weeks of pregnancy: 25% (-26-56)
    - After 20 weeks of pregnancy: 57% (25-75)
- Effectiveness of Pfizer/BioNTech against symptomatic infection with Omicron in Israeli children aged 5 to 11 years (Page 21).
    - One dose: 18% (-2 – 34) at 14 to 27 days
    - Two doses: 48% (29-63) at 7 to 21 days.
- The Centers for Disease Control and Prevention has recommended Pfizer/BioNTech or Moderna to children aged 6 months to 5 years[16]
- The European Medicines Agency (EMA) has recommended Novavax to adolescents aged 12 to 17 years[17]
- The Israeli Health ministry has recommended vaccination of children between the age of 6 months to five years against COVID-19.
- Due to current interest, in this edition we have included summary slides of fourth dose studies from recent months(Page 6,7,8,9,10).
- Paediatric COVID-19 Vaccine Safety Summary is on Page 53

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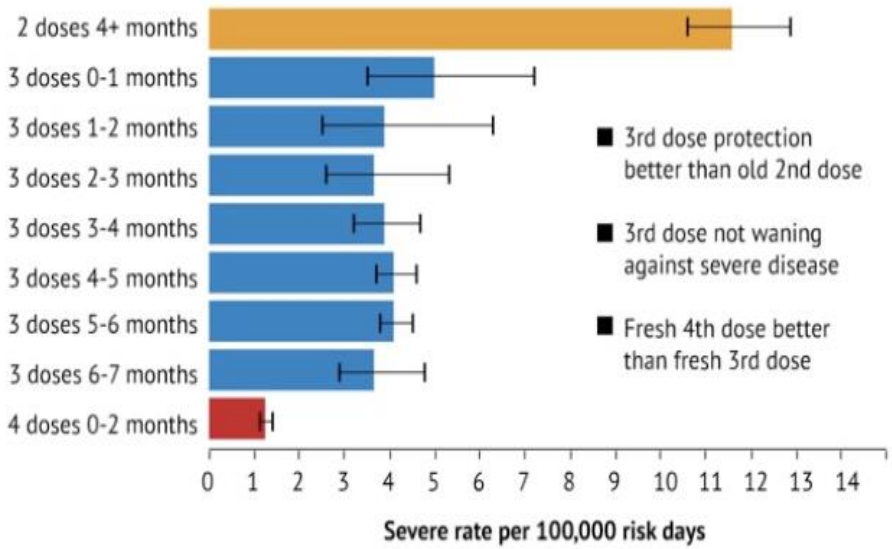
Summary data from new studies

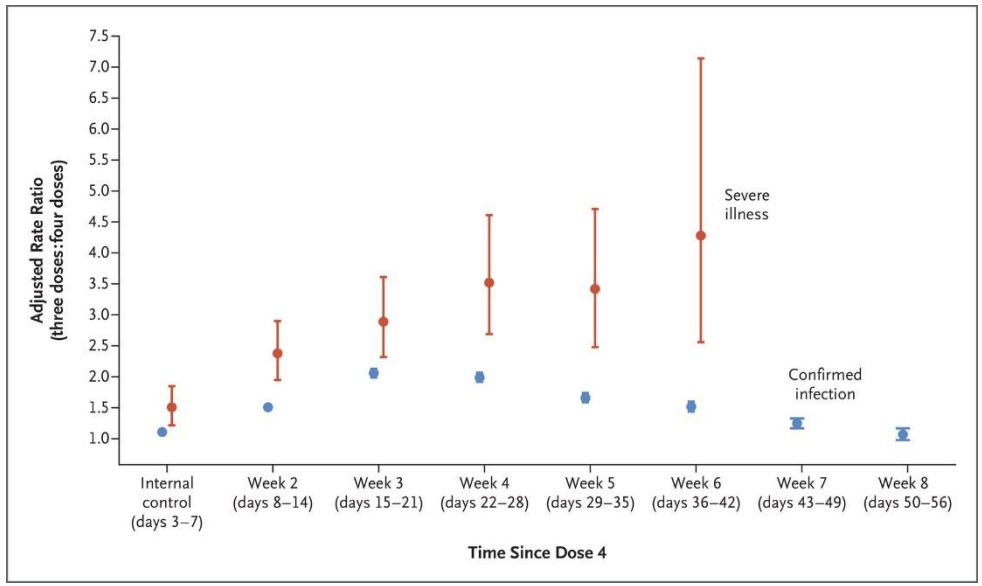
(Highlighted fourth dose studies)

Rates of severe disease with Omicron following two, three or four doses of Pfizer/BioNTech in those aged >60 years in Israel[18]



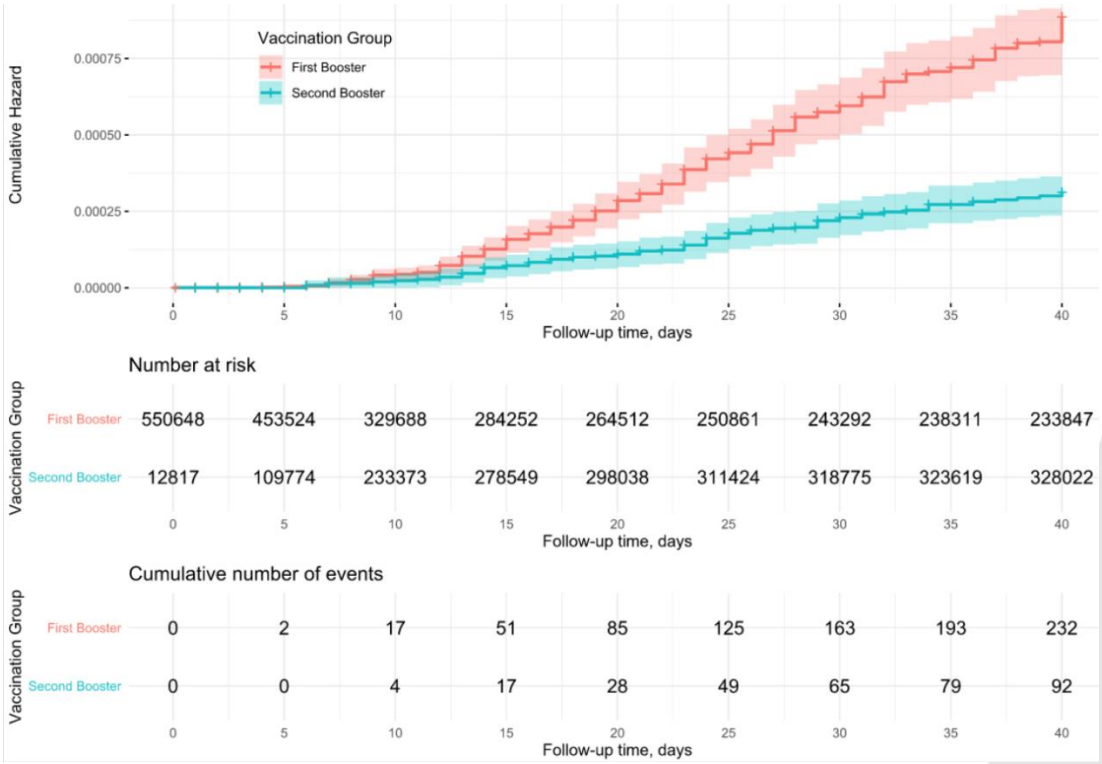
Fourth dose of Pfizer/BioNTech in Israel

- Relative effectiveness of fourth dose compared to third dose at least 4 months earlier against infection and severe outcomes with Omicron among adults ≥60 years of age[19]
  - Any infection: 52% (49-54)
  - Symptomatic infection: 61% (58–64)
  - Hospitalisation: 72% (63–79)
  - Death: 76% (48–91)



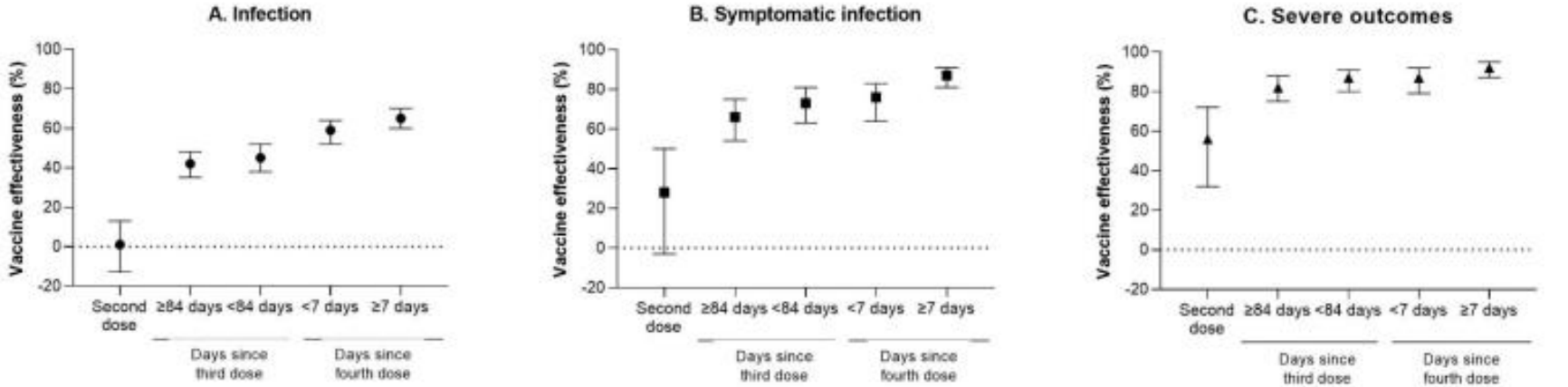
Fourth dose of Pfizer/BioNTech against severe outcomes in Israel

- The adjusted hazard ratio (HR) for death due to Omicron in the second-booster group compared with the first-booster group was 0.22 (0.17-0.28)[20]



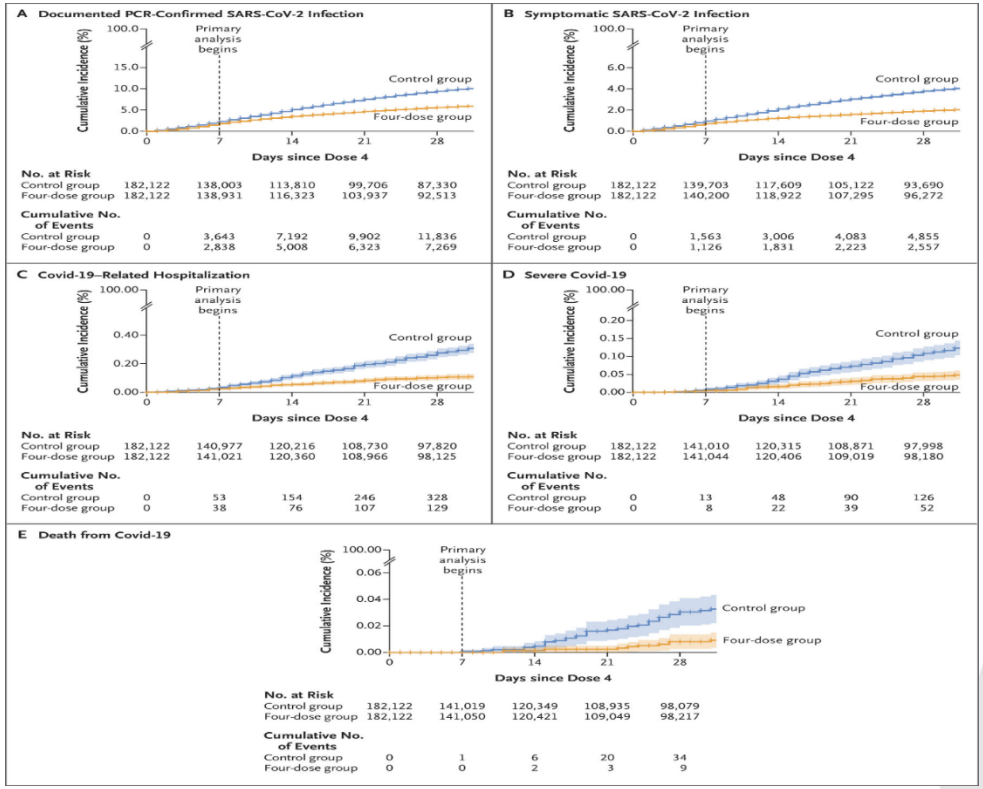
Fourth dose of Pfizer/BioNTech against Omicron among long-term care residents in Ontario, Canada

- Fourth dose VE ≥7 days post-vaccination was higher against infection: 65% (60-70%), symptomatic infection: 87% (81-91%), and severe outcomes: 92% (87-95%) compared to 3 doses[21]



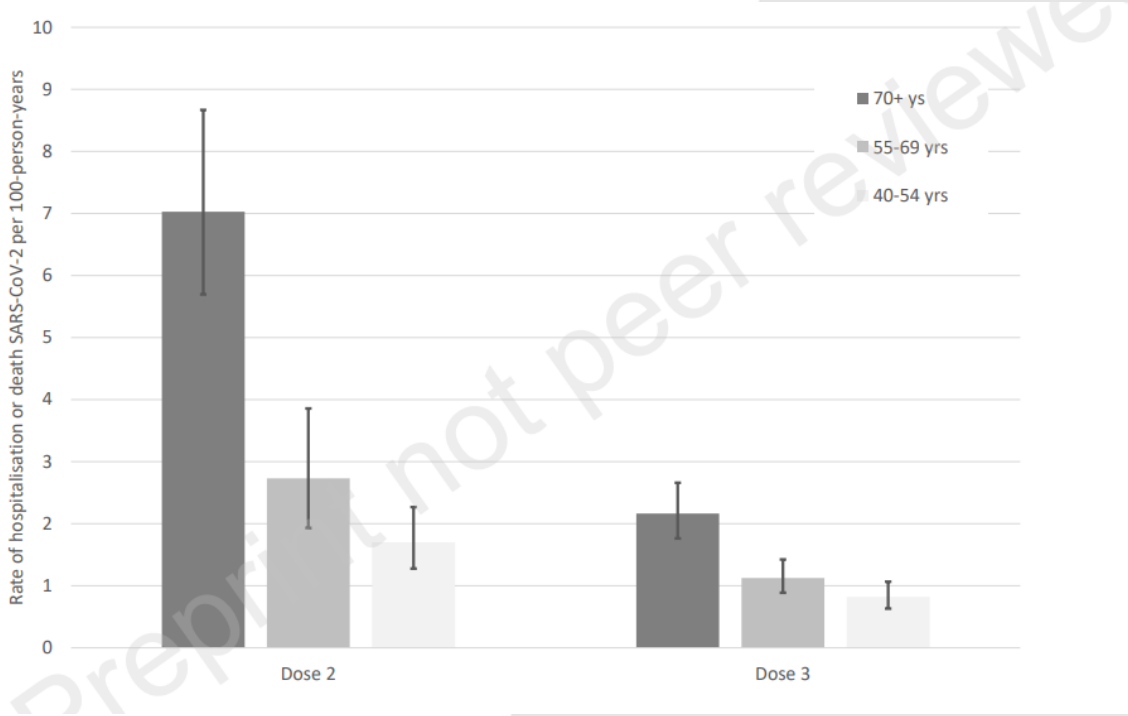
Fourth Dose of Pfizer/BioNTech in a Nationwide Setting

- Fourth dose of Pfizer/BioNTech was effective in reducing the short-term risk of COVID-19–related outcomes among persons who had received a 3rd dose at least 4 months earlier[22]



Relative effectiveness of three doses compared to two doses of mRNA vaccines against severe disease with Omicron among Australian adults

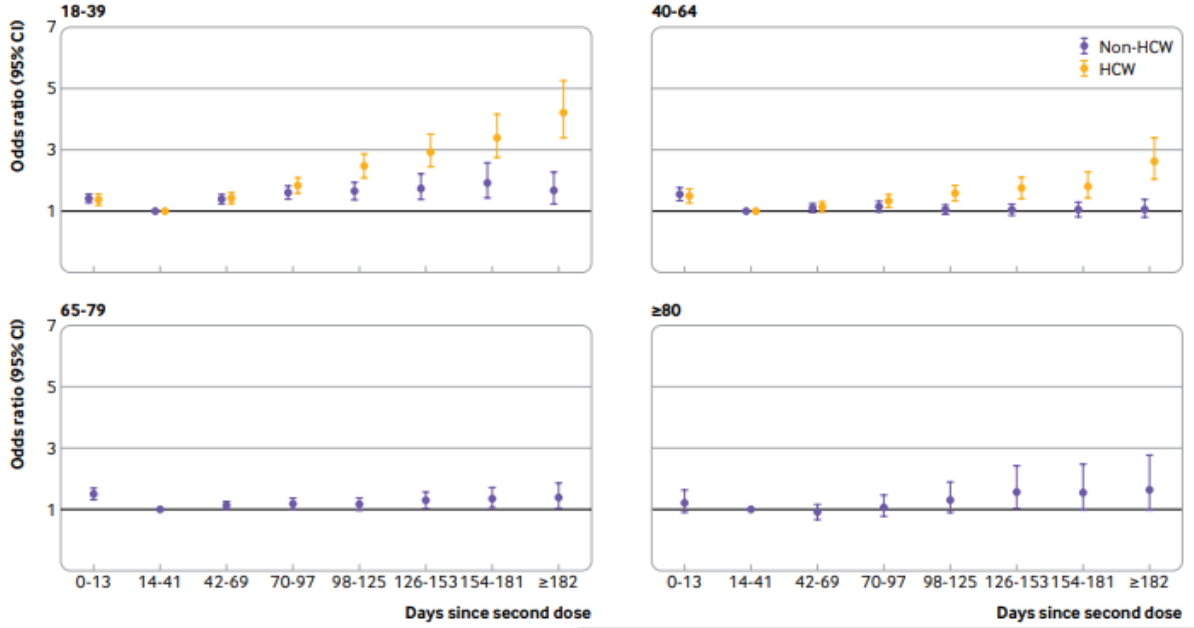
- Third dose of mRNA vaccines improved protection against hospitalisation and death due to Omicron among all adults and especially those aged >70 years[23].



Preprint not peer reviewed

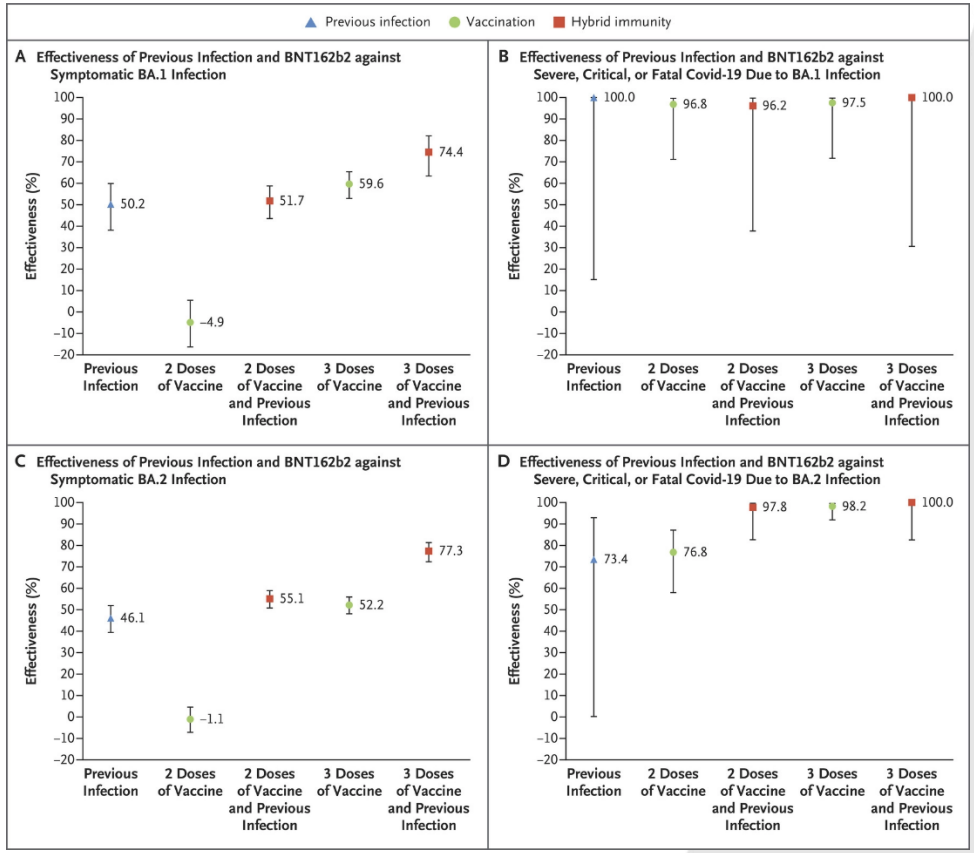
Change in COVID-19 risk over time following Sinovac primary series, by age: test negative case-control study

- The odds ratio for symptomatic infection increased with time among unvaccinated compared to vaccinated people, particularly for people <65 years and health care workers[24]



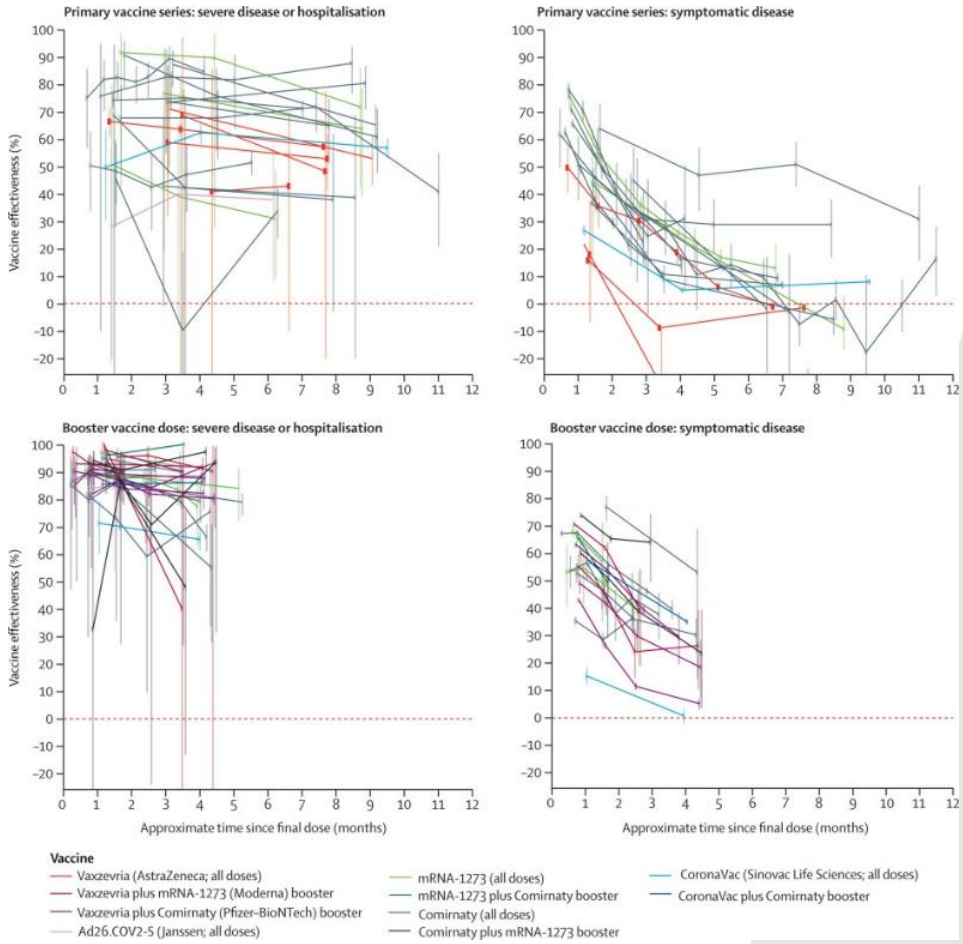
Effectiveness of previous infection and vaccination against symptomatic Omicron infections

- Vaccination enhanced protection among adults who had had a previous infection.
- Previous infection and no vaccination provided moderate protection but hybrid immunity resulting from previous infection and recent booster vaccination conferred stronger protection against BA.1 and BA.2 than either vaccination or previous infection alone[25]



Meta-analysis of duration of effectiveness of vaccination against Omicron variant

- Mean decrease in effectiveness of primary series and booster doses of Pfizer/BioNTech, AstraZeneca, Sinovac, Moderna, and Johnson & Johnson against symptomatic infection and severe disease 1-6 months post-vaccination among adults. Protection decreased against Omicron over 6 months, particularly against symptomatic infection[26]



Effectiveness of Pfizer/BioNTech against Omicron among 5–11-year-olds

- Effectiveness of 2 doses of Pfizer/BioNTech was approximately 50% against infection with Omicron among children aged 5-11 years[27]

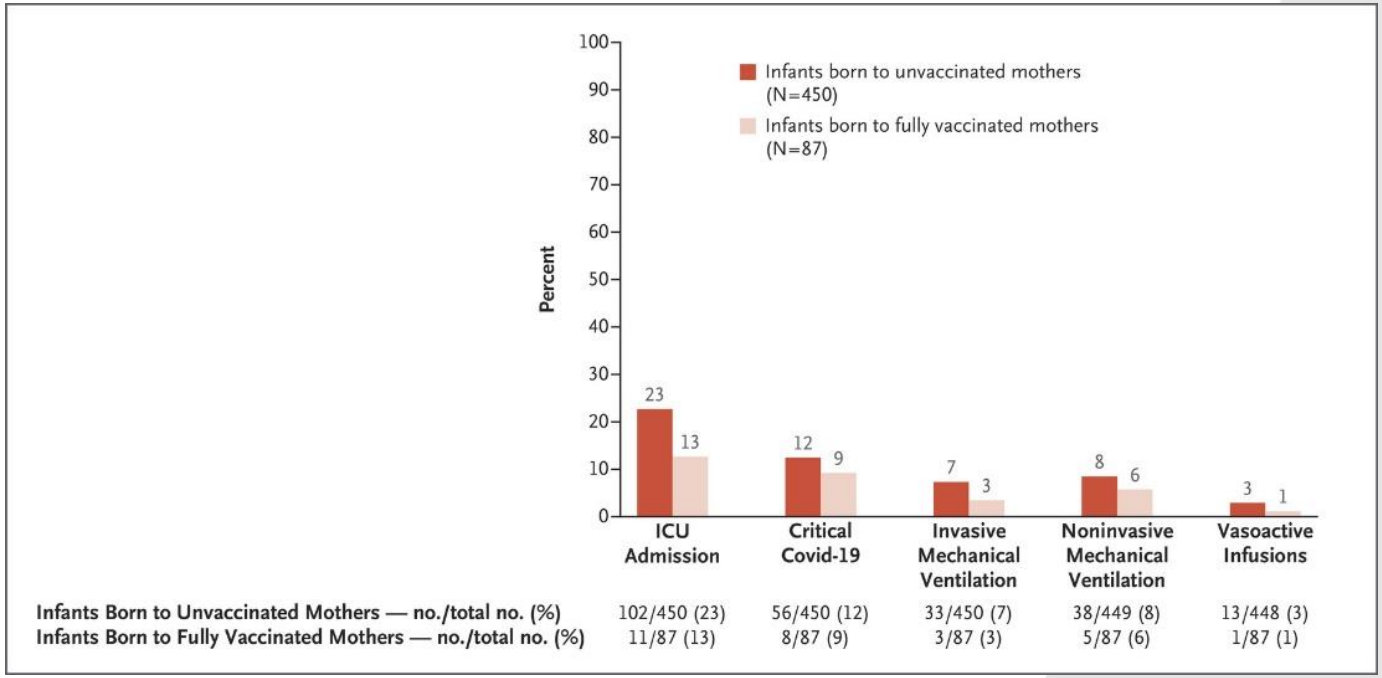
Table 2. Vaccine Effectiveness against Documented SARS-CoV-2 Infection and Symptomatic Covid-19.*

Outcome	Total Population in Each Study Group†	Events in the Unvaccinated Group	Events in the Vaccinated Group	Risk in the Unvaccinated Group‡	Risk in the Vaccinated Group‡	Vaccine Effectiveness (95% CI)	Risk Difference (95% CI)
		number		*events/100,000*		*percent*	*events/100,000*
Documented SARS-CoV-2 infection§							
At 14 to 27 days after the first dose	55,510	608	507	1528	1272	17 (7 to 25)	255 (102 to 408)
At 7 to 21 days after the second dose	22,109	423	201	3754	1849	51 (39 to 61)	1905 (1294 to 2440)
Symptomatic Covid-19							
At 14 to 27 days after the first dose	56,015	198	154	488	401	18 (–2 to 34)	87 (–9 to 187)
At 7 to 21 days after the second dose	22,386	133	68	1244	645	48 (29 to 63)	599 (296 to 897)

* SARS-CoV-2 denotes severe acute respiratory syndrome coronavirus 2.
† The total population in each study group represents the total number of children in each study group at the first day of the relevant follow-up period.
‡ Risk was estimated with the use of the Kaplan–Meier estimator.
§ Documented SARS-CoV-2 infection was confirmed on polymerase-chain-reaction testing.

Maternal vaccination and risk of hospitalisation for COVID-19 among infants

- Maternal vaccination with 2 doses of Pfizer/BioNTech or Moderna is associated with a reduced risk of severe illness in infants <6 months of age[28]



Infants Born to Unvaccinated Mothers — no./total no. (%)	102/450 (23)	56/450 (12)	33/450 (7)	38/449 (8)	13/448 (3)
Infants Born to Fully Vaccinated Mothers — no./total no. (%)	11/87 (13)	8/87 (9)	3/87 (3)	5/87 (6)	1/87 (1)

COVID-19 Vaccine Specifications

	ASTRAZENECA	GAMALEYA	JOHNSON & JOHNSON	MODERNA	NOVAVAX	PFIZER/ BIONTECH	SINOVAC	SINOPHARM	BHARAT BIOTECH	CANSINO BIOLOGICS	CLOVER
VACCINE TYPE	Viral vector (chimpanzee adenovirus ChAdOx1)	Viral vector (recombinant adenovirus types 5 and 26)	Viral vector (recombinant adenovirus type 26)	mRNA	Protein subunit	mRNA	Inactivated virus	Inactivated virus	Inactivated virus	Viral vector (recombinant adenovirus type 5)	Protein
Available Through COVAX	✓	-	✓	-	✓	✓	-	-	-		-
Doses Required	4-12 weeks apart	3 weeks apart	2 doses with 2-6 month interval also recommended	4 weeks apart*	3 weeks apart	3-4 weeks apart*	2-4 weeks apart*	3-4 weeks apart*	3 weeks apart		3 weeks apart
Third dose/ boosters	As part of primary series for those with immunocomp.	-	-	As part of primary series for those with immunocomp. USA: at least 6 months after primary series in at-risk groups and ≥65 years	As part of primary series for those with immunocomp.	As part of primary series for those with immunocomp. USA: at least 6 months after primary series in at-risk groups and ≥65 years	As part of primary series for ≥60 years	As part of primary series for ≥60 years	-	As part of primary series for high priority groups and ≥65: 4-6 months after primary series	-
Shipping, Storage & Presentation	Normal cold chain requirements (2-8°C); 10-dose vials	-18.5°C (liquid form); 2-8°C (dry form)	Shipped at -20°C; 2-8°C for up to 3 months; 5-dose vials	-25°C to -15°C; 10-dose vials	2-8°C; 10-dose vials	-80°C to -60°C; 2-8°C for up to 1 month; 6-dose vials	2-8°C; Single-dose vials	2-8°C; Single-dose vials/ pre-filled syringes	2-8°C; 10-dose or 20-dose vials	2-8°C; Single-dose or 3-dose vials	2-8°C
Approval by a Stringent Regulatory Authority (SRA)	WHO EUL, EMA, TGA, MHRA	Under review by WHO SAGE	WHO EUL, EMA, FDA, MHRA	WHO EUL, EMA, FDA, TGA	WHO EUL, EMA, TGA	WHO EUL, EMA, FDA, TGA, MHRA	WHO EUL	WHO EUL	WHO EUL	WHO EUL	-

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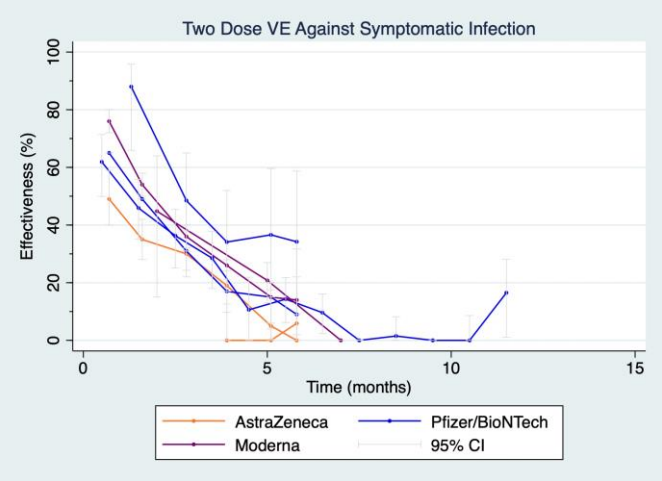
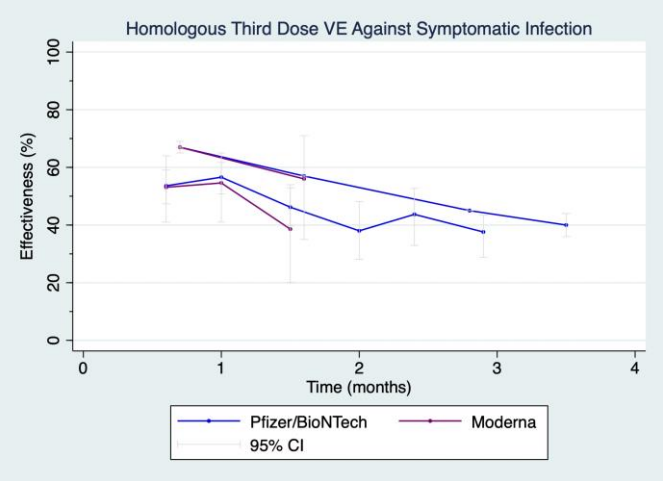
Graphs of Vaccine Effectiveness Against Omicron in Adults

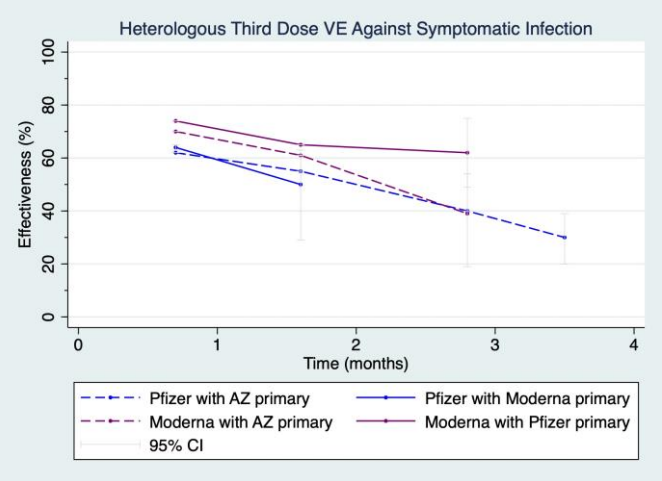
Each line represents data from an individual study; note the scale changes on the x axis.
Although VE against symptomatic infection declines after 2 or 3 doses of any vaccine, VE against severe disease/hospitalisation is still moderately high after 2 doses and even higher after a third dose, irrespective of which vaccine was given as a primary series.



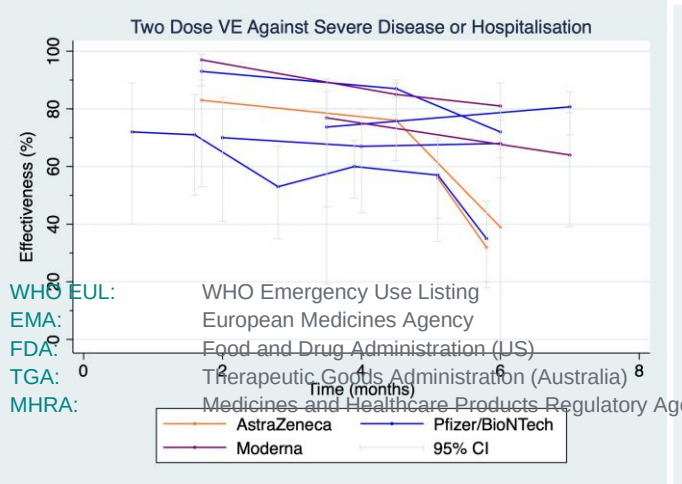
References: [29–31]



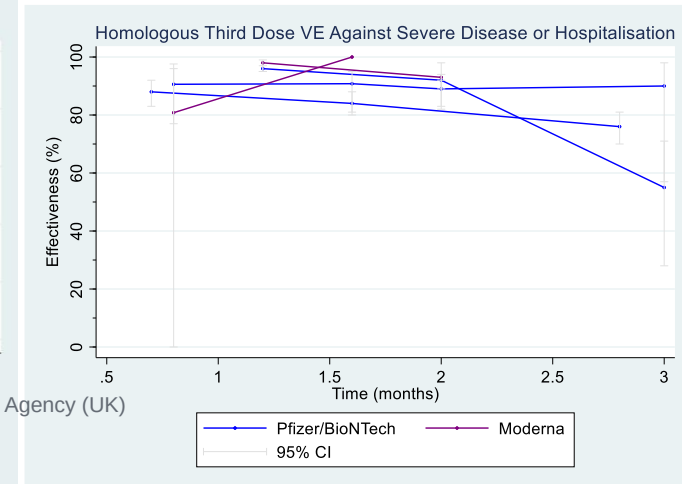
References: [67,86]



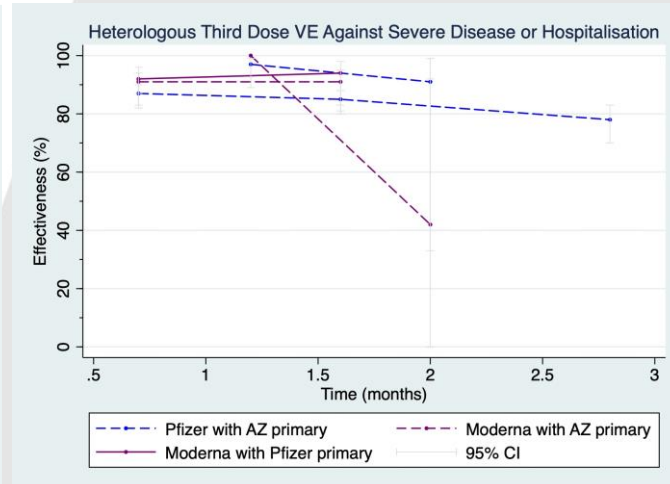
References: [30]



References: [30,31,33,34]



References: [30–34]



References: [30,34]

WHO EUL: WHO Emergency Use Listing
EMA: European Medicines Agency
FDA: Food and Drug Administration (US)
TGA: Therapeutic Goods Administration (Australia)
MHRA: Medicines and Healthcare Products Regulatory Agency (UK)

Vaccine Efficacy/Effectiveness Against Omicron at-a-glance

Detailed summary of vaccine efficacy/effectiveness against other variants available in Appendix 4.
At-a-glance summary of one and two-dose efficacy/effectiveness against Delta available in Appendix 5; and of booster efficacy/effectiveness against Delta in Appendix 6.
Detailed summary of booster efficacy/effectiveness against Delta available in Appendix 7.

VACCINE	VACCINE EFFECTIVENESS (AFTER 2 DOSES) UNLESS OTHERWISE STATED		
	ANY INFECTION	SYMPTOMATIC INFECTION	HOSPITALISATION AND DEATH
AstraZeneca	Booster: 0-3 months: 30-51[35]	No protective effect beyond 15 weeks[29] -39-50%[30,36]	55-83%[30,34] 3-6 months: 76%[34] ≥6 months: 25-39%[30,34] Third dose: 52.9[23]
Johnson & Johnson	Strong antibody response[37]	-	Booster: Hospitalisation: 85% (54-95)[38]
Moderna	30-37%[39,40] Single dose: 20%[40] Booster: 64%[40]	45%[31] ≥7 months: 0-2%[31,41] Booster: 47-55%[31,4243] Booster ≥6 weeks: 39%[31] Booster >6 months: 61%[41] Single dose: 0%[31]	77-97%[31,34] ≥6 months: 64-86%[31,34,41] Booster: Hospitalisation: 83-98%[30,34,41] Booster: Hospitalisation ≥2 months: 93%[34] Efficacy: Fourth dose compared to three doses: Any infection: 11% (-43-44); Symptomatic infection: 31% (-18-60)[44]
Pfizer/BioNTech	55%[39] Booster: 55%[39]	-18-88%[29,31,36,43–46] ≥15 weeks: 34-37%[29] >6 months: 0%[31] Booster: 49-86%[29,31,36,41,42] Booster ≥12 weeks: 38%[31] Booster: >6 months: 0%[41] Single dose: 26-34%[29,31] Third dose following previous infection: 76.3%[25] Second dose following previous infection: 55.5% [25]	Hospitalisation: 70-93%[9,14,18,4620,21] Hospitalisation >6 months: 68-81%[31,33,34,41,46,47] Booster: Hospitalisation: 49-96%[23,30,31,33,34,41,42] Booster: Hospitalisation ≥2 months: 75-92%[30,34] Booster: Hospitalisation >3 months 33% [46] Second booster compared to single booster ≥60 years: 78%)[20]
Sinovac	Booster: 33%.[35]	Booster: 79%[48]	Booster: Hospitalisation: 86% [48] Booster: Death: 87% [48]

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Vaccine Efficacy/Effectiveness of Fourth Dose against Omicron at-a-glance

Detailed summary of vaccine efficacy/effectiveness against other variants available in Appendix 4.

VACCINE	VACCINE EFFECTIVENESS UNLESS OTHERWISE STATED		
	ANY INFECTION	SYMPTOMATIC INFECTION	HOSPITALISATION AND DEATH
Johnson & Johnson		-	Booster: Hospitalisation: 85% (54-95)[38]
Moderna	Efficacy: Fourth dose compared to third dose: 11% (-43-44)[44]	Efficacy: Fourth dose compared to third dose: 31% (-18-60)[44]	
Pfizer/BioNTech	Efficacy: Fourth dose compared to third dose: 30% (9-55)[44] Fourth dose compared to third dose: 40-45%[21,22] Fourth dose compared to third dose: 14-20 days: 65%[49] 56-62 days: 33[49]	Efficacy: Fourth dose compared to third dose: 43% (7-65)[44] Fourth dose compared to third dose: 51-74[21,22]	Second booster compared to single booster ≥60 years: 78% (72-83)[20] Hospitalisation and death: Fourth dose compared to third dose: 50-90%[21,22]

Vaccine Efficacy/Effectiveness in Children against Omicron

VACCINE	VACCINE EFFICACY, EFFECTIVENESS AND OTHER OUTCOMES (EFFECTIVENESS UNLESS OTHERWISE STATED)	
	<12 years	12-18 years
Novavax	7-12 years trial underway in India	Various clinical trials are currently underway to determine the safety and efficacy in 12–18-year-olds
Pfizer/BioNTech	USA: Hospitalisation due to Delta or Omicron: 5-11 years: 2 doses 14-67 days: 74% (-35-95)[50] USA: Hospitalisation: 5-11 years: 68% (42-82)[51] USA: Symptomatic infection: 2 doses 2 months: 5-11 years: 28.9% (24.5-33.1)[52] Israel;: Symptomatic infection: Single dose: 18%(-2-34) at 14 to 27 days; 2 doses: 48% (29-63) at 7 to 21 days[27].	12-15 years: Single dose: 14-20 days: 49.6% (43.9-54.8); 70-83 days: 16.1% (12.1-20.0); Two doses: 7-13 days: 83.1% (78.2-86.9); 16-17 years: Single dose: 21-27 days: 52.7% (43.3-60.5); ≥15 weeks: 12.5% (6.9-17.8); Two doses: 7-13 days: 76.1% (73.4-78.6); ≥10 weeks: 22.6% (14.5-29.9)[53] USA: Hospitalisation due to Delta or Omicron: 12-15 years: 2 doses: 14-149 days: 92% (79-97);≥150 days: 73% (43-88); 16-17 years: 2 doses: 14-149 days: 94% (87-97); ≥150 days: 88% (72-95)[50] USA: Hospitalisation: 2-22 weeks: 43% (-1-68); 23-44 weeks: 38% (-3-62)[51] USA: Symptomatic infection: Two doses during month 2: 12-15 years: 16.6%(8.1-24.3)[52] Norway: Symptomatic infection: <63 days: 23%(3-40)[54] Brazil: Symptomatic infection: Two doses: <14 days: 75%(57.3-85.9)[55] Scotland: Hospitalisation: Two doses: >98 days: 31%(4.8-50.5)[55]
Sinovac	Chile: 2 doses: Any infection: 38.2% (36.5-39.9); Hospitalisation: 64.6% (49.6-75.2)[56]	-

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Vaccine Efficacy/Effectiveness in High-Risk Groups at-a-glance

Detailed summary available in Appendix 8.

VACCINE	VACCINE EFFICACY/EFFECTIVENESS			
	DIABETES	OBESITY	AT RISK FOR SEVERE COVID-19	ELDERLY*
AstraZeneca	-	-	Efficacy against symptomatic infection: 76%[57] Effectiveness of single dose against: Symptomatic infection: 60%[58] Effectiveness against: Symptomatic infection: 80%[58] Hospitalisation: 63%[59]	Efficacy against infection: 85%[57] Effectiveness of single dose against: Symptomatic infection: 53-61%[58,60] Hospitalisation: 80%[61] Death: 83%[62] Effectiveness against: Symptomatic infection: 39-81%[58,63–67] Hospitalisation: 37-94%[63,64,66–68] Death: 65-94%[62,66,67,69]
Bharat Biotech	-	-	Efficacy against infection: 66%[70]	Efficacy against symptomatic infection: 68%[70]
Gamaleya	-	-	-	Symptomatic infection: 92%[71]
Johnson & Johnson	Efficacy: 23%[72]	Efficacy: 66%[72]	Efficacy: 59%[72]	Efficacy 66%[72]
Moderna	-	-	Efficacy against symptomatic infection: 84-91%[73] Effectiveness against hospitalisation: 84% (80-87)[74]	Efficacy against symptomatic infection: 86%[73] Effectiveness against infection: pre-Omicron: 75-97%[40,75,76]; Omicron: 57%[40]
Novavax			Efficacy against infection: 91%[77]	
Pfizer/BioNTech	Effectiveness against infection: 82%[78] 89%[79]	Effectiveness against infection: 90%[79]	Efficacy against symptomatic infection: 95%[80] Effectiveness of single dose against symptomatic infection: 56%[58] Effectiveness against: Infection: 71-90%[79,81] Symptomatic infection: 89%[58] Hospitalisation: 72-81%[81] Effectiveness against hospitalisation: <3 months since third dose: 55%; ≥3 months since third dose: 25%[82]	Efficacy against symptomatic infection: 95-100%[80,83] Effectiveness of single dose against: Infection: 76%[60] Symptomatic infection: 40-80%[58,67,84] Hospitalisation: 71-91%[61,67,68] Death: 77-92%[62,67] Effectiveness against: Infection: 70-89%[78,79,81,85] Smptomatic infection: 61-93%[58,63,65,84] Hospitalisation: 43-93%[63,68,85] Death: 87-98%[62,69]
Sinopharm	-	81%[86]	-	Effectiveness against symptomatic infection 91%[86]
Sinovac	-	Infection: 75%[86]	Infection: 49%[86]	Infection: 28%[66] Hospitalisation: 32%[66] Death: 34%[66]

*Estimates in those ≥60 years to ≥90 years

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Vaccine Efficacy/Effectiveness in Children

Most studies conducted during Delta predominance.

VACCINE	VACCINE EFFICACY, EFFECTIVENESS AND OTHER OUTCOMES		COUNTRIES VACCINATING CHILDREN BY AGE GROUP
	<12 years	12-18 years	
Moderna	Well tolerated and produced strong antibody response in 6-11 year olds in USA (Moderna press release)[87]	Efficacy: Symptomatic infection in USA, 12-15 years: 96%[88]	≥12 years: Authorised by EMA, MHRA, TGA ≥12 years: France, Italy, Japan, Australia, Canada, Guinea, Philippines ≥3 years: Colombia
Novavax	7-12 years trial underway in India	Study in 12-18 years has started recruitment	-
Pfizer/BioNTech	5-11 years: Antibody response and safety profile for reactogenicity similar to 16-25 year-olds[89] Efficacy: Symptomatic infection in 5-11 year olds in USA during Delta predominance: 90.9% (68.3-98.3)[90] <5 years: Evaluation of a 3 dose schedule underway due to low immunogenicity of 2 doses[91] UK JCVI: estimated impact of single dose in 5-11 years with underlying health conditions: Prevented per million first doses: 105 PICU admissions; 1265 hospital admissions; 16 PIMS-TS cases[92] Effectiveness: Hospitalisation in USA in the week beginning 20 December 2021: 5-11 years: 76%[93] USA: Hospitalisation due to Delta or Omicron: 5-11 years: 2 doses 14-67 days: 74% (-35-95)[50] USA: Effectiveness: Hospitalisation: 5-11 years: Omicron: 68% (42-82)[51]	Efficacy: Symptomatic infection in USA, 12-15 years: 100%[94]; Up to 4 months after second dose: 100% (87.5-100)[95] Efficacy: Symptomatic infection in Israel, 12-15 years: 100%[96] Effectiveness in Israel 12-18 years: Any infection: 90% (88-92); Symptomatic infection: 93% (88-97)[97] Effectiveness against hospitalisation in USA: 12-18 years: 93% (83-97)[98] Effectiveness: Symptomatic infection 12-15 years: Single dose 2 weeks: 75.4% (73.9-76.9); Single dose 8-9 weeks: 46.8% (14.9-66.7); 16-17 years: Single dose 2 weeks: 75.9% (74.3-77.4); Single dose 8-9 weeks: 34.3 (30.7 to 37.7); 2 doses 2-9 weeks: 94.6% (92.8-95.9); Hospitalisation: 16-17 years: Single dose: 84.5% (64.6-93.2)[99] USA: Effectiveness: MIS-C: 91% (78-97)[100] USA: Effectiveness: 2 doses: Hospitalisation: 94% (90-96); ICU admission: 98% (93-99); Single dose: Hospitalisation: 97% (86-100)[101] Effectiveness: Hospitalisation in USA in the week beginning 20 December 2021: 12-17 years: 81%[93] UK: Effectiveness: Symptomatic infection: Delta: 12-15 years: Single dose: 14-20 days: 74.5% (73.2-75.6); 70-83 days: 45.9% (41.2-50.1); Two doses: 7-13 days: 93.2% (81.5-97.5); 16-17 years: Single dose: 14-20 days: 75.9% (74.3-77.3); 84-101 days: 29.3% (25.9-32.6); Two doses: 14-34 days: 96.1% (95.2-96.8); ≥10 weeks: 83.7% (72.0-90.5) Omicron: 12-15 years: Single dose: 14-20 days: 49.6% (43.9-54.8); 70-83 days: 16.1% (12.1-20.0); Two doses: 7-13 days: 83.1% (78.2-86.9); 16-17 years: Single dose: 21-27 days: 52.7% (43.3-60.5); ≥15 weeks: 12.5% (6.9-17.8); Two doses: 7-13 days: 76.1% (73.4-78.6); ≥10 weeks: 22.6% (14.5-29.9)[53] USA: Hospitalisation due to Delta or Omicron: 12-15 years: 2 doses: 14-149 days: 92% (79-97); ≥150 days: 73% (43-88); 16-17 years: 2 doses: 14-149 days: 94% (87-97); ≥150 days: 88% (72-95)[50] France: Effectiveness: MIS-C: Delta (>95% Pfizer/BioNTech in the study and <5% Moderna): 91% (79-96)[102] USA: Effectiveness: Hospitalisation: Delta: 2-22 weeks: 93% (89-95); 23-44 weeks: 92% (80-97); Omicron: 2-22 weeks: 43% (-1-68); 23-44 weeks: 38% (-3-62)[51]	≥5 years: Authorised by FDA, EMA, TGA ≥5 years: USA, Israel, Canada, Oman, Saudi Arabia, Bahrain, UAE, Costa Rica, UK ≥12 years: Authorised by EMA, MHRA TGA, Medsafe ≥12 years: USA, Canada, UK Israel, France, Spain, Italy, Netherlands, Germany, South Africa, Singapore, Japan, Australia, Estonia, Denmark, Greece, Ireland, Lithuania, Sweden, Finland, Norway, Switzerland, Jordan, Morocco, Egypt, Guinea, Namibia, South Korea, Philippines, Brazil 12-15 years single dose: South Africa 12-17 years single dose: Hong Kong ≥3 years: Colombia
Sinovac	Phase I/II studies complete in 3-17 year old's in China[103]; Phase 3 studies underway in Chile, Kenya, Malaysia, the Philippines, and South Africa	-	≥12 years: Indonesia ≥6 years: Chile, El Salvador, Ecuador Indonesia ≥3 years: China, Colombia, Hong Kong
Sinopharm	Phase I/II studies in 3-17 year olds in China		≥12 years: Morocco ≥3 years: China, UAE, Venezuela, Argentina, Bahrain
AstraZeneca	Trials suspended when evidence emerged of the higher risk of TTS in younger adults compared to older adults		≥3 years: Colombia
Bharat Biotech	Phase 2/3 trial in 2-18 year olds		-

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Maternal Vaccination

VACCINE	VACCINE EFFICACY/EFFECTIVENESS IN PREGNANT WOMEN	OTHER OUTCOMES
AstraZeneca	-	In four clinical trials in the UK, Brazil and South Africa, fertility was unaffected by vaccination and there was no increased risk of miscarriage and no instances of stillbirth in women vaccinated before pregnancy[104]
Moderna	-	Following maternal vaccination with mRNA vaccines, 100% of neonates (n=36) had protective antibodies at birth[105] Comparison in USA of 35,691 participants who received an mRNA vaccine in pregnancy and nonpregnant women (v-safe registry and VAERS): Injection-site pain more frequent in pregnancy; headache, myalgia, chills, and fever less frequent. Adverse pregnancy and neonatal outcomes similar in pregnant women to studies conducted before the Covid-19 pandemic[106] Durability of anti-spike antibodies in infants after maternal Pfizer or Moderna: 98% of infants had antibodies at 2 months of age; higher antibody levels than in infants of those previously infected; 57% of infants of vaccinated mothers had antibodies at 6 months of age compared to 8% of infants of infected mothers[107] Pooled effectiveness of maternal vaccination with two doses of Pfizer or Moderna against hospitalisation in infants <6 months of age: Overall: 61% (31-78); During first 20 weeks of pregnancy: 32% (-43-68); From 21 weeks to 14 days before delivery: 80% (55-91)[108] Effectiveness of maternal vaccination with two doses of Pfizer/BioNTech or Moderna against hospitalisation in infants <6 months of age: Overall: 38% (8-58); Vaccination within first 20 weeks of pregnancy: 25% (-26- 56); Vaccination after 20 weeks of pregnancy: 57% (25-75)[28]
Novavax	-	Norway: Infants in the first four months of life born to mothers who received a second or third dose of vaccine during pregnancy than those born to unvaccinated mothers have lower risk of infection: aHR:0.67 (0.57-0.79)[109].
Pfizer/BioNTech	Effectiveness in Israel: Any infection: 96% (89-100); Symptomatic infection: 97% (91-100); Hospitalisation: 89% (43-100)[110] Effectiveness in Israel: Any infection: 78% (57-89)[111]	Following maternal vaccination with mRNA vaccines, 100% of neonates (n=36) had protective antibodies at birth[105] NIH-funded MOMI-VAX study will assess antibody responses in 750 pregnant women and 250 women vaccinated with any US-licensed vaccine within 2 months of birth, and their infants[112] Comparison in USA of 35,691 participants who received an mRNA vaccine in pregnancy and nonpregnant women (v-safe registry and VAERS): Injection-site pain more frequent in pregnancy; headache, myalgia, chills, and fever less frequent. Adverse pregnancy and neonatal outcomes similar in pregnant women to studies conducted before the Covid-19 pandemic[106] Durability of anti-spike antibodies in infants after maternal Pfizer or Moderna: 98% of infants had antibodies at 2 months of age; higher antibody levels than in infants of those previously infected; 57% of infants of vaccinated mothers had antibodies at 6 months of age compared to 8% of infants of infected mothers[107] Infants of vaccinated and unvaccinated mothers in Israel: No difference in preterm birth, congenital anomalies, hospitalisation, or death[113] Pooled effectiveness of maternal vaccination with two doses of Pfizer or Moderna against hospitalisation in infants <6 months of age: Overall: 61% (31-78); During first 20 weeks of pregnancy: 32% (-43-68); From 21 weeks to 14 days before delivery: 80% (55-91)[108] Effectiveness of maternal vaccination with two doses of Pfizer/BioNTech or Moderna against hospitalisation in infants <6 months of age: Overall: 38% (8-58); Vaccination within first 20 weeks of pregnancy: 25% (-26- 56); Vaccination after 20 weeks of pregnancy: 57% (25-75)[28]
Sinopharm	-	-
Sinovac	-	-

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Mixed Dose Vaccine Safety and Immune Responses

Mixed vaccine schedules (i.e., delivering different types of vaccine for the first and second dose) could be particularly useful to facilitate better protection against variants of concern and enable vaccination programs to continue if a particular vaccine is unavailable.

SCHEDULE	SAFETY	IMMUNE RESPONSES OR EFFECTIVENESS	COUNTRIES USING SCHEDULE
AZ-PF	Spain: Similar side effects to those receiving 2 doses of the same vaccine; no safety concerns (not peer reviewed)[114] UK: Greater systemic side effects (mild-moderate symptoms) following the booster dose than with 2 doses of the same vaccine; no safety concerns[115] Germany: greater reactogenicity with first dose of AstraZeneca than with the Pfizer/BioNTech booster[116] Increased reactogenicity (54.4%; 49.4-59.5) vs AstraZeneca-AstraZeneca (33.5%; 28.0-39.2)[117] Total adverse event reporting in Korea: 0.28% (vs AZ-AZ: 0.22%; and PF-PF: 0.31%)	Spain: ≥8 week dose interval: Stronger immune response following Pfizer/BioNTech than after 2 doses of AstraZeneca vaccine (not peer reviewed)[114] Spain: 8-12 week dose interval: robust antibody response[118] UK: 4 week dose interval: stronger antibody and cellular response than after 2 doses of AstraZeneca vaccine[119] Germany: 9-12 week dose interval: Significantly stronger immune response following Pfizer/BioNTech booster than AstraZeneca, and slightly stronger than after 2 doses of Pfizer/BioNTech (not peer reviewed)[120] Germany: 4-fold greater immune response than 2 doses of AstraZeneca[121] South Korea: 6-fold greater neutralising antibody response than 2 doses of AstraZeneca Germany: Higher neutralising antibody response against wild-type, Alpha, Beta, Gamma and Delta variants than AZ-AZ[122]	Canada, Denmark, Finland, France, Germany, Sweden, Norway, Spain and South Korea[123]
PF-AZ	UK: Greater systemic side effects (mild-moderate symptoms) following the booster dose than with 2 doses of the same vaccine; no safety concerns[115] Greater reactogenicity with first of homologous and heterologous prime-boost immunisation with BNT162b2 and ChAdOx1-nCoV19: a prospective cohort study increased reactogenicity (55.2%; 46.1-64.1) vs Pfizer/BioNTech-Pfizer/BioNTech (33.3%; 23.4-44.5)[117]	UK: 4 week dose interval: weaker antibody response than after 2 doses of Pfizer/BioNTech vaccine (but stronger than after 2 doses of AstraZeneca vaccine)[119]	-
AZ-mRNA (PF or MO)	-	Effectiveness in Canada: Infection: 90% (89-91); 87% (85-89); Hospitalisation: 99% (98-100); 98% (95-99)[64]	
Primary series of PF, J&J or MO followed by PF, J&J or MO booster	Reactogenicity for all combinations similar to primary series[37]	Homologous boosters increased neutralising antibody titres 4.2 to 20-fold; Heterologous boosters increased neutralising antibody titres 6 to 76-fold[37]	-
AZ, MO and PF	-	Canada: Trial underway mixing and matching all three vaccines with study arms assessing 4 week and 16 week dose intervals[124] Denmark: Vaccine effectiveness against infection: AZ-PF or AZ-MO: 88% (83-92)[125]	AstraZeneca followed by either Moderna or Pfizer/BioNTech: Denmark, Finland, France, Germany, Sweden, Norway and Spain[123]
Sinovac primary series	-	Chile: Symptomatic infection: Sinovac booster: 78.8% (76.8-80.6); PF booster: 96.5% (96.2-96.7); AZ booster: 93.2% (92.9-93.6); Hospitalisation: Sinovac: 86.3% (83.7-88.5); PF: 96·1% (95.3-96.9); AZ: 97.7 (97.3-98.0); Death: Sinovac: 86.7% (80.5-91.0); PF: 96.8% (93.9-98.3); AZ: 98.1% (97.3-98.6)[126] Chile: Symptomatic infection with Omicron: PF booster: 96.5% (96.2-96.7); AZ booster: 93.2 (92.9-93.6)[126,127] Pfizer/BioNTech booster: Symptomatic infection among ≥75: 45.9%[128] Pfizer/BioNTech booster: Hospitalisation among ≥75 years: 79.9%[128]	Sinovac-AZ: Thailand

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COVID-19 Vaccine Efficacy

All studies conducted prior to Omicron predominance and most prior to Delta. Efficacy is dependent on variants circulating at the time of the study, so it is difficult to directly compare efficacy between vaccines.

VACCINE	VACCINE EFFICACY			
	SYMPTOMATIC INFECTION	MODERATE-SEVERE	SEVERE	HOSPITALISATION/DEATH
AstraZeneca	UK: 66.7% (57.4-74.0)[129] USA, Chile, Peru: 76%[57] (not peer-reviewed) Single dose in UK (22-90 days post-vaccination): 76.0% (59.3 to 85.9)[129] Efficacy with different interval between doses in UK: 12+ weeks: 82.4% (2.7-91.7) <6 weeks: 54.9% (32.7-69.7)[129]	-	Severe/critical and hospitalisation in USA, Chile, Peru: 100%[57] (not peer-reviewed) UK: 100% (15 cases in the placebo group)[129]	Hospitalisation in UK: 100% (9 cases in placebo group)[129]
Bharat Biotech	India: 77.8% (65.2-86.4)[70]	-	India: 93.4% (57.1-99.8)[70]	-
Clover	Philippines, Colombia, Brazil, South Africa and Belgium: Overall: 67.2% (54.3-76.8); Delta: 78.7% (57.3-90.4)[130]	Philippines, Colombia, Brazil, South Africa and Belgium: Overall: 83.7% (55.9-95.4); Delta: 81.7% (35.9-96.6)[130]		Hospitalisation in Philippines, Colombia, Brazil, South Africa and Belgium: 100% (42.7-100)[130]
Gamaleya	Russia: 91.6% (85.6–95.2)[71] Single dose (Sputnik Light) in Argentina: 78.6%[131]	Moderate-severe: 100% (20 cases in the placebo group)[71]	-	-
Johnson & Johnson	USA: 93.2% (91.0-94.8)[132] USA, Brazil, Peru, South Africa: 55.9% (51.0-60.5)[133]	Moderate to severe/critical: All sites: 66.1% (55.0-74.8) USA: 72.0% (58.2-81.7) Latin America: 61.0% (46.9-71.8) South Africa: 64.0% (41.2-78.7)[72,134] South Africa: 67-71%[135]	85.4% (54.2-96.9)[134] USA: 98.2% (92.8-99.6)[132] USA, Brazil, Peru, South Africa: 73.3% (63.9-80.5)[133]	100% (5 deaths in placebo group)[134] Death in South Africa: 96%[135] USA, Brazil, Peru, South Africa: Death: 84.5% (47.3-97.1)[133]
Moderna	USA: 94.1% (89.3-96.8)[73] USA: >90%[136] Efficacy in USA: 12-17 years: Symptomatic: 92.7% (67.8-99.2) Infection: 69.8% (49.9-82.1) Asymptomatic infection: 59.5% (28.4-77.3)[137]	-	USA: 100% (30 cases in placebo group)[73] US: >95%[136]	USA: 100% (1 death in placebo group)[73]
Novavax	UK: 89.7% (80.2-94.6)[138] US and Mexico: 90.4% (82.9-94.6)[77]	US and Mexico: 100% (87.0-100)[77]	-	-
Pfizer/BioNTech	Argentina, Brazil, Germany, South Africa, Turkey and the USA: 94.6% (89.9–97.3)[80] Infection over 6 months: 91.3% (89.0-93.2)[83] Single dose: 100%	-	Argentina, Brazil, Germany, South Africa, Turkey and the USA: 88.9% (20.1–99.7)[80] Severe disease: 96.7% (80.3-99.9)[83]	-
Sinopharm	UAE, Bahrain, Egypt and Jordan: 78.1% (64.9-86.3)[86]	-	-	Hospitalisation in UAE, Bahrain, Egypt and Jordan: 78.7% (26.0-93.9)[86]
Sinovac	Brazil: 50.7% (35.9-62.0) Chile: 67% (65-69) Indonesia: 65% (20-85)[86] Turkey: 83·5% (65·4-92·1)[139]	Requiring medical assistance in Brazil: 83.7% (58.0-93.7) Moderate-severe: 100% (56.4-100.0)[140]	-	Hospitalisation: Brazil: 100% (56-100) Chile: 85% (83-97) Turkey: 100% (20-100)[86]
CanSino Biologics	Pakistan, Mexico, Argentina, Russia and Chile: 57.5% (39.7-70.0)[141]	-	-	-

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Vaccine Effectiveness of Primary Series Summary at-a-glance

Detailed summary available in Appendix 1.
At-a-glance summary of vaccine efficacy/effectiveness against asymptomatic infection available in Appendix 2 and details of vaccine efficacy/effectiveness against transmission available in Appendix 3.

VACCINE	ANY INFECTION	SYMPTOMATIC INFECTION	HOSPITALISATION/ SEVERE DISEASE	DEATH	EFFECTIVENESS 3 to <6 MONTHS	EFFECTIVENESS ≥6 MONTHS
AstraZeneca	45-73%[66,142–148] Single dose 30-67%[142,144,147,149]	-39-78%[29,36,58,64,65,67,145,150,151*] Single dose: 38-68%[58,60,151,152] Moderate-Severe: 82%; Single dose: 79%[147]	83-100%[34,59,153,154,64–67,74,145,150,151] Single dose: 49-94%[60,151,154,155]	90-100%[65–67,69,150]	Infection: 44-45%[29,67,151] Hospitalisation or death: 42-80%[34,67,151] Death: 85%[67]	Infection: 42-72%[29,148] Hospitalisation: 39%[34]
Bharat Biotech	-	50%[156]	-	-	-	-
Johnson & Johnson	50-88%[145,157–160]	54%[145]	71-91%[74,135,145,158,161]	-	-	Infection: 13%[162] Death: <65 years: 73%; ≥65 years: 52%[162]
Moderna	37-92%[39,75,76,145,159,163,164] Single dose: 20-72%[40,149]	45-95%[31,65,76,84,145,164,165] Single dose: 0-72%[31,62,84]	77-98%[31,34,164,40,65,74–76,145,161,163] Single dose: 69-96%[40,149]	98%[76]	85%[34]	Infection: 2-58%[31,41,162,164] Hospitalisation: 64-81%[31,34] Hospitalisation and death: 56-83%[41,164] Death: <65 years: 82%; ≥65 years: 76%[162]
Pfizer/BioNTech	55-95%[18,39,159,163,166–170,60,78,81,142,143,145,146,148] Single dose: 36-57%[142,144,149]	-18-97%[29,31,165,166,169,171–173,36,58,60,65,67,84,145,150*] Single dose: 26-61%[31,58,62,84,173]	74-99%[31,33,150,154,161,163,166,169–171,174,175,34,60,65,67,74,79,81,145] Single dose: 85-94%[154,155]	90-100%[65,67,69,79,81,150,166,169,174]	Infection: 47-65%[29,67,170] Hospitalisation: 87-92%[34,67] Death 92%[67]	Infection: 0-64%[29,31,41,148,162,173] Death: <65 years: 84%; ≥65 years: 70%[162] Hospitalisation: 68-81%[31,33,34,41]
Sinopharm	-	90%[86]	-	-	-	-
Sinovac	53-60%[66,174]	59[150]	73-91%[66,150,174]	74-95%[66,150,174]	-	-

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Adverse Events Following Immunisation with WHO EUL Vaccines

Adverse events following immunisation (AEFIs) are any reactions occurring after immunisation. They can be either expected or unexpected. The vaccine may not actually cause the AEFI; it may occur coincidentally as millions of people are being vaccinated so some people may get sick after vaccination, but this does not necessarily mean that it is due to the vaccine. Special investigations determine whether they are due to the vaccine. Adverse events of special interest (AESIs) are of scientific and medical concern that are found through active surveillance, that have the potential to be causally associated with a vaccine and that need to be carefully monitored and confirmed by further special studies.

For all injectable vaccines, appropriate medical treatment and supervision should always be readily available in case of an anaphylactic event following administration.

	ASTRAZENECA	MODERNA	PFIZER/BIONTECH	JOHNSON & JOHNSON	SINOPHARM	SINOVAC	CLOVER	BHARAT BIOTECH
Adverse events following immunisation (AEFIs)*	Very common (more than 1 in 10 people): headache, nausea, muscle pain, joint pain, injection site tenderness/ pain/ warmth/ itch, fatigue, malaise, fever, chills Common (between 1 in 10 and 1 in 100 people): injection site swelling/ redness[176]	Injection site pain (92%)/ swelling (15%)/ redness (10%), fatigue (70%), headache (65%), muscle pain (62%), joint pain (46%), fever (16%), chills (45%), nausea/vomiting (23%), axillary swelling/tenderness (20%)[177]	Very common: headache, muscle pain, joint pain, injection site pain/ swelling, fatigue, fever, chills; Common: nausea, injection site redness[176] Uncommon (between 1 in 100 and 1 in 1000 people): lymphadenopathy, insomnia, pain in extremity of vaccinated arm, malaise, injection site itch; Rare: (between 1 in 1000 and 1 in 10,000): acute peripheral facial paralysis[178]	Injection site pain/ redness/ swelling, headache, fatigue, muscle pain, nausea, fever[179]	Injection site pain (16%)/ itch (1%)/ swelling (2%)/ redness (1%), fever (4%), fatigue (3%), nausea (1%), headache (1%), diarrhoea (1%), muscle pain (<1%), itch (non-injection site) (1%)[180]	Fatigue (8.3%), fever (3.3%), diarrhoea (0.8%), nausea (1.7%), headache (2.5%), muscle pain (1.7%), injection site pain (10.0%)/ redness (0%)/ swelling (0%)[181]	Very common: Injection site pain, fatigue, headache Common: Injection site erythema, myalgia, arthralgia, loss of appetite, nausea, chills Uncommon: Injection site swelling, fever[130]	Common: Injection site pain/redness/ itching, headache, fever, malaise, fatigue, body ache
Adverse events of special interest (AESIs)	Thrombosis with thrombocytopaenia syndrome (TTS) (see page 13 for estimated risk); EMA PRAC: Guillain-Barre syndrome (GBS)[182] Australia: Guillain-Barre syndrome: 52 cases (10.4 per million doses)[183] Australia: Immune thrombocytopaenia (ITP)	Myopericarditis (most common in younger males) USA VAERS: myocarditis cases per million second doses: 18-24 year males 38.5, females: 5.3; 25-29 year males: 17.2, females: 5.7[184] ITP**[185]	Myopericarditis (most common in younger males) USA VAERS: myocarditis cases per million second doses: 12-15 year males: 39.9, females: 3.9; 16-17 year males: 69.1, females: 7.9; 18-24 year males: 36.8, females: 2.5; 25-29 year males 10.8, females: 1.2[184] >1 in 20,000 males under 25 years of age[12] Israel: 1 to 5 cases of myocarditis per 100,000 persons[186,187] ITP**[185]	TTS (see page 14 for estimated risk) USA: Guillain-Barre Syndrome: 100 preliminary reports of GBS following 12.5 million doses of vaccine administered (mostly males >50 years)[188]	-	-	-	-

*Details for AstraZeneca, Moderna, Pfizer/BioNTech and Johnson & Johnson from product information sheets in SRA countries, based on data from clinical trials; Sinopharm, Sinovac and Bharat Biotech details from published clinical trials
**The ITP cases are mostly without the thrombotic events characteristic of TTS

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Serious Adverse Events

Caution is required when comparing safety profiles as definitions and reporting systems vary in trials and in particular phase IV studies. Risk of TTS in PICs available in Appendix 9.

VACCINE	VACCINE SAFETY
AstraZeneca	108 SAEs in 12,282 (0.9%) vaccine recipients and 127 in 11,962 (1.1%) placebo recipients; 7 deaths all considered unrelated to vaccination (2 vaccine, 5 placebo)[129] US Phase III study: No serious safety concerns involving 32,449 participants[57] (not peer-reviewed) EMA investigation: possible link between the AstraZeneca vaccine and Thrombosis with Thrombocytopaenia Syndrome (TTS) Blood clots affected the brain (central venous sinus thrombosis, CVST) and abdomen (splanchnic vein thrombosis) There have been reports of 169 cases of CVST and 53 cases of splanchnic vein thrombosis in ~34 million vaccinated people in Europe The EMA confirmed the overall benefits of the vaccine in preventing COVID-19 outweigh the risks of side effects[8] UK: Risk factors for death in patients with TTS following the AstraZeneca vaccine: baseline platelet count; and intracranial haemorrhage[189] TTS reported to occur in ~1 in 50,000 vaccinated adults in Australia[190] Several countries introduced age recommendations for the vaccine: >60 years in Germany and Australia; >55 years in France and Canada; >40 years in the UK[191–193] EMA has started a review of reports of capillary leak syndrome following 5 cases of this very rare disorder post vaccination[194] WHO GACVS reports Guillain Barre Syndrome (GBS) rates following adenovirus vector vaccines: EU/EEA: 4.4; AUS: 9.7; KOR: 0.4; PHL: <1[195] Guillain-Barre Syndrome in England: IRR 15-21 days: 2.90 (2.15-3.92); Scotland: IRR 1-28 days: 2.32 (1.08-5.02); following SARS-CoV-2 infection: IRR 1-28 days: 5.25 (3.00-9.18); Bell's Palsy in England: IRR 15-21 days: 1.29 (1.08-1.56); IRR 1-28 days: 1.07 (0.94-1.21)[196] Immune thrombocytopaenia (ITP) in Victoria, Australia: 8 cases per million doses (17 cases; 15 after second dose) (Expected background rate: 20-49 years: 1.9; ≥50 years: 4.1)[197]
Gamaleya	45 SAEs in 16,427 (0.3%) vaccine recipients and 23 in 5,435 (0.4%) placebo recipients; 4 deaths all considered unrelated to vaccination (3 vaccine, 1 placebo)[71]
Johnson & Johnson	83 SAEs in 21,895 (0.4%) vaccine recipients and 96 in 21,888 placebo recipients (0.4%); 19 deaths all considered unrelated to vaccination (3 vaccine, 16 placebo)[72] EMA investigation of 8 reports of TTS. Most cases occurred in women <60 years of age but specific risk factors have not been confirmed[9] USA: Cases of TTS per million doses: Overall: 3.1; Female: 5.2; Male: 1.5[184] Deaths: 5 (4 female, 1 male)Guillain-Barre Syndrome: 100 preliminary reports of GBS following 12.5 million doses of vaccine administered in USA (mostly males >50 years)[188] WHO GACVS reports Guillain Barre Syndrome (GBS) rates following adenovirus vector vaccines: USA: 7.8; KOR: 0.9; EU/EEA: AZ: 2.1[195]
Moderna	153 SAEs in 15,166 (1.0%) placebo recipients and 147 in 15,185 (1.0%) vaccine recipients; 5 deaths considered unrelated to vaccine (2 vaccine, 3 placebo)[73] Anaphylaxis reported in the US at a rate of 2.5 per million doses[198] No obvious safety signals among pregnant women who received mRNA COVID-19 vaccines in USA[106] USA: Myo/pericarditis reported in 40.6 males and 4.2 females aged 12-29 years per million second doses of mRNA vaccine; and 2.4 males and 1.0 females aged 30+[199] USA VAERS: myocarditis cases per million second doses: 18-24 year old males: 38.5, females: 5.3; 25-29 year old males: 17.2, females: 5.7[184] Ontario, Canada; Myo/pericarditis cases per million second doses in those aged 18-24 years: Males 198.6; Females 59.6[200] Overall rates in the UK per million second doses: Myocarditis: 28.3; Pericarditis: 17.2[201] EMA PRAC: French study: 57 extra cases of myocarditis per million 16-24-year-old males compared to unexposed; Nordic study: 190 extra cases of myocarditis per million 16-24-year-old males[202] Myo/pericarditis in Ontario, Canada: Rates in males 18-24 years 5.1 (1.9-15.5) times higher following Moderna second dose than Pfizer/BioNTech; Rates higher with shorter dose interval (i.e. ≤30 days)[203] Myocarditis excess cases in people <40 years in the UK: First dose: 8 (4-9) per million; Second dose: 15 (12-16)[204] Myo/pericarditis in Australia: 25 cases per million doses (18-33)[205] Australia: Myo/pericarditis following boosters: 4 cases[206]
Novavax	SAEs at low levels and similar between vaccine and placebo groups[207]
Pfizer/BioNTech	SAEs and deaths were low and comparable between vaccine and placebo groups (total 37,586 participants)[80] Anaphylaxis reported in the US at a rate of 4.7 per million doses[198] No obvious safety signals among pregnant women who received mRNA COVID-19 vaccines in USA[106] Brazil: SAEs: 5.4/100,000 doses USA: Myopericarditis reported in 40.6 males and 4.2 females aged 12-29 years per million second doses of mRNA vaccine; and 2.4 males and 1.0 females aged 30+[199] USA VAERS: myocarditis cases per million second doses: 12-15 year males: 39.9, females: 3.9; 16-17 year males: 69.1, females: 7.9; 18-24 year males: 36.8, females: 2.5; 25-29 year males 10.8, females: 1.2[184] Ontario, Canada; Myo/pericarditis cases per million second doses in those aged 18-24 years: Males 35.5; females 39.9[200] Overall rates in the UK per million second doses: Myocarditis7.4; Pericarditis 5.6[201] Israel: Myo/pericarditis: 106.9 (69.3-144.6) cases per million in those aged 16-29[208]; 137.3 (81.1-194.6) cases per million people aged 16-19[209] Haemorrhagic stroke in England: IRR 15-21 days: 1.38 (1.12-1.71) (not replicated in Scotland data)[196] Israel: Myo/pericarditis: 16-19 year old males: Second dose: 161 cases per million; Third dose: 52 cases per million[210] EMA PRAC: French study: 26 extra cases of myocarditis per million 12-29-year-old males compared to unexposed; Nordic study: 130 extra cases of myocarditis per million 12-29-year-old males[202] Hong Kong: Myo/pericarditis in 12-17 year-olds: After first dose: 34 (11-95) cases per million; Second dose: 212 (138-323); Males, first dose: 56 (24-125); Males, second dose: 373 (270-513)[211] Myo/pericarditis in Ontario, Canada: Rates higher with shorter dose interval (i.e. ≤30 days)[203] Myocarditis excess cases in people <40 years in the UK: First dose: 2 (1-3) per million; Second dose: 3 (2-4)[204] Myo/pericarditis in Australia: 16 cases per million doses (15-17)[205] USA: Myocarditis 5-11 years: 11 confirmed cases following ~8 million doses administered[212] Australia: Myo/pericarditis following boosters: 14 cases[206] France: MIS-C following vaccination in 12-17 year olds: 1.1 cases per million doses (post-SARS-CoV-2 MIS-C in the same age group in the same population was 113 per million doses)[213] USA: MIS-C following vaccination in 12-20 year olds: 21 cases (1 case per million persons vaccinated)[214] Israel: Myocarditis in 18-24 year old military recruits following a *third dose* of Pfizer/BioNTech: 64.3 (1.3-127.3) per million within 1 week of booster; 112.5 (29.2-195.9) per million within 2 weeks[215]
Sinovac	Brazil: SAEs: 79.7/100,000 doses Safety in Chile 6-11 years: Adverse events following 0.011% of doses administered (most common: vomiting, itching, injection site pain and erythema)[216]

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Risk of Myo/Pericarditis in 12-17 Year Olds Following mRNA Vaccines

Estimated number of myo/pericarditis cases that potentially might occur in Pacific Island Countries if all 12–17-year-olds received the Pfizer/BioNTech or Moderna vaccine, based on official country population estimates and incidence of myo/pericarditis (highest and lowest estimates) in other settings. The risk is reduced with an extended dose interval of ≥8 weeks between first and second doses. Nearly all myo/pericarditis cases related to mRNA vaccination are mild and managed conservatively.

COUNTRY	TOTAL POPULATION	ESTIMATED POPULATION AGED 12-17 YEARS*	POTENTIAL NUMBER OF MYO/PERICARDITIS CASES IF ALL 12-17 YEAR OLDS RECEIVED THE PFIZER/BIONTECH VACCINE**	POTENTIAL NUMBER OF MYO/PERICARDITIS CASES IF ALL 12-17 YEAR OLDS RECEIVED THE MODERNA VACCINE ***
American Samoa	55,519	7,217	0.3-1.5	0.1-1.4
Cook Islands	15,300	1,989	<1	<1
Federated States of Micronesia	102,300	13,299	0.5-2.8	0.3-2.6
Fiji	867,000	112,710	4.2-23.9	2.3-22.0
French Polynesia	275,918	35,869	1.3-7.6	0.7-7.0
Guam	159,358	20,717	0.8-4.4	0.4-4.1
Kiribati	113,400	14,742	0.6-3.1	0.3-2.9
Marshall Islands	54,900	7,137	0.3-1.5	0.1-1.4
Nauru	10,900	1,417	<1	<1
New Caledonia	271,407	35,283	1.3-7.5	0.7-6.9
Niue	1,611	209	<1	<1
Northern Mariana Islands	53,883	7,005	0.3-1.5	0.1-1.4
Palau	18,000	2,340	<1	<1
Papua New Guinea	7,744,700	1,006,811	37.7-213.4	20.8-196.8
Samoa	195,979	25,477	1.0-5.4	0.5-5.0
Solomon Islands	642,000	83,460	3.117.7	1.7-16.3
Tokelau	1,160	151	<1	<1
Tonga	99,419	12,924	0.5-2.7	0.3-2.5
Tuvalu	10,507	1,366	<1	<1
Vanuatu	272,173	35,382	1.3-7.5	0.7-6.9
Wallis and Futuna	11,558	1,503	<1	<1
All Pacific Island Countries	10,976,992	1,427,009	53.4-302.5	29.5-279.0

* Based on estimate of 13% of population aged 12-17 years
** Based on estimates of myo/pericarditis occurring in 212 per million second doses of Pfizer/BioNTech in 12-17 year olds in Hong Kong and 37.4 per million second doses in 16-17 year olds in USA (VAERS data)[184,211]
*** Based on estimates of myo/pericarditis occurring in 195.5 per million doses in 18-24 year olds in Canada (data not available for <18 years) and 20.7 per million second doses in 18-24 year olds in USA (VAERS data; not available for <18 years)[184,203]

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Who Can be Vaccinated Based on WHO SAGE Recommendations?

WHO SAGE have made recommendations for use of AstraZeneca, Moderna, Pfizer/BioNTech, Johnson & Johnson, Sinopharm, Sinovac, Bharat Biotech and Novavax vaccines: https://www.who.int/groups/strategic-advisory-group-of-experts-on-immunization/covid-19-materialss

	ASTRAZENECA	MODERNA	PFIZER/BIONTECH	JOHNSON & JOHNSON	SINOPHARM	SINOVAC	BHARAT BIOTECH	NOVAVAX
Minumum Age	18 years	12 years	5 years	18 years	18 years	18 years	18 years	18 years
Maximum Age (SAGE WHO)	None	None	None	None	None	None	None	None
Pregnancy	Yes if high priority group & approved by health provider	Yes if high priority group & approved by health provider	Yes if high priority group & approved by health provider	Yes if high priority group & approved by health provider	Yes if high priority group & approved by health provider	Yes if high priority group & approved by health provider	Yes if the benefits outweigh the potential risks	Yes if the benefits outweigh the potential risks
Breastfeeding	Yes	Yes	Yes	Yes	Yes	Yes	Yes	Yes
People previously infected with SARS-CoV-2	May delay 6 months; Within 90 days if VOCs associated with reduced effectiveness are circulating (e.g. Beta)	May delay 6 months; Within 90 days if VOCs associated with reduced effectiveness are circulating (e.g. Beta)	May delay 6 months; Within 90 days if VOCs associated with reduced effectiveness are circulating (e.g. Beta)	May delay 6 months; <6 months may be advisable if VOCs with reduced neutralisation activity are circulating	May delay 6 months; <6 months may be advisable if VOCs associated with reduced effectiveness are circulating	May delay 6 months; <6 months may be advisable if VOCs associated with reduced effectiveness are circulating	May delay 6 months; <6 months may be advisable if VOCs associated with reduced effectiveness are circulating	May delay 6 months; <6 months may be advisable if VOCs associated with reduced effectiveness are circulating
Immunocompromised Including HIV	An additional dose at least 1 month, and within 3 months, after completing the primary series	An additional dose at least 1 month, and within 3 months, after completing the primary series	An additional dose at least 1 month, and within 3 months, after completing the primary series	An additional dose at least 1 month, and within 3 months, after completing the primary series	An additional dose at least 1 month, and within 3 months, after completing the primary series	An additional dose at least 1 month, and within 3 months, after completing the primary series	An additional dose at least 1 month, and within 3 months, after completing the primary series	An additional dose at least 1 month, and within 3 months, after completing the primary series
History of Anaphylaxis (Severe Allergy)	Yes (unless the allergy is to the vaccine or its components)	Yes (unless the allergy is to the vaccine or its components)	Yes (unless the allergy is to the vaccine or its components)	Yes (unless the allergy is to the vaccine or its components)	Yes (unless the allergy is to the vaccine or its components)	Yes (unless the allergy is to the vaccine or its components)	Yes (unless the allergy is to the vaccine or its components)	Yes (unless the allergy is to the vaccine or its components)

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Vaccine Development Pipeline

WHO has recommended that vaccines adopted by countries have WHO SAGE EUL and/or Stringent Regulatory Approval. Last updated 26th June 2022.

VACCINE TYPE	NUMBER OF VACCINE CANDIDATES AT EACH PHASE OF DEVELOPMENT				
	PRE-CLINICAL	PHASE I/II	PHASE III	PHASE IV	IN USE*
RNA	24	20	5	2	2 (Pfizer/BioNTech, Moderna)
DNA	16	9	3	0	1 (Zydus Cadila Healthcare Limited)
Vector (non-replicating)	26	9	2	3	4 (CanSino, Gamaleya, Johnson & Johnson, AstraZeneca)
Vector (replicating)	18	7	0	0	0
Inactivated	5	10	8	3	12 (Sinopharm/BBIP; Sinopharm/WIBP; Sinovac; Bharat; Chumakov; Organisation of Defensive Innovation and Research; Research Institute for Biological Safety Problems; Shenzhen Kangtai Biological Products; Shifa Pharmed; Erciyes University; Valneva/Dynavax; Institute of Medical Biology)
Live-attenuated	2	1	0	0	0
Protein subunit	73	23	18	1	12 (Novavax; Vector institute; Anhui Zhifei Longcom Biopharmaceutical Chinese Academy of sciences; Center for Genetic Engineering and Biotechnology; Instituto Finlay de Vacunas [peptides 1 and 2]; Medigen Vaccine Biologics; Vaxine Pty Medytox CinnaGen Co; Biological E Ltd; Razi Vaccine and Serum Research Institute; National Vaccine and Serum Institute/Lanzhou Institute of Biological Products Co Ltd; Bagheiat-allah University of Medical Sciences)
Virus-like particle	22	3	3	0	1 (Medicago Inc)
Other/unknown	32	5	0	0	0

*Not all vaccines in use have SRA (as recognised by WHO) approval (see Vaccine specifications table and WHO SAGE Emergency Use Listing and prequalification timeline for approval status of vaccines).

Source: London School of Hygiene and Tropical Medicine
COVID-19 vaccine tracker.

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WHO SAGE Emergency Use Listing and Prequalification Timeline

MANUFACTURER	NAME OF VACCINE	PLATFORM	STATUS OF ASSESSMENT	ANTICIPATED DECISION DATE
Pfizer/BioNTech	BNT162b2/COMIRNATY Tozinameran (INN)	mRNA	Final decision made	Authorised 31/12/20
AstraZeneca	AZD1222	Adenoviral vector	Final decision made	SK Bio: Authorised 15/02/21 EU nodes: Authorised 16/04/21 CSL, Australia: Authorised 09/07/21 Daiichi Sankyo, Japan: Authorised 09/07/21
Serum Institute of India	Covishield (ChAdOx1_nCoV19)	Adenoviral vector	Final decision made	Authorised 15/02/21
Sinopharm/Beijing Institute of Biological Products (BIBP)	SARS-CoV-2 Vaccine (Vero Cell), Inactivated (InCoV)	Inactivated	In progress	Authorised: 07/05/2021
Sinovac	SARS-CoV-2 Vaccine (Vero Cell), Inactivated	Inactivated	In progress	Authorised 01/06/2021
Moderna	mRNA-1273	mRNA	In progress (to use abridged procedure relying on EMA)	Authorised 30/04/2021
Johnson & Johnson	Ad26.COV2.S	Adenoviral vector	Final decision made	Authorised 12/03/21
Russian Direct Investment Fund	Sputnik V	Adenoviral vector	Process restarted, awaiting completion of rolling submission	Will be determined when all data are submitted
Bharat Biotech	Covaxin; BBV152	Inactivated	Rolling data assessment started 6 July 2021	Authorised 03/11/2021
CanSino Biologics	Ad5-nCoV	Adenoviral vector	Final decision made	Authorised 19/05/2022
Novavax	NVX-CoV2373	Protein subunit	Rolling data assessment started 19 August 2021	Authorised 20/12/2021
CureVac	Zorecimeran	mRNA	Application withdrawn by manufacturer	-
Clover Biopharmaceuticals	SCB-2019 (CpG 1018/Alum)	Protein subunit	Rolling data starting 20 September 2021	TBC

Source: WHO Guidance Document: Status of COVID-19 Vaccines within WHO EUL/PQ evaluation process. Available at: https://www.who.int/teams/regulation-prequalification/eul/covid-19

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Other resources on COVID-19 vaccines:

WHO COVID-19 vaccines website: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines
EMA COVID-19 vaccines website: https://www.ema.europa.eu/en/human-regulatory/overview/public-health-threats/coronavirus-disease-covid-19/treatments-vaccines/covid-19-vaccines

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Appendix 1: COVID-19 Vaccine Effectiveness

VACCINE	SEVERE / HOSPITALISATION / DEATH	INFECTION AND OTHER OUTCOMES
AstraZeneca	Single dose in Scotland: 94% (73-99)[155] Risk of death in vaccine failures compared to unvaccinated cases in England reduced by: 55% (41-66)[217] (not peer reviewed) Single dose against hospitalisation in Spain: 92% (46-99)[60] Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Hospitalisation: 89% (85-91); Death: 93% (89-96)[218] Chile: Hospitalisation: 100%; ICU admission: 100%; Death: 100%[150] Scotland: Hospitalisation: 94% (90-99)[59] Netherlands: Hospitalisation: 94% (92-95)[74] Spain: Hospitalisation: 95% (79-99)[145] Scotland: Death: 91% (86-94)[69] British Colombia and Quebec, Canada: Hospitalisation: 94% (90-96); 94% (89-97)[64] Scotland and Brazil, *respectively* (delta variant dominant in Scotland; gamma variant common in Brazil): Hospitalisation or death: Single dose: 49.3% (43.3-54.6); 57.9% (56.9-58.9). 2 doses: 2-3 weeks: 83.7% (79.7-87.0); 86.4% (85.4-87.3). 2 doses 18-19 weeks: 63.7% (59.6-67.4); 42.2% (32.4-50.6)[151] England: Hospitalisation: 2-9 weeks: 95.2% (94.7-95.7); ≥20 weeks: 80.0% (76.8-82.7) Death: 2-9 weeks: 95.0% (93.1-96.4); ≥20 weeks: 84.8% (76.2-90.3)[67] Effectiveness of third doses following Sinovac primary series: Hospitalisation with Omicron: 97.7% (97.3- 98). Death: 98.1% (97.3-98.6)[126,127]	Pooled analysis of Pfizer/BioNTech and AstraZeneca vaccines in elderly care home residents in UK: Reduction in risk of infection 4 weeks after-single dose: 56% Reduction in risk of infection 5 weeks after single dose: 62%[219] Pooled analysis of Pfizer/BioNTech and AstraZeneca vaccines: reduced odds of infection post-second dose: 70% (62-77)[220] Single dose in Spain: Any infection: 44% (31-54); Symptomatic infection: 50% (37-61)[60] Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Infection: 78% (76-79)[218] Single dose against symptomatic infection in multiple European countries: 68% (39-83)[152] Symptomatic infection in 16-64 years in UK: single dose: 50.2% (40.8-58.2); 2 doses: 78.0% (69.7-84.0)[58] Symptomatic infection in Chile: 68.7% (39.8-83.7)[150] Spain: Any infection: 54% (48-60); Symptomatic infection: 56% (48-63)[145] British Colombia and Quebec, Canada: Symptomatic infection: 71% (69-74); 73% (69-77)[64] England REACT-1 study: Any infection: 44.8% (22.5-60.7)[146] India: Any infection: 2 doses: 63·1% (51·5-72·1); Single dose: 46·2% (31·6-57·7). Moderate-severe disease: 2 doses: 81·5% (9·9-99·0); Single dose: 79·2% (46·1-94·0)[147] UK: Symptomatic infection: 2-9 weeks: 76.2% (63.7-84.4); 15-19 weeks: 48.5% (44.7-52.0) 20-24 weeks: 45.4% (43.0-47.6); ≥25 weeks: 41.8% (39.4-44.1)[29] Brazil: Infection: 72.9% (71.9-73.8); Hospitalisation: 88.0% (86.8-89.2); Death: 90.2% (88.5-91.5)[66] England: Omicron: Symptomatic infection: -39% (-50--30); Delta: 25.0% (24.3-25.7)[36] Scotland and Brazil, *respectively* (delta variant dominant in Scotland; gamma variant common in Brazil): Symptomatic infection: Single dose: 37.6% (34.6-40.5); 37.6% (37.3-37.9). 2 doses 2-3 weeks: 67.9% (65.9-69.8); 69.8% (69.3-70.4); 2 doses 18-19 weeks: 44.6% (41.5-47.6); 57.7% (55.4-60.0)[151] England: Symptomatic infection: 2-9 weeks: 67.6% (67.3-67.9); ≥20 weeks: 44.3% (43.2-45.4)[67] UK: Any infection Dec 2020 - Sep 2021: 14-73 days: 58% (23-77); 134-220 days: 72% (39-87)[148] Finland: Effectiveness: Hospitalisation with Omicron: 2 doses: 14-90 days: 83% (53-94); 91-180 days: 76% (62-84); ≥181 days: 39% (-1-63)[34] Effectiveness of third doses following Sinovac primary series: Symptomatic infection with Omicron: 93.2% (92.9-93.6)[126,127] Malaysia: Effectiveness of third dose following Sinovac primary series with Omicron: 49.05% (46.74-51.26)[35] Malaysia: Effectiveness of third dose following AstraZeneca primary series with Omicron: 30.14% (28.39-31.84)[35] Australia: Booster against hospitalisation with Omicron: 52.9% (36.9-64.8) [23]
Johnson & Johnson	USA: Hospitalisation: 81% (79-84)[158] USA: 71% (56-81)[161] Netherlands: Hospitalisation: 91% (88-94)[74] Spain: Hospitalisation: 74% (43-88)[145] Death in veterans in USA: <65 years: 73.0% (52.0-84.8); ≥65 years: 52.2% (37.2-63.6)[162] South Africa: Booster against hospitalisation during Omicron wave: 85% (54-95)[38]	USA: Any infection: 76.7% (30.3-95.3)[157] USA: Infection: 79% (77-80)[158] Efficacy following booster 2 months after first dose: Moderate-Severe infection in USA: 94% (58-100); worldwide: 75% (55-87)[221] Spain: Any infection: 50% (42-57); Symptomatic infection: 54% (45-62)[145] Symptomatic infection in veterans in USA: 88% (87-89)[159] Any infection in USA: 73.6% (65.9-79.9)[160] Infection in veterans in USA: March: 86.4% (85.2-87.6); September: 13.1% (9.2-16.8)[162]
Moderna	Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna in Italy: Hospitalisation: 89% (85-91); Death: 93% (89-96)[218] Pooled analysis of Pfizer/BioNTech and Moderna against hospitalisation: 2-12 weeks after second dose: 86% (82%-90%) 13-24 weeks after second dose: 84% (77%-90%)[222] USA: Hospitalisation: 95.8% (90.7-98.1); Death: 97.9% (66.9-99.9)[76] Scotland: Pooled Pfizer/BioNTech and Moderna against hospitalisation: 92% (85-99)[59] USA: 93% (91-95)[161] Spain: Hospitalisation: 98% (82-100)[145] Qatar: Decline in effectiveness accelerated beyond the fourth month after the second dose; First month after second dose: 96.0% (93.9-97.4); ≥7 months: 55.6% (−44.3-86.3)[164] USA: Hospitalisation: 97.6% (92.8-99.2)[75] Moderna and Pfizer/BioNTech in British Colombia and Quebec, Canada: Hospitalisation:98% (97-98); 97% (96-97)[64] Death in veterans in USA: <65 years: 81.5% (70.7-88.4); ≥65 years:75.5% (71.8-78.7)[162] USA: Hospitalisation with Delta: Single dose: 68.9% (0.0-99.4); 2 doses Delta: 98.0% (87.2-99.7)[40] USA: Moderna and Pfizer: Hospitalisation: Delta: 2 doses: <6 months: 90% (89-90); ≥6 months: 81% (80-82); 3 doses: 94% (93-95); Omicron: 2 doses: <6 months: 81% (65-90); ≥6 months: 57% (39-70); 3 doses: 90% (80-94)[223] USA: Pooled Pfizer/BioNTech and Moderna against hospitalisation: Delta: 2 doses: <2 months: 94 (92–96); ≥5 months: 82 (82–83); 3 doses: <2 months: 96 (95–97); ≥4 months: 76 (14–93); Omicron: 2 doses: <2 months: 71 (51–83); ≥5 months: 54 (48–59); 3 doses: <2 months: 91 (88–93); ≥4 months: 78 (67–85)[224] Qatar (Omicron): Hospitalisation: 2 doses: 1-3 months: 76.9% (19.2-93.4); ≥7 months: 64.0% (39.1-78.7)[31] USA: Effectiveness against hospitalisation with Omicron: 90% (85-93)[165] USA: Pooled effectiveness of Moderna and Pfizer against hospitalisation: 2 doses: Delta: Overall: 85% (83-87); ≤150 days: 88% (86-90); >150 days: 81% (78-84); Omicron: 65% (51-75); 3 doses: Delta: 94% (92-95); Omicron: 86% (77-91)[165] Qatar: Effectiveness against Omicron BA.1 and BA.2 (median time since second dose ~9 months): Hospitalisation and death: 2 doses: 86.3% (78.5-93.6); 3 doses: 82.7% (60.2-98.3)[41]	Pooled analysis of Moderna and Pfizer/BioNTech vaccines in USA: Infections in nonvaccinated: 234 of 8969; 2.61% (2.29-2.96) Fully vaccinated: 4/8121; 0.05% (0.01-0.13)[225] Pooled analysis of Moderna and Pfizer/BioNTech vaccines against infection in USA: Fully vaccinated: 90% (68–97) Two weeks after first dose: 80% (59–90)[226] Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Infection: 78% (76-79)[218] Single dose against symptomatic disease in the UK: Age 15-39 years: 72% (46-86)[62] Minnesota, USA: January to July 2021 (Delta variant <0.7% in May): Infection: 86% (81-91); Hospitalisation: 92% (81-97) July (Delta variant >70%): Infection: 76% (58-87); Hospitalisation: 81% (33-96)[163] Infection in USA (98% vaccines used Pfizer/BioNTech and Moderna): Pre-Delta variant predominant: 91% (81–96); Delta variant predominant: 66% (26–84)[227] Infection in Canada: 1 dose: 72% (63-80); 2 doses: 94% (86-97)[84] USA: Any infection: 87.4% (84.8-89.6); Symptomatic infection: 88.3% (86.1-90.2)[76] Spain: Any infection: 82% (78-86); Symptomatic infection: 85% (80-89)[145] Qatar: First month after second dose: 77.5% (76.4-78.6); ≥7 months: 22.3% (−1.7-40.7)[164] USA: Any infection: 86.7% (84.3-88.7)[75] Moderna and Pfizer/BioNTech in British Colombia and Quebec, Canada: Symptomatic infection: 90% (89-90); 88% (88-89)[64] Infection in veterans in USA: March: 89.2% (88.8-89.6); September: 58.0% (56.9-59.1)[162] Denmark: Effectiveness against infection: Omicron: First month: 36.7% (-69.9-76.4); Third month: 4.2% (-30.8-29.8); Delta: First month: 88.2% (83.1-91.8); Third month: 72.2% (70.4-74.0); Booster first month: 82.8% (58.8-92.9)[39] USA: Any infection: Single dose: Delta: 60.2% (42.6-72.3); Omicron: 20.3% (0.0-39.8); 2 doses: Delta 14-90 days: 82.8% (69.6-90.3); 181-270 days: 61.4% (56.8-65.5); Omicron 14-90 days: 30.4% (5.0-49.0); 181-270 days: 0.0% (0.0-1.2); 3 doses: Delta ≤2 months: 95.7% (94.2-96.9); >2 months: 90.7% (81.4-95.3); Omicron ≤2 months: 63.6% (57.4-68.9); >2 months: 39.1% (3.8-61.5)[40] Qatar (Omicron): Symptomatic infection: Single dose: -1.6% (-56.8-34.1); 2 doses: 1-3 months: 44.8% (16.0-63.8); ≥7 months: -9.3% (-16.3--2.8);

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		3 doses: 4-5 weeks: 54.6% (41.1-65.0); ≥6 weeks: 38.6% (19.4-53.1)[31] Qatar: Effectiveness of third dose compared to primary series: Symptomatic infection: Omicron: 47.3% (40.7-53.3)[42] Finland: Effectiveness: Hospitalisation with Omicron: 2 doses: 14-90 days: 97% (88-99); 91-180 days: 85% (78-90); ≥181 days: 81% (67-89); 3 doses: 14-60 days: 98% (95-99); ≥61 days: 93% (82-98)[34] Qatar: Effectiveness against Omicron BA.1 and BA.2 (median time since second dose ~9 months): Symptomatic infection: 2 doses: 2.2% (-4.6-8.5); 3 doses: 61.3% (53.3-67.9)[41] Qatar: Effectiveness of third dose against Omicron: 50.8% (43.4-57.3) after 35 days[43]
Pfizer/BioNTech	Severe in Israel: 92% (75-100)[171] Severe/critical in Israel: 97.5% (97.1-97.8)[166] Single dose against hospitalisation in Scotland: 85% (76-91)[155] Risk of death in vaccine failures compared to unvaccinated cases in England reduced by: Single dose: 44% (32-53) Fully vaccinated: 69% (31-86)[217] (not peer reviewed) Israel: Hospitalisation: 97.2% (96.8-97.5); Death: 96.7% (96.0-97.3)[166] Hospitalisation in Spain: 94% (60-99)[60] Priority groups in Denmark: Hospitalisation: 93% (89-96); Death: 94% (90-96)[81] Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Hospitalisation: 89% (85-91); Death: 93% (89-96)[218] USA care facility: Hospitalisation: 94.4 (73.9-98.8); Death 94.4 (44.6–99.4)[169] Uruguay: Hospitalisation: 97.8% (96.0-98.8); Death: 96.2 (95.4-96.8)[174] Israel: Hospitalisation: 93·4% (91·9-94·7); Death: 91·1% (86·5-94·1)[79] Chile: Hospitalisation: 97.2% (96.6-97.6); ICU admission: 98.3% (97.6-98.8); Death: 100%[150] Pooled analysis of Pfizer/BioNTech and Moderna against hospitalisation: 2-12 weeks after second dose: 86% (82%-90%) 13-24 weeks after second dose: 84% (77%-90%)[222] Pooled analysis of Moderna and Pfizer/BioNTech against hospitalisation or death: 98% (83-100)[84] Pooled Pfizer/BioNTech and Moderna against hospitalisation in Scotland: 92% (85-99)[59] USA: 88% (85-91)[161] Netherlands: Hospitalisation: 96% (95-96)[74] USA: Hospitalisation: 93% (84–96)[170] Spain: Hospitalisation: 93% (88-96)[145] Scotland: Death: 90% (83-94)[69] Moderna and Pfizer/BioNTech in British Colombia and Quebec, Canada: Hospitalisation:98% (97-98); 97% (96-97)[64] Death in veterans in USA: <65 years: 84.3% (76.3-89.7); ≥65 years: 70.1% (66.1-73.6)[162] Israel: Booster ≥5 months after the primary series: Hospitalisation: 93%; Death 81%[228] USA: Hospitalisation: Delta: 2 doses <3 months: 88% (71-95); ≥6 months: 74% (65-80); 3 doses <3 months: 95% (91-97); ≥3 months: 65% (16-85) Omicron: 2 doses: <3 months: 70% (41-84); ≥6 months: 68% (56-76); 3 doses: <3 months: 89% (83-92); ≥3 months: 90% (57-98)[33] USA: Moderna and Pfizer: Hospitalisation: Delta: 2 doses: <6 months: 90% (89-90); ≥6 months: 81% (80-82); 3 doses: 94% (93-95); Omicron: 2 doses: <6 months: 81% (65-90); ≥6 months: 57% (39-70); 3 doses: 90% (80-94)[223] England: Hospitalisation: 2-9 weeks: 98.7% (98.3-99.0); ≥20 weeks: 91.7% (90.2-93.0); Death: 2-9 weeks: 98.5% (96.5-99.3); ≥20 weeks: 91.9% (88.5-94.3)[67] Pfizer/BioNTech and Moderna against hospitalisation: Delta: 2 doses: <2 months: 94 (92–96); ≥5 months: 82 (82–83); 3 doses: <2 months: 96 (95–97); ≥4 months: 76 (14–93); Omicron: 2 doses: <2 months: 71 (51–83); ≥5 months: 54 (48–59); 3 doses: <2 months: 91 (88–93); ≥4 months: 78 (67–85)[224] Qatar (Omicron): Hospitalisation: 2 doses: 1-6 months: 73.7% (46.8-87.0); ≥7 months: 80.7% (71.3-87.0); 3 doses: 1-6 weeks: 90.6% (77.8-96.0); (≥7 months: 90.8% (81.5-95.5)[31] Qatar: Effectiveness of third dose compared to primary series: Hospitalisation or death: Omicron: 76.5% (55.9-87.5)[42] USA: Effectiveness against hospitalisation with Omicron: 82% (80-84)[165] USA: Pooled effectiveness of Moderna and Pfizer against hospitalisation: 2 doses: Delta: Overall: 85% (83-87); ≤150 days: 88% (86-90); >150 days: 81% (78-84); Omicron: 65% (51-75); 3 doses: Delta: 94% (92-95); Omicron: 86% (77-91)[165] Qatar: Effectiveness against Omicron BA.1 and BA.2 (median time since second dose ~9 months): Hospitalisation and death: 2 doses: 73.5% (60.5-83.2); 3 doses: 92.5 (84.4-96.3)[41] Israel: Effectiveness of second booster compared to single booster against death ≥60 years: 78% (72-83)[20] Hospitalisation: Fourth dose compared to third dose: 68%(59 -74)[22] Death: Fourth dose compared to third dose: 74%% (50 -90)[22] Hospitalisation and death: Fourth dose compared to third dose among long-term care residents:Severe infection: 54%(31-70)[21] Fourth dose compared to third doses: Severe illness: Week 4: 3.5 (2.7-4.6)[19] Third dose following Sinovac primary series: Hospitalisation with Omicron: 86.3% (83.7-88.5); Death: 86.7% (80.5-91.0) [126,127]	Pooled analysis of Moderna and Pfizer/BioNTech vaccines in USA: Infections in nonvaccinated: 234 of 8969; 2.61% (2.29-2.96) Fully vaccinated: 4/8121; 0.05% (0.01-0.13)[225] Pooled analysis of Moderna and Pfizer/BioNTech vaccines in USA: Fully vaccinated: 90% (68–97); Two weeks after first dose: 80% (59–90)[226] Symptomatic infection in Israel: 94% (87-98)[171] Any infection in Israel: 90% (79-95)[78] Israel: Any infection: 95.3% (94.9-95.7); Symptomatic infection: 97.0% (96.7-97.2)[166] Pooled analysis of Pfizer/BioNTech and AstraZeneca vaccines in elderly care home residents in UK: 4 weeks after first dose: 56%; 5 weeks after first dose: 62%[219] Documented infection in Israel: incidence decreased from 9.4 infections per 1,000 HCWs in the week following first dose to <1.0 infection per 1,000 HCWs per week from 1 week after the second dose[229] Pooled analysis of Pfizer/BioNTech and AstraZeneca vaccines: reduced odds of infection post-second dose: 70% (62-77)[220] Spain: Any infection: 65% (56-73); Symptomatic infection: 82% (73-88)[60] Infection in priority groups in Denmark: 82% (79-84)[81] USA: Symptomatic infection: 84% (75-90)[172] Denmark: Infection in care facility residents: >14 days after first dose:17% (4-28); >7 days after second dose: 64% (14-84)[167] USA: Single dose against infection in 2 care facilities: 63% (33-79)[168] A care facility in USA: Infection 66% (41-81); Symptomatic illness 87% (66-95)[169] Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Infection: 78% (76-79)[218] Uruguay: Infection: 78.1% (77.0-79,1)[174] Israel: Infection: 93·0% (92·6-93·4)[79] Single dose against symptomatic disease in the UK: Age 15-39 years: 61% (56-66)[62] Symptomatic infection in multiple European countries: single dose: 61% (39-75); 2 doses: 87% (74-93)[152] Symptomatic infection in 16-64 years in UK: single dose: 48.6% (27.9-63.3); 2 doses: 93.3% (85.8-96.8)[58] Symptomatic infection in Chile: 87.7% (87.3-88.1)[150] Minnesota, USA: January to July 2021 (Delta variant <0.7% in May): Infection: 76% (69-81); Hospitalisation: 85% (73-93) July (Delta variant >70%): Infection: 42% (13-62); Hospitalisation: 75% (24-94)[163] Infection in USA (98% vaccines used Pfizer/BioNTech and Moderna): Pre-Delta variant predominant: 91% (81–96); Delta variant predominant: 66% (26–84)[227] Infection in Canada: 1 dose: 59% (55-62); 2 doses: 91% (88-93)[84] Any infection with Delta in USA: 1 month after vaccination: 93% (85–97); 4 months: 53% (39-65)[170] Spain: Any infection: 69% (66-72); Symptomatic infection: 72% (69-75)[145] Moderna and Pfizer/BioNTech in British Colombia and Quebec, Canada: Symptomatic infection: 90% (89-90); 88% (88-89)[64] Symptomatic infection in veterans in USA: 91% (91-92) England REACT-1 study: Any infection: 71.3% (56.6-81.0)[146] Infection in veterans in USA: March: 86.9% (86.5-87.3); September:43.3% (41.9-44.6)[162] UK: Symptomatic infection: 2-9 weeks: 88.2% (86.7-89.5); 15-19 weeks: 72.2% (71-73.4); 20-24 weeks: 64.8% (62.6-66.9); ≥25 weeks: 63.5% (61.4-65.5)[29] England: Omicron: Symptomatic infection: Single dose: 2% (-7-11); 2 doses: -18% (-26--11); Delta: Single dose: 33.1% (32.7-33.6); 2 doses: 55.9% (55.5-56.3)[38] Denmark: Effectiveness against infection: Omicron: First month: 55.2% (23.5-73.7); Third month: 9.8% (-10.0-26.1); Booster first month: 54.6% (30.4-70.4); Delta: First month: 86.7% (84.6-88.6); Third month: 72.8% (71.7-73.8); Booster first month: 81.2% (79.2-82.9)[39] England: Symptomatic infection: 2-9 weeks: 89.7% (89.5-89.8); ≥20 weeks: 66.3% (65.7-66.9)[67] Wales: Any infection: Single dose: 52% (45-58); 2 doses: 2-5 weeks: 86% (79-91); ≥26 weeks: 45% (39-51)[173] Qatar (Omicron): Symptomatic infection: Single dose: 26.1% (5.8-42.0); 2 doses: First month: 61.9% (49.9-71.1); Seventh month): 9.6% (2.4-16.3); 3 doses: 4-5 weeks: 56.6% (50.8-61.7); ≥12 weeks: 37.6% (28.8-45.4)[31] UK: Any infection Dec 2020 - Sep 2021: ≥6 week dose interval: 14-73 days: 85% (72-92); 194-239 days: 51% (22-69); <6 week dose interval: 14-73 days: 89% (78-94); 194-265 days: 53% (28-69)[148] Qatar: Effectiveness of third dose compared to primary series: Symptomatic infection: Omicron: 49.4% (47.1-51.6); Delta: 86.1% (67.3-94.1)[42] Finland: Effectiveness: Hospitalisation with Omicron: 2 doses: 14-90 days: 93% (90-95); 91-180 days: 87% (84-89); ≥181 days: 72% (66-77); 3 doses: 14-60 days: 96% (95-97); ≥61 days: 92% (89-94)[34] Qatar: Effectiveness against Omicron BA.1 and BA.2 (median time since second dose ~9 months): Symptomatic infection: 2 doses: -0.2% (-5.5-4.9); 3 doses: 54.0% (50.4-57.3)[41] Canada: Fourth dose compared to third dose among long-term care residents: Symptomatic infection: 63%(51-71)[21] Third doses following Sinovac primary series: Symptomatic infection with Omicron: 96.5% (96.2-96.7)[126,127] Third dose of vaccine against Omicron after 14-30 days: 55.2 (54.7-55.6)[46]

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		Qatar: Effectiveness of third dose against Omicron variant: Pfizer: 50.1% (47.3-52.8) after 49 days[43] Israel: Effectiveness of fourth dose against infection 65.1% (63-67.1) after 14-20 days: 33.4% (23.8-41.8) after 56-62 days[49] Malaysia: Effectiveness of third dose following Sinovac primary series with Omicron: 47.64 (46.95-48.32)[35] Malaysia: Effectiveness of third dose following AstraZeneca primary series with Omicron: 52.96 (51.59-54.29)[35] Qatar: Effectoveness of third dose after previous infection with Omicron: 76.3% (71.7-80.1)[25] Qatar: Effectiveness of second dose after previous infection with Omicron: 55.5 (51.8-59.0)[25] Australia: Effectiveness of booster: Hospitalisation with Omicron: 49.4% (30.8-63)[23]
Sinovac	Uruguay: Hospitalisation: 90.9% (88.6-92.7); Death: 94.7% (93.4-95.7)[174] Chile: Hospitalisation: 86.0% (85.6-86.5); ICU admission: 89.7% (89.1-90.2); Death: 86.4% (85.6-87.2)[150] Brazil: Infection: 52.7% (52.1-53.4); Hospitalisation: 72.8% (71.8-73.7); Death: 73.7% (72.3-75.0)[66] Third dose: Hospitalisation: 86.3% (83.7-88.5); Death: 86.7% (80.5-91.0)[48] Three doses: Hospitalisation with Omicron: 86.3% (83.7-88.5); Death: 86.7% (80.5-91.0)[126,127] Two doses: Hospitalisation with Omicron in Chile: 64.6(49.6-75.2)[56]	Uruguay: Infection: 59.9% (59.1-60.7)[174] Symptomatic infection in Chile: 58.5% (58.0-59.0)[150] Third dose:Symptomatic infection: 78.8% (76.8-80.6)[48] Two doses against Delta variant in China: 59% (16-81.6)[230] Three doses: Symptomatic infection with Omicron: 78.8% (76.8-80.6) [126,127] Two doses: Infection with Omicron in Chile: 38.2 (36.5-39.9)[56] Malaysia: Effectiveness of third dose following Sinovac primary series with Omicron: 33.42(31.85-34.95)[35]
Sinopharm	-	Symptomatic infection in Bahrain: 90% (88-91)[86]
Bharat Biotech	-	India: Symptomatic infection: 50% (33-62)[156]

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Appendix 2: Vaccine Efficacy/Effectiveness Against Asymptomatic Infection at-a-glance

Some of these studies assessed multiple variants, including Delta but none analyzed the Delta variant alone.
Detailed summary of vaccine efficacy/effectiveness against transmission available in Appendix 7.

VACCINE	VACCINE EFFECTIVENESS UNLESS OTHERWISE STATED
AstraZeneca	Efficacy: 54%[129]
Bharat Biotech	Efficacy: 64[70]
Johnson & Johnson	Efficacy: 60%[72]
Moderna	73%[76]
Pfizer/BioNTech	65-92%[164,166,171,172,231,232]

Appendix 3: Vaccine Efficacy/Effectiveness Against Transmission

There are limitations related to the analysis and comparison of transmission data between studies and vaccines. Criteria for testing vary between studies and may include, for example, random testing, testing at defined intervals, or retrospective serology.

VACCINE	EFFICACY/EFFECTIVENESS AGAINST ASYMPTOMATIC INFECTION	OTHER OUTCOMES
AstraZeneca	EFFICACY (UK only): 22·2% (−9·9-45·0); Symptomatic and asymptomatic combined (UK, SOUTH AFRICA & BRAZIL): 54.1% (44.7-61.9)[129] ENGLAND: Hazard ratio for single dose in vaccinated vs. unvaccinated care facility residents: 0.32 (0.15-0.66)[233]; Odds ratio for household contacts of vaccinated vs non-vaccinated health workers testing positive: 0.52 (0.43-0.62)[234] Effectiveness against household transmission of Delta: 42% (14-69); Vaccination of household contacts against infection from a symptomatic household index case: 14% (−5-46)[235] UK: Regular testing of randomly selected households: 79% (65-88)[236]; Single dose against symptomatic and asymptomatic infection: 60% (49–68)[237] NETHERLANDS: Effectiveness against transmission (secondary attack rate among household contacts): 58% (−12-84)[175]	SCOTLAND: POOLED ANALYSIS OF PFIZER/BIONTECH AND ASTRAZENECA: Hazard ratio for household contacts of vaccinated vs non-vaccinated health workers testing positive: 0.70 (0.63-0.78)[238] PF and AZ: Secondary attack rates in household contacts in the UK: Vaccinated contacts: 25% (18-33); Unvaccinated contacts: 38% (24-53); Unvaccinated index cases: 23% (15-31); Vaccinated index cases: 25% (15-35)[239]
Bharat Biotech	EFFICACY IN INDIA: Asymptomatic: 63.6% (29.0-82.4); Symptomatic and asymptomatic combined: 68.8% (46.7-82.5)[70]	-
Johnson & Johnson	EFFICACY (multiple countries): Asymptomatic infection: 59.7% (32.8-76.6)[72] UK: Single dose against symptomatic and asymptomatic infection: 60% (49–68)[237] Netherlands: Effectiveness against transmission (secondary attack rate among household contacts): 77% (6-94)[175] USA: POOLED ANALYSIS OF PFIZER/BIONTECH, MODERNA AND JOHNSON & JOHNSON: Omicron: Attack rate: Overall: 52.7% (227 of 431); Household contacts who had received: Booster: 47.8% (54 of 113); Primary series <5 months before the index date: 50.0% (14 of 28); Primary series ≥5 months before the index date: 70% (60-80); Unvaccinated: 53% (45-61)[240]	USA (Kentucky): OR for reinfection in unvaccinated vs vaccinated with Johnson & Johnson, Moderna or Pfizer/BioNTech): 2.34 (1.58–3.47)[241]
Moderna	USA: Asymptomatic infection: 72.7% (53.4-84.0)[76] USA: POOLED ANALYSIS OF PFIZER/BIONTECH AND MODERNA: 88.7% (68.4-97.1)[242]; 90% (68%-97)[243]; single dose: 80% (59-90)[243]; Relative risk of infection in asymptomatic pre-surgical patients >10 days after first dose compared to unvaccinated residents: 0.21 (0.12-0.37)[244]; Incident cases in unvaccinated nursing home residents decreased from 4.3% within 14 days of the first vaccination clinic to 0.3% after 42 days[245] MODELLING: Reduced potential for transmission: at least 61%[246] UK: Single dose against symptomatic and asymptomatic infection: 60% (49–68)[237] Netherlands: Effectiveness against transmission (secondary attack rate among household contacts): 88% (50-97)[175] USA: 63.0% (56.6-68.5)[132] Qatar: First month after second dose: 73.1% (70.3-75.5); declining to no evidence of any effect by 4 months post-vaccination[164] USA: POOLED ANALYSIS OF PFIZER/BIONTECH, MODERNA AND JOHNSON & JOHNSON: Omicron: Attack rate: Overall: 52.7% (227 of 431); Household contacts who had received: Booster: 47.8% (54 of 113); Primary series <5 months before the index date: 50.0% (14 of 28); Primary series ≥5 months before the index date: 70% (60-80); Unvaccinated: 53% (45-61)[240]	USA (Kentucky): OR for reinfection in unvaccinated vs vaccinated with Johnson & Johnson, Moderna or Pfizer/BioNTech): 2.34 (1.58–3.47)[241]
Pfizer/BioNTech	ENGLAND: 86% (76-97) 7 days after 2 doses; 72% (58-86) 21 days after 1 dose[231] Effectiveness against household transmission of Delta: 31% (−3-61); Vaccination of household contacts against infection from a symptomatic household index case: 24% (−2-64)[235] ISRAEL: 92% (88-95)[171]; 91.5% (90.7-92.2)[166]; 65% (45-79%)[232]; single dose: 75% (72-84)[247]; Effectiveness against transmission: 88.5% (82.3-94.8)[248]; Effectiveness against infection in the household: 78% (30-94)[249] USA: Asymptomatic screening: 90% (78-96)[172] USA: POOLED ANALYSIS OF PFIZER/BIONTECH AND MODERNA: 88.7% (68.4-97.1)[242]; 90% (68%-97)[243]; single dose: 80% (59-90)[243]; Relative risk of infection in asymptomatic pre-surgical patients >10 days after first dose compared to unvaccinated residents: 0.21 (0.12-0.37)[244]; Incident cases in unvaccinated nursing home residents decreased from 4.3% within 14 days of the first vaccination clinic to 0.3% after 42 days[245] UK: single dose: 4-fold decrease in risk amongst HCWs ≥12 days post-vaccination[250]; Regular testing of randomly selected households: 80% (73-85)[236]; Single dose against symptomatic and asymptomatic infection: 72% (63–79)[237]; 60% (49–68)[237] FINLAND: Effectiveness against transmission to unvaccinated household contacts: 2 weeks after first dose: 8.7% (-28.9-35.4); 10 weeks after first dose: 42.9% (22.3-58.1)[251] Netherlands: Effectiveness against transmission (secondary attack rate among household contacts): 70% (61-77)[175] Finland: Effectiveness against transmission to unvaccinated household contacts of vaccinated cases: 42.9% (22.3-58.1)[251] USA: POOLED ANALYSIS OF PFIZER/BIONTECH, MODERNA AND JOHNSON & JOHNSON: Omicron: Attack rate: Overall: 52.7% (227 of 431); Household contacts who had received: Booster: 47.8% (54 of 113); Primary series <5 months before the index date: 50.0% (14 of 28); Primary series ≥5 months before the index date: 70% (60-80); Unvaccinated: 53% (45-61)[240]	ISRAEL: Lower viral load in vaccine failure cases 12-37 days after the first dose of vaccine compared to within the first 11 days, indicating potentially lower infectiousness[252]; Data from 223 communities: strong correlation between community vaccination rate and a later decline in infection among children under 16 years of age who were unvaccinated[253]; Substantially decreased viral load for infections occurring 12-37 days after the first dose of vaccine, indicating likely lower infectiousness[252] Detectable transmission in long-term care facilities in Spain reduced by 90% (76-93)[254] ENGLAND: Odds ratio for household contacts of vaccinated health workers vs non-vaccinated health workers testing positive: 0.54 (0.47-0.62)[234] SCOTLAND: POOLED ANALYSIS OF PFIZER/BIONTECH AND ASTRAZENECA: Hazard ratio for single dose in vaccinated vs. unvaccinated care facility residents: 0.35 (0.17-0.71)[233] USA (Kentucky): OR for reinfection in unvaccinated vs vaccinated with Johnson & Johnson, Moderna or Pfizer/BioNTech): 2.34 (1.58–3.47)[241] PF and AZ: Secondary attack rates in household contacts in the UK: Vaccinated contacts: 25% (18-33); Unvaccinated contacts: 38% (24-53); Unvaccinated index cases: 23% (15-31); Vaccinated index cases: 25% (15-35)[239]

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Appendix 4: Vaccine Efficacy/Effectiveness Against Variants

Refer to Appendix 1 for vaccine effectiveness results for the Pfizer/BioNTech vaccine in Scotland, England and Israel, where all locations had predominant B.1.1.7 circulation. There are four Variants of Concern listed by WHO.[255] The WHO recommends labelling SARS-CoV-2 variants with letters of the Greek alphabet, as in the tables below.[256]

VACCINE	VACCINE EFFICACY/EFFECTIVENESS (EFFECTIVENESS AGAINST INFECTION UNLESS SPECIFIED)		
	B.1.1.7 (ALPHA) VARIANT	B.1.351 (BETA) VARIANT	P.1 (GAMMA) VARIANT
AstraZeneca	UK: 70·4% (43·6-84·5) (vs. 81·5% (67·9-89·4) against wild variant)[257] England: ≥21 days after one dose: 48.7% (45.2-51.9). ≥14 days after two doses: 74.5% (68.4-79.4)[142] Scotland: 73% (66-78)[143] Canada: Single dose: 64% (60-68)[149] UK: Single dose: 63% (55-69); 2 doses: 79% (56-90)[144] Severe disease in Canada: Single dose: 85% (81-88)[149]	South Africa: 10.4% (−76.8 to 54.8)[258] Study against severe disease underway[72]	Brazil: Symptomatic infection: Single dose: 37.6% (37.3-37.9); 2 doses 2-3 weeks: 69.8% (69.3-70.4); 2 doses 18-19 weeks: 57.7% (55.4-60.0); Hospitalisation or death: Single dose: 57.9% (56.9-58.9); 2 doses 2-3 weeks: 86.4% (85.4-87.3); 2 doses 18-19 weeks: 42.2% (32.4-50.6)[151]
Johnson & Johnson	-	Moderate to severe/critical: 64.0% (41.2-78.7) Severe/critical: 81.7% (46.2-95.4)[72] Efficacy against hospitalisation in South Africa: 67%[135]	Moderate to severe/critical: 68.1% (48.8-80.7); Severe/critical: 87.6% (7.8-99.7)[72]
Moderna	Canada: Single dose: 83% (80-86); 2 doses: 92% (86-96)[149] Severe disease in Canada: Single dose: 79% (74-83); 2 doses: 94% (89-97)[149]	-	-
Novavax	UK: 86.3% (71.3-93.5) (vs. 96.4% (73.8-99.5) against wild variant)[138]	South Africa: 51.0% (−0.6 to 76.2)[259]	-
Pfizer/BioNTech	Case-control study in Israel: After one dose, vaccinees were disproportionally infected with B.1.1.7 (OR: 26:10) [260] Qatar: 89.5% (85.9-92.3)[261] England: ≥21 days after one dose: 47.5% (41.6 to 52.8) ≥14 days after second dose: 93.7% (91.6-95.3)[142] Scotland: 92% (90-93)[143] Canada: Single dose: 66% (64-68); 2 doses: 89% (86-91)[149] UK: Single dose: 59% (52-65); 2 doses: 78% (68-84)[144] Severe disease in Qatar: 100% (81.7-100)[261] Severe disease in Canada: Single dose: 80% (78-82); 2 doses: 95% (92-97)[149]	Israel case-control study: Vaccinees infected at least 1 week after the second dose were disproportionally infected with B.1.351 (odds ratio: 8:1)[260] Qatar: 75.0% (70.5-78.9)[261] South Africa: 100% (53.5-100)[83] Severe disease in Qatar: 100% (73.7-100)[261]	-
Sinovac	Chile: 67% (65-69)*[86]	-	Brazil: 1 or 2 doses: 37.9% (−46.4-73.6)[262] Chile: 67% (65-69)*[86] Brazil: ≥70 years: 41.6% (26.9-53.3); 70-74 years: 61.8% (34.8-77.7); 75-79 years: 48.9% (23.3-66.0); ≥80 years: 28.0% (0.6-47.9)[263]

* While it is known P.1. and B.1.1.7 were circulating at the time of the study, the extent is unknown based on available surveillance

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VACCINE	VACCINE EFFICACY/EFFECTIVENESS (EFFECTIVENESS AGAINST INFECTION UNLESS SPECIFIED)	
	B.1.617.2 (DELTA) VARIANT	OMICRON VARIANT
AstraZeneca	England: ≥21 days after one dose: 30.0% (24.3-35.3); ≥14 days after second dose: 67.0% (61.3-71.8)[142] Scotland: 60% (53-66)[143] Canada: Single dose: 67% (44-80)[149] UK: Single dose: 46% (35-55); 2 doses: 67% (62-71)[144] Symptomatic infection in England: 66.7% (66.3-67.0)[65] Hospitalisation in England: 1 dose: 71% (51-83); 2 doses: 92% (75-97)[154]; 93.9% (91.3-95.7)[65] Death in England: 94.1% (91.8-95.8)[65] Severe disease in Canada: Single dose: 88% (60-96)[149] Hospitalisation and death in Scotland: 88% (85-90)[153] Scotland: Death: 91% (86-94)[69] India: Any infection: 2 doses: 63·1% (51·5-72·1); Single dose: 46·2% (31·6-57·7); Moderate-severe: 2 doses: 81·5% (9·9-99·0); Single dose: 79·2% (46·1-94·0)[147] UK: Symptomatic infection: 2-9 weeks: 76.2% (63.7-84.4); 15-19 weeks: 48.5% (44.7-52.0) 20-24 weeks: 45.4% (43.0-47.6); ≥25 weeks: 41.8% (39.4-44.1)[29] England: Symptomatic infection: 25% (24.3-25.7)[36] Scotland: Symptomatic infection: Single dose: 37.6% (34.6-40.5); 2 doses 2-3 weeks: 67.9% (65.9-69.8); 2 doses 18-19 weeks: 44.6% (41.5-47.6); Hospitalisation or death: Single dose: 49.3% (43.3-54.6); 2 doses: 2-3 weeks: 83.7% (79.7-87.0); 2 doses 18-19 weeks: 63.7% (59.6-67.4)[151] England: Symptomatic infection: 2-9 weeks: 67.6% (67.3-67.9); ≥20 weeks: 44.3% (43.2-45.4); Hospitalisation: 2-9 weeks: 95.2% (94.7-95.7); ≥20 weeks: 80.0% (76.8-82.7); Death: 2-9 weeks: 95.0% (93.1-96.4); ≥20 weeks: 84.8% (76.2-90.3)[57]	UK: No protective effect beyond 15 weeks[29] England: Symptomatic infection: -39% (-50--30)[36] England: Hazard ratio for hospitalisation with Omicron relative to primary Delta infection in unvaccinated: Single dose: 0.42; 2 doses: 0.37; 2 doses plus Pfizer booster: 0.21[264] Finland: Effectiveness: Hospitalisation: 2 doses: 14-90 days: 83% (53-94); 91-180 days: 76% (62-84); ≥181 days: 39% (-1-63)[34]
Johnson & Johnson	Efficacy against hospitalisation in South Africa: 71%[135] USA: Infection: 78% (73-82); Hospitalisation: 85% (73-91)[158]	South Africa: Booster against hospitalisation: 85% (54-95)[38]
Moderna	Canada: Single dose: 72% (57-82)[149] Minnesota, USA: 76% (58-87)[163] England: 95.2% (94.4-95.9)[65] Severe disease in Canada: Single dose: 96% (72-99)[149] Severe disease in Minnesota: 81% (33-96)[163] Hospitalisation in England: 97.5% (82.3-99.7)[65] Pooled Pfizer/BioNTech and Moderna against hospitalisation and death in Scotland: 91% (88-93)[153] USA: Infection: 86.7% (84.3-88.7); Hospitalisation: 97.6% (92.8-99.2)[75] Denmark: First month: 88.2% (83.1-91.8); Third month: 72.2% (70.4-74.0); Booster first month: 82.8% (58.8-92.9)[39] USA: Infection: Single dose: 60.2% (42.6-72.3); 2 doses: 14-90 days: 82.8% (69.6-90.3); 181-270 days: 61.4% (56.8-65.5); 3 doses: ≤2 months: 95.7% (94.2-96.9); >2 months: 90.7% (81.4-95.3); Hospitalisation: Single dose: 68.9% (0.0-99.4); 2 doses: 98.0% (87.2-99.7)[40] Moderna and Pfizer in USA: Hospitalisation: 2 doses: <6 months: 90% (89-90); ≥6 months: 81% (80-82); 3 doses: 94% (93-95)[223]	Denmark: First month: 36.7% (-69.9-76.4); Third month: 4.2% (-30.8-29.8)[39] USA: Infection: Single dose: 20.3% (0.0-39.8); 2 doses: 14-90 days: 30.4% (5.0-49.0); 181-270 days: 0.0% (0.0-1.2); 3 doses: ≤2 months: 63.6% (57.4-68.9); >2 months: 39.1% (3.8-61.5)[40] Moderna and Pfizer in USA: Hospitalisation: 2 doses: <6 months: 81% (65-90); ≥6 months: 57% (39-70); 3 doses: 90% (80-94)[223] Qatar: Symptomatic infection: Single dose: -1.6% (-56.8-34.1); 2 doses: 1-3 months: 44.8% (16.0-63.8); ≥7 months: -9.3% (-16.3--2.8); 3 doses: 4-5 weeks: 54.6% (41.1-65.0); ≥6 weeks: 38.6% (19.4-53.1); Hospitalisation: 2 doses: 1-3 months: 76.9% (19.2-93.4); ≥7 months: 64.0% (39.1-78.7)[31] Efficacy: Fourth dose compared to three doses: Any infection: 11% (-43-44); Symptomatic infection: 31% (-18-60)[44] USA: Effectiveness against hospitalisation: 90% (85-93) Finland: Effectiveness: Hospitalisation: 2 doses: 14-90 days: 97% (88-99); 91-180 days: 85% (78-90); ≥181 days: 81% (67-89); 3 doses: 14-60 days: 98% (95-99); ≥61 days: 93% (82-98)[34] Qatar: Effectiveness against Omicron BA.1 and BA.2 (median time since second dose ~9 months): Symptomatic infection: 2 doses: 2.2% (-4.6-8.5); 3 doses: 61.3% (53.3-67.9); Hospitalisation and death: 2 doses: 86.3% (78.5-93.6); 3 doses: 82.7% (60.2-98.3)[41]
Pfizer/BioNTech	England: ≥21 days after one dose: 35.6% (22.7-46.4); ≥14 days after second dose: 88.0% (85.3-90.1)[142] Scotland: 79% (75-82)[143] Canada: Single dose: 56% (45-64); 2 doses: 87% (64-95)[149] Effectiveness in Israel: Infection: 64%; Symptomatic illness: 64%[265] Israel 6m after roll out: 39.0% (9.0-59.0)[18] Minnesota, USA: 42% (13-62)[163] UK: Single dose: 57% (50-63); 2 doses: 80% (77-83)[144] England: 89.8% (89.6-90.0)[65] Hospitalisation in England: 1 dose: 94% (46-99); 2 doses: 96% (86-99)[154]; 99.7% (97.6-100.0)[65] Death in England: 98.2% (95.9-99.2)[65] Severe disease in Canada: Single dose: 78% (65-86)[149] Hospitalisation in Israel: 93%[265]	UK: Symptomatic infection: Single dose: 34.2% (-3.5-58.1); 2 doses: 2-9 weeks: 88.0% (65.9-95.8); 15-19 weeks: 34.1% (9.7-52.0); Booster after PF primary series: 75.5% (56.1-86.3); Booster after AZ primary series: 71.4% (41.8-86.0)[29] South Africa: Symptomatic infection: 33%; Hospitalisation: 70% (risk of hospital admission 29% lower for Omicron compared to first wave in mid-2020, adjusted for vaccination status)[45] England: Hazard ratio for hospitalisation with Omicron relative to primary Delta infection in unvaccinated: Single dose: 0.66; 2 doses: 0.26; 3 doses: 0.37[264] Denmark: First month: 55.2% (23.5-73.7); Third month: 9.8% (-10.0-26.1); Booster first month: 54.6% (30.4-70.4)[39] USA: Effectiveness against hospitalisation: 2 doses: <3 months: 70% (41-84); ≥6 months: 68 (56-76); 3 doses: <3 months: 89% (83-92); ≥3 months: 90% (57-98)[33]

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	Severe disease in Israel: 91.4% (82.5-95.7)[18] Severe disease in Minnesota: 75% (24-94)[163] Pooled Pfizer/BioNTech and Moderna against hospitalisation and death in Scotland: 91% (88-93)[153] Scotland: Death: 90% (83-94)[69] UK: Symptomatic infection: 2-9 weeks: 88.2% (86.7-89.5); 15-19 weeks: 72.2% (71-73.4); 20-24 weeks: 64.8% (62.6-66.9); ≥25 weeks: 63.5% (61.4-65.5)[29] Denmark: First month: 86.7% (84.6-88.6); Third month: 72.8% (71.7-73.8); Booster first month: 81.2% (79.2-82.9)[39] USA: Hospitalisation: 2 doses: <3 months: 88% (71-95); ≥6 months: 74% (65-80); 3 doses: <3 months: 95% (91-97); ≥3 months: 65% (16-85)[33] Moderna and Pfizer in USA: Hospitalisation: Delta: 2 doses: <6 months: 90% (89-90); ≥6 months: 81% (80-82); 3 doses: 94% (93-95)[223] England: Symptomatic infection: 2-9 weeks: 89.7% (89.5-89.8); ≥20 weeks: 66.3% (65.7-66.9); Hospitalisation: 2-9 weeks: 98.7% (98.3-99.0); ≥20 weeks: 91.7% (90.2-93.0); Death: 2-9 weeks: 98.5% (96.5-99.3); ≥20 weeks: 91.9% (88.5-94.3)[67] Qatar: Effectiveness of third dose compared to primary series: Symptomatic infection: 86.1% (67.3-94.1)[42]	Moderna and Pfizer in USA: Hospitalisation: Omicron: 2 doses: <6 months: 81% (65-90); ≥6 months: 57% (39-70); 3 doses: 90% (80-94)[223] Qatar: Symptomatic infection: Single dose: 26.1% (5.8-42.0); 2 doses: First month: 61.9% (49.9-71.1); Seventh month): 9.6% (2.4-16.3); 3 doses: 4-5 weeks: 56.6% (50.8-61.7); ≥12 weeks: 37.6% (28.8-45.4); Hospitalisation: 2 doses: 1-6 months: 73.7% (46.8-87.0); ≥7 months: 80.7% (71.3-87.0); 3 doses: 1-6 weeks: 90.6% (77.8-96.0); (≥7 months: 90.8% (81.5-95.5)[31] Efficacy: Fourth dose compared to three doses: Any infection: 30% (-9-55); Symptomatic infection: 43% (7-65)[44] Qatar: Effectiveness of third dose compared to primary series: Symptomatic infection: 49.4% (47.1-51.6); Hospitalisation or death: 76.5% (55.9-87.5)[42] USA: Effectiveness against hospitalisation: 82% (80-84)[165] Finland: Effectiveness: Hospitalisation: 2 doses: 14-90 days: 93% (90-95); 91-180 days: 87% (84-89); ≥181 days: 72% (66-77); 3 doses: 14-60 days: 96% (95-97); ≥61 days: 92% (89-94)[34] Qatar: Effectiveness against Omicron BA.1 and BA.2 (median time since second dose ~9 months): Symptomatic infection: 2 doses: -0.2% (-5.5-4.9); 3 doses: 54.0% (50.4-57.3); Hospitalisation and death: 2 doses: 73.5% (60.5-83.2); 3 doses: 92.5 (84.4-96.3)[41] Israel: Effectiveness of second booster compared to single booster against death ≥60 years: 78% (72-83)[20] Hospitalisation: Fourth dose compared to third dose: 68%(59 -74); Death: Fourth dose compared to third dose: 74%% (50 -90)[22] Hospitalisation and death: Fourth dose compared to third dose among long-term care residents: Severe infection: 54%(31-70)[21]
Sinovac	China (combined Sinovac and Sinopharm): Single dose: 13.8% (-60.2-54.8);; 2 doses: 59.0% (16.0-81.6) Severe disease: 100%[266]	Third dose: Symptomatic infection: 78.8% (76.8-80.6)[48] Third dose: Hospitalisation: 86.3% (83.7-88.5); Death: 86.7% (80.5-91.0)[48] Odds ratios among vaccinated compared to unvaccinated adults in Brazil: Symptomatic infection: OR: 1.38 at 42-69 days; 1.92 at 154-181 days; Hospitalisation and death: OR: 1.25 at 70-97 days; 1.94 at 182 days[24]
Sinopharm	China (combined Sinovac and Sinopharm): Single dose: 13.8% (-60.2-54.8); 2 doses: 59.0% (16.0-81.6) Severe disease: 100%[266]	-
Bharat Biotech	Efficacy against infection in India: 65.2% (33.1-83.0)[70] India: Symptomatic infection: 50% (33-62)[156]	-
Clover	Efficacy in Philippines, Colombia, Brazil, South Africa and Belgium: Symptomatic infection: 78.7% (57.3-90.4); Mod-Severe: 81.7% (35.9-96.6)[130]	-

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Appendix 5: Vaccine Efficacy/Effectiveness of Primary Series Against Delta at-a-glance

VACCINE	VACCINE EFFECTIVENESS UNLESS OTHERWISE STATED				
	ANY INFECTION	SYMPTOMATIC INFECTION	HOSPITALISATION AND DEATH	EFFECTIVENESS 4 to <6 MONTHS	EFFECTIVENESS ≥6 MONTHS
AstraZeneca	60-67%[142–144,147] Single dose 30-67%[142,144,147,149]	25-76%[29,36,64,65,67,151] Moderate-Severe: 82%; Single dose: 38-79%[147,151]	84-95%[64,65,67,69,151,153,154] Single dose: 49-88%[149,151,154]	Infection: 44-45%[29,67,151] Hospitalisation: 64-80%[67,151] Death: 82%[67]	Infection: 42%[29]
Bharat Biotech	Efficacy: 65%[70]	50%[156]	-	-	-
Clover	-	Efficacy: 79% [130]	Efficacy (moderate-severe): Delta: 82%[130]	-	-
Johnson & Johnson	78%[158]	-	71-85%[135,158]	-	Infection: 13%[162] Death: <65 years: 73%; ≥65 years: 52%[162]
Moderna	76-88%[39,75,163] Single dose: 60-72%[40,149]	95%[65]	81-98%[40,65,75,163,165] Single dose: 69-96%[40,149]	-	Infection: 22-58%[162,164] Death: <65 years: 82%; ≥65 years: 76%[162] 56%[164]
Pfizer/BioNTech	39-93%[18,39,142,143,163,170] Single dose: 36-57%[142,144,149]	56-90%[29,36,65,67] Single dose: 33%[36]	75-100%[18,33,65,67,69,154,163,165,170] Single dose: 78-94%[149,154]	Infection: 53-66%[29,67,170] Hospitalisation: 92%[67] Death: 92%[67]	Infection: 43-64%[29,65,162] Death: <65 years: 84%; ≥65 years: 70%[162] Hospitalisation: 74%[33]

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Appendix 6: Vaccine Efficacy/Effectiveness and Immunogenicity of Boosters Against Delta at-a-glance

Booster refers to an additional dose administered at least 5 months after completion of the primary series.
Booster efficacy/effectiveness reported relative to primary series (not unvaccinated) unless otherwise specified.
Detailed summary available in Appendix 3.

VACCINE	IMMUNOGENICITY	BOOSTER VACCINE EFFECTIVENESS (UNLESS OTHERWISE STATED)			
		ANY INFECTION	SYMPTOMATIC INFECTION	HOSPITALISATION	DEATH
Johnson & Johnson	Strong antibody response[37]	-	-	-	-
Moderna	Strong antibody response[37]	83-96%*[39,40]	87%[267] 95%*[267]	-	-
Pfizer/BioNTech	Strong antibody response[37]	81%*[39]	Efficacy: 84-95%[268,269] 86%[42,267] 89-94%*[29,36,267] After AZ primary series: 90-94%*[29,36,267]	93-99%[33,228,267] ≥3 months: 65%[33]	81-99%[228,267,270]
Sinopharm	Strong antibody response but stronger with a Sinopharm recombinant protein vaccine booster[271]	90%[86]	-	-	-
Sinovac	Strong antibody response[272]	-	79%[126]	86%[126]	87%[126]

*Relative to unvaccinated

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Appendix 7: Vaccine Efficacy/Effectiveness and Immunogenicity of Boosters Against Delta

Booster refers to an additional dose administered at least 5 months after completion of the primary series.
Booster efficacy/effectiveness reported relative to primary series (not unvaccinated) unless otherwise specified.

VACCINE	IMMUNOGENICITY	VACCINE EFFECTIVENESS UNLESS OTHERWISE STATED			
		ANY INFECTION	SYMPTOMATIC INFECTION	HOSPITALISATION	DEATH
Johnson & Johnson	Strong antibody response[37]	-	-	-	-
Moderna	Strong antibody response[37]	USA (relative to unvaccinated): Delta: ≤2 months: 95.7% (94.2-96.9); >2 months: 90.7% (81.4-95.3)[40]	England (after Pfizer primary series): Relative to primary series at least 6 months earlier: 86.8% (81.5-90.5); relative to unvaccinated: 94.8% (92.7-96.3)[267]	Moderna and Pfizer in USA: 94% (93-95)[223]	-
Pfizer/BioNTech	Strong antibody response[37]	Israel; Infection ~10 times lower in boosted group (range across five age groups, 9.0 to 17.2)[270] Denmark (relative to unvaccinated): First month: 54.6% (30.4-70.4)[39]	Efficacy: ≥6 months (median 10.8 months) in USA, South Africa, Brazil: 95.3 (89.5-98.3)[268] UK: Relative to primary series at least 4.6 months earlier: PF primary: 84.4% (82.8-85.8); AZ primary: 87.4% (84.9-89.4); Relative to unvaccinated: PF primary: 94.0% (93.4-94.6); AZ primary: 93.1% (91.7-94.3)[269] UK: relative to unvaccinated: PF primary: 92.6% (92.0-93.1); AZ primary: 93.8% (93.2-94.3)[29] England: PF primary: 88.6% (88.1-89.1) AZ primary: 89.7% (88.9-90.4)[36] England: Relative to primary series at least 6 months earlier: 85.6% (84.9-86.3); relative to unvaccinated: 94.4% (94.1-94.7)[267] Qatar: Symptomatic infection: 86.1% (67.3-94.1)[42]	Israel ≥5 months: 93% (88-97)[228] Israel: Severe disease: ≥60 years: 17.9 times lower in boosted group (15.1-21.2); 40-59 years: 21.7 times lower (10.6-44.2)[270] USA: <3 months: 95% (91-97); ≥3 months: 65% (16-85)[33] Moderna and Pfizer in USA: 94% (93-95)[223] England: Relative to unvaccinated: 98.6 (98.0 to 99.0)[267]	Israel ≥5 months: 81% (59-97)[228] Israel ≥5 months: 90% (86-93)[273] Israel ≥60 years: mortality 14.7 times lower in boosted group: (10.0-21.4)[270] England: Relative to unvaccinated: 98.7% (97.4-99.4)[267]
Sinovac	Strong antibody response[272]	-	Chile: 78·8% (76·8-80·6)[126]	Chile: 86·3% (83·7-88·5)[126]	Chile: 86·7% (80·591·0)[126]

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Appendix 8: Vaccine Efficacy/Effectiveness in High-Risk Groups

VACCINE	VACCINE EFFICACY UNLESS OTHERWISE STATED			
	DIABETES	OBESITY	AT RISK FOR SEVERE COVID-19	ELDERLY
AstraZeneca	-	-	76% against symptomatic infection in a sample where 60% had comorbidities, including diabetes, severe obesity or cardiac disease[57] (not peer-reviewed) Effectiveness against symptomatic infection in the UK in those with comorbidities and ≥65 years: Single dose: 60.0% (46.5-70.1); 2 doses: 79.7% (61.6-89.3)[58] Hospitalisation in Scotland: 63% (46-75)[59]	In ≥65 years: 85%[57] (not peer-reviewed) Effectiveness against hospitalisation at 28-34 days after a single dose (pooled analysis of AstraZeneca and Pfizer vacines): 18-64 years: 85% (68-93); 65-79 years: 79% (17-95); ≥80 years: 81% (65-90)[155] Effectiveness of single dose against hospitalisation in England: ≥80 years: 73% (60-81)[68] Effectiveness in England: Symptomatic infection ≥70 years: 73% (27-90); Hospitalisation ≥80 years: 37% (3-59)[63] Hospitalisation following single dose in the UK: ≥80 years: 80.4% (36.4-94.5)[61] Single dose in Spain: ≥60 years: 53% (19-72) vs. 18-59 years: 50% (34-62)[60] Effectiveness against death in the UK: ≥65 years: Single dose: 83% (78-86); Two doses: 94% (80-98)[62] Effectiveness against symptomatic infection in the UK, ≥65 years: single dose: 60.9% (49.0-70.0); 2 doses: 76.4% (58.8-86.5)[58] Effectiveness against death in Scotland ≥60 years: 90% (84-94)[69] British Colombia and Quebec, Canada: Symptomatic infection ≥70 years: 73% (42-88); 81% (74-86)[64] Brazil: Infection: 80-89 years: 73.1% (71.2-74.9); ≥90 years: 39.0% (23.5-51.4); Hospitalisation: 80-89 years: 85.1% (83.0-86.9); ≥90 years: 50.9% (31.3-64.9); Death: 80-89 years: 89.9% (87.7-91.7); ≥90 years: 65.4% (46.1-77.8)[66] England: ≥65 years: Symptomatic infection: 2-9 weeks: 59.1% (55.4-62.6); ≥25 weeks: 27.8% (16.3-37.8); Hospitalisation: 2-9 weeks: 91.7% (88.8-93.9); ≥20 weeks: 81.8% (76.6-85.9); Death: 2-9 weeks: 94.1% (89.6-96.7); ≥20 weeks: 82.1% (70.1-89.3)[67] Finland: Effectiveness: Hospitalisation with Omicron ≥70 years: 2 doses: 14-90 days: 83% (53-94); 91-180 days: 76% (62-84); ≥181 days: 39% (-1-63)[34]
Gamaleya	-	-	-	Symptomatic infection >60 years: 91.8% (67.1–98.3)[71]
Johnson & Johnson	Moderate to severe/critical: 23.0% (-90.1-69.8)[72]	Moderate to severe/critical: 65.9% (47.8-78.3)[72]	Moderate to severe/critical: With any comorbidity: 58.6% (40.6-71.6)[72] No comorbidity: 68.8% (59.0-76.6)[72]	Moderate-severe/critical disease ≥28 post vaccination: 18-59 years: 66.1% (53.3-75.8) 60+ years: 66.2% (36.7-83.0)[72]
Moderna	-	-	Symptomatic infection, comorbidities, including diabetes and obesity: In low risk: 95.1% (89.6-97.7) In high risk: 90.9% (74.7-96.7)[73] Pooled Pfizer/BioNTech and Moderna against hospitalisation in Scotland: 72% (51-84)[59] Netherlands: Hospitalisation in a population at high risk for severe COVID-19: 84% (80-87)[74] USA: Pooled effectiveness of Moderna and Pfizer against hospitalisation: 2 doses: Delta: At least one chronic comorbidity: 80% (78-82); No chronic comorbidities: 96% (95-98)[165]	Symptomatic infection: 18-64 years: 95.6% (90.6-97.9) ≥65 years: 86.4% (61.4-95.2)[73] Pooled Moderna and Pfizer vaccines against hospitalisation ≥65 years: 94% (49-99)[274] Infection in Canada: 1 dose ≥70 years: 54% (31-69); 2 doses ≥70 years: 95% (83-98)[84] Pooled Moderna and Pfizer vaccines in Portugal: Hospitalisation 65-79 years: 94% (88-97); ≥80 years: 82% (72-89); Death 65-79 years: 96% (92-98); Death ≥80 years: 81% (74-87)[275] USA: Hospitalisation: ≥65 years: 75.2% (59.6-84.8) vs 18-64 years: 87.9% (85.5-89.9)[75] USA: Effectiveness against infection: Delta ≥65 years: 97.2% (94.1-98.7); Omicron ≥65 years: 57.1% (14.2-78.6)[40] USA: Pooled effectiveness of Moderna and Pfizer against hospitalisation: 2 doses: Delta: ≥65 years: 81% (77-84); 18-64 years 88% (86-89)[165] Finland: Effectiveness: Hospitalisation with Omicron ≥70 years: 2 doses: 14-90 days: 97% (88-99); 91-180 days: 85% (78-90); ≥181 days: 81% (67-89); 3 doses: 14-60 days: 98% (95-99); ≥61 days: 93% (82-98)[34]
Pfizer/BioNTech	Effectiveness in Israel: Diabetes or cardoiovascular disease: 82% (62-92)[78] Effectiveness against infection in Israel: (88·9% (87·3-90·2)[79]	Effectiveness against infection in Israel: (89·7% (88·6-90·7)[79]	Symptomatic infection: With any comorbidity or obesity: 95.3% With no comorbidity: 94.7%[80] Denmark: Infection: 71% (58-80); Hospitalisation: 81% (49-93)[81] Effectiveness against infection in Israel: Hypertension: (89·7% (88.6-91.7)[79] Effectiveness against symptomatic infection in the UK in those with comorbidities and ≥65 years: Single dose: 56.4% (46.2-64.6) 2 doses: 88.5% (81.5-92.9)[58] Pooled Pfizer/BioNTech and Moderna against hospitalisation in Scotland: 72% (51-84)[59] USA: Pooled effectiveness of Moderna and Pfizer against hospitalisation: 2 doses: Delta: At least one chronic comorbidity: 80% (78-82); No chronic comorbidities: 96% (95-98)[165]	Efficacy against infection ≥75 years: 96.2% (76.9-99.9)[83] Mymptomatic infection: >55 years: 93.7% (80.6-98.8); >65 years: 94.7% (66.7-99.9); >75 years: 100% (-13.1-100)[80] Effectiveness against hospitalisation 28-34 days after a single dose (pooled analysis of AstraZeneca and Pfizer vacines): 18-64 years: 85% (68-93); 65-79 years: 79% (17-95); ≥80 years: 81% (65-90)[155] England 80-83 years: Documented infection: 70.1% (55.1-80.1) Hospital attendance: 78.9% (60.0-89.9); Hospital admission: 75.6% (52.8-87.6)[85] Reduction in incidence of infection in vaccinated people aged >60 years and unvaccinated people aged 20-39 years, respectively: Documented infection: 45% versus 28%; Hospitalisation: 68% versus 22%[276] Pooled Moderna and Pfizer vaccines against hospitalisation ≥65 years: 94% (49-99)[274] Effectiveness in England: Symptomatic infection ≥70 years: 61% (51-69); Hospitalisation ≥80 years: 43% (33-52); Death ≥80 years (vaccine failure vs non-vaccinated): 51% (37-62)[63] Effectiveness against hospitalisation in England ≥80 years: Single dose: 81% (76-85) Fully vaccinated: 93% (89-95)[68] (not peer reviewed) Effectiveness in Israel: 65-74 years: 82% (63-92); ≥75 years: 82% (61-91)[78] Hospitalisation following single dose in the UK: ≥80 years: 71.4% (43.1-86.2)[61] Single dose in Spain: ≥60 years: 76% (55-87) vs. 18-59 years: 85% (74-91)[60] Effectiveness against infection in Denmark: ≥80 years: 77% (50-89)[81] Effectiveness against infection in Israel: ≥70 years: 89·1% (83-93)[79] Effectiveness against death in the UK: ≥65 years: Single dose: 77% (72-81); Two doses: 98% (94-99)[62] Effectiveness against symptomatic infection in the UK, ≥65 years: single dose: 56.6% (47.6-64.1); 2 doses: 86.7% (80.1-91.1)[58] Infection in Canada: 1 dose ≥70 years: 40% (29-50); 2 doses ≥70 years: 93% (82-98)[84]

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				Pooled Moderna and Pfizer vaccines in Portugal: Hospitalisation 65-79 years: 94% (88-97); ≥80 years: 82% (72-89); Death 65-79 years: 96% (92-98); Death ≥80 years: 81% (74-87)[275] Effectiveness against death in Scotland ≥60 years: 87% (77-93)[69] England: ≥65 years: Symptomatic infection: 2-9 weeks: 79.6% (77.0-81.8); ≥25 weeks: 51.8% (45.4-57.4); Hospitalisation: 2-9 weeks: 98.0% (95.9-99.1); ≥20 weeks: 90.5% (87.6-92.7); Death 2-9 weeks: 97.1% (91.7-99.0); ≥65 years, ≥20 weeks: 90.2% (85.3-93.5)[67] USA: Pooled effectiveness of Moderna and Pfizer against hospitalisation: 2 doses: Delta: ≥65 years: 81% (77-84); 18-64 years 88% (86-89)[165] Finland: Effectiveness: Hospitalisation with Omicron ≥70 years: 2 doses: 14-90 days: 93% (90-95); 91-180 days: 87% (84-89); ≥181 days: 72% (66-77); 3 doses: 14-60 days: 96% (95-97); ≥61 days: 92% (89-94)[34] Israel: Effectiveness of a second booster compared to a single booster against death ≥60 years: 78% (72-83)[20] USA: Effectiveness of 3 doses against hospitalisation: <3 months since third dose: 55% (17-75); ≥3 months since third dose: 25% (-40-60)[27]
Novavax			Any infection with comorbidity, age ≥65 years or frequent COVID-19 exposure in USA and Mexico: 91.0% (83.6-95.0)[77]	
Sinovac	-	74.9% (53.7-86.4)[86]	Any comorbidity: 48.9% (26.6-64.5)[86]	Brazil: Infection: 80-89 years: 55.6% (53.3-57.8); ≥90 years: 27.6% (20.5-34.0); Hospitalisation: 80-89 years: 63.5% (60.4-66.3); ≥90 years: 31.8% (21.9-40.5); Death: 80-89 years: 67.2% (63.6-70.5); ≥90 years: 33.6% (21.9-43.5)[66]
Sinopharm	-	80.7% (56.7-91.4)[86]	-	Effectiveness against symptomatic infection in Bahrain: ≥60 years: 91% (87-94)[86]
Bharat Biotech	-	-	Any infection with comorbidity: 66.2% (33.8-84.0)[70]	Symptomatic infection in India: ≥60 years: 67.8% (8.0-90.0) vs 18-59 years: 79.4% (66.0-88.2)[70]

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Appendix 9: Risk of Rare Unusual Blood Clotting with Low Platelets (Thrombosis with Thrombocytopaenia Syndrome – TTS)

Estimated number of TTS that potentially might occur in Pacific Island Countries if all adults received the AstraZeneca or Johnson & Johnson vaccines, based on most recent official estimate of the adult population in each country and the incidence of these events in Europe and Australia.

COUNTRY	TOTAL POPULATION	ESTIMATED POPULATION AGED 18 YEARS AND OVER*	POTENTIAL NUMBER OF TTS CASES IF ALL ADULTS IN EACH COUNTRY RECEIVED ASTRAZENECA VACCINE**	POTENTIAL NUMBER OF TTS CASES IF ALL ADULTS IN EACH COUNTRY RECEIVED JOHNSON & JOHNSON VACCINE***
American Samoa	55,519	33,311	<1	<1
Cook Islands	15,300	9,180	<1	<1
Federated States of Micronesia	102,300	61,380	0.6-1.2	<1
Fiji	867,000	520,200	5.2-10.4	1.6
French Polynesia	275,918	165,551	1.7-3.3	<1
Guam	159,358	95,615	1.0-1.9	<1
Kiribati	113,400	68,040	0.7-1.4	<1
Marshall Islands	54,900	32,940	<1	<1
Nauru	10,900	6,540	<1	<1
New Caledonia	271,407	162,844	1.6-3.3	<1
Niue	1,611	967	<1	<1
Northern Mariana Islands	53,883	32,330	<1	<1
Palau	18,000	10,800	<1	<1
Papua New Guinea	7,744,700	4,646,820	46.5-92.9	14.6
Samoa	195,979	117,587	1.2-2.4	<1
Solomon Islands	642,000	385,200	3.9-7.7	1.2
Tokelau	1,160	696	<1	<1
Tonga	99,419	59,651	0.6-1.2	<1
Tuvalu	10,507	6,304	<1	<1
Vanuatu	272,173	163,304	1.6-3.3	<1
Wallis and Futuna	11,558	6,935	<1	<1
All Pacific Island Countries	10,976,992	6,586,195	65.9-131.7	20.8

* Based on estimate of 60% of population aged ≥18 years[277]
** Based on estimates of TTS occurring in ~1 in 100,000 vaccinated adults by the European Medicines Agency and ~1 in 50,000 in Australia[190,278]
*** Based on estimates of TTS occurring in ~1 in 319,000 vaccinated adults in USA (may be an underestimate as only cerebral venous sinus thrombosis are reported)[11]

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Appendix 10: Paediatric COVID-19 Vaccine Safety Summary

Post-licensure vaccine surveillance is undertaken to monitor vaccine safety and identify signals for rare events. Post-licensure safety data for COVID-19 vaccines in children <18 years, for both primary courses and booster doses, are still emerging.

Estimates of frequency of adverse events vary depending on setting, definitions and methodology, as well as vaccine roll-out progress. Original data regarding rare serious adverse events have been converted to per million vaccine doses/people where relevant to enable comparison across settings.

Relevant dates: The CDC (USA) endorsed the Pfizer vaccine for 12–15 year olds on 12 May 21, 5–11 year olds on 2 Nov 21, and children 6 months-5 years on 18 June 22. The CDC endorsed Pfizer booster doses for 16–17 year olds on 9 Dec 21, 12-15 year olds on 5 Jan 22 and 5-11 year olds on 19 May 22. The CDC endorsed the Moderna vaccine for children 6 months-5 years on 18 June 22, and for 6-17 year olds on 24 June 22. ATAGI (Australia) recommended Pfizer or Moderna vaccine for adolescents ≥12 years on 27 Aug 21, Pfizer vaccine for 5-11 year olds on 9 Dec 21 (with roll out commencing 10 Jan 22) and Moderna vaccine for 6-11 year olds on 23 Feb 22. ATAGI recommended Pfizer booster doses for 16-17 year olds on 3 Feb 22, an additional winter booster dose for children ≥16 years at increased risk of severe COVID-19 illness (preferring Pfizer from 16 years or Moderna from 18 years) on 25 May 22, and Pfizer booster doses for 12-15 year olds at increased risk for severe COVID-19 illness on 9 June 2022.

Key messages

Adverse events following immunisation (AEFI) – any untoward medical event following immunisation, whether or not caused by the vaccine. (1)
- Local and systemic side effects are common and tend to be mild-moderate and well-tolerated. They typically occur 1-2 days following vaccine, and resolve within 3 days. - Children <12 years have tended to report fewer side effects that older age groups. (2) (3) - Differences in vaccine dose and formulation for children <12 years increase the potential for vaccine administration errors (4) (5), highlighting the importance of preventive actions to avoid vaccine errors, and procedures to appropriately manage errors if they occur. (6) (7) (8)
Adverse events of special interest (AESI) - pre-specified medically significant events that have the potential to be causally associated with vaccines. They can be serious or non-serious, and must be carefully monitored and confirmed by further studies. (1) Myocarditis/pericarditis and PIMS-TS are AESIs of particular relevance following COVID-19 vaccine administration in children.
Myocarditis and pericarditis are rare AESI that have been reported following mRNA vaccines. Myocarditis in particular has been reported more commonly after the second dose, and in males aged 16-17 years. The most recent estimates from the largest group of vaccinated children (VAERS USA) reported 75.9 myocarditis cases in males and 7.5 myocarditis cases in females aged 16-17 years per million second doses, with lower rates in 12-15 year olds and much lower rates in 5-11 year olds. (9) (10) (11) Early estimates show myocarditis also occurs following booster doses, but less frequently than following second doses. (9) (5) (12) Most cases of myocarditis following COVID-19 mRNA vaccines have had a mild clinical course and rapid symptom improvement, with normal or rapid normalisation of heart systolic function on echocardiogram. (3) (13) (14) (9) Longer term follow-up of cases is ongoing. A recent report indicated persistence of cardiac MRI changes at 3-8 months in some adolescents, the clinical significance of which is still uncertain. (15) Myocarditis and pericarditis can also occur as complications of COVID-19 infection, at higher rates than following immunisation. (16) (17) PIMS-TS is a rare inflammatory syndrome occurring in children following COVID-19 infection. There is emerging evidence that vaccination is likely to provide protection against PIMS-TS. (18) (19) There have been very rare reports of PIMS-TS following COVID-19 vaccination - these are being closely monitored. (20) (21)

New updates

A recent French study found increased risks of myocarditis and pericarditis in the first week following mRNA vaccines across a wide range of ages and in both males and females, with the largest association seen for myocarditis following the Moderna vaccine in males aged 18-24 years. (22) The authors report adjusted odds ratios of myocarditis of 18 and 7.1, and adjusted odds ratios of pericarditis of 6.8 and 10, respectively in males and females aged 12-17 years receiving the Pfizer vaccine. Among children aged 12-17 years, they estimated one case of vaccine-associated myocarditis per 52,300 second Pfizer vaccine doses in males, and one case of vaccine-associated myocarditis per 414,500 second Pfizer vaccine doses in females. (22)

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Primary course

12-17 years (except where different age specified)	
VACCINE	**AEFI**
Pfizer/BioNTech & Moderna	Most common reported to v-safe (USA – Pfizer) and Ausvaxsafety (Aus – Pfizer & Moderna): Injection site reaction, fatigue, headache, myalgia, fever, gastrointestinal symptoms (23) (24) Reported missing work, study or routine duties (majority ≤1 day): 6-8% post dose 1, 21-28.8% post dose 2, 19-20% post dose 3 (Pfizer), 9-11% post dose 1 & 31-38% post dose 2 (Moderna) (24) (25) (5) Most common notified to VAERS (USA – Pfizer) - dizziness, syncope, headache, nausea, fever, vomiting, fatigue (11) – 10,458 reports from 18,707,169 doses, 92% non-serious (19/12/21, 12-15 years) Most common notified to TGA (Aus – Pfizer & Moderna) - chest pain, headache, dizziness, nausea, fever (26) – 4,200 reports from 3.7 million doses given (26/06/22)
	AESI
Pfizer/BioNTech Myocarditis & pericarditis	VAERS (USA) – cases of myocarditis per million second doses (within 7 days): *16-17 years* Males – 75.9 Females – 7.5 (9) Both sexes – 37.4 Males – 69.1 Females – 7.9 (27) Males – 105.86 Females – 10.98 (compared with expected: Males – 1.34 Females 0.42) (28) *12-15 years* Males – 46.4 Females – 4.1 (9) Both sexes – 21.5 Males – 39.9 Females – 3.91 (27) Males – 70.73 Females – 6.35 (compared with expected: Males – 0.53 Females 0.17) (28) VSD (USA) – excess myocarditis and pericarditis cases per million second doses (in 0-7 day risk interval) compared with vaccinated comparators: *16-17 years* Males – 138.7 Females – 7.9 (9) *12-15 years* Males – 151.0 Females – 24.8 (9) France – excess cases of myocarditis per million second doses (within 7 days) – rates estimated from matched case-control study, *12-17 years:* Males – 19 Females – 4 (22) Ontario, Canada – crude reporting rate of myocarditis/pericarditis per million second doses administered, *12-17 years:* Both sexes – 99.0 Males – 162.9 Females – 33.3 (29) Both sexes – 54.4 Males – 97.3 Females – 9.7 (30) Canada – myocarditis/pericarditis cases per million second doses, *12-17 years:* Males – 86 (31) Australia – cases of myocarditis per million second doses, *12-17 years:* Males – 127 Females - 24 (26) Australia – cases of pericarditis per million doses, *12-17 years:* Both sexes – 22 (26) Victoria, Australia – cases of myocarditis per million doses (combined Pfizer and Moderna): *16-17 years* Both sexes – 113 (32) *12-15 years* Both sexes – 74 (32) Israel – cases of myocarditis after second dose per million vaccinees: *16-19 years* Males – 153 Females – 9 (33) Males – 150.7 Females – 10.0 (34) *12-15 years* Males – 66 Females – 6 (33) UK – suspected myocarditis and pericarditis per million second doses, *<18 years:* Both sexes – 11 (35) Hong Kong – incidence rate of myocarditis/pericarditis after second dose, per one million people vaccinated (within 14 days), *12-17 years:* Both sexes – 212.2 Males - 373.2 Females - 47.7 (36)
PIMS-TS	France - PIMS-TS cases per million doses (>95% Pfizer), *12-17 years*: Both sexes - 1.5 Males – 2.4 Females – 0.5 (21) (compared to PIMS-TS cases per million children infected with COVID-19: both sexes – 113.3, males – 126, females – 100) VAERS (USA) – PIMS-TS cases per million vaccinated people (one or more doses, 85% of doses Pfizer), *12-20 years:*

	Both sexes - 1 (20)
Moderna	Australia – cases of myocarditis per million second doses, *12-17 years:* Males – 202 Females – 51 (26) Australia – cases of pericarditis per million doses, *12-17 years:* Both sexes – 9 (26) Moderna Global Safety Database - reporting rates of myocarditis per million second doses, *12-17 years:* Males – 13.3 Females – 1.17 (37)

5-11 years	
VACCINE	**AEFI**
Pfizer/BioNTech (5-11 years) & **Moderna** (6-11 years)	Most commonly reported to Ausvaxsafety (Aus - Pfizer) and v-safe (USA - Pfizer): injection site pain, fatigue, headache, myalgia, gastrointestinal symptoms, fever (10) (38) (23) Reported missing work, study or routine duties (majority for ≤1 day): 3-5.1% post dose 1, 7.4-8% after post dose 2 (4) (38) Most common notified to VAERS (USA- Pfizer): fever, vomiting, headache, dizziness, fatigue – 9,001 reports from 18,182,496 doses given, 97% non-serious (24/04/22) (10) Most common notified to TGA (Aus – Pfizer and Moderna): chest pain, vomiting, fever, headache, abdominal pain (26) – 1,550 notifications from 2.2 million doses given (26/05/22)
	AESI
Pfizer/BioNTech	VAERS (USA) - cases of myocarditis per million second doses (within 7 days): Males – 2.6 Females 0.7 (9) (10) Australia – cases of myocarditis per million second doses: Males – 2 (26) Australia – cases of pericarditis per million doses: Both sexes – 3 (26) Ontario, Canada – crude reporting rate of myocarditis/pericarditis per million second doses administered: Both sexes – 4.3 Females – 8.8 (29)
Moderna	No cases of death, PIMS-TS or myocarditis/pericarditis reported in trial data, but trial not powered to detect these events or other rare unanticipated adverse events (39) Awaiting post-licensure data.

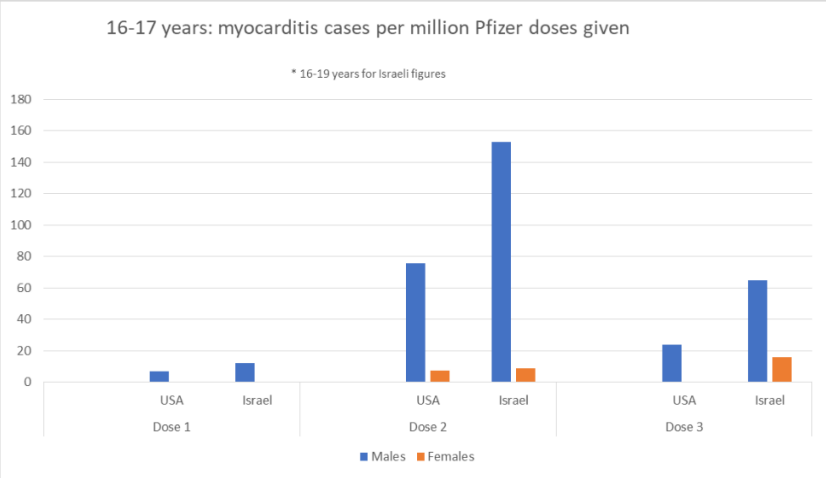
Booster doses

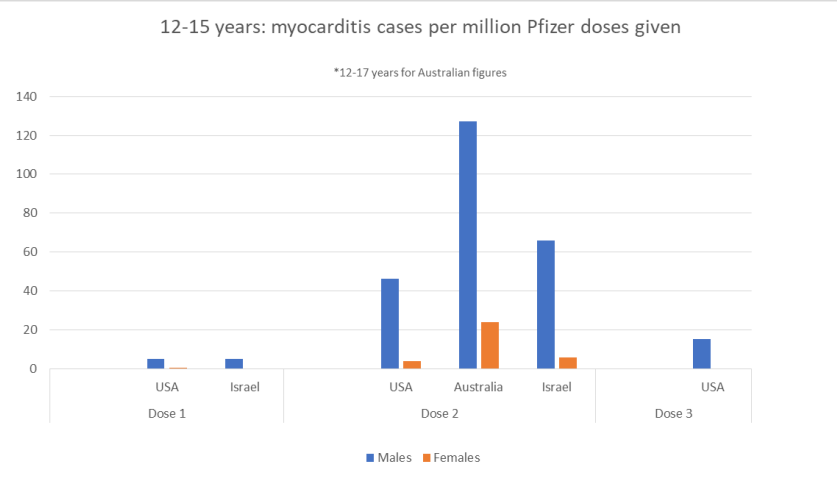
12-17 years (except where different age bracket specified)	
	AEFI
Pfizer/BioNTech	Most commonly reported to v-safe (USA, 12-17 years) & Ausvaxsafety (Aus, 16-17 years): injection site reaction, fatigue, headache, myalgia, fever, gastrointestinal symptoms (5) (24) Reported missing work, study or routine duties (majority for ≤1 day): 20-25.8% (5) (24) Most common notified to VAERS (USA): product storage error, dizziness, syncope – 914 reports from 2.8 million booster doses given, 91.6% non-serious, at 20 Feb 22 (5)
	AESI
Pfizer/BioNTech	VAERS (USA) – cases of myocarditis per million booster doses given (within 7 days) – 5 month interval: *16-17 years* Males – 24.1 (9) *12-15 years* Males – 15.3 (9) VSD (USA) – excess myocarditis and pericarditis cases per million first booster doses (in 0-7 day risk interval) compared with vaccinated comparators: *16-17 years* Males – 200 Females – 4.0 (9) *12-15 years* Males – 12.7 (9) Ontario, Canada – crude reporting rate of myocarditis/pericarditis per million booster doses administered, *12-17 years:* Both sexes – 31.5 Males – 65.6 (29) Israel – cases of myocarditis per million third doses – 5 month interval: *16-19 years* Males – 65 Females – 16 (from 123,355 3rd doses given to males, 125,088 3rd doses given to females, at 15 Dec 21) (33) *12-15 years* 2 cases myocarditis following 41,610 booster doses given (both male), at 5 Jan 22 (40)

Appendix 11: International comparison – myocarditis cases post Pfizer vaccine

Myocarditis cases per million doses Pfizer vaccine (9) (26) (12) (41) (33) (10)						
16-17 years*				**12-15 years #**		
		Males	Females		Males	Females
Dose 1						
	USA	7.2	0	USA	5.3	0.7
	Israel	12	0	Israel	5	0
Dose 2						
	USA	75.9	7.5	USA	46.4	4.1
	Israel	153	9	Australia	127	24
				Israel	66	6
Dose 3						
	USA	24.1		USA	15.3	
	Israel	65	16			

* Israeli data for 16-19 years # Australian data for 12-17 years
NB: Cases reporting both myocarditis and pericarditis included in suspected myocarditis cases.





Ausvaxsafety = voluntary smartphone-based safety surveillance system for adverse events after vaccination (Australia)
ATAGI = Australian Technical Advisory Group on Immunisation
FDA – United States Food and Drug Administration
PIMS-TS = Paediatric Inflammatory Multisystem Syndrome Temporally associated with SARS-CoV-2
TGA = Therapeutic Goods Administration (Australia), administers a national passive vaccine safety surveillance system
VAERS = Vaccine Adverse Event Reporting System, a passive vaccine safety surveillance system co-managed by CDC and FDA (USA)
VSD RCA = Vaccine Safety Datalink Rapid Cycle Analyses (USA), active surveillance system, a collaboration between CDC's Immunization Safety Office and nine health care organizations
v-safe = voluntary smartphone-based safety surveillance system for adverse events after COVID-19 vaccination (USA)

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