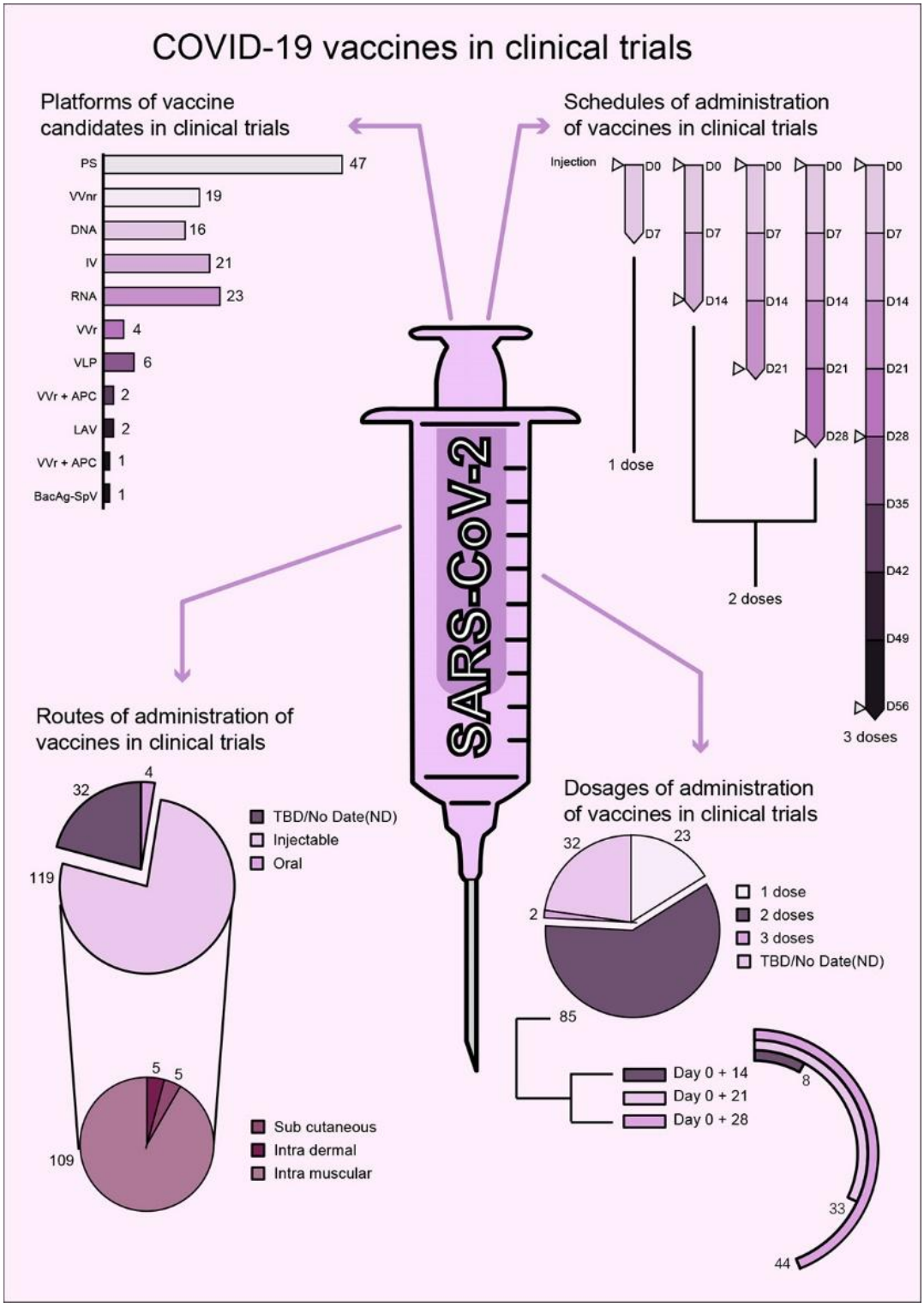
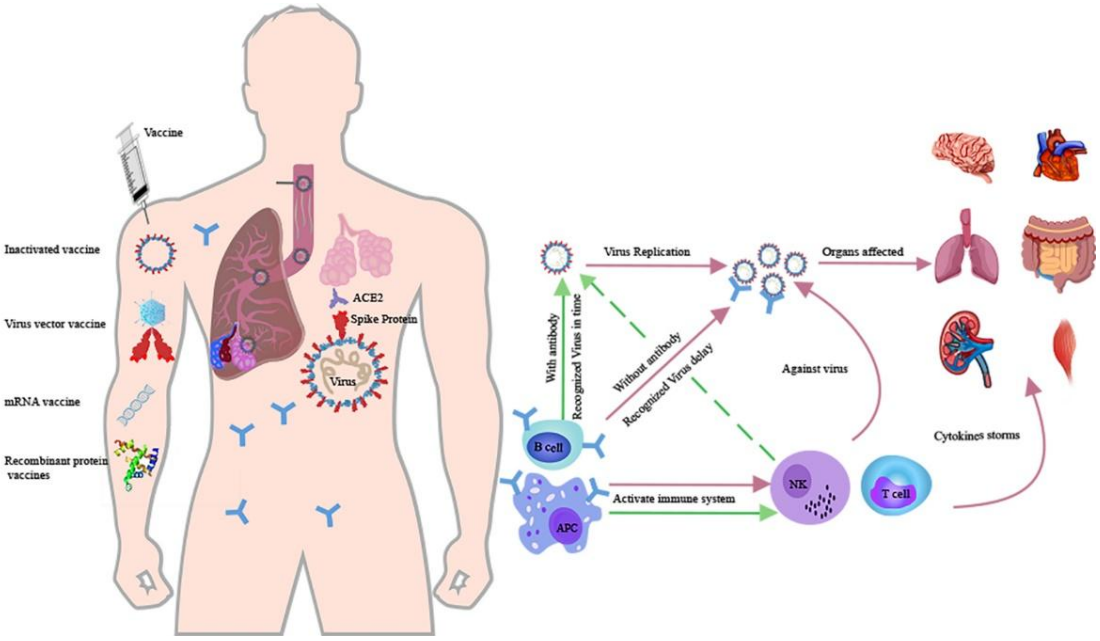


Supplementary Figure 1: COVID-19 vaccines in clinical trials. COVID-19: Coronavirus disease 2019; SARS-CoV-2: Severe acute respiratory syndrome coronavirus-2.



Supplementary Figure 2: Mechanisms of how the immune system responds after vaccination. After natural infection, APC and B cells recognize viral antigens and activate T cells and NK cells to induce a relatively delayed immune response to virus, leading to cytokine storm and damage to organs. But after vaccination, an immune memory for viral antigens is built up. Then, if there is a natural infection, the immune system can recognize and eradicate the virus in time, protecting organs from the immune effects of a cytokine storm. ACE2: Angiotensin-converting enzyme 2; APC: Antigen-presenting cells, NK: Natural killer cells.

Supplementary Table 1: Basic information of most procured vaccines worldwide.

Vaccine	Total doses (million) and percentage	Type of candidate vaccine	Manufacturer	Dose	Current status	Registration number	Adverse reactions
Comirnaty	5202 (28.2%)	RNA based vaccine	Pfizer/BioNTech + Fosun Pharma	2	Phase 4	NCT04760132, NCT05060991	Anaphylaxis, Myocarditis, Lymphadenopathy, Appendicitis, Pericarditis, Transverse myelitis
Spikevax	3201 (17.3%)	RNA based vaccine	Moderna + NIAID	2	Phase 4	NCT05060991, NCT04792567	Anaphylaxis, Myocarditis, Pericarditis
Vaxzevria	2085 (11.3%)	Viral vector (Non-replicating)	AstraZeneca + University of Oxford	1–2	Phase 4	NCT05074368	Thrombosis with thrombocytopenia syndrome, Capillary Leak Syndrome, Myocarditis, Pericarditis, Anaphylaxis, or anaphylactoid reactions
Covishield	1675 (9.1%)	Viral vector (Non-replicating)	Serum Institute of India	1–2	Phase 4	NCT04794946	Thromboembolic events, Guillain-Barré syndrome
CoronaVac	1405	Inactivated	Sinovac	2	Phase 4	NCT04775069,	Bell's palsy, Encephalopathy,

	(7.6%)	virus	Research and Development Co., Ltd.			NCT04789356	Anaphylaxis, Thromboembolic events, GBS
Ad26.COV2.S	1355 (7.4)	Viral vector (Non-replicating)	Janssen Pharmaceutical	1–2	Phase 4	NCT05030974, NCT05037266	Thrombosis with thrombocytopenia syndrome, GBS
NUVAXOVID	877 (4.8%)	Protein subunit	Novavax	2	Phase 3	NCT04611802 NCT04583995	No serious side effects were reported
BBIBP-CorV	853 (4.6%)	Inactivated virus	Beijing CNBG	2	Phase 4	NCT04863638 NCT05065879	No serious side effects were reported
Covaxin	384 (2.1%)	Inactivated virus	Bharat Biotech International Limited	2	Phase 3	NCT04641481	No serious side effects were reported

Data from WHO: https://www.who.int/emergencies/diseases/novel-coronavirus-2019/covid-19-vaccines. GBS: Guillain–Barré syndrome; NIAID: National Institute of Allergy and Infectious Diseases; WHO: World Health Organization.

Supplementary Table 2: Efficiency of currently used vaccines to different variants.

Vaccine	Evaluation timepoint	Effectiveness (%, 95% CI)			
		B.1.1.7 (alpha)	**B.1.351 (beta)**	**P.1 (gamma)**	**B.1.617.2 (delta)**
Comirnaty[1–3]	One dose only	54.1 (26.1–71.9)	0 (0–19)	60 (52–67)	35.6 (22.7–46.4)
	14 days after the second dose	100 (81.7–100)	100 (73.7–100)	84 (69–92)	88.0 (85.3–90.1)
Spikevax[3, 4]	One dose only	83 (80–86)	77 (63–86)	77 (63–86)	79.0 (58.9–90.1)
	14 days after the second dose	92 (86–96)			84.8 (75.9–90.8)
Vaxzevria[2, 3]	One dose only	48.7 (45.2–51.9)	48 (28–63)	48 (28–63)	30.0 (24.3–35.3)
	14 days after the second dose	74.5 (68.4–79.4)			67.0 (61.3–71.8)
CoronaVac[5–7]	One dose only		50.7 (35.6–62.2)	35.1 (−6.6 to 60.5)	13.8 (−60.2 to 54.8)
	14 days after the second dose			61.8 (34.8–77.7)	59 (16–81.6)
Ad26.COV2.S[8]	One single dose		66.9 (59.0–73.4)		78 (73–82)

References

1. Abu-Raddad LJ, Chemaitelly H, Butt AA; National Study Group for COVID-19 Vaccination. Effectiveness of the BNT162b2 covid-19 vaccine against the B.1.1.7 and B.1.351 variants. N Engl J Med 2021;385:187–189. doi: 10.1056/NEJMc2104974.

2. Bernal JL, Andrews N, Gower C, Gallagher E, Simmons R, Thelwall S, *et al*. Effectiveness of COVID-19 vaccines against the B.1.617.2 variant. N Engl J Med 2021;385:585–594. doi: 10.1056/NEJMoa2108891.

3. Nasreen S, Chung H, He S, Brown KA, Gubbay JB, Buchan SA, *et al*. Effectiveness of mRNA and ChAdOx1 COVID-19 vaccines against symptomatic SARS-CoV-2 infection and severe outcomes with variants of concern in Ontario. Nat Microbiol 2022;7:379–385. doi: 10.1038/s41564-021-01053-0.

4. Vasileiou E, Simpson CR, Shi T, Kerr S, Agrawal U, Akbari A, *et al*. Interim findings from first-dose mass COVID-19 vaccination roll-out and COVID-19 hospital admissions in Scotland: A national prospective cohort study. Lancet 2021;397:1646–1657. doi: 10.1016/s0140-6736(21)00677-2.

5. Hitchings MDT, Ranzani OT, Torres MSS, de Oliveira SB, Almiron M, Said R, *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 Health Am 2021;1:100025. doi: 10.1016/j.lana.2021.100025.

6. Ranzani OT, Hitchings MDT, Dorion M, D'Agostini TL, Cardoso de Paula R, Pereira de Paula OF, *et al*. Effectiveness of the CoronaVac vaccine in the elderly population during a Gamma variant-associated epidemic of COVID-19 in Brazil: A test-negative case-control study. BMJ 2021;374:n2015. doi: 10.1136/bmj.n2015.

7. Li XN, Huang Y, Wang W, Jing QL, Zhang CH, Qin PZ, *et al*. Effectiveness of inactivated SARS-CoV-2 vaccines against the Delta variant infection in Guangzhou: A test-negative case-control real-world study. Emerg Microbes Infect 2021;10:1751–1759. doi: 10.1080/22221751.2021.1969291.

8. Polinski JM, Weckstein AR, Batech M, Kabelac C, Kamath T, Harvey R, *et al*. Effectiveness of the single-dose Ad26.COV2.S COVID vaccine. medRxiv 2021. doi: 10.1101/2021.09.10.21263385.

Supplementary Table 3: Vaccine efficiency of booster on Omicron.

First two doses	Booster	Vaccine effectiveness		Reference
		3 months after two doses	2 weeks after booster (95% CI)	
BNT162b2	BNT162b2	48.5%	75.5% (56.1–86.3)	[1]
ChAdOx1	BNT162b2		71.4% (41.8–86.0)	
At least one dose mRNA vaccine	mRNA vaccine	36%	61% (56–65)	[2]
mRNA-1273	mRNA-1273	44.8%	55%	[3]

References

1. Andrews N, Stowe J, Kirsebom F, Toffa S, Rickeard T, Gallagher E, *et al*. Effectiveness of COVID-19 vaccines against the Omicron (B.1.1.529) variant of concern. medRxiv 2021. doi: 10.1101/2021.12.14.21267615.

2. Buchan SA, Chung H, Brown KA, Austin PC, Fell DB, Gubbay JB, *et al*. Effectiveness of COVID-19 vaccines against Omicron or Delta symptomatic infection and severe outcomes. medRxiv 2022. doi: 10.1101/2021.12.30.21268565.

3. Chemaitelly H, Ayoub HH, AlMukdad S, Tang P, Hasan MR, Yassine HM, *et al*. Duration of protection of BNT162b2 and mRNA-1273 COVID-19 vaccines against symptomatic SARS-CoV-2 Omicron infection in Qatar. medRxiv 2022. doi: 10.1101/2022.02.07.22270568.