

Weekly COVID-19 Vaccine Updates

Number 31, 28 October 2021



Table of Contents

Introduction	3
COVID-19 Vaccine Specifications	4
COVID-19 Vaccine Efficacy	5
Vaccine Effectiveness Summary at-a-glance	6
Vaccine Efficacy/Effectiveness Against Delta VOC at-a-glance	7
Vaccine Efficacy/Effectiveness in High-Risk Groups at-a-glance	8
Vaccine Efficacy/Effectiveness in Children	9
Maternal Vaccination	10
Vaccine Efficacy/Effectiveness Against Asymptomatic Infection at-a-glance	11
Mixed Dose Vaccine Safety and Immune Responses	12
Adverse Events Following Immunisation with WHO EUL Vaccines	13
Serious Adverse Events	14
Who Can be Vaccinated Based on WHO SAGE Recommendations?	15
Vaccine Development Pipeline	16
WHO SAGE Emergency Use Listing and Prequalification Timeline	17
References	18
Acknowledgements	22
Appendix 1: COVID-19 Vaccine Effectiveness	23
Appendix 2: Vaccine Efficacy/Effectiveness Against Variants	24
Appendix 3: Vaccine Efficacy/Effectiveness in High-Risk Groups	25
Appendix 4: Vaccine Efficacy/Effectiveness Against Transmission	26
Appendix 5: Risk of Rare Unusual Blood Clotting with Low Platelets (Thrombosis with Thrombocytopenia Syndrome – TTS)	27

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 (including circulation of variants of concern)
- All COVID-19 vaccines in late phase development report high vaccine efficacy against severe COVID-19 and favourable safety profiles
- Pfizer/BioNTech and AstraZeneca both have high vaccine effectiveness against the Delta variant and both vaccines are similarly effective against transmission in the UK. Sinovac has shown high vaccine effectiveness in Chile where the Gamma and Alpha variants are circulating. Sinopharm has shown high vaccine effectiveness in Bahrain and several vaccines have shown effectiveness against mortality in infected adults in Bahrain: Unvaccinated: 1.32% mortality (857 deaths); Sinopharm: 0.46% (112 deaths); Pfizer/BioNTech: 0.15% (3 deaths); Sputnik: 0.09 (3 deaths); AstraZeneca: 0.03% (1 death).¹ The Johnson & Johnson and Moderna vaccines have both shown good vaccine effectiveness against infection in the US. One or 2 doses of the Moderna vaccine is effective against the Alpha variant in Canada, and a single dose is effective against infection and very effective against severe disease with the Delta variant.
- The US FDA, UK MHRA, EU EMA, NZ Medsafe, Health Canada and the Australian TGA have authorised the Pfizer/BioNTech vaccine for emergency use in adolescents aged 12-15 years.²⁻⁶ The EMA, MHRA and TGA have also authorised the Moderna vaccine in this age group.⁷⁻⁹
- WHO SAGE recommends that 1) immunocompromised persons should be offered an additional dose of all WHO EUL COVID-19 vaccines as part of an extended primary series; and 2) following the Sinovac and Sinopharm inactivated vaccines, a third dose of the same vaccine or a different vaccine should be offered as part of an extended primary series.¹⁰ ATAGI has recommended that immunocompromised persons in Australia receive a third dose as part of the primary series and booster doses of Pfizer/BioNTech be offered to all irrespective of the primary COVID-19 vaccine given.^{11,12} Several countries, including the US and UK, are offering boosters to older age groups and at-risk groups.^{13,14}
- Mixed vaccine schedules (i.e. delivering different types of vaccine for the first and second dose) are under investigation as these could facilitate better protection against variants of concern and enable vaccination programs to continue if a particular vaccine is unavailable
- Seven intranasal vaccines are in development (6 live-attenuated viruses or virus-vectored vaccines; 1 protein subunit.¹⁵ These may be beneficial in preventing transmission (Page 15)
- A very rare clotting disorder with low platelets (Thrombosis with Thrombocytopenia Syndrome – TTS) has been associated with the AstraZeneca and Johnson & Johnson vaccines.¹⁶⁻¹⁸ 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.^{19,20} 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.²¹
- The risk of TTS following the first dose of Johnson & Johnson vaccine has been estimated as 1 in 319,000 in the USA²²
- 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.²³ Highest rate in males 16-17 years of age following Pfizer/BioNTech vaccine but no clear difference in risk between Moderna and Pfizer/BioNTech.²⁴ 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 (Page 13) remains crucial to maintain confidence in immunisation programmes and to avoid vaccine hesitancy.

New updates

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

- Vaccine efficacy of booster dose of the Pfizer/BioNTech vaccine compared to non-booster group in USA (booster given at median 11 months after second dose):
 - Symptomatic infection: 95.6% (89.3-98.6)
- Vaccine effectiveness against death with the Delta variant in Scotland (Pages 6, 7, 8, 23, 24 and 25):
 - Pfizer/BioNTech: 90% (83-94)
 - Pfizer/BioNTech ≥60 years: 87% (77-93)
 - AstraZeneca: 91% (86-94)
 - AstraZeneca ≥60 years: 90% (84-94)
- Vaccine effectiveness of Pfizer/BioNTech in adolescents aged 12-18 years in USA (Page 9):
 - Hospitalisation: 93% (83-97)
- Vaccine effectiveness against infection over time in veterans in USA (Pages 6 and 23):
 - Pfizer/BioNTech March 2021: 91% (91-92)
 - Pfizer/BioNTech August 2021: 50% (47-52)
 - Moderna March 2021: 92% (92-93)
 - Moderna August 2021: 64% (62-66)
 - Johnson & Johnson March 2021: 88% (87-89)
 - Johnson & Johnson August 2021: 3% (-7-12)
- Vaccine effectiveness of AstraZeneca and mRNA vaccines (Moderna and Pfizer/BioNTech) in British Columbia and Quebec, Canada (Pages 6, 7, 8, 12, 24 and 26):
 - Infection in British Columbia and Quebec, respectively:
 - mRNA: 90% (89-90); 88% (88-89)
 - mRNA ≥7 months: 77% (74-79); 80% (61-90)
 - AstraZeneca: 71% (69-74); 73% (69-77)
 - AstraZeneca ≥3 months: 69% (64-72); 71% (65-75)
 - Mixed mRNA doses: 91% (90-92); 89% (87-91)
 - Mixed AstraZeneca-mRNA: 90% (89-91); 87% (85-89)
 - Hospitalisation in British Columbia and Quebec, respectively:
 - mRNA: 98% (97-98); 97% (96-97)
 - mRNA ≥7 months: 97% (94-99); 95% (67-99)
 - AstraZeneca: 94% (90-96); 94% (89-97)
 - AstraZeneca ≥3 months: 95% (89-98); 93% (87-96)
 - Mixed mRNA doses: 98% (96-99); 94% (87-97)
 - Mixed AstraZeneca-mRNA: 99% (98-100); 98% (95-99)
- New table added on maternal vaccination (Page 10):
 - Pregnant women who are vaccinated against COVID-19 with mRNA vaccines pass high levels of antibodies to their babies:
 - 100% of neonates in a US study (n=36) had protective antibodies at birth
 - Effectiveness of Pfizer/BioNTech vaccine in pregnant women in Israel:
 - Any infection: 96% (89-100)
 - Symptomatic infection: 97% (91-100)
 - Hospitalisation: 89% (43-100)
 - Effectiveness of Pfizer/BioNTech vaccine in pregnant women in Israel:
 - Any infection: 78% (57-89)
 - In an analysis of four clinical trials of the AstraZeneca vaccine 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
 - NIH-funded MOMI-VAX study will follow 750 pregnant women and 250 women within 2 months of birth who will receive any US-licensed vaccine
- Moderna vaccine in 6-11 year olds was well tolerated and produced a robust antibody response (Page 9)
- An FDA advisory committee has recommended authorisation of the Pfizer/BioNTech vaccine in children aged 5-11 years (Page 9)
- ATAGI has recommended booster doses of Pfizer/BioNTech vaccine to start in Australia from 8 November 2021 irrespective of the primary COVID-19 vaccine given
- Investigation of neurological complications after first dose of AstraZeneca and Pfizer/BioNTech vaccines and after SARS-CoV-2 infection in the UK. Risk of neurological complications considerably higher following SARS-CoV-2 infection (Page 14):
 - AstraZeneca
 - Guillain-Barre Syndrome in England: IRR 15-21 days: 2.90 (2.15-3.92)
 - Guillain-Barre Syndrome in Scotland: IRR 1-28 days: 2.32 (1.08-5.02)
 - 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)
 - Pfizer/BioNTech
 - Haemorrhagic stroke in England: IRR 15-21 days: 1.38 (1.12-1.71) (not replicated in Scotland data)
 - SARS-CoV-2 infection
 - Guillain-Barre Syndrome: IRR 1-28 days: 5.25 (3.00-9.18)

COVID-19 Vaccine Specifications

	ASTRAZENECA	GAMALEYA	JOHNSON & JOHNSON	MODERNA	NOVAVAX	PFIZER/ BIONTECH	SINOVAC	SINOPHARM	BHARAT BIOTECH	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	Protein
Available Through COVAX	✓	-	✓	-	✓	✓	-	-	-	-
Doses Required	 4-12 weeks apart	 3 weeks apart	 1 dose	 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 2 months after primary dose in ≥18 years	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. 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	-	-
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
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	Under review by WHO SAGE	WHO EUL, EMA, FDA, TGA, MHRA	WHO EUL	WHO EUL	-	-

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

COVID-19 Vaccine Efficacy

VACCINE	VACCINE EFFICACY			
	SYMPTOMATIC INFECTION	MODERATE-SEVERE	SEVERE	HOSPITALISATION/DEATH
AstraZeneca	UK: 66.7% (57.4-74.0) ²⁵ USA, Chile, Peru: 76% ²⁶ (not peer-reviewed) Single dose in UK (22-90 days post-vaccination): 76.0% (59.3 to 85.9) ²⁵ Efficacy with different interval between doses in UK: 12+ weeks: 82.4% (2.7-91.7) <6 weeks: 54.9% (32.7-69.7) ²⁵	-	Severe/critical and hospitalisation in USA, Chile, Peru: 100% ²⁶ (not peer-reviewed) UK: 100% (15 cases in the placebo group) ²⁵	Hospitalisation in UK: 100% (9 cases in placebo group) ²⁵
Bharat Biotech	India: 77.8% (65.2-86.4) ²⁷	-	India: 93.4% (57.1-99.8) ²⁷	-
Clover	Philippines, Colombia, Brazil, South Africa and Belgium: Overall: 67.2% (54.3-76.8); Delta: 78.7% (57.3-90.4) ²⁸	Philippines, Colombia, Brazil, South Africa and Belgium: Overall: 83.7% (55.9-95.4); Delta: 81.7% (35.9-96.6) ²⁸	-	Hospitalisation in Philippines, Colombia, Brazil, South Africa and Belgium: 100% (42.7-100) ²⁸
Gamaleya	Russia: 91.6% (85.6-95.2) ²⁹ Single dose (Sputnik Light) in Argentina: 78.6% ³⁰	Moderate-severe: 100% (20 cases in the placebo group) ²⁹	-	-
Johnson & Johnson	USA: 93.2% (91.0-94.8) ³¹	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) ^{32,33} South Africa: 67-71% ³⁴	85.4% (54.2-96.9) ³³ USA: 98.2% (92.8-99.6) ³¹	100% (5 deaths in placebo group) ³³ Death in South Africa: 96% ³⁴
Moderna	USA: 94.1% (89.3-96.8) ³⁵ USA: >90% ³⁶ 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) ³⁷	-	USA: 100% (30 cases in placebo group) ³⁵ US: >95% ³⁶	USA: 100% (1 death in placebo group) ³⁵
Novavax	UK: 89.7% (80.2-94.6) ³⁸ US and Mexico: 90.4% (82.9-94.6) ³⁹	US and Mexico: 100% (87.0-100) ³⁹	-	-
Pfizer/BioNTech	Argentina, Brazil, Germany, South Africa, Turkey and the USA: 94.6% (89.9-97.3) ⁴⁰ Infection over 6 months: 91.3% (89.0-93.2) ⁴¹	-	Argentina, Brazil, Germany, South Africa, Turkey and the USA: 88.9% (20.1-99.7) ⁴⁰ Severe disease: 96.7% (80.3-99.9) ⁴¹	-
Sinopharm	UAE, Bahrain, Egypt and Jordan: 78.1% (64.9-86.3) ⁴²	-	-	Hospitalisation in UAE, Bahrain, Egypt and Jordan: 78.7% (26.0-93.9) ⁴²
Sinovac	Brazil: 50.7% (35.9-62.0) Chile: 67% (65-69) Indonesia: 65% (20-85) ⁴² Turkey: 83.5% (65.4-92.1) ⁴³	Requiring medical assistance in Brazil: 83.7% (58.0-93.7) Moderate-severe: 100% (56.4-100.0) ⁴⁴	-	Hospitalisation: Brazil: 100% (56-100) Chile: 85% (83-97) Turkey: 100% (20-100) ⁴²

Vaccine Effectiveness Summary at-a-glance

Detailed summary available in Appendix 1.

VACCINE	ANY INFECTION	SYMPTOMATIC INFECTION	HOSPITALISATION/ SEVERE DISEASE	DEATH
AstraZeneca	54-67% ⁴⁵⁻⁴⁸ Single dose 30-67% ^{45,47,49}	56-78% ^{48,50-53} Single dose: 50-68% ^{50,54,55}	88-100% ^{48,51-53,56-59} Single dose: 71-94% ^{54,58,60}	91-100% ^{51,52,61}
Bharat Biotech	Efficacy: 65.2% ²⁷	-	-	-
Johnson & Johnson	50-88% ^{48,62-64}	54% ⁴⁸	71-91% ^{34,48,59,63,65}	-
Moderna	76-92% ^{48,64,66-69} Single dose: 72% ⁴⁹	82-95% ^{48,52,67,68,70} Single dose: 72% ^{70,71}	92-98% ^{48,52,59,65-69} Single dose: 96% ⁴⁹	98% ⁶⁷
Pfizer/BioNTech	63-95% ^{45,46,48,54,64,66,72-79} Single dose: 36-57% ^{45,47,49}	72-97% ^{48,50-52,54,70,73,77,80,81} Single dose: 49-61% ^{50,70,71}	85-98% ^{48,51,52,54,58,59,65,66,73,75,77,78,80,82-84} Single dose: 85-94% ^{58,60}	90-100% ^{51,52,61,73,77,78,82,83}
Sinopharm	-	90% ⁴²	-	-
Sinovac	60% ⁸²	59% ⁵¹	86-91% ^{51,82}	86-95% ^{51,82}

Vaccine Efficacy/Effectiveness Against Delta VOC at-a-glance

Detailed summary and vaccine efficacy/effectiveness against other variants available in Appendix 2

VACCINE	LAB STUDIES	VACCINE EFFECTIVENESS UNLESS OTHERWISE STATED		
		ANY INFECTION	SYMPTOMATIC INFECTION	HOSPITALISATION AND DEATH
AstraZeneca	✓	60-67% ⁴⁵⁻⁴⁷ Single dose 30-67% ^{45,47,49}	67-70% ^{52,53}	88-94% ^{52,53,57,58,61} Single dose: 71-88% ^{49,58}
Bharat Biotech	✓	Efficacy: 65.2% ²⁷	-	-
Clover	-	-	Efficacy: 79% ²⁸	Efficacy (moderate-severe): Delta: 82% ²⁸
Gamaleya	✓	-	-	-
Johnson & Johnson	✓	78% ⁶³	-	71-85% ^{34,63}
Moderna	✓	76-87% ^{66,69} Single dose: 72% ⁴⁹	95% ⁵²	81-98% ^{52,66,69} Single dose: 96% ⁴⁹
Pfizer/BioNTech	✓	39-93% ^{45,46,66,74,75} Single dose: 36-57% ^{45,47,49}	90% ⁵²	75-100% ^{52,58,61,66,74,75} Single dose: 78-94% ^{49,58}

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

Detailed summary available in Appendix 3

VACCINE	VACCINE EFFICACY/EFFECTIVENESS			
	DIABETES	OBESITY	AT RISK FOR SEVERE COVID-19	ELDERLY*
AstraZeneca	-	-	Efficacy against symptomatic infection: 76% ²⁶ Effectiveness of single dose against: Symptomatic infection: 60% ⁵⁰ Effectiveness against: Symptomatic infection: 80% ⁵⁰ Hospitalisation: 63% ⁵⁶	Efficacy against infection: 85% ²⁶ Effectiveness of single dose against: Symptomatic infection: 53-61% ^{50,54} Hospitalisation: 80% ⁸⁵ Death: 83% ⁷¹ Effectiveness against: Symptomatic infection: 59-81% ^{50,52,53,86} Hospitalisation: 37-94% ^{53,86,87} Death: 90-94% ^{81,71}
Bharat Biotech	-	-	Efficacy against infection: 66% ²⁷	Efficacy against symptomatic infection: 68% ²⁷
Gamaleya	-	-	-	Symptomatic infection: 92% ²⁹
Johnson & Johnson	Efficacy: 23% ³²	Efficacy: 66% ³²	Efficacy: 59% ³²	Efficacy 66% ³²
Moderna	-	-	Efficacy against symptomatic infection: 84-91% ³⁵ Effectiveness against hospitalisation: 84% (80-87) ⁵⁹	Efficacy against symptomatic infection: 86% ³⁵ Effectiveness against infection: 75-83% ^{67,69}
Novavax			Efficacy against infection: 91% ³⁹	
Pfizer/BioNTech	Effectiveness against infection: 82% ⁷⁶ 89% ⁸³	Effectiveness against infection: 90% ⁸³	Efficacy against symptomatic infection: 95% ⁴⁰ Effectiveness of single dose against symptomatic infection: 56% ⁵⁰ Effectiveness against: Infection: 71-90% ^{78,83} Symptomatic infection: 89% ⁵⁰ Hospitalisation: 72-81% ⁷⁸	Efficacy against symptomatic infection: 95-100% ^{40,41} Effectiveness of single dose against: Infection: 76% ⁵⁴ Symptomatic infection: 40-56% ^{50,70} Hospitalisation: 71-81% ^{85,87} Death 77% ⁷¹ Effectiveness against: Infection: 70-89% ^{76,78,83,88} Symptomatic infection: 61-93% ^{50,52,70,86} Hospitalisation: 43-93% ⁸⁶⁻⁸⁸ Death: 87-98% ^{81,71}
Sinopharm	-	81% ⁴²	-	Effectiveness against symptomatic infection 91% ⁴²
Sinovac	-	75% ⁴²	49% ⁴²	-

*Estimates in those ≥60 years to ≥80 years

Vaccine Efficacy/Effectiveness in Children

VACCINE	VACCINE EFFICACY, EFFECTIVENESS AND OTHER OUTCOMES	COUNTRIES VACCINATING CHILDREN BY AGE GROUP
AstraZeneca	Trials suspended when evidence emerged of the higher risk of TTS in younger adults compared to older adults	-
Bharat Biotech	-	-
Gamaleya	-	-
Johnson & Johnson	-	-
Moderna	Efficacy in USA, 12-15 years: 96% ⁸⁹ Well tolerated and produced strong antibody response in 6-11 year olds in USA (Moderna press release) ⁹⁰	Authorised in those aged ≥12 years by EMA and MHRA France, Italy: ≥12 years
Novavax	Study in 12-18 years has started recruitment and study in birth-11 years is planned	-
Pfizer/BioNTech	Efficacy in USA, 12-15 years: 100% ⁹¹ 5-11 years: Antibody response and safety profile for reactogenicity similar to 16-25 year-olds ⁹² Efficacy against symptomatic infection in 5-11 year olds in USA: 90.9% (68.3-98.3) ⁹³ Israel: Effectiveness 12-18 years: Any infection: 90% (88-92); Symptomatic infection: 93% (88-97) ⁹⁴ USA: Effectiveness against hospitalisation: 12-18 years: 93% (83-97) ⁹⁵ An FDA advisory committee has recommended authorisation of the Pfizer/BioNTech vaccine in children aged 5-11 years	Authorised in those aged ≥12 years by EMA, FDA, TGA, Medsafe UK, Sweden: 16-17 years and high-risk groups ≥12 years US, Canada, France, Spain, Italy, Netherlands, Germany, Singapore, Australia: ≥12 years The UK Chief Medical Officers have advised the government to offer a single dose to all 12-15 year olds ⁹⁶
Sinopharm	Phase I/II studies in 3-17 year olds in China	China: ≥3 years
Sinovac	Phase I/II studies complete in 3-17 year olds in China ⁹⁷ ; efficacy studies underway	Indonesia: ≥12 years China: ≥3 years

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 ⁹⁸
Bharat Biotech	-	-
Gamaleya	-	-
Johnson & Johnson	-	-
Moderna	-	Following maternal vaccination with mRNA vaccines, 100% of neonates (n=36) had protective antibodies at birth ⁹⁹
Novavax	-	-
Pfizer/BioNTech	Effectiveness in Israel: Any infection: 96% (89-100); Symptomatic infection: 97% (91-100); Hospitalisation: 89% (43-100) ¹⁰⁰ Effectiveness in Israel: Any infection: 78% (57-89) ¹⁰¹	Following maternal vaccination with mRNA vaccines, 100% of neonates (n=36) had protective antibodies at birth ⁹⁹ 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 ¹⁰²
Sinopharm	-	-
Sinovac	-	-

Vaccine Efficacy/Effectiveness Against Asymptomatic Infection at-a-glance

Some of these studies assessed multiple variants, including Delta but none analysed the Delta variant alone.
Detailed summary of vaccine efficacy/effectiveness against transmission available in Appendix 4

VACCINE	VACCINE EFFECTIVENESS UNLESS OTHERWISE STATED
AstraZeneca	Efficacy: 54% ²⁵
Bharat Biotech	Efficacy: 64 ²⁷
Johnson & Johnson	Efficacy: 60% ³²
Moderna	73% ⁶⁷
Pfizer/BioNTech	65-92% ^{68,77,80,81,103,104}

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	<p>Spain: Similar side effects to those receiving 2 doses of the same vaccine; no safety concerns (not peer reviewed)¹⁰⁵</p> <p>UK: Greater systemic side effects (mild-moderate symptoms) following the booster dose than with 2 doses of the same vaccine; no safety concerns¹⁰⁶</p> <p>Germany: greater reactivity with first dose of AstraZeneca than with the Pfizer/BioNTech booster¹⁰⁷</p> <p>Increased reactivity (54.4%; 49.4-59.5) vs AstraZeneca-AstraZeneca (33.5%; 28.0-39.2)¹⁰⁸</p> <p>Total adverse event reporting in Korea: 0.28% (vs AZ-AZ: 0.22%; and PF-PF: 0.31%)</p>	<p>Spain: ≥8 week dose interval: Stronger immune response following Pfizer/BioNTech than after 2 doses of AstraZeneca vaccine (not peer reviewed)¹⁰⁵</p> <p>Spain: 8-12 week dose interval: robust antibody response¹⁰⁹</p> <p>UK: 4 week dose interval: stronger antibody and cellular response than after 2 doses of AstraZeneca vaccine¹¹⁰</p> <p>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)¹¹¹</p> <p>Germany: 4-fold greater immune response than 2 doses of AstraZeneca¹¹²</p> <p>South Korea: 6-fold greater neutralising antibody response than 2 doses of AstraZeneca</p> <p>Germany: Higher neutralising antibody response against wild-type, Alpha, Beta, Gamma and Delta variants than AZ-AZ¹¹³</p>	<p>Canada, Denmark, Finland, France, Germany, Sweden, Norway, Spain and South Korea¹¹⁴</p>
PF-AZ	<p>UK: Greater systemic side effects (mild-moderate symptoms) following the booster dose than with 2 doses of the same vaccine; no safety concerns¹⁰⁶</p> <p>Greater reactivity with first of homologous and heterologous prime-boost immunisation with BNT162b2 and ChAdOx1-nCoV19: a prospective cohort study</p> <p>increased reactivity (55.2%; 46.1-64.1) vs Pfizer/BioNTech-Pfizer/BioNTech (33.3%; 23.4-44.5)¹⁰⁸</p>	<p>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)¹¹⁰</p>	-
AZ-mRNA (PF or MO)	-	<p>Effectiveness in Canada: Infection: 90% (89-91); 87% (85-89); Hospitalisation: 99% (98-100); 98% (95-99)⁵⁹</p>	-
Primary series of PF, J&J or MO followed by PF, J&J or MO booster	<p>Reactivity for all combinations similar to primary series¹¹⁵</p>	<p>Homologous boosters increased neutralising antibody titres 4.2 to 20-fold; Heterologous boosters increased neutralising antibody titres 6 to 76-fold¹¹⁵</p>	-
AZ, MO and PF	-	<p>Canada: Trial underway mixing and matching all three vaccines with study arms assessing 4 week and 16 week dose intervals¹¹⁶</p> <p>Denmark: Vaccine effectiveness against infection: AZ-PF or AZ-MO: 88% (83-92)¹¹⁷</p>	<p>AstraZeneca followed by either Moderna or Pfizer/BioNTech: Denmark, Finland, France, Germany, Sweden, Norway and Spain¹¹⁴</p>
Sinovac-AZ	-	-	Thailand

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
Adverse events following immunisation (AEFIs)*	<p>Very common (more than 1 in 10 people): headache, nausea, muscle pain, joint pain, injection site tenderness/ pain/ warmth/ itch, fatigue, malaise, fever, chills</p> <p>Common (between 1 in 10 and 1 in 100 people): injection site swelling/ redness¹¹⁸</p>	<p>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%)¹¹⁹</p>	<p>Very common: headache, muscle pain, joint pain, injection site pain/ swelling, fatigue, fever, chills;</p> <p>Common: nausea, injection site redness¹¹⁸</p> <p>Uncommon (between 1 in 100 and 1 in 1000 people): lymphadenopathy, insomnia, pain in extremity of vaccinated arm, malaise, injection site itch;</p> <p>Rare: (between 1 in 1000 and 1 in 10,000): acute peripheral facial paralysis⁶</p>	<p>Injection site pain/ redness/ swelling, headache, fatigue, muscle pain, nausea, fever¹²⁰</p>	<p>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%)¹²¹</p>	<p>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%)¹²²</p>	<p>Very common: Injection site pain, fatigue, headache</p> <p>Common: Injection site erythema, myalgia, arthralgia, loss of appetite, nausea, chills</p> <p>Uncommon: Injection site swelling, fever²⁸</p>
Adverse events of special interest (AESIs)	<p>Thrombosis with thrombocytopaenia syndrome (TTS) (see page 13 for estimated risk);</p> <p>EMA PRAC: Guillain-Barre syndrome (GBS)¹²³</p> <p>Australia: Guillain-Barre syndrome: 52 cases (10.4 per million doses)¹²⁴</p>	<p>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: 5.7¹²⁵</p> <p>Immune thrombocytopaenia (ITP)**¹²⁶</p>	<p>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: 1.2¹²⁵</p> <p>>1 in 20,000 males under 25 years of age²³</p> <p>Israel: 1 to 5 cases of myocarditis per 100,000 persons^{127, 128}</p> <p>ITP**¹²⁶</p>	<p>TTS (see page 14 for estimated risk)</p> <p>USA: Guillain-Barre Syndrome: 100 preliminary reports of GBS following 12.5 million doses of vaccine administered (mostly males >50 years)¹²³</p>	-	-	-

*Details for AstraZeneca, Moderna, Pfizer/BioNTech and Johnson & Johnson from product information sheets in SRA countries, based on data from clinical trials; Sinopharm and Sinovac details from published clinical trials

**The ITP cases are mostly without the thrombotic events characteristic of TTS

Serious Adverse Events

Caution is required when comparing safety profiles as definitions and reporting systems vary in trials and in particular phase IV studies.

VACCINE	VACCINE SAFETY
AstraZeneca	<p>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)²⁵</p> <p>US Phase III study: No serious safety concerns involving 32,449 participants²⁶ (not peer-reviewed)</p> <p>EMA investigation: possible link between the AstraZeneca vaccine and Thrombosis with Thrombocytopenia Syndrome (TTS) Blood clots affected the brain (central venous sinus thrombosis, CVST) and abdomen (splanchnic vein thrombosis)</p> <p>There have been reports of 169 cases of CVST and 53 cases of splanchnic vein thrombosis in ~34 million vaccinated people in Europe</p> <p>The EMA confirmed the overall benefits of the vaccine in preventing COVID-19 outweigh the risks of side effects¹⁷</p> <p>UK: Risk factors for death in patients with TTS following the AstraZeneca vaccine: baseline platelet count; and intracranial haemorrhage¹³⁰</p> <p>TTS reported to occur in ~1 in 50,000 vaccinated adults in Australia²⁰</p> <p>Several countries introduced age recommendations for the vaccine: >60 years in Germany and Australia; >55 years in France and Canada; >40 years in the UK¹³¹⁻¹³³</p> <p>EMA has started a review of reports of capillary leak syndrome following 5 cases of this very rare disorder post vaccination¹³⁴</p> <p>WHO GACVS reports Guillain Barre Syndrome (GBS) rates following adenovirus vector vaccines: EU/EEA: 4.4; AUS: 9.7; KOR: 0.4; PHL: <1¹³⁵</p> <p>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)¹³⁶</p>
Gamaleya	<p>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)²⁹</p>
Johnson & Johnson	<p>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)³²</p> <p>EMA investigation of 8 reports of TTS. Most cases occurred in women <60 years of age but specific risk factors have not been confirmed¹⁸</p> <p>USA: Cases of TTS per million doses: Overall: 3.1; Female: 5.2; Male: 1.5¹²⁵</p> <p>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)¹²⁹</p> <p>WHO GACVS reports Guillain Barre Syndrome (GBS) rates following adenovirus vector vaccines: USA: 7.8; KOR: 0.9; EU/EEA: AZ: 2.1¹³⁵</p>
Moderna	<p>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)³⁵</p> <p>Anaphylaxis reported in the US at a rate of 2.5 per million doses¹³⁷</p> <p>No obvious safety signals among pregnant women who received mRNA COVID-19 vaccines in USA¹³⁸</p> <p>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+¹³⁹</p> <p>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: 5.7¹²⁵</p> <p>Ontario, Canada; Myo/pericarditis cases per million second doses in those aged 18-24 years: Males 198.6; Females 59.6¹⁴⁰</p> <p>Overall rates in the UK per million second doses: Myocarditis: 28.3; Pericarditis: 17.2¹⁴¹</p>
Novavax	<p>SAEs at low levels and similar between vaccine and placebo groups¹⁴²</p>
Pfizer/BioNTech	<p>SAEs and deaths were low and comparable between vaccine and placebo groups (total 37,586 participants)⁴⁰</p> <p>Anaphylaxis reported in the US at a rate of 4.7 per million doses¹³⁷</p> <p>No obvious safety signals among pregnant women who received mRNA COVID-19 vaccines in USA¹³⁸</p> <p>Brazil: SAEs: 5.4/100,000 doses</p> <p>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+¹³⁹</p> <p>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: 1.2¹²⁵</p> <p>Ontario, Canada; Myo/pericarditis cases per million second doses in those aged 18-24 years: Males 35.5; females 39.9¹⁴⁰</p> <p>Overall rates in the UK per million second doses: Myocarditis 7.4; Pericarditis 5.6¹⁴¹</p> <p>Israel: Myo/pericarditis: 106.9 (69.3-144.6) cases per million in those aged 16-29¹⁴³; 137.3 (81.1-194.6) cases per million people aged 16-19¹⁴⁴</p> <p>Haemorrhagic stroke in England: IRR 15-21 days: 1.38 (1.12-1.71) (not replicated in Scotland data)¹³⁶</p>
Sinovac	<p>Brazil: SAEs: 79.7/100,000 doses</p>

Risk of TTS in PICs available as Appendix 5

Who Can be Vaccinated Based on WHO SAGE Recommendations?

So far, WHO SAGE have made recommendations for use of AstraZeneca, Moderna, Pfizer/BioNTech, Johnson & Johnson and Sinopharm vaccines:

<https://www.who.int/groups/strategic-advisory-group-of-experts-on-immunization/covid-19-materials>

	ASTRAZENECA	MODERNA	PFIZER/BIONTECH	JOHNSON & JOHNSON	SINOPHARM	SINOVAC
Minimum Age	18 years	18 years	12 years	18 years	18 years	18 years
Maximum Age (SAGE WHO)	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
Breastfeeding	Yes	Yes	Yes	Yes	Yes	Yes
Timing after previous SARS-CoV-2 infection	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
Immunocompromised Including HIV	✓	✓	✓	✓	✓	✓
People Previously Infected by SARS-CoV-2 (PCR Confirmed)	Yes, although that person may choose to delay vaccination by 6 months	Yes, although that person may choose to delay vaccination by 6 months	Yes, although that person may choose to delay vaccination by 6 months	Yes, although that person may choose to delay vaccination by 6 months	Yes, although that person may choose to delay vaccination by 6 months	Yes, although that person may choose to delay vaccination by 6 months
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)

Vaccine Development Pipeline

WHO has recommended that vaccines adopted by countries have WHO SAGE EUL and/or Stringent Regulatory Approval. Last updated 4 October 2021.

VACCINE TYPE	NUMBER OF VACCINE CANDIDATES AT EACH PHASE OF DEVELOPMENT				
	PRE-CLINICAL	PHASE I/II	PHASE III	PHASE IV	IN USE*
RNA	27	10	3	2	2 (Pfizer/BioNTech, Moderna)
DNA	18	7	3	0	1 (Zydus Cadila Healthcare Limited)
Vector (non-replicating)	27	7	2	3	4 (CanSino, Gamaleya, Johnson & Johnson, AstraZeneca)
Vector (replicating)	18	6	1	0	0
Inactivated	7	7	8	2	8 (Sinopharm/BIBP; Sinopharm/WIBP; Sinovac; Bharat; Chumakov; Research Institute for Biological Safety Problems; Shenzhen Kangtai Biological Products; Shifa Pharmed)
Live-attenuated	2	1	0	0	0
Protein subunit	73	22	12	1	6 (Vector institute; Anhui Zhifei Longcom Biopharmaceutical Chinese Academy of sciences; Center for Genetic Engineering and Biotechnology; Instituto Finlay de Vacunas, Cuba [peptides 1 and 2]; Medigen Vaccine Biologics, Taiwan)
Virus-like particle	20	4	1	0	0
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.

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
The Gamaleya National Center	Sputnik V	Adenoviral vector	On hold, awaiting completion of rolling submission	Will be determined when all data are submitted
CanSinoBIO	Ad5-nCoV	Adenoviral vector	Rolling data assessment started 9 August 2021	TBC
Novavax	NVX-CoV2373	Protein subunit	Pre-submission meeting held; rolling data starting in August 2021	TBC
CureVac	Zorecimeran	mRNA	Expression of interest accepted; Pre-submission meeting planned for Q4 2021	-
Bharat Biotech	Covaxin; BBV152	Inactivated	Rolling data assessment started 6 July 2021	October 2021
Clover Biopharmaceuticals	SCB-2019 (CpG 1018/Alum)	Protein subunit	Rolling data starting 20 September	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>

References

- AlQahtani M, Bhattacharyya S, Alawadi A, et al. Morbidity and mortality from COVID-19 postvaccination breakthrough infections in association with vaccines and the emergence of variants in Bahrain. *Res Sq Prepr*. doi:10.21203/rs.3.rs-828021/v1
- Wallace M, Woodworth KR, Gargano JW, et al. The Advisory Committee on Immunization Practices' Interim Recommendation for Use of Pfizer-BioNTech COVID-19 Vaccine in Adolescents Aged 12–15 Years — United States, May 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(20):749-752. doi:10.15585/mmwr.mm7020a1
- UK Government Medicines and Healthcare Products Regulatory Agency (MHRA). The MHRA concludes positive safety profile for Pfizer/BioNTech vaccine in 12- to 15-year-olds. 4 June 2021. Available at: <https://www.gov.uk/government/news/the-mhra-concludes-positive-safety-profile-for-pfizerbiontech-vaccine-in-12-to-15-year-olds>.
- European Medicines Agency (EMA). First COVID-19 vaccine approved for children aged 12 to 15 in EU 28 May 2021. Available at: <https://www.ema.europa.eu/en/news/first-covid-19-vaccine-approved-children-aged-12-15-eu>.
- Government of Canada. Health Canada authorizes use of the Pfizer-BioNTech COVID-19 vaccine in children 12 to 15 years of age - 5 May 2021. Available at: <https://www.canada.ca/en/health-canada/news/2021/05/health-canada-authorizes-use-of-the-pfizer-biontech-covid-19-vaccine-in-children-12-to-15-years-of-age.html>.
- Australian Government Therapeutic Goods Administration (TGA). Australian Product Information - Comirnaty (BNT162b2 [mRNA]) COVID-19 Vaccine. Available at: <https://www.tga.gov.au/sites/default/files/covid-19-vaccine-pfizer-australia-comirnaty-bnt162b2-mma-pi.pdf>.
- Moderna COVID-19 vaccine approved by MHRA in 12-17 year olds. Press release 17 August 2021. Available at: <https://www.gov.uk/government/news/moderna-covid-19-vaccine-approved-by-mhra-in-12-17-year-olds>.
- European Medicines Agency (EMA). COVID-19 vaccine Spikevax approved for children aged 12 to 17 in EU. 23 July 2021. Available at: <https://www.ema.europa.eu/en/news/covid-19-vaccine-spikevax-approved-children-aged-12-17-eu>.
- Australian Government Therapeutic Goods Administration. Australian Product Information - Spikevax (Elasmoran) COVID-19 Vaccine. Available at: <https://www.tga.gov.au/sites/default/files/auspar-elasmoran-210903-pi.pdf>.
- World Health Organisation. Highlights from the Meeting of the Strategic Advisory Group of Experts (SAGE) on Immunization 4-7 October 2021. Available at: https://cdn.who.int/media/docs/default-source/immunization/sage/2021/october/sage_oct2021_meetinghighlights.pdf?sfvrsn=3dcae610_15.
- Australian Technical Advisory Group on Immunisation (ATAGI). ATAGI update following weekly COVID-19 meeting – 26 May 2021. Available at: <https://www.health.gov.au/news/atagi-update-following-weekly-covid-19-meeting-26-may-2021>.
- Australian Technical Advisory Group on Immunisation (ATAGI) recommendations on the use of a booster dose of COVID-19 vaccine 27 October 2021. Available at: <https://www.health.gov.au/sites/default/files/documents/2021/10/atagi-recommendations-on-the-use-of-a-booster-dose-of-covid-19-vaccine.pdf>.
- UK Government Department of Health and Social Care press release 14 September 2021. Most vulnerable to be offered COVID-19 booster vaccines from next week. Available at: https://cdn.who.int/media/docs/default-source/immunization/sage/2021/october/sage_oct2021_meetinghighlights.pdf?sfvrsn=3dcae610_11.
- United States Centers for Disease Control and Prevention. Who Is Eligible for a COVID-19 Vaccine Booster Shot? Updated 7 October 2021. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/booster-shot.html#Data>.
- Lund FE, Randall TD. Scent of a vaccine. *Science (80-)*. 2021;373(6553):397-399. doi:10.1126/science.abg9857
- Center for Disease Control (CDC) Advisory Committee on Immunization Practices (ACIP). Thrombosis with thrombocytopenia syndrome (TTS) following Janssen COVID-19 vaccine 23 April 2021. Available at: <https://www.cdc.gov/vaccines/acip/meetings/downloads/slides-2021-04-23/03-COVID-Shimabukuro-508.pdf>.
- European Medicines Agency (EMA). AstraZeneca's COVID-19 vaccine: EMA finds possible link to very rare cases of unusual blood clots with low blood platelets 7 April 2021. Available at: <https://www.ema.europa.eu/en/news/astrazenecas-covid-19-vaccine-ema-finds-possible-link-very-rare-cases-unusual-blood-clots-low-blood>.
- European Medicines Agency (EMA). COVID-19 Vaccine Janssen: EMA finds possible link to very rare cases of unusual blood clots with low blood platelets 20 April 2021. Available at: <https://www.ema.europa.eu/en/news/covid-19-vaccine-janssen-ema-finds-possible-link-very-rare-cases-unusual-blood-clots-low-blood>.
- European Medicines Agency (EMA) press release. AstraZeneca's COVID-19 vaccine: benefits and risks in context 23 April 2021. Available at: <https://www.ema.europa.eu/en/news/astrazenecas-covid-19-vaccine-benefits-risks-context>.
- Australian Government Therapeutic Goods Administration (TGA). COVID-19 vaccine weekly safety report - 12-08-2021. Available at: <https://www.tga.gov.au/periodic/covid-19-vaccine-weekly-safety-report-12-08-2021>.
- UK Government Medicines and Healthcare Products Regulatory Agency. Coronavirus vaccine - weekly summary of Yellow Card reporting 17 June 2021. <https://www.gov.uk/government/publications/coronavirus-vaccine-summary-of-yellow-card-reporting>.
- Centers for Disease Control and Prevention (CDC). Selected Adverse Events Reported after COVID-19 Vaccination. Updated 27 May 2021. Available at: <https://www.cdc.gov/coronavirus/2019-ncov/vaccines/safety/adverse-events.html>.
- United States Advisory Committee on Immunization Practices (ACIP). ACIP Presentation Slides: June 23-25, 2021 Meeting. Available at: <https://www.cdc.gov/vaccines/acip/meetings/slides-2021-06.html>.
- United States Advisory Committee on Immunization Practices (ACIP). ACIP Presentation Slides: August 30, 2021 Meeting. Available at: <https://www.cdc.gov/vaccines/acip/meetings/slides-2021-08-30.html>.
- Voysey M, Costa Clemens SA, Madhi SA, et al. Single-dose administration and the influence of the timing of the booster dose on immunogenicity and efficacy of ChAdOx1 nCoV-19 (AZD1222) vaccine: a pooled analysis of four randomised trials. *Lancet*. 2021;397(10277):881-891. doi:10.1016/S0140-6736(21)00432-3
- AstraZeneca press release. AZD1222 US Phase III primary analysis confirms safety and efficacy 25 March 2021. Available at: <https://www.astrazeneca.com/media-centre/press-releases/2021/azd1222-us-phase-iii-primary-analysis-confirms-safety-and-efficacy.html#:~:text=Positive high-level results from,on Monday 22 March 2021.&text=The vaccine was well tolerated,to the vaccine were>.
- Ella R, Reddy S, Blackwelder W, et al. Efficacy, safety, and lot to lot immunogenicity of an inactivated SARS-CoV-2 vaccine (BBV152): a, double-blind, randomised, controlled phase 3 trial. *medRxiv*. January 2021:2021.06.30.21259439. doi:10.1101/2021.06.30.21259439
- Clover Biopharmaceuticals SCB-2019 (CpG 1018/Alum) COVID-19 Vaccine Candidate: Phase 2/3 Clinical Trial Results. Presentation 22 September 2021. Available at: https://www.cloverbiopharma.com/upload/pdf/SPECTRA-Data-Presentation_2021.09.22_FINAL_EN.pdf.
- Logunov DY, Dolzhenko I V, Shcheblyakov D V, et al. Safety and efficacy of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine. *Lancet*. 2021.
- Russian Direct Investment Fund Press Release 2 June 2021. Sputnik Light (the first component of Sputnik V vaccine) demonstrates 78.6-83.7% efficacy among the elderly in Argentina. Available at: <https://sputnikvaccine.com/newsroom/pressreleases/sputnik-light-vaccine-the-first-component-of-sputnik-v-vaccine-demonstrates-78-6-83-7-efficacy-among/>.
- El Sahly HM, Baden LR, Essink B, et al. Efficacy of the mRNA-1273 SARS-CoV-2 Vaccine at Completion of Blinded Phase. *N Engl J Med*. September 2021. doi:10.1056/NEJMoa2113017
- US federal Drug Administration (FDA) Briefing Document Janssen Ad26.COVID.S Vaccine for the Prevention of COVID-19. Vaccines and Related Biological Products Advisory Committee Meeting February 26, 2021. Available at: <https://www.fda.gov/media/146217/download>.
- Sadoff J, Gray G, Vandebosch A, et al. Safety and Efficacy of Single-Dose Ad26.COVID.S Vaccine against Covid-19. *N Engl J Med*. 2021;384(23):2187-2201. doi:10.1056/NEJMoa2101544
- Sisonke Phase 3b clinical trial. Available at: <http://sisonkestudy.samrc.ac.za/>.
- Baden LR, El Sahly HM, Essink B, et al. Efficacy and Safety of the mRNA-1273 SARS-CoV-2 Vaccine. *N Engl J Med*. 2021. doi:10.1056/nejmoa2035389
- Moderna press release. Moderna Provides Clinical and Supply Updates on COVID-19 Vaccine Program Ahead of 2nd Annual Vaccines Day 13 April 2021. Available at: <https://investors.modernatx.com/news-releases/news-release-details/moderna-provides-clinical-and-supply-updates-covid-19-vaccine>.
- Ali K, Berman G, Zhou H, et al. Evaluation of mRNA-1273 SARS-CoV-2 Vaccine in Adolescents. *N Engl J Med*. August 2021:NEJMoa2109522. doi:10.1056/NEJMoa2109522
- Heath PT, Galiza EP, Baxter DN, et al. Safety and Efficacy of NVX-CoV2373 Covid-19 Vaccine. *N Engl J Med*. June 2021:NEJMoa2107659. doi:10.1056/NEJMoa2107659
- Dunkle LM, Kotloff KL, Gay CL, et al. Efficacy and Safety of NVX-CoV2373 in Adults in the United States and Mexico. *medRxiv*. January 2021:2021.10.05.21264567. doi:10.1101/2021.10.05.21264567
- World Health Organisation (WHO). *Background Document on the mRNA Vaccine BNT162b2 (Pfizer-BioNTech) against COVID-19*; 2021. [https://www.who.int/publications/i/item/background-document-on-mrna-vaccine-bnt162b2-\(pfizer-biontech\)-against-covid-19](https://www.who.int/publications/i/item/background-document-on-mrna-vaccine-bnt162b2-(pfizer-biontech)-against-covid-19).
- Thomas SJ, Moreira ED, Kitchin N, et al. Safety and Efficacy of the BNT162b2 mRNA Covid-19 Vaccine through 6 Months. *N Engl J Med*. September 2021. doi:10.1056/NEJMoa2110345
- World Health Organisation Extraordinary meeting of the Strategic Advisory Group of Experts on Immunization (SAGE) – 29 April 2021. Available at: [https://www.who.int/news-room/events/detail/2021/04/29/default-calendar/extraordinary-meeting-of-the-strategic-advisory-group-of-experts-on-immunization-\(sage\)-29-april-2021](https://www.who.int/news-room/events/detail/2021/04/29/default-calendar/extraordinary-meeting-of-the-strategic-advisory-group-of-experts-on-immunization-(sage)-29-april-2021).
- Tanriover MD, Doğanay HL, Akova M, et al. Efficacy and safety of an inactivated whole-virion SARS-CoV-2 vaccine (CoronaVac); interim results of a double-blind, randomised, placebo-controlled, phase 3 trial in Turkey. *Lancet*. 2021;398(10296):213-222. doi:10.1016/S0140-6736(21)01429-X
- Palacios R, Batista AP, Albuquerque CSN, et al. Efficacy and Safety of a COVID-19 Inactivated Vaccine in Healthcare Professionals in Brazil: The PROFISCOV Study. *SSRN Electron J*. 2021.
- Lopez Bernal J, Andrews N, Gower C, et al. Effectiveness of Covid-19 Vaccines against the B.1.617.2 (Delta) Variant. *N Engl J Med*. July 2021:NEJMoa2108891. doi:10.1056/NEJMoa2108891
- Sheikh A, McMenamin J, Taylor B, Robertson C. SARS-CoV-2 Delta VOC in Scotland: demographics, risk of hospital admission, and vaccine effectiveness. *Lancet*. June 2021. doi:10.1016/S0140-6736(21)01358-1
- Pouwels KB, Pritchard E, Matthews PC, et al. Effect of Delta variant on viral burden and vaccine effectiveness against new SARS-CoV-2 infections in the UK. *Nat Med*. October 2021. doi:10.1038/s41591-021-01548-7
- Martínez-Baz I, Trobajo-Sanmartín C, Miquelèiz A, et al. Product-specific COVID-19 vaccine effectiveness against secondary infection in close contacts, Navarre, Spain, April to August 2021. *Eurosurveillance*. 2021;26(39). doi:10.2807/1560-7917.ES.2021.26.39.2100894
- Nasreen S, Chung H, He S, et al. Effectiveness of COVID-19 vaccines against variants of concern in Ontario, Canada. *medRxiv*. January 2021:2021.06.28.21259420. doi:10.1101/2021.06.28.21259420
- Whitaker HJ, Tsang RS, Byford R, et al. Pfizer-BioNTech and Oxford AstraZeneca COVID-19 vaccine effectiveness and immune response among individuals in clinical risk groups. Khub preprint.

- <https://khub.net/documents/135939561/430986542/RCGP+VE+riskgroups+paper.pdf/a6b54cd9-419d-9b63-e2bf-5dc796f5a91f>. Published 2021.
51. Vacunas contra SARS- CoV-2 utilizadas en Chile mantienen altos niveles de efectividad para evitar hospitalización, ingreso a UCI y muerte. 3 August 2021. Available at: <https://www.minsal.cl/vacunas-contra-sars-cov-2-utilizadas-en-chile-mantienen-altos-niveles-de-efectividad-para-evitar-hospitalizacion-ingreso-a-uci-y-muerte/>.
 52. Andrews N, Tessier E, Stowe J, et al. Vaccine effectiveness and duration of protection of Comirnaty, Vaxzevria and Spikevax against mild and severe COVID-19 in the UK. *Khub Prepr Available*. doi:10.1101/2021.09.15.21263583
 53. Skowronski DM, Setayeshgar S, Febriani Y, et al. Two-dose SARS-CoV-2 vaccine effectiveness with mixed schedules and extended dosing intervals: test-negative design studies from British Columbia and Quebec, Canada. *medRxiv*. January 2021:2021.10.26.21265397. doi:10.1101/2021.10.26.21265397
 54. Martínez-Baz I, Miquelz A, Casado I, et al. Effectiveness of COVID-19 vaccines in preventing SARS-CoV-2 infection and hospitalisation, Navarre, Spain, January to April 2021. *Eurosurveillance*. 2021;26(21). doi:10.2807/1560-7917.ES.2021.26.21.2100438
 55. Kissling E, Hooiveld M, Sandonis Martín V, et al. Vaccine effectiveness against symptomatic SARS-CoV-2 infection in adults aged 65 years and older in primary care: I-MOVE-COVID-19 project, Europe, December 2020 to May 2021. *Eurosurveillance*. 2021;26(29). doi:10.2807/1560-7917.ES.2021.26.29.2100670
 56. McKeigue PM, McAllister DA, Robertson C, et al. Efficacy of two doses of COVID-19 vaccine against severe COVID-19 in those with risk conditions and residual risk to the clinically extremely vulnerable: the REACT-SCOT case-control study. *medRxiv*. January 2021:2021.09.13.21262360. doi:10.1101/2021.09.13.21262360
 57. McKeigue PM, McAllister DA, Hutchinson SJ, et al. Efficacy of vaccination against severe COVID-19 in relation to Delta variant and time since second dose: the REACT-SCOT case-control study. *medRxiv*. January 2021:2021.09.12.21263448. doi:10.1101/2021.09.12.21263448
 58. Public Health England (PHE) press release. Vaccines highly effective against hospitalisation from Delta variant. Available at: <https://www.gov.uk/government/news/vaccines-highly-effective-against-hospitalisation-from-delta-variant>.
 59. de Gier B, Kooijman M, Kemmeren J, et al. COVID-19 vaccine effectiveness against hospitalizations and ICU admissions in the Netherlands, April- August 2021. *medRxiv*. January 2021:2021.09.15.21263613. doi:10.1101/2021.09.15.21263613
 60. Vasileiou E, Simpson CR, Robertson C, et al. Effectiveness of First Dose of COVID-19 Vaccines Against Hospital Admissions in Scotland: National Prospective Cohort Study of 5.4 Million People. *SSRN Electron J*. 2021. doi:10.2139/ssrn.3789264
 61. Sheikh A, Robertson C, Taylor B. BNT162b2 and ChAdOx1 nCoV-19 Vaccine Effectiveness against Death from the Delta Variant. *N Engl J Med*. October 2021. doi:10.1056/NEJMc2113864
 62. Corchado-García J, Puyraimond-Zemmour D, Hughes T, et al. Real-world effectiveness of Ad26.COV2.S adenoviral vector vaccine for COVID-19. *medRxiv*. January 2021:2021.04.27.21256193. doi:10.1101/2021.04.27.21256193
 63. Polinski JM, Weckstein AR, Batech M, et al. Effectiveness of the Single-Dose Ad26.COV2.S COVID Vaccine. *medRxiv*. January 2021:2021.09.10.21263385. doi:10.1101/2021.09.10.21263385
 64. Cohn BA, Cirillo PM, Murphy CC, Krigbaum NY, Wallace AW. Breakthrough SARS-CoV-2 infections in 620,000 U.S. Veterans, February 1, 2021 to August 13, 2021. *medRxiv*. January 2021:2021.10.13.21264966. doi:10.1101/2021.10.13.21264966
 65. Self WH, Tenforde MW, Rhoads JP, et al. Comparative Effectiveness of Moderna, Pfizer-BioNTech, and Janssen (Johnson & Johnson) Vaccines in Preventing COVID-19 Hospitalizations Among Adults Without Immunocompromising Conditions — United States, March–August 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(38):1337–1343. doi:10.15585/mmwr.mm7038e1
 66. Puranik A, Lenehan PJ, Silver E, et al. Comparison of two highly-effective mRNA vaccines for COVID-19 during periods of Alpha and Delta variant prevalence. *medRxiv*. January 2021:2021.08.06.21261707. doi:10.1101/2021.08.06.21261707
 67. Bruxvoort K, Sy LS, Qian L, et al. Real-World Effectiveness of the mRNA-1273 Vaccine Against COVID-19: Interim Results from a Prospective Observational Cohort Study. *SSRN Electron J*. 2021. doi:10.2139/ssrn.3916094
 68. Chemaiteily H, Tang P, Hasan MR, et al. Waning of BNT162b2 Vaccine Protection against SARS-CoV-2 Infection in Qatar. *N Engl J Med*. October 2021. doi:10.1056/NEJMoa2114114
 69. Bruxvoort KJ, Sy LS, Qian L, et al. Effectiveness of mRNA-1273 against Delta, Mu, and other emerging variants. *medRxiv*. January 2021:2021.09.29.21264199. doi:10.1101/2021.09.29.21264199
 70. Chung H, He S, Nasreen S, et al. Effectiveness of BNT162b2 and mRNA-1273 covid-19 vaccines against symptomatic SARS-CoV-2 infection and severe covid-19 outcomes in Ontario, Canada: test negative design study. *BMJ*. August 2021:n1943. doi:10.1136/bmj.n1943
 71. Public Health England. COVID-19 vaccine surveillance report: 1 July 2021 (week 26). Available at: <https://www.gov.uk/government/publications/covid-19-vaccine-surveillance-report>.
 72. Britton A, Jacobs Slika KM, Edens C, et al. Effectiveness of the Pfizer-BioNTech COVID-19 Vaccine Among Residents of Two Skilled Nursing Facilities Experiencing COVID-19 Outbreaks — Connecticut, December 2020–February 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(11):396–401. doi:10.15585/mmwr.mm7011e3
 73. Cavanaugh AM, Fortier S, Lewis P, et al. COVID-19 Outbreak Associated with a SARS-CoV-2 R.1 Lineage Variant in a Skilled Nursing Facility After Vaccination Program — Kentucky, March 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(17):639–643. doi:10.15585/mmwr.mm7017e2
 74. Israel Ministry of Health press release. Data Compiled by the Vaccine Operation's Supervising Committee Published 22 July 2021. Available at: <https://www.gov.il/en/departments/news/22072021-03>.
 75. Tartof SY, Slezak JM, Fischer H, et al. Effectiveness of mRNA BNT162b2 COVID-19 vaccine up to 6 months in a large integrated health system in the USA: a retrospective cohort study. *Lancet*. October 2021. doi:10.1016/S0140-6736(21)02183-8
 76. Chodick G, Tene L, Rotem RS, et al. The effectiveness of the TWO-DOSE BNT162b2 vaccine: analysis of real-world data. *Clin Infect Dis*. May 2021. doi:10.1093/cid/ciab438
 77. Haas EJ, Angulo FJ, McLaughlin JM, et al. Impact and effectiveness of mRNA BNT162b2 vaccine against SARS-CoV-2 infections and COVID-19 cases, hospitalisations, and deaths following a nationwide vaccination campaign in Israel: an observational study using national surveillance data. *Lancet*. 2021;397(10287):1819–1829. doi:10.1016/S0140-6736(21)00947-8
 78. Emborg H-D, Valentiner-Branth P, Scheide AB, et al. Vaccine effectiveness of the BNT162b2 mRNA COVID-19 vaccine against RT-PCR confirmed SARS-CoV-2 infections, hospitalisations and mortality in prioritised risk groups. *medRxiv*. January 2021:2021.05.27.21257583. doi:10.1101/2021.05.27.21257583
 79. Moustsen-Helms IR, Emborg H-D, Nielsen J, et al. Vaccine effectiveness after 1st and 2nd dose of the BNT162b2 mRNA Covid-19 Vaccine in long-term care facility residents and healthcare workers – a Danish cohort study. *medRxiv*. January 2021:2021.03.08.21252200. doi:10.1101/2021.03.08.21252200
 80. Dagan N, Barda N, Kepten E, et al. BNT162b2 mRNA Covid-19 Vaccine in a Nationwide Mass Vaccination Setting. *N Engl J Med*. February 2021:NEJMoa2101765. doi:10.1056/NEJMoa2101765
 81. Tang L, Hijano DR, Gaur AH, et al. Asymptomatic and Symptomatic SARS-CoV-2 Infections After BNT162b2 Vaccination in a Routinely Screened Workforce. *JAMA*. May 2021. doi:10.1001/jama.2021.6564
 82. Uruguay Ministry of Public Health. Third study of effectiveness of vaccination against SARS-CoV-2 in Uruguay as of June 30, 2021. Press release 3 July 2021. Available at: <https://www.gub.uy/ministerio-salud-publica/comunicacion/noticias/segundo-estudio-efectividad-vacunacion-anti-sars-cov-2-uruguay-8-junio-2021>.
 83. Saciuk Y, Kertes J, Mandel M, Hemo B, Shamir Stein N, Zohar AE. Pfizer-BioNTech Vaccine Effectiveness Against SARS-CoV-2 Infection: Findings From a Large Observational Study in Israel. *SSRN Electron J*. 2021. doi:10.2139/ssrn.3868853
 84. de Gier B, Andrewes S, Joosten R, et al. Vaccine effectiveness against SARS-CoV-2 transmission and infections among household and other close contacts of confirmed cases, the Netherlands, February to May 2021. *Eurosurveillance*. 2021;26(31). doi:10.2807/1560-7917.ES.2021.26.31.2100640
 85. Hyams C, Marlow R, Maseko Z, et al. Effectiveness of BNT162b2 and ChAdOx1 nCoV-19 COVID-19 vaccination at preventing hospitalisations in people aged at least 80 years: a test-negative, case-control study. *Lancet Infect Dis*. June 2021. doi:10.1016/S1473-3099(21)00330-3
 86. Lopez Bernal J, Andrews N, Gower C, et al. Effectiveness of the Pfizer-BioNTech and Oxford-AstraZeneca vaccines on covid-19 related symptoms, hospital admissions, and mortality in older adults in England: test negative case-control study. *BMJ*. May 2021:n1088. doi:10.1136/bmj.n1088
 87. Ismail S, Vilaplana T, Elgohari S, et al. Effectiveness of BNT162b2 mRNA and ChAdOx1 adenovirus vector COVID-19 vaccines on risk of hospitalisation among older adults in England: an observational study using surveillance data. *Khub Prepr* <https://khub.net/documents/135939561/430986542/Effectiveness%20of%2BBNT162b2%2BmRNA%2Bband%2BChAdOx1%2Badenovirus%2Bvector%2BCOVID-19%2Bvaccines%2Bont%2Brisik%2Bof%2Bhospitalisation%2Bamong%2Bolder%2Badults%2Bin%2BEngland.pdf/9e18c525-dde6-5ee4>.
 88. Mason T, Whitston M, Hodgson J, et al. Effects of BNT162b2 mRNA vaccine on Covid-19 infection and hospitalisation among older people: matched case control study for England. *medRxiv*. January 2021:2021.04.19.21255461. doi:10.1101/2021.04.19.21255461
 89. Moderna press release. Moderna Announces TeenCOVE Study of its COVID-19 Vaccine in Adolescents Meets Primary Endpoint and Plans to Submit Data to Regulators in Early June 25 May 2021. Available at: <https://investors.modernatx.com/news-releases/news-release-details/moderna-announces-teencove-study-its-covid-19-vaccine>.
 90. Moderna press release. Moderna Announces Positive Top Line Data from Phase 2/3 Study of COVID-19 Vaccine in Children 6 to 11 Years of Age. 25 October 2021. Available at: <https://investors.modernatx.com/news-releases/news-release-details/moderna-announces-positive-top-line-data-phase-23-study-covid-19>.
 91. Mahase E. Covid-19: Pfizer reports 100% vaccine efficacy in children aged 12 to 15. *BMJ*. April 2021:n881. doi:10.1136/bmj.n881
 92. Pfizer press release. Pfizer and BioNTech announce positive topline results from pivotal trial of COVID-19 vaccine in children 5 to 11 years. Available at: <https://www.pfizer.com/news/press-release/press-release-detail/pfizer-biontech-announce-positive-topline-results-pivotal>.
 93. United States Food and Drug Administration (FDA). Vaccines and Related Biological Products Advisory Committee October 26, 2021 Meeting Document. Available at: <https://www.fda.gov/media/153409/download>.
 94. Reis BY, Barda N, Leshchinsky M, et al. Effectiveness of BNT162b2 Vaccine against Delta Variant in Adolescents. *N Engl J Med*. October 2021. doi:10.1056/NEJMc2114290
 95. Olson SM, Newhams MM, Halasa NB, et al. Effectiveness of Pfizer-BioNTech mRNA Vaccination Against COVID-19 Hospitalization Among Persons Aged 12–18 Years — United States, June–September 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(42):1483–1488. doi:10.15585/mmwr.mm7042e1
 96. UK Government Department of Health & Social Care correspondence. Universal vaccination of children and young people aged 12 to 15 years against COVID-19. Published 13 September 2021. [https://www.gov.uk/government/publications/universal-vaccination-of-children-and-young-people-aged-12-to-15-years-against-covid-19](https://www.gov.uk/government/publications/universal-vaccination-of-children-and-young-people-aged-12-to-15-years-against-covid-19/universal-vaccination-of-children-and-young-people-aged-12-to-15-years-against-covid-19).
 97. Han B, Song Y, Li C, et al. Safety, tolerability, and immunogenicity of an inactivated SARS-CoV-2 vaccine (CoronaVac) in healthy children and adolescents: a double-blind, randomised, controlled, phase 1/2 clinical trial. *Lancet Infect Dis*. June 2021. doi:10.1016/S1473-3099(21)00319-4
 98. Hillson K, Clemens SC, Madhi SA, Voysey M, Pollard AJ, Minassian AM. Fertility rates and birth outcomes after ChAdOx1 nCoV-19 (AZD1222) vaccination. *Lancet*. October 2021. doi:10.1016/S0140-6736(21)02282-0
 99. Trostle ME, Agüero-Rosenfeld ME, Roman AS, Lighter JL. High antibody levels in cord blood from pregnant women vaccinated against COVID-19. *Am J Obstet Gynecol MFM*. September 2021:100481. doi:10.1016/j.ajogmf.2021.100481
 100. Dagan N, Barda N, Biron-Shental T, et al. Effectiveness of the BNT162b2 mRNA COVID-19 vaccine in pregnancy. *Nat Med*. 2021;27(10):1693–1695. doi:10.1038/s41591-021-01490-8
 101. Goldstein I, Nevo D, Steinberg DM, et al. Association Between BNT162b2 Vaccination and Incidence of SARS-CoV-2 Infection in Pregnant Women. *JAMA*. 2021;326(8):728. doi:10.1001/jama.2021.11035
 102. United States National Institutes of Health (NIH) News release. NIH begins study of COVID-19 vaccination during pregnancy and postpartum. 23 June 2021. Available at: <https://www.nih.gov/news-events/news-releases/nih-begins-study-covid-19-vaccination-during-pregnancy>.

- postpartum.
103. Hall VJ, Foulkes S, Saei A, et al. COVID-19 vaccine coverage in health-care workers in England and effectiveness of BNT162b2 mRNA vaccine against infection (SIREN): a prospective, multicentre, cohort study. *Lancet*. 2021;397(10286):1725-1735. doi:10.1016/S0140-6736(21)00790-X
104. Regev-Yochay G, Amit S, Bergwerk M, et al. Decreased Infectivity Following BNT162b2 Vaccination. *SSRN Electron J*. 2021. doi:10.2139/ssrn.3815668
105. Government of Spain Ministry of Health and Innovation. The combined use of AstraZeneca and Pfizer vaccines against SARS-CoV-2 offers a powerful immune response. Press release 18 May 2021. Available at: <https://www.isciii.es/Noticias/Noticias/Paginas/Noticias/Presentación-resultados-preliminares-CombivacS.aspx>.
106. Shaw RH, Stuart A, Greenland M, Liu X, Van-Tam JSN, Snape MD. Heterologous prime-boost COVID-19 vaccination: initial reactivity data. *Lancet*. 2021;397(10289):2043-2046. doi:10.1016/S0140-6736(21)01115-6
107. Hillus D. Reactogenicity of homologous and heterologous prime-boost immunisation with BNT162b2 and ChAdOx1-nCoV19: a prospective cohort study. *medRxiv Prepr*. doi:doi.org/10.1101/2021.05.19.21257334
108. Powell AA, Power L, Westrop S, et al. Real-world data shows increased reactivity in adults after heterologous compared to homologous prime-boost COVID-19 vaccination, March–June 2021, England. *Eurosurveillance*. 2021;26(28). doi:10.2807/1560-7917.ES.2021.26.28.2100634
109. Borobia AM, Carcas AJ, Pérez-Olmeda M, et al. Immunogenicity and reactivity of BNT162b2 booster in ChAdOx1-S-primed participants (CombiVAcS): a multicentre, open-label, randomised, controlled, phase 2 trial. *Lancet*. 2021;398(10295):121-130. doi:10.1016/S0140-6736(21)01420-3
110. Liu X, Shaw RH, Stuart AS, et al. Safety and Immunogenicity Report from the Com-COV Study – a Single-Blind Randomised Non-Inferiority Trial Comparing Heterologous And Homologous Prime-Boost Schedules with An Adenoviral Vectedored and mRNA COVID-19 Vaccine. *SSRN Electron J*. 2021. doi:10.2139/ssrn.3874014
111. Schmidt T, Klemis V, Schub D, et al. Immunogenicity and reactivity of a heterologous COVID-19 prime-boost vaccination compared with homologous vaccine regimens. *medRxiv*. January 2021:2021.06.13.21258859. doi:10.1101/2021.06.13.21258859
112. Barros-Martins J, Hammerschmidt SI, Cossmann A, et al. Humoral and cellular immune response against SARS-CoV-2 variants following heterologous and homologous ChAdOx1 nCoV-19/BNT162b2 vaccination. *medRxiv*. January 2021:2021.06.01.21258172. doi:10.1101/2021.06.01.21258172
113. Behrens GM, Cossmann A, Stankov M V, et al. SARS-CoV-2 delta variant neutralisation after heterologous ChAdOx1-S/BNT162b2 vaccination. *Lancet*. August 2021. doi:10.1016/S0140-6736(21)01891-2
114. Public Health Agency of Canada. An Advisory Committee Statement (ACS) National Advisory Committee on Immunization (NACI) Recommendations on the use of COVID-19 Vaccines. 17 June 2021. Available at: <https://www.canada.ca/content/dam/phac-asp/communications/immunization/national-advisory-committee-on-immunization-naci/recommendations-use-covid-19-vaccines/recommendations-use-covid-19-vaccines-en.pdf>.
115. Atmar RL, Lyke KE, Deming ME, et al. Heterologous SARS-CoV-2 Booster Vaccinations: Preliminary Report. *medRxiv*. January 2021:2021.10.10.21264827. doi:10.1101/2021.10.10.21264827
116. US National Library of Medicine ClinicalTrials.gov. Mix and Match of the Second COVID-19 Vaccine Dose for Safety and Immunogenicity (MOSAIC). Available at: <https://clinicaltrials.gov/ct2/show/NCT04894435?term=mixed+schedule%2C+covid+19%2C+vaccine&draw=2&rank=1>.
117. Gram MA, Nielsen J, Schelde AB, et al. Vaccine effectiveness when combining the ChAdOx1 vaccine as the first dose with an mRNA COVID-19 vaccine as the second dose. *medRxiv*. January 2021:2021.07.26.21261130. doi:10.1101/2021.07.26.21261130
118. Australian Government Therapeutic Goods Administration (TGA). Australian Product Information - COVID-19 Vaccine AstraZeneca (ChAdOx1-S) solution for injection. Available at: <https://www.ebs.tga.gov.au/ebs/picmi/picmirepository.nsf/pdf?OpenAgent&id=CP-2021-PI-01194-1&d=202105261016933>.
119. US Federal Drug Administration (FDA). Fact sheet for healthcare providers administering vaccine (vaccination providers) emergency use authorisation (EUA) of the Moderna COVID-19 vaccine to prevent coronavirus disease 2019 (COVID-19). Available at: <https://www.modernatx.com/covid19vaccine-eua/eua-fact-sheet-providers.pdf>.
120. US Federal Drug Administration (FDA). Fact sheet for healthcare providers administering vaccine (vaccination providers). Emergency use authorisation (EUA) of the Janssen COVID-19 vaccine to prevent coronavirus disease 2019 (COVID-19). Available at: <https://www.janssenlabels.com/emergency-use-authorization/Janssen+COVID-19+Vaccine-HCP-fact-sheet.pdf>.
121. Xia S, Zhang Y, Wang Y, et al. Safety and immunogenicity of an inactivated SARS-CoV-2 vaccine, BBIBP-CorV: a randomised, double-blind, placebo-controlled, phase 1/2 trial. *Lancet Infect Dis*. 2021;21(1):39-51. doi:10.1016/S1473-3099(20)30831-8
122. Zhang Y, Zeng G, Pan H, et al. Safety, tolerability, and immunogenicity of an inactivated SARS-CoV-2 vaccine in healthy adults aged 18–59 years: a randomised, double-blind, placebo-controlled, phase 1/2 clinical trial. *Lancet Infect Dis*. 2021;21(2):181-192. doi:10.1016/S1473-3099(20)30843-4
123. European Medicines Agency (EMA). Meeting highlights from the Pharmacovigilance Risk Assessment Committee (PRAC) 3-6 May 2021. Available at: <https://www.ema.europa.eu/en/news/meeting-highlights-pharmacovigilance-risk-assessment-committee-prac-3-6-may-2021>.
124. Australian Government Therapeutic Goods Administration (TGA). COVID-19 vaccine weekly safety report - 08-07-2021. Available at: <https://www.tga.gov.au/periodic/covid-19-vaccine-weekly-safety-report-08-07-2021>.
125. United States Advisory Committee on Immunization Practices (ACIP). ACIP Presentation Slides: October 20-21, 2021 Meeting. Available at: <https://www.cdc.gov/vaccines/acip/meetings/slides-2021-10-20-21.html>.
126. Welsh KJ, Baumblatt J, Chege W, Goud R, Nair N. Thrombocytopenia including immune thrombocytopenia after receipt of mRNA COVID-19 vaccines reported to the Vaccine Adverse Event Reporting System (VAERS). *Vaccine*. 2021;96(5):534-537. doi:10.1016/j.vaccine.2021.04.054
127. Vogel G. Israel reports link between rare cases of heart inflammation and COVID-19 vaccination in young men. *Science (80-)*. June 2021. doi:10.1126/science.abj7796
128. Barda N, Dagan N, Ben-Shlomo Y, et al. Safety of the BNT162b2 mRNA Covid-19 Vaccine in a Nationwide Setting. *N Engl J Med*. August 2021:NEJMoa2110475. doi:10.1056/NEJMoa2110475
129. US Food and Drug Administration (FDA) press release. Coronavirus (COVID-19) Update: July 13, 2021. Available at: <https://www.fda.gov/news-events/press-announcements/coronavirus-covid-19-update-july-13-2021>.
130. Pavord S, Scully M, Hunt BJ, et al. Clinical Features of Vaccine-Induced Immune Thrombocytopenia and Thrombosis. *N Engl J Med*. August 2021:NEJMoa2109908. doi:10.1056/NEJMoa2109908
131. Government of Canada National Advisory Committee on Immunization (NACI) statement. NACI rapid response: Recommended use of AstraZeneca COVID-19 vaccine in younger adults.
132. Australian Technical Advisory Group on Immunisation (ATAGI) ATAGI statement on revised recommendations on the use of COVID-19 Vaccine AstraZeneca, 17 June 2021. Available at: <https://www.health.gov.au/news/atagi-statement-on-revised-recommendations-on-the-use-of-covid-19-vaccine-astrazeneca-17-june-2021>.
133. UK Government press release. JCVI advises on COVID-19 vaccine for people aged under 40. 7 May 2021. Available at: <https://www.gov.uk/government/news/jcvi-advises-on-covid-19-vaccine-for-people-aged-under-40>.
134. European Medicines Agency (EMA). Meeting highlights from the Pharmacovigilance Risk Assessment Committee (PRAC) 6-9 April 2021. Available at: <https://www.ema.europa.eu/en/news/meeting-highlights-pharmacovigilance-risk-assessment-committee-prac-6-9-april-2021>.
135. Statement of the WHO Global Advisory Committee on Vaccine Safety (GACVS) COVID-19 subcommittee on reports of Guillain-Barré Syndrome (GBS) following adenovirus vector COVID-19 vaccines 26 July 2021. Available at: <https://www.who.int/news/item/26-07-2021-statement-of-the-who-gacvs-covid-19-subcommittee-on-gbs>.
136. Patone M, Handunnetthi L, Saatci D, et al. Neurological complications after first dose of COVID-19 vaccines and SARS-CoV-2 infection. *Nat Med*. October 2021. doi:10.1038/s41591-021-01556-7
137. Shimabukuro TT, Cole M, Su JR. Reports of Anaphylaxis After Receipt of mRNA COVID-19 Vaccines in the US—December 14, 2020–January 18, 2021. *JAMA*. 2021;325(11):1101. doi:10.1001/jama.2021.1967
138. Shimabukuro TT, Kim SY, Myers TR, et al. Preliminary Findings of mRNA Covid-19 Vaccine Safety in Pregnant Persons. *N Engl J Med*. April 2021:NEJMoa2104983. doi:10.1056/NEJMoa2104983
139. World Health Organisation (WHO). COVID-19 subcommittee of the WHO Global Advisory Committee on Vaccine Safety (GACVS): updated guidance regarding myocarditis and pericarditis reported with COVID-19 mRNA vaccines. 9 July 2021. Available at: <https://www.who.int/news/item/09-07-2021-gacvs-guidance-myocarditis-pericarditis-covid-19-mrna-vaccines>.
140. Public Health Ontario enhanced epidemiological summary. Myocarditis and Pericarditis Following Vaccination with COVID-19 mRNA Vaccines in Ontario: December 13, 2020 to August 7, 2021. Available at: https://www.publichealthontario.ca/-/media/documents/ncov/epi/covid-19-myocarditis-pericarditis-vaccines-epi.pdf?sc_lang=en.
141. UK Medicines & Healthcare products Regulatory Agency. Coronavirus vaccine - weekly summary of Yellow Card reporting. Updated 7 October 2021. Available at: <https://www.gov.uk/government/publications/coronavirus-covid-19-vaccine-adverse-reactions/coronavirus-vaccine-summary-of-yellow-card-reporting>.
142. Novavax COVID-19 Vaccine Demonstrates 89.3% Efficacy in UK Phase 3 Trial. Novavax press release 28 January 2021. <https://ir.novavax.com/news-releases/news-release-details/novavax-covid-19-vaccine-demonstrates-89-3-eficacy-uk-phase-3>.
143. Witberg G, Barda N, Hoss S, et al. Myocarditis after Covid-19 Vaccination in a Large Health Care Organization. *N Engl J Med*. October 2021. doi:10.1056/NEJMoa2110737
144. Mevorach D, Anis E, Cedar N, et al. Myocarditis after BNT162b2 mRNA Vaccine against Covid-19 in Israel. *N Engl J Med*. October 2021. doi:10.1056/NEJMoa2109730
145. Bernal J, Andrews N, Gower C, et al. Effectiveness of BNT162b2 mRNA vaccine and ChAdOx1 adenovirus vector vaccine on mortality following COVID-19. *Prepr medRxiv*. doi:10.1101/2021.05.14.21257218
146. Mateo-Urdiales A, Spila Alegiani S, Fabiani M, et al. Risk of SARS-CoV-2 infection and subsequent hospital admission and death at different time intervals since first dose of COVID-19 vaccine administration, Italy, 27 December 2020 to mid-April 2021. *Eurosurveillance*. 2021;26(25). doi:10.2807/1560-7917.ES.2021.26.25.2100507
147. University College London press release. Covid-19 vaccine: care home residents gain 62% protection from one dose. 29 March 2021.
148. Pritchard E, Mathews PC, Stoesser N, et al. Impact of vaccination on SARS-CoV-2 cases in the community: a population-based study using the UK's COVID-19 Infection Survey. *medRxiv*. January 2021:2021.04.22.21255913. doi:10.1101/2021.04.22.21255913
149. Johnson & Johnson press release. Johnson & Johnson Announces Real-World Evidence and Phase 3 Data Confirming Strong and Long-Lasting Protection of Single-Shot COVID-19 Vaccine in the U.S. 21 September 2021. Available at: <https://www.jnj.com/johnson-johnson-announces-real-world-evidence-and-phase-3-data-confirming-strong-and-long-lasting-protection-of-single-shot-covid-19-vaccine-in-the-u-s>.
150. Tenforde MW, Self WH, Nalio EA, et al. Sustained Effectiveness of Pfizer-BioNTech and Moderna Vaccines Against COVID-19 Associated Hospitalizations Among Adults — United States, March–July 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(34). doi:10.15585/mmwr.mm7034e2
151. Daniel W, Nivet M, Warner J, Podolsky DK. Early Evidence of the Effect of SARS-CoV-2 Vaccine at One Medical Center. *N Engl J Med*. March 2021:NEJMoa2102153. doi:10.1056/NEJMoa2102153
152. Thompson MG, Burgess JL, Naleway AL, et al. Interim Estimates of Vaccine Effectiveness of BNT162b2 and mRNA-1273 COVID-19 Vaccines in Preventing SARS-CoV-2 Infection Among Health Care Personnel, First Responders, and Other Essential and Frontline Workers — Eight U.S. Locations, December 2020–March. *MMWR Morb Mortal Wkly Rep*. 2021;70(13):495-500. doi:10.15585/mmwr.mm7013e3
153. Fowlkes A, Gaglani M, Groover K, These MS, Tyner H, Ellingson K. Effectiveness of COVID-19 Vaccines in Preventing SARS-CoV-2 Infection Among Frontline Workers Before and During B.1.617.2 (Delta) Variant Predominance — Eight U.S. Locations, December 2020–August 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(34):1167-1169. doi:10.15585/mmwr.mm7034e4

154. Benenson S, Oster Y, Cohen MJ, Nir-Paz R. BNT162b2 mRNA Covid-19 Vaccine Effectiveness among Health Care Workers. *N Engl J Med*. March 2021;NEJMc2101951. doi:10.1056/NEJMc2101951
155. World Health Organisation (WHO). Weekly epidemiological update on COVID-19 - 11 May 2021. Available at: <https://www.who.int/publications/m/item/weekly-epidemiological-update-on-covid-19---11-may-2021>.
156. World Health Organisation (WHO). Tracking SARS-CoV-2 variants. Available at: <https://www.who.int/en/activities/tracking-SARS-CoV-2-variants/>.
157. Emary KRW, Golubchik T, Aley PK, et al. Efficacy of ChAdOx1 nCoV-19 (AZD1222) vaccine against SARS-CoV-2 variant of concern 202012/01 (B.1.1.7): an exploratory analysis of a randomised controlled trial. *Lancet*. March 2021. doi:10.1016/S0140-6736(21)00628-0
158. Madhi SA, Bailly V, Cutland CL, et al. Safety and efficacy of the ChAdOx1 nCoV-19 (AZD1222) Covid-19 vaccine against the B.1.351 variant in South Africa. *Alex Sigal*. 2021.
159. Shinde V, Bhikha S, Hoosain Z, et al. Efficacy of NVX-CoV2373 Covid-19 Vaccine against the B.1.351 Variant. *N Engl J Med*. May 2021;NEJMoa2103055. doi:10.1056/NEJMoa2103055
160. Kustin T, Harel N, Finkel U, et al. Evidence for increased breakthrough rates of SARS-CoV-2 variants of concern in BNT162b2 mRNA vaccinated individuals. *medRxiv*. January 2021;2021.04.06.21254882. doi:10.1101/2021.04.06.21254882
161. Abu-Raddad LJ, Chemaitelly H, Butt AA. Effectiveness of the BNT162b2 Covid-19 Vaccine against the B.1.1.7 and B.1.351 Variants. *N Engl J Med*. May 2021;NEJMc2104974. doi:10.1056/NEJMc2104974
162. Thomas SJ, Moreira ED, Kitchin N, et al. Six Month Safety and Efficacy of the BNT162b2 mRNA COVID-19 Vaccine. *medRxiv*. January 2021;2021.07.28.21261159. doi:10.1101/2021.07.28.21261159
163. Israel Ministry of Health press release. Decline in Vaccine Effectiveness Against Infection and Symptomatic Illness. 5 July 2021. Available at: <https://www.gov.il/en/departments/news/05072021-03>.
164. Hitchings MDT, Ranzani OT, Torres MSS, et al. Effectiveness of CoronaVac among healthcare workers in the setting of high SARS-CoV-2 Gamma variant transmission in Manaus, Brazil: A test-negative case-control study. *Lancet Reg Heal - Am*. July 2021;100025. doi:10.1016/j.lana.2021.100025
165. Ranzani OT, Hitchings M, Nieto MD, et al. Effectiveness of the CoronaVac vaccine in the elderly population during a P.1 variant-associated epidemic of COVID-19 in Brazil: A test-negative case-control study. *medRxiv*. January 2021;2021.05.19.21257472. doi:10.1101/2021.05.19.21257472
166. Li X, Huang Y, Wang W, et al. Efficacy of inactivated SARS-CoV-2 vaccines against the Delta variant infection in Guangzhou: A test-negative case-control real-world study. *Emerg Microbes Infect*. August 2021;1-32. doi:10.1080/22221751.2021.1969291
167. Tenforde MW, Olson SM, Self WH, et al. Effectiveness of Pfizer-BioNTech and Moderna Vaccines Against COVID-19 Among Hospitalized Adults Aged ≥65 Years — United States, January–March 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(18). doi:10.15585/mmwr.mm7018e1
168. Nunes B, Rodrigues AP, Kislaya I, et al. mRNA vaccine effectiveness against COVID-19-related hospitalisations and deaths in older adults: a cohort study based on data linkage of national health registries in Portugal, February to August 2021. *Eurosurveillance*. 2021;26(38). doi:10.2807/1560-7917.ES.2021.26.38.2100833
169. Rossman H, Shilo S, Meir T, Gorfine M, Shalit U, Segal E. COVID-19 dynamics after a national immunization program in Israel. *Nat Med*. April 2021. doi:10.1038/s41591-021-01337-2
170. Shrotri M, Krutikov M, Palmer T, et al. Vaccine effectiveness of the first dose of ChAdOx1 nCoV-19 and BNT162b2 against SARS-CoV-2 infection in residents of long-term care facilities in England (VIVALDI): a prospective cohort study. *Lancet Infect Dis*. June 2021;2021.03.26.21254391. doi:10.1016/S1473-3099(21)00289-9
171. Harris RJ, Hall JA, Zaidi A, Andrews NJ, Dunbar JK, Dabrera G. Effect of Vaccination on Household Transmission of SARS-CoV-2 in England. *N Engl J Med*. June 2021;NEJMc2107717. doi:10.1056/NEJMc2107717
172. Pritchard E, Matthews PC, Stoesser N, et al. Impact of vaccination on new SARS-CoV-2 infections in the United Kingdom. *Nat Med*. June 2021. doi:10.1038/s41591-021-01410-w
173. Menni C, Klaser K, May A, et al. Vaccine side-effects and SARS-CoV-2 infection after vaccination in users of the COVID Symptom Study app in the UK: a prospective observational study. *Lancet Infect Dis*. 2021;21(7):939-949. doi:10.1016/S1473-3099(21)00224-3
174. V Shah AS, Gribben C, Bishop J, et al. Effect of vaccination on transmission of COVID-19: an observational study in healthcare workers and their households. *medRxiv*. January 2021;2021.03.11.21253275. doi:10.1101/2021.03.11.21253275
175. Cavanaugh AM, Spicer KB, Thoroughman D, Glick C, Winter K. Reduced Risk of Reinfection with SARS-CoV-2 After COVID-19 Vaccination — Kentucky, May–June 2021. *MMWR Morb Mortal Wkly Rep*. 2021;70(32):1081-1083. doi:10.15585/mmwr.mm7032e1
176. Pawlowski C, Lenehan P, Puranik A, et al. FDA-authorized COVID-19 vaccines are effective per real-world evidence synthesized across a multi-state health system. *medRxiv*. January 2021;2021.02.15.21251623. doi:10.1101/2021.02.15.21251623
177. Thompson MG, Burgess JL, Naleway AL, et al. Interim Estimates of Vaccine Effectiveness of BNT162b2 and mRNA-1273 COVID-19 Vaccines in Preventing SARS-CoV-2 Infection Among Health Care Personnel, First Responders, and Other Essential and Frontline Workers. *medRxiv*. 2021;2021.03.11.21253275. doi:10.1101/2021.03.11.21253275
178. Tande AJ, Pollock BD, Shah ND, et al. Impact of the COVID-19 Vaccine on Asymptomatic Infection Among Patients Undergoing Pre-Operational COVID-19 Molecular Screening. *Clin Infect Dis*. March 2021. doi:10.1093/cid/ciab229
179. White EM, Yang X, Blackman C, Feifer RA, Gravenstein S, Mor V. Incident SARS-CoV-2 Infection among mRNA-Vaccinated and Unvaccinated Nursing Home Residents. *N Engl J Med*. May 2021;NEJMc2104849. doi:10.1056/NEJMc2104849
180. Lipsitch M, Kahn R. Interpreting vaccine efficacy trial results for infection and transmission. *Vaccine*. June 2021. doi:10.1016/j.vaccine.2021.06.011
181. Amit S, Regev-Yochay G, Afek A, Kreiss Y, Leshem E. Early rate reductions of SARS-CoV-2 infection and COVID-19 in BNT162b2 vaccine recipients. *Lancet*. 2021;397(10277):875-877. doi:10.1016/S0140-6736(21)00448-7
182. Prunas O, Warren JL, Crawford FW, et al. Vaccination with BNT162b2 reduces transmission of SARS-CoV-2 to household contacts in Israel. *medRxiv*. January 2021;2021.07.13.21260393. doi:10.1101/2021.07.13.21260393
183. Layan M, Gilboa M, Gonen T, et al. Impact of BNT162b2 vaccination and isolation on SARS-CoV-2 transmission in Israeli households: an observational study. *medRxiv*. January 2021;2021.07.12.21260377. doi:10.1101/2021.07.12.21260377
184. Michael Weekes, Nick K Jones, Lucy Rivett, et al. Single-dose BNT162b2 vaccine protects against asymptomatic SARS-CoV-2 infection. *Authorea*. February 24, 2021. doi:10.22541/au.161420511
185. Salo J, Hägg M, Kortelainen M, et al. The indirect effect of mRNA-based Covid-19 vaccination on unvaccinated household members. *medRxiv*. January 2021;2021.05.27.21257896. doi:10.1101/2021.05.27.21257896
186. Levine-Tiefenbrun M, Yelin I, Katz R, et al. Initial report of decreased SARS-CoV-2 viral load after inoculation with the BNT162b2 vaccine. *Nat Med*. 2021;27(5):790-792. doi:10.1038/s41591-021-01316-7
187. Milman O, Yelin I, Aharoni N, et al. SARS-CoV-2 infection risk among unvaccinated is negatively associated with community-level vaccination rates. *medRxiv*. January 2021;2021.03.26.21254394. doi:10.1101/2021.03.26.21254394
188. De Salazar PM, Link N, Lamarca K, Santillana M. High coverage COVID-19 mRNA vaccination rapidly controls SARS-CoV-2 transmission in Long-Term Care Facilities. *medRxiv*. January 2021;2021.04.08.21255108. doi:10.1101/2021.04.08.21255108
189. United Nations Children's Fund (UNICEF), Pacific Office. Situation Analysis of Children in the Pacific Island Countries. December 2017.

Acknowledgements

This document was compiled by Dr John Hart

Technical leads: Professor Fiona Russell and Professor Kim Mulholland

Quality checks: Professor Julie Bines, Associate Professor Nigel Crawford and Associate Professor Margie Danchin

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>

To subscribe to receive the weekly updates, please email kase.anderson@unimelb.edu.au

Murdoch Children's Research Institute

50 Flemington Rd, Parkville
Victoria 3052 Australia
ABN 21 006 566 972

Weekly COVID-19 Vaccine Updates
Number 31, 28 October 2021



Appendix 1: COVID-19 Vaccine Effectiveness

VACCINE	SEVERE / HOSPITALISATION / DEATH	INFECTION AND OTHER OUTCOMES
AstraZeneca	<p>Single dose in Scotland: 94% (73-99)⁵⁰ Risk of death in vaccine failures compared to unvaccinated cases in England reduced by: 55% (41-66)¹⁴⁵ (not peer reviewed) Single dose against hospitalisation in Spain: 92% (46-99)⁵⁴ Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Hospitalisation: 89% (85-91); Death: 93% (89-96)¹⁴⁶ Chile: Hospitalisation: 100%; ICU admission: 100%; Death: 100%⁵¹ Scotland: Hospitalisation: 94% (90-99)⁵² Netherlands: Hospitalisation: 94% (92-95)⁵⁹ Spain: Hospitalisation: 95% (79-99)⁴⁸ Scotland: Death: 91% (86-94)⁵¹ British Columbia and Quebec, Canada: Hospitalisation: 94% (90-96); 94% (89-97)⁵²</p>	<p>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%¹⁴⁷ Pooled analysis of Pfizer/BioNTech and AstraZeneca vaccines: reduced odds of infection post-second dose: 70% (62-77)¹⁴⁸ Single dose in Spain: Any infection: 44% (31-54); Symptomatic infection: 50% (37-61)⁵⁴ Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Infection: 78% (76-79)¹⁴⁶ Single dose against symptomatic infection in multiple European countries: 68% (69-83)⁵³ Symptomatic infection in 16-64 years in UK: single dose: 50.2% (40.8-58.2); 2 doses: 78.0% (69.7-84.0)⁵⁰ Symptomatic infection in Chile: 68.7% (39.8-87.3)⁵¹ Spain: Any infection: 54% (48-60); Symptomatic infection: 56% (48-63)⁴⁸ British Columbia and Quebec, Canada: Symptomatic infection: 71% (69-74); 73% (69-77)⁵²</p>
Johnson & Johnson	<p>USA: Hospitalisation: 81% (79-84)⁶³ USA: 71% (56-81)⁶⁵ Netherlands: Hospitalisation: 91% (88-94)⁵⁹ Spain: Hospitalisation: 74% (43-88)⁴⁸</p>	<p>USA: Any infection: 76.7% (30.3-95.3)⁶² USA: Infection: 79% (77-80)⁶³ Efficacy following booster 2 months after first dose: Moderate-Severe infection in USA: 94% (89-100); worldwide: 75% (55-87)¹⁴⁹ Spain: Any infection: 50% (42-57); Symptomatic infection: 54% (45-62)¹⁵¹ Vaccine effectiveness against symptomatic infection in veterans in USA: 81% (67-89)¹⁵⁴</p>
Moderna	<p>Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna in Italy: Hospitalisation: 89% (85-91); Death: 93% (89-96)¹⁴⁶ 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%)¹⁵⁰ USA: Hospitalisation: 95.8% (90.7-98.1); Death: 97.9% (66.9-99.9)⁶⁷ Pooled Pfizer/BioNTech and Moderna against hospitalisation in Scotland: 92% (85-99)⁵⁹ USA: 93% (91-95)⁶⁵ Spain: Hospitalisation: 98% (82-100)⁴⁸ Qatar: Decline in effectiveness accelerated beyond the fourth month after the second dose; First month after second dose: 96.0% (93.3-97.4); >7 months: 55.6% (-44.3-86.3)⁶⁸ USA: Hospitalisation: 97.6% (92.8-99.2)⁶⁹ Moderna and Pfizer/BioNTech in British Columbia and Quebec, Canada: Hospitalisation: 98% (97-98); 97% (96-97)⁵²</p>	<p>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)¹⁵¹ Pooled analysis of Moderna and Pfizer/BioNTech vaccines against infection in USA: Fully vaccinated: 90% (68-97) Two weeks after first dose: 80% (69-90)¹⁵² Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Infection: 78% (76-79)¹⁴⁶ Single dose against symptomatic disease in the UK: Age 15-39 years: 72% (48-86)⁷¹ 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)⁶⁶ Infection in USA (98% vaccines used Pfizer/BioNTech and Moderna): Pre-Delta variant predominant: 91% (81-98); Delta variant predominant: 66% (26-84)¹⁵³ Infection in Canada: 1 dose: 72% (63-80); 2 doses: 94% (86-97)⁷⁰ USA: Any infection: 87.4% (84.8-89.6); Symptomatic infection: 88.3% (86.1-90.2)⁶⁷ Spain: Any infection: 82% (78-86); Symptomatic infection: 85% (80-89)⁴⁸ Qatar: First month after second dose: 77.5% (76.4-78.6); ≥7 months: 22.3% (-1.7-40.7)⁶⁸ USA: Any infection: 96.7% (84.3-88.7)⁶⁹ Moderna and Pfizer/BioNTech in British Columbia and Quebec, Canada: Symptomatic infection: 90% (89-90); 88% (88-89)⁵² Vaccine effectiveness against symptomatic infection in veterans in USA: 92% (92-93)¹⁵⁴</p>
Pfizer/BioNTech	<p>Severe in Israel: 92% (75-100)⁸⁰ Severe/critical in Israel: 97.5% (97.1-97.8)⁷⁷ Single dose against hospitalisation in Scotland: 85% (76-91)⁶⁰ Risk of death in vaccine failures compared to unvaccinated cases in England reduced by: Single dose: 44% (32-53) Fully vaccinated: 69% (31-86)¹⁴⁵ (not peer reviewed) Israel: Hospitalisation: 97.2% (96.8-97.5); Death: 96.7% (96.0-97.3)⁷⁷ Hospitalisation in Spain: 94% (60-99)⁵⁴ Priority groups in Denmark: Hospitalisation: 93% (89-96); Death: 94% (90-96)¹⁴⁸ Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Hospitalisation: 89% (85-91); Death: 93% (89-96)¹⁴⁶ USA care facility: Hospitalisation: 94.4 (73.9-98.8); Death 94.4 (44.6-99.4)⁷³ Uruguay: Hospitalisation: 97.8% (96.0-99.8); Death: 96.2 (95.4-96.8)⁶² Israel: Hospitalisation: 93.4% (91.9-94.7); Death: 91.1% (86.5-94.1)⁶³ Chile: Hospitalisation: 97.2% (96.6-97.6); ICU admission: 98.3% (97.6-98.8); Death: 100%⁶¹ 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%)¹⁵⁰ Pooled analysis of Moderna and Pfizer/BioNTech against hospitalisation or death: 98% (83-100)⁷⁰ Pooled Pfizer/BioNTech and Moderna against hospitalisation in Scotland: 92% (85-99)⁵⁹ USA: 88% (85-91)⁶⁵ Netherlands: Hospitalisation: 96% (95-96)⁵⁹ USA: Hospitalisation: 93% (84-96)⁷⁵ Spain: Hospitalisation: 93% (88-96)⁴⁸ Scotland: Death: 90% (83-94)⁵¹ Moderna and Pfizer/BioNTech in British Columbia and Quebec, Canada: Hospitalisation: 98% (97-98); 97% (96-97)⁵²</p>	<p>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 dose¹⁵⁴ Pooled analysis of Pfizer/BioNTech and AstraZeneca vaccines: reduced odds of infection post-second dose: 70% (62-77)¹⁴⁸ Spain: Any infection: 65% (56-73); Symptomatic infection: 82% (73-88)¹⁴ Infection in priority groups in Denmark: 82% (79-84)⁷² USA: Symptomatic infection: 84% (76-90)⁶¹ Denmark: Infection in care facility residents: >14 days after first dose: 17% (4-28); >7 days after second dose: 64% (14-84)⁷⁹ USA: Single dose against infection in 2 care facilities: 63% (33-79)⁷² A care facility in USA: Infection 66% (41-81); Symptomatic illness 87% (66-95)⁷³ Pooled analysis of AstraZeneca, Pfizer/BioNTech and Moderna vaccines in Italy: Infection: 78% (76-79)¹⁴⁶ Uruguay: Infection: 78.1% (77.0-79.1)⁶² Israel: Infection: 93.0% (92.6-93.4)⁶³ Single dose against symptomatic disease in the UK: Age 15-39 years: 61% (56-66)⁷¹ Symptomatic infection in multiple European countries: single dose: 61% (39-75); 2 doses: 87% (74-93)⁵⁵ Symptomatic infection in 16-64 years in UK: single dose: 48.6% (27.9-63.3); 2 doses: 93.3% (85.8-96.8)⁵⁰ Symptomatic infection in Chile: 87.7% (87.3-88.1)⁵¹ 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)⁶⁶ Infection in USA (98% vaccines used Pfizer/BioNTech and Moderna): Pre-Delta variant predominant: 91% (81-96); Delta variant predominant: 66% (26-84)¹⁵³ Infection in Canada: 1 dose: 59% (55-62); 2 doses: 91% (88-93)⁷⁰ Any infection with Delta in USA: 83% (85-87)⁷³ Spain: Any infection: 69% (66-72); Symptomatic infection: 72% (69-75)⁴⁸ Moderna and Pfizer/BioNTech in British Columbia and Quebec, Canada: Symptomatic infection: 90% (89-90); 88% (88-89)⁵² Vaccine effectiveness against symptomatic infection in veterans in USA: 81% (81-82)</p>
Sinovac	<p>Uruguay: Hospitalisation: 90.9% (88.6-92.7); Death: 94.7% (93.4-95.7)⁶² Chile: Hospitalisation: 86.0% (85.6-86.5); ICU admission: 89.7% (89.1-90.2); Death: 86.4% (85.6-87.2)⁶¹</p>	<p>Uruguay: Infection: 59.9% (59.1-60.7)⁶² Symptomatic infection in Chile: 58.5% (58.0-59.0)⁶¹</p>
Sinopharm		<p>Symptomatic infection in Bahrain: 90% (88-91)⁶²</p>

Appendix 2: 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.¹⁵⁵ The WHO recommends labelling SARS-CoV-2 variants with letters of the Greek alphabet, as in the table below.¹⁵⁶

VACCINE	VACCINE EFFICACY/EFFECTIVENESS (EFFECTIVENESS AGAINST INFECTION UNLESS SPECIFIED)			
	B.1.1.7 (ALPHA) VARIANT	B.1.351 (BETA) VARIANT	P.1 (GAMMA) VARIANT	B.1.617.2 (DELTA) VARIANT
AstraZeneca	UK: 70.4% (43.6-84.5) (vs. 81.5% (67.9-89.4) against wild variant) ¹⁵⁷ England: ≥21 days after one dose: 48.7% (45.2-51.9); ≥14 days after two doses: 74.5% (68.4-79.4) ¹⁴⁵ Scotland: 73% (66-78) ¹⁴⁶ Canada: Single dose: 64% (60-68) ¹⁴⁹ UK: Single dose: 63% (55-69); 2 doses: 79% (56-90) ¹⁴⁷ Severe disease in Canada: Single dose: 85% (81-88) ¹⁴⁹	South Africa: 10.4% (-76.8 to 54.8) ¹⁵⁸ Study against severe disease underway ³²	-	England: ≥21 days after one dose: 30.0% (24.3-35.3); ≥14 days after second dose: 67.0% (61.3-71.8) ¹⁴⁵ Scotland: 60% (53-66) ¹⁴⁶ Canada: Single dose: 67% (44-80) ¹⁴⁹ UK: Single dose: 46% (35-55); 2 doses: 67% (62-71) ¹⁴⁷ Symptomatic infection in England: 66.7% (66.3-67.0) ⁵² Hospitalisation in England: 1 dose: 71% (51-83); 2 doses: 92% (75-97) ⁵⁸ ; 93.9% (91.3-95.7) ⁵² Death in England: 94.1% (91.8-95.8) ⁵² Severe disease in Canada: Single dose: 88% (60-96) ¹⁴⁹ Hospitalisation and death in Scotland: 88% (85-90) ⁵⁷ Scotland: Death: 81% (65-94)
Johnson & Johnson	-	Moderate to severe/critical: 64.0% (41.2-78.7) Severe/critical: 81.7% (46.2-95.4) ³² Efficacy against hospitalisation in South Africa: 67% ³⁴	Moderate to severe/critical: 68.1% (48.8-80.7); Severe/critical: 87.6% (7.8-99.7) ³²	Efficacy against hospitalisation in South Africa: 71% ³⁴ USA: Infection: 78% (73-82); Hospitalisation: 85% (73-91) ⁶³
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	-	-	Canada: Single dose: 72% (57-82) ¹⁴⁹ Minnesota, USA: 76% (58-87) ⁶⁶ England: 95.2% (94.4-95.9) ⁵² Severe disease in Canada: Single dose: 96% (72-99) ¹⁴⁹ Severe disease in Minnesota: 81% (33-96) ⁶⁶ Hospitalisation in England: 97.5% (82.3-99.7) ⁵² Pooled Pfizer/BioNTech and Moderna against hospitalisation and death in Scotland: 91% (88-93) ⁵⁷ USA: Infection: 86.7% (84.3-88.7); Hospitalisation: 97.6% (92.8-99.2) ⁶⁹
Novavax	UK: 86.3% (71.3-93.5) (vs. 96.4% (73.8-99.5) against wild variant) ³⁸	South Africa: 51.0% (-0.6 to 76.2) ¹⁵⁹	-	-
Pfizer/BioNTech	Case-control study in Israel: After one dose, vaccinees were disproportionately infected with B.1.1.7 (OR: 26:10) ¹⁶⁰ Qatar: 89.5% (85.9-92.3) ¹⁶¹ England: ≥21 days after one dose: 47.5% (41.6 to 52.8) ≥14 days after second dose: 93.7% (91.6-95.3) ¹⁴⁵ Scotland: 92% (90-93) ¹⁴⁶ Canada: Single dose: 66% (64-68); 2 doses: 89% (86-91) ¹⁴⁹ UK: Single dose: 59% (52-65); 2 doses: 78% (68-84) ¹⁴⁷ Severe disease in Qatar: 100% (81.7-100) ¹⁶¹ 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 disproportionately infected with B.1.351 (odds ratio: 8:1) ¹⁶⁰ Qatar: 75.0% (70.5-78.9) ¹⁶¹ South Africa: 100% (53.5-100) ¹⁶² Severe disease in Qatar: 100% (73.7-100) ¹⁶¹	-	England: ≥21 days after one dose: 35.6% (22.7-46.4); ≥14 days after second dose: 88.0% (85.3-90.1) ¹⁴⁵ Scotland: 79% (75-82) ¹⁴⁶ Canada: Single dose: 56% (45-64); 2 doses: 87% (64-95) ¹⁴⁹ Effectiveness in Israel: Infection: 64%; Symptomatic illness: 64% ¹⁶³ Israel 6m after roll out: 39.0% (9.0-59.0) ⁷⁴ Minnesota, USA: 42% (13-62) ⁶⁶ UK: Single dose: 57% (50-63); 2 doses: 80% (77-83) ¹⁴⁷ England: 89.8% (89.6-90.0) ⁵² Hospitalisation in England: 1 dose: 94% (46-99); 2 doses: 96% (86-99) ⁵⁸ ; 99.7% (97.6-100.0) ⁵² Death in England: 98.2% (95.9-99.2) ⁵² Severe disease in Canada: Single dose: 78% (65-86) ¹⁴⁹ Hospitalisation in Israel: 93% ¹⁶³ Severe disease in Israel: 91.4% (82.5-95.7) ⁷⁴ Severe disease in Minnesota: 75% (24-94) ⁶⁶ Pooled Pfizer/BioNTech and Moderna against hospitalisation and death in Scotland: 91% (88-93) ⁵⁷ Scotland: Death: 90% (83-94) ¹⁴¹
Sinovac	Chile: 67% (65-69) ¹⁴²	-	Brazil: 1 or 2 doses: 37.9% (-46.4-73.6) ¹⁶⁴ Chile: 67% (65-69) ¹⁴² 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) ¹⁶⁵	China (combined Sinovac and Sinopharm): Single dose: 13.8% (-60.2-54.8); 2 doses: 59.0% (16.0-81.6) Severe disease: 100% ¹⁶⁶
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% ¹⁶⁶
Bharat Biotech	-	-	-	Efficacy against infection in India: 65.2% (33.1-83.0) ²⁷
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) ²⁸

* 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



Appendix 3: 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 ²⁵ (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) ⁵⁰ Hospitalisation in Scotland: 63% (46-75) ⁵⁶	In ≥65 years: 85% ²⁵ (not peer-reviewed) Effectiveness against hospitalisation at 28-34 days after a single dose (pooled analysis of AstraZeneca and Pfizer vaccines): 18-64 years: 85% (68-93); 65-79 years: 79% (17-95); ≥80 years: 81% (65-90) ⁶⁰ Effectiveness of single dose against hospitalisation in England: ≥80 years: 73% (60-81) ⁵⁷ Effectiveness in England: Symptomatic infection ≥70 years: 73% (27-90); Hospitalisation ≥80 years: 37% (3-59) ⁸⁶ Hospitalisation following single dose in the UK: ≥80 years: 80.4% (36.4-94.5) ⁸⁵ Single dose in Spain: ≥60 years: 53% (19-72) vs. 18-59 years: 50% (34-62) ⁵⁴ Effectiveness against death in the UK: ≥65 years: Single dose: 83% (78-86); Two doses: 94% (80-98) ⁷¹ 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) ⁵⁰ Effectiveness against death in Scotland ≥60 years: 90% (84-94) ⁶¹ British Columbia and Quebec, Canada: Symptomatic infection ≥70 years: 73% (42-88); 81% (74-86) ⁵³
Gamaleya	-	-	-	Symptomatic infection ≥60 years: 91.8% (67.1-98.3) ²⁹
Johnson & Johnson	Moderate to severe/critical: 23.0% (-90.1-69.8) ³²	Moderate to severe/critical: 65.9% (47.8-78.3) ³²	Moderate to severe/critical: With any comorbidity: 58.6% (40.6-71.6) ³² No comorbidity: 68.8% (59.0-76.6) ³²	Moderate-severe/critical disease ≥28 post vaccination: 18-59 years: 66.1% (53.3-75.8) 60+ years: 66.2% (36.7-83.0) ³²
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) ³⁵ Pooled Pfizer/BioNTech and Moderna against hospitalisation in Scotland: 72% (51-84) ⁵⁶ Netherlands: Hospitalisation in a population at high risk for severe COVID-19: 84% (80-87) ⁶⁹	Symptomatic infection: 18-64 years: 95.6% (90.6-97.9) ≥65 years: 86.4% (61.4-95.2) ³⁵ Pooled Moderna and Pfizer vaccines against hospitalisation ≥65 years: 94% (49-99) ¹⁶⁷ Infection in Canada: 1 dose ≥70 years: 54% (31-69); 2 doses ≥70 years: 95% (83-98) ⁷⁰ 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) ¹⁶⁸ USA: Hospitalisation: ≥65 years: 75.2% (59.6-84.8) vs 18-64 years: 87.9% (85.5-89.9) ⁶⁹
Pfizer/BioNTech	Effectiveness in Israel: Diabetes or cardiovascular disease: 82% (62-92) ⁷⁶ Effectiveness against infection in Israel: (88-9% (87-3-90-2) ⁸³	Effectiveness against infection in Israel: (89-7% (88-6-90-7) ⁸³	Symptomatic infection: With any comorbidity or obesity: 95.3% With no comorbidity: 94.7% ⁴⁰ Denmark: Infection: 71% (58-80); Hospitalisation: 81% (49-93) ⁷⁸ Effectiveness against infection in Israel: Hypertension: (89-7% (88-6-91-7) ⁸³ 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) ⁵⁰ Pooled Pfizer/BioNTech and Moderna against hospitalisation in Scotland: 72% (51-84) ⁵⁶	Efficacy against infection ≥75 years: 96.2% (76.9-99.9) ⁴¹ Mympomatic infection: >55 years: 93.7% (80.6-98.8); >65 years: 94.7% (66.7-99.9); >75 years: 100% (-13.1-100) ⁴⁰ Effectiveness against hospitalisation 28-34 days after a single dose (pooled analysis of AstraZeneca and Pfizer vaccines): 18-64 years: 85% (68-93); 65-79 years: 79% (17-95); ≥80 years: 81% (65-90) ⁶⁰ 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) ⁸⁸ 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% ¹⁶⁹ Pooled Moderna and Pfizer vaccines against hospitalisation ≥65 years: 94% (49-99) ¹⁶⁷ 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) ⁸⁸ Effectiveness against hospitalisation in England ≥80 years: Single dose: 81% (76-85) Fully vaccinated: 93% (89-95) ⁸⁷ (not peer reviewed) Effectiveness in Israel: 65-74 years: 82% (63-92); ≥75 years: 82% (61-91) ⁷⁶ Hospitalisation following single dose in the UK: ≥80 years: 71.4% (43.1-86.2) ⁸⁵ Single dose in Spain: ≥60 years: 76% (55-87) vs. 18-59 years: 85% (74-91) ⁵⁴ Effectiveness against infection in Denmark: ≥80 years: 77% (50-89) ⁷⁸ Effectiveness against infection in Israel: ≥70 years: 89-1% (83-93) ⁸³ Effectiveness against death in the UK: ≥65 years: Single dose: 77% (72-81); Two doses: 98% (94-99) ⁷¹ 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) ⁵⁰ Infection in Canada: 1 dose ≥70 years: 40% (29-50); 2 doses ≥70 years: 93% (82-98) ⁷⁰ 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) ¹⁶⁸ Effectiveness against death in Scotland ≥60 years: 87% (77-93) ⁶¹
Novavax	-	-	Any infection with comorbidity, age ≥65 years or frequent COVID-19 exposure in USA and Mexico: 91.0% (83.6-95.0) ⁸⁹	-
Sinovac	-	74.9% (53.7-86.4) ⁴²	Any comorbidity: 48.9% (26.6-64.5) ⁴²	-
Sinopharm	-	80.7% (56.7-91.4) ⁴²	-	Effectiveness against symptomatic infection in Bahrain: ≥60 years: 91% (87-94) ⁴²
Bharat Biotech	-	-	Any infection with comorbidity: 66.2% (33.8-84.0) ²⁷	Symptomatic infection in India: ≥60 years: 67.8% (8.0-90.0) vs 18-59 years: 79.4% (66.0-88.2) ²⁷

Appendix 4: 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) ²⁵ ENGLAND: Hazard ratio for single dose in vaccinated vs. unvaccinated care facility residents: 0.32 (0.15-0.66) ¹⁷⁰ ; Odds ratio for household contacts of vaccinated vs non-vaccinated health workers testing positive: 0.52 (0.43-0.62) ¹⁷¹ UK: Regular testing of randomly selected households: 79% (65-88) ¹⁷² ; Single dose against symptomatic and asymptomatic infection: 60% (49-68) ¹⁷³ NETHERLANDS: Effectiveness against transmission (secondary attack rate among household contacts): 58% (-12-84) ⁸⁴	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) ¹⁷⁴
Bharat Biotech	EFFICACY IN INDIA: Asymptomatic: 63.6% (29.0-82.4); Symptomatic and asymptomatic combined: 68.8% (46.7-82.5) ²⁷	-
Johnson & Johnson	EFFICACY (multiple countries): Asymptomatic infection: 59.7% (32.8-76.6) ³² UK: Single dose against symptomatic and asymptomatic infection: 60% (49-68) ¹⁷³ Netherlands: Effectiveness against transmission (secondary attack rate among household contacts): 77% (6-94) ⁸⁴	USA (Kentucky): OR for reinfection in unvaccinated vs vaccinated with Johnson & Johnson, Moderna or Pfizer/BioNTech): 2.34 (1.58-3.47) ¹⁷⁵
Moderna	USA: Asymptomatic infection: 72.7% (53.4-84.0) ⁶⁷ USA: POOLED ANALYSIS OF PFIZER/BIONTECH AND MODERNA: 88.7% (68.4-97.1) ¹⁷⁶ ; 90% (68%-97) ¹⁷⁷ ; single dose: 80% (59-90) ¹⁷⁷ ; Relative risk of infection in asymptomatic pre-surgical patients >10 days after first dose compared to unvaccinated residents: 0.21 (0.12-0.37) ¹⁷⁸ ; 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 ¹⁷⁹ MODELLING: Reduced potential for transmission: at least 61% ¹⁸⁰ UK: Single dose against symptomatic and asymptomatic infection: 60% (49-68) ¹⁷³ Netherlands: Effectiveness against transmission (secondary attack rate among household contacts): 88% (50-97) ⁸⁴ USA: 63.0% (56.6-68.5) ³¹ Qatar: First month after second dose: 73.1% (70.3-75.5); declining to no evidence of any effect by 4 months post-vaccination ⁶⁸	USA (Kentucky): OR for reinfection in unvaccinated vs vaccinated with Johnson & Johnson, Moderna or Pfizer/BioNTech): 2.34 (1.58-3.47) ¹⁷⁵
Pfizer/BioNTech	ENGLAND: 86% (76-97) 7 days after 2 doses; 72% (58-86) 21 days after 1 dose ¹⁰³ ISRAEL: 92% (88-95) ⁸⁰ ; 91.5% (90.7-92.2) ⁷⁷ ; 65% (45-79%) ¹⁰⁴ ; single dose: 75% (72-84) ¹⁸¹ ; Effectiveness against transmission: 88.5% (82.3-94.8) ¹⁸² ; Effectiveness against infection in the household: 78% (30-94) ¹⁸³ USA: Asymptomatic screening: 90% (78-96) ⁸¹ USA: POOLED ANALYSIS OF PFIZER/BIONTECH AND MODERNA: 88.7% (68.4-97.1) ¹⁷⁶ ; 90% (68%-97) ¹⁷⁷ ; single dose: 80% (59-90) ¹⁷⁷ ; Relative risk of infection in asymptomatic pre-surgical patients >10 days after first dose compared to unvaccinated residents: 0.21 (0.12-0.37) ¹⁷⁸ ; 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 ¹⁷⁹ UK: single dose: 4-fold decrease in risk amongst HCWs ≥12 days post-vaccination ¹⁸⁴ ; Regular testing of randomly selected households: 80% (73-85) ¹⁷² ; Single dose against symptomatic and asymptomatic infection: 72% (63-79) ¹⁷³ ; 60% (49-68) ¹⁷³ 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) ¹⁸⁵ Netherlands: Effectiveness against transmission (secondary attack rate among household contacts): 70% (61-77) ⁸⁴ Finland: Effectiveness against transmission to unvaccinated household contacts of vaccinated cases: 42.9% (22.3-58.1) ¹⁸⁵	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 ¹⁸⁶ ; 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 ¹⁸⁷ ; Substantially decreased viral load for infections occurring 12-37 days after the first dose of vaccine, indicating likely lower infectiousness ¹⁸⁶ Detectable transmission in long-term care facilities in Spain reduced by 90% (76-93) ¹⁸⁸ ENGLAND: Odds ratio for household contacts of vaccinated health workers vs non-vaccinated health workers testing positive: 0.54 (0.47-0.62) ¹⁷¹ 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) ¹⁷⁰ USA (Kentucky): OR for reinfection in unvaccinated vs vaccinated with Johnson & Johnson, Moderna or Pfizer/BioNTech): 2.34 (1.58-3.47) ¹⁷⁵

Appendix 5: Risk of Rare Unusual Blood Clotting with Low Platelets (Thrombosis with Thrombocytopenia 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 years¹⁸⁹

** 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^{19,20}

*** 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)²²