Efficacy Estimates for Various COVID-19 Vaccines: What we Know from the Literature and Reports

Julia Shapiro[1], Natalie E. Dean[1], Zachary J. Madewell[1], Yang Yang[1], M.Elizabeth Halloran[2, 3], and Ira Longini[1*]

[1]Department of Biostatistics, University of Florida, Gainesville, FL, USA
[2]Vaccine and Infectious Diseases Division, Fred Hutchinson Cancer Center, Seattle, WA, USA
[3]Department of Biostatistics, University of Washington, Seattle, WA, USA
[*]address correspondence to Ira Longini at ilongini@ufl.edu

June 17, 2021

Abstract

In this report, we provide summary estimates, from publications and reports, of vaccine efficacy (VE) for the COVID-19 vaccines that are being rolled out on a global scale. We find that, on average, the efficacy against any disease with infection is 85% (95% CI: 71 - 93%) after a fully course of vaccination. The VE against severe disease, hospitalization or death averages close to 100%. The average VE against infection, regardless of symptoms, is 84% (95% CI: 70 - 91%). We also find that the average VE against transmission to others for infected vaccinated people is 48% (95% CI: 45 - 52%). Finally, we prove summary estimates of the VE against any disease with infection for some of the variants of concern (VOC). The average VE for the VOC γ (P1) is 61% (95% CI: 43 - 73%). The average VE for the VOC α (B.1.1.7), β (B.1.351), and δ (B.1.617.2) after dose 1 are 48% (95% CI: 44 - 51%), 35% (95% CI: -11 - 62%), and 33% (95% CI: 21 - 43%), respectively. The average VE for the VOC α (B.1.1.7), β (B.1.351), and δ (B.1.617.2) after dose 2 are 85% (95% CI: 25 - 97%), 57% (95% CI: 14 - 78%), and 78% (95% CI: 28 - 93%), respectively.

Introduction

In this report, we summarize estimates of vaccine efficacy (VE) for the COVID-19 vaccines that are being rolled out on local and global scales. This includes the Pfizer, Moderna, Johnson & Johnson, AstraZeneca, Sputnik, Novavax, Sinovac, and Sinopharm vaccines. VE estimates are taken from journal articles and media reports for the vaccines that have gone through double-blinded, placebo-controlled, phase III vaccine trials, as well as observational studies. Some of the estimates are based on rigorous, preplanned statistical analyses from double-blinded, placebo-controlled trials, while others are extracted from observational studies with different levels of control. These studies are reported from a variety of sources including publications, reports, and sometimes press releases. Because of this, we do not carry out a formal meta analysis. In all cases, we try to extract estimates for one or more of the triplet of vaccine efficacy parameters (VE_S, VE_P, VE_I) [1], where VE_S is VE against infection; VE_P is VE against disease, given infection; and VE_I is VE against transmission to others, given infection. A fourth parameter, VE_{SP}, which is VE against disease and infection, tends to be available from vaccine trials, and it is the usual primary outcome for those trials (i.e., cases of disease that are confirmed infections). The VE_{SP} is a function of both the VE_S and VE_P. If we believe in a multiplicative and independent relationship, then $VE_{SP} = 1–(1 - VE_S)(1 - VE_P)$. Thus, if we have two of these VE's, we can always calculate the third.

In the material that follows, we give estimates of these VE's as a function of time when protection is believed to begin to occur after the first and second dose for two-dose vaccines, and after the first dose for one-dose vaccines. We also provide VE_{SP} estimates for protection against the variants of concern (VOC) γ (P1), α (B.1.1.7), β (B.1.351), and δ (B.1.617.2). The methods for creating the forest plots are given in the Appendix. The supporting tables for the analysis are also given in the Appendix. Not all estimates described in the tables are given in the figures, as we have tried to extract the essential information without getting lost in too much detail. However, virtually all the complete information is given in the Appendix tables.

Results

We first consider VE for the original wild type viruses. Figure 1 (Table A1) give the estimates of the VE_{SP} after the second dose for two-dose vaccines. All the estimates are from double-blinded, placebo-controlled vaccine trials. With the exception of the Sinovac vaccine, they are all over 80%, with a summary estimate of 85% (95% CI: 71 - 93%). The Sinovac VE_{SP} estimate is 51% (95% CI: 36 - 62%).

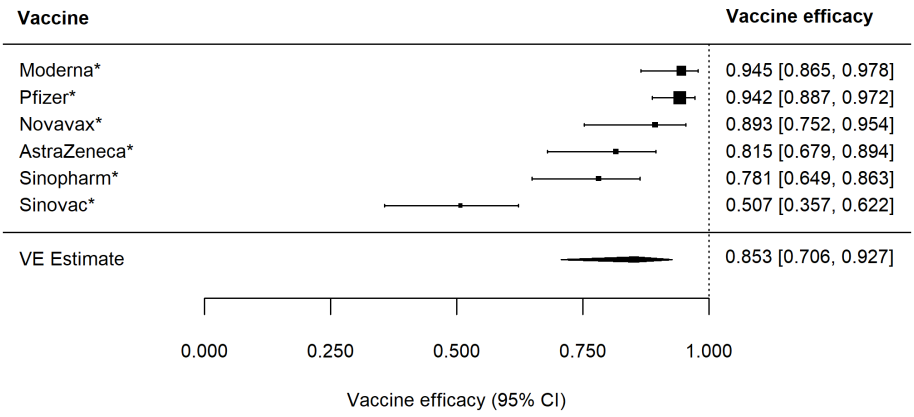

Figure 1: Forest plot of vaccine efficacy to prevent any disease after dose 2, VE_{SP}. * indicates double-blinded, randomized vaccine trial.

The estimated VE_{SP} after one dose, for both two-dose and one-dose vaccines, is given in Figure 2 (Table A2), where the Johnson & Johnson vaccine is the only one-dose vaccine listed. The estimates are generally almost as high as protection after one dose, with summary estimated of 82% (95% CI: 72 - 88%).

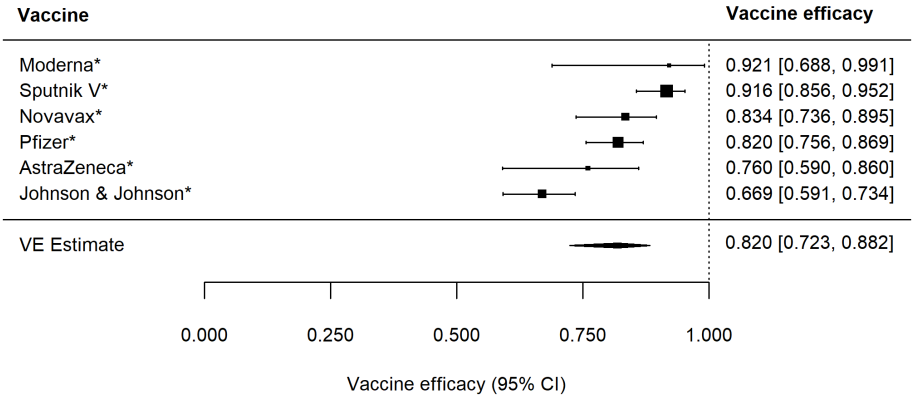

Figure 2: Forest plot of vaccine efficacy to prevent any disease after dose 1, VE_{SP}. * indicates double-blinded, randomized vaccine trial.

Figure 3 (Table A3) give the estimates of the VE_{SP}^{S} (VE for severe disease with infection) after the second dose for two-dose vaccines. The estimates a very high, and generally close to 100%, with relatively poor precision.

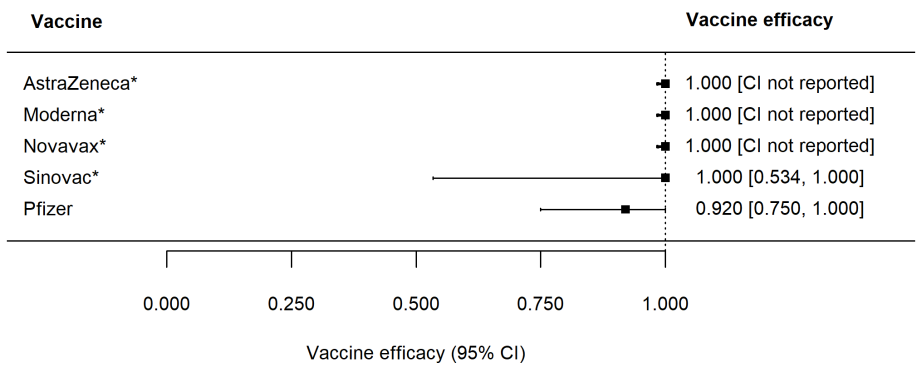

Figure 3: Forest plot of vaccine efficacy to prevent severe disease after dose 2, $\boldsymbol{VE_{SP}^{S}}$. * indicates double-blinded, randomized vaccine trial.

Figure 4 (Table A4) give the estimates of the VE_{SP}^{S} (VE for severe disease with infection) after the first dose for two-dose vaccines and one dose for the one-dose vaccine. The summary estimated is quite high at 86% (95% CI: 39 - 97%).

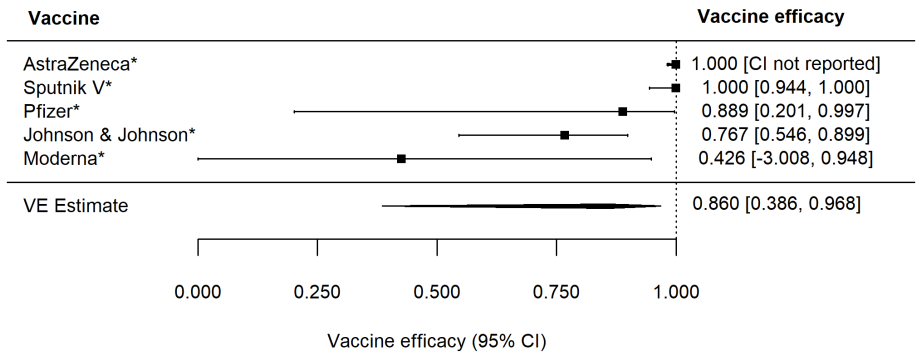

Figure 4: Forest plot of vaccine efficacy to prevent severe disease after dose 1, $\boldsymbol{VE_{SP}^{S}}$. * indicates double-blinded, randomized vaccine trial.

VE against hospitalization and death were quite high, as shown in Figures 5 and 6 (Tables A5 and A6).

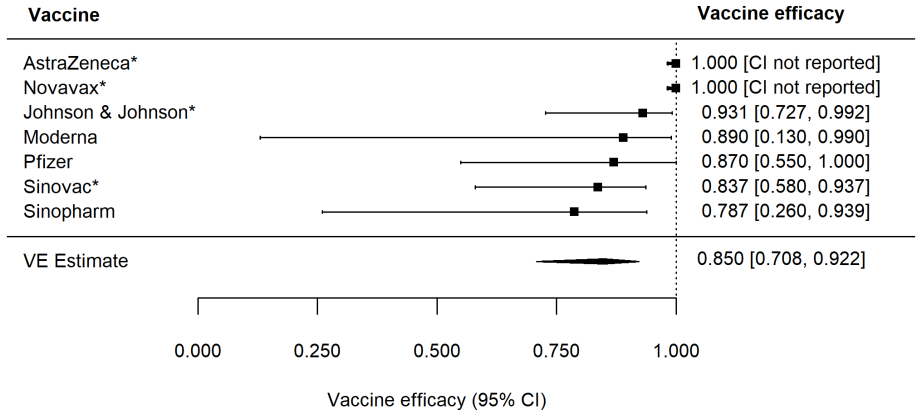

Figure 5: Forest plot of vaccine efficacy to prevent hospitalization, $\boldsymbol{VE_{SP}^{H}}$. * indicates double-blinded, randomized vaccine trial.

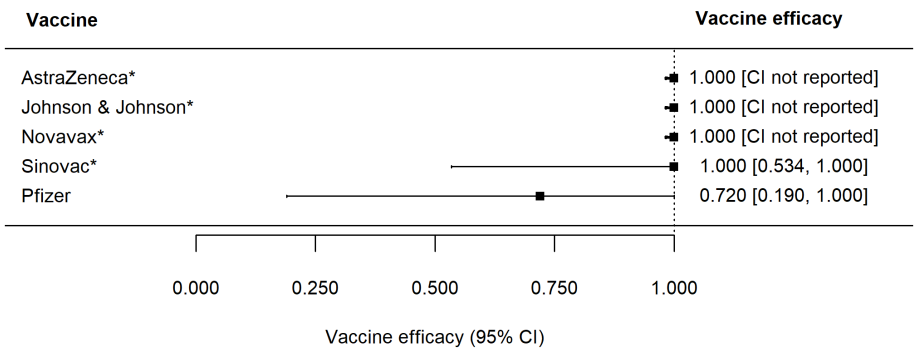

Figure 6: Forest plot of vaccine efficacy to prevent death, VE_{SP}^{D}. * indicates double-blinded, randomized vaccine trial.

Figure 7 (Table A7) give the estimates of the VE_S, i.e., VE against infection. The estimates were quite high, with a summary estimate of 84% (95% CI: 70 - 91%).

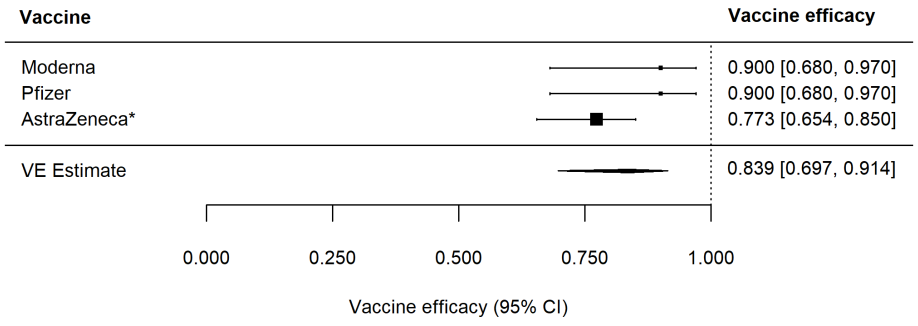

Figure 7: Forest plot of vaccine efficacy to prevent infection, VE_S. * indicates double-blinded, randomized vaccine trial.

(Table A8) give estimates of the VE_I, i.e., VE against infectiousness or direct transmission to others. The summary measure is 48% (95% CI: 45 - 52%), indicating the vaccination reduces the transmission to others by 48% when vaccinated people are infected, compared to unvaccinated people who become infected.

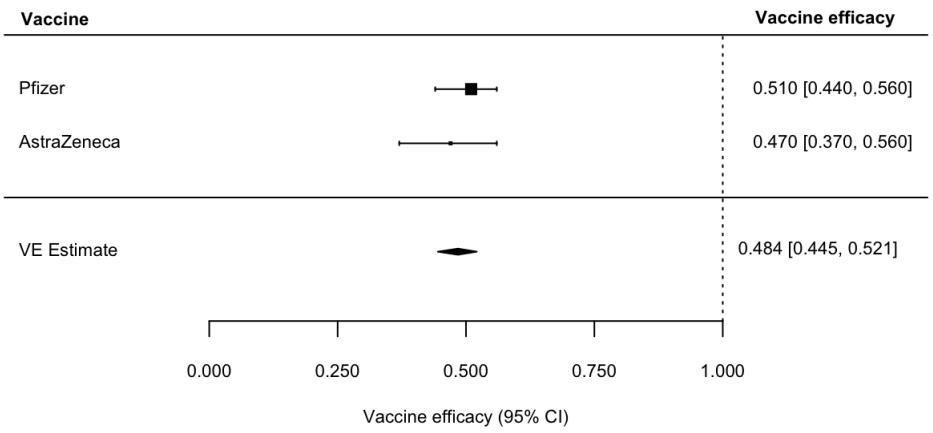

Figure 8: Forest plot of vaccine efficacy to prevent infectiousness to others, VE_I

Now we consider VE's for the variants of concern (VOC). Estimates are available for the VE_{SP}, mostly after the first dose for the one dose vaccine and the second dose for the two dose vaccines. These estimates are given in Figures 9-15 (Tables A9-A15).

For α (B.1.1.7), VE is 48% (95% CI: 44 - 51%) after dose 1, and VE is 85% (95% CI: 25 - 97%) after dose 2. The summary estimate for VE after dose 1 is considerably lower than the VE for the wild type virus. In contrast, however, the summary estimate after dose 2 is just somewhat reduced compared to the wild type virus. It is necessary to note that this VOC does not have a mutation that affects immunity, whereas the other VOC's have mutations that affect immune function.

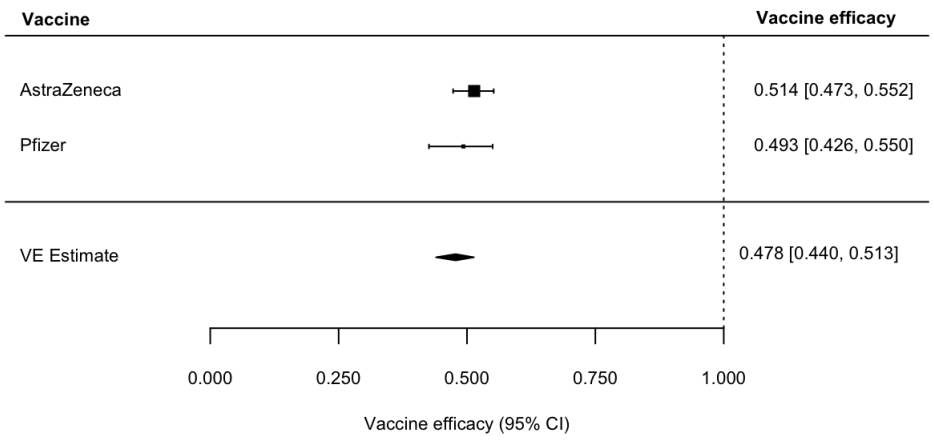

Figure 9: Forest plot of vaccine efficacy against α (B.1.1.7) after dose 1

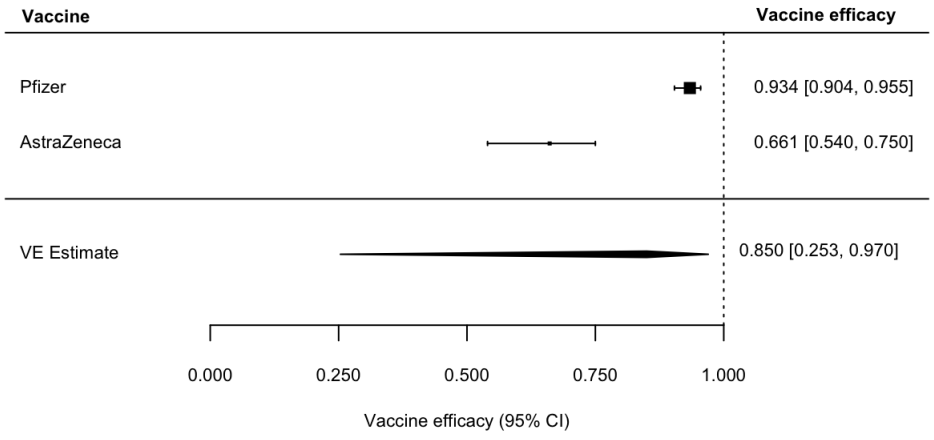

Figure 10: Forest plot of vaccine efficacy against α (B.1.1.7) after dose 2

The average VE for the VOC γ (P1) is 61% (95% CI: 43 - 73%). For β (B.1.351), VE is 35% (95% CI: -11 - 62%) after dose 1, and VE is 57% (95% CI: 14 - 78%) after dose 2. The summary estimates for VE after dose 1 and dose 2 are considerably lower than the VE's for the wild type virus.

For δ (B.1.617.2), VE is 33% (95% CI: 21 - 43%) after dose 1, and VE is 78% (95% CI: 28 - 93%) after dose 2. The summary estimate for VE after dose 1 is considerably lower than the VE for the wild type virus. In contrast, however, the summary estimate after dose 2 is just somewhat reduced compared to the wild type virus.

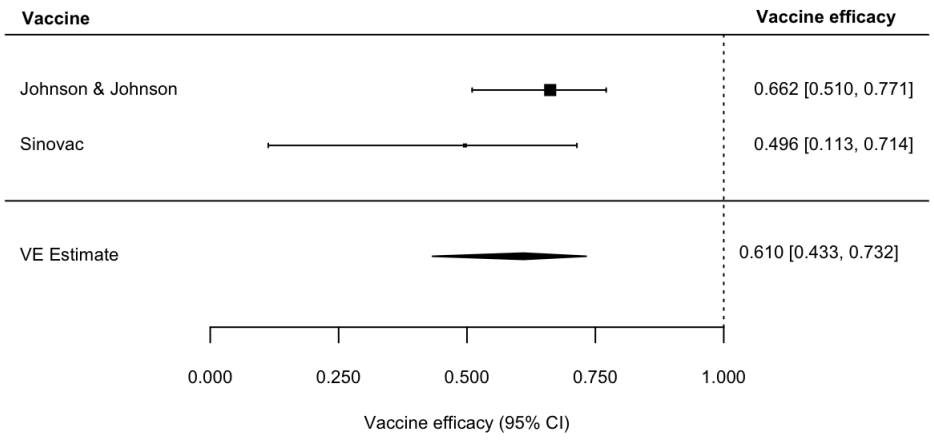

Figure 11: Forest plot of vaccine efficacy against (γ) (P.1)

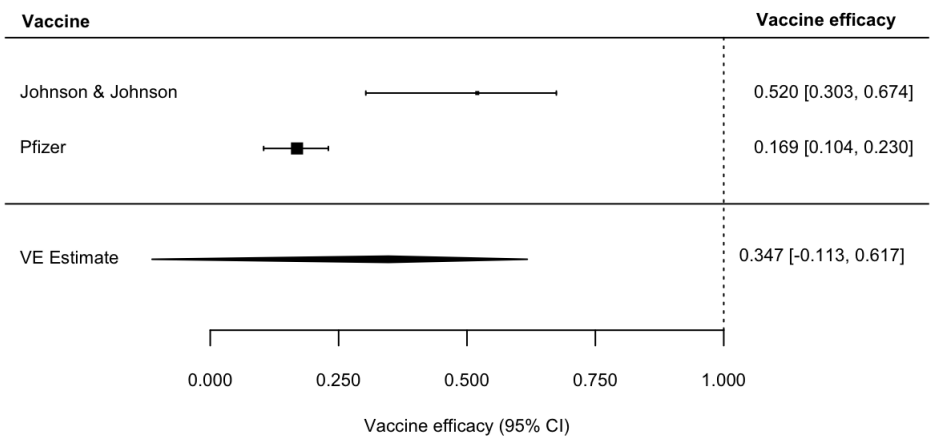

Figure 12: Forest plot of vaccine efficacy against β (B.1.351) after dose 1

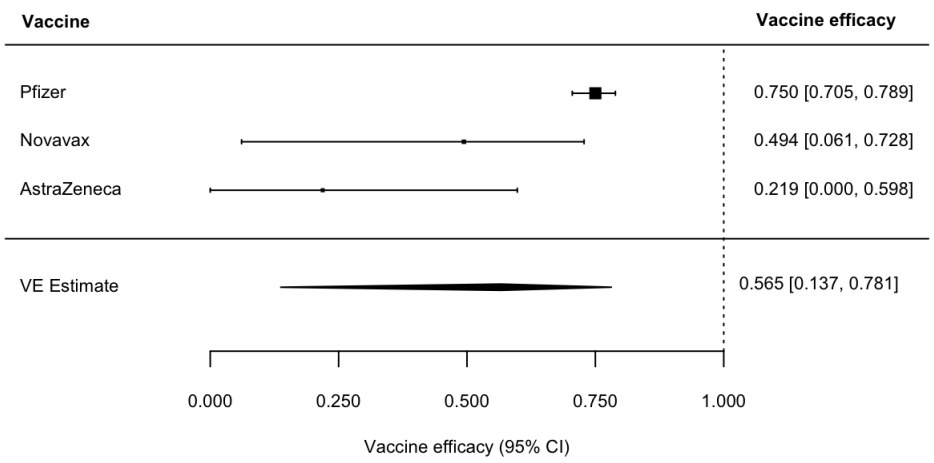

Figure 13: Forest plot of vaccine efficacy against β (B.1.351) after dose 2

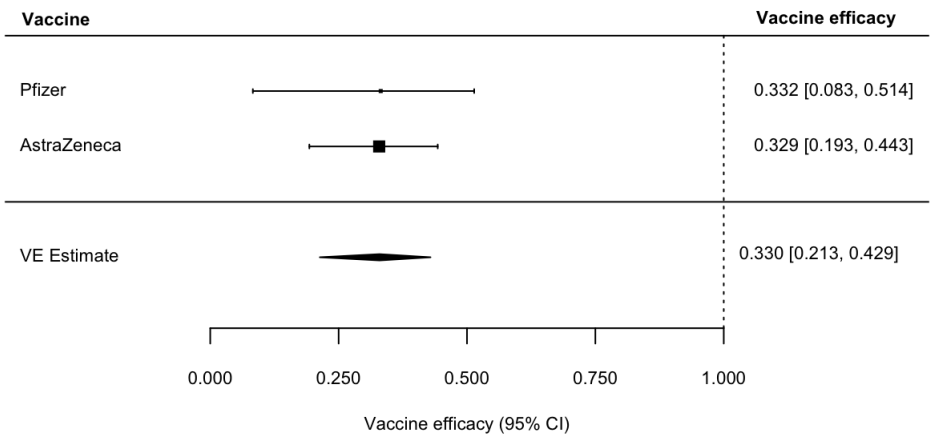

Figure 14: Forest plot of vaccine efficacy against δ (B.1.617.2) after dose 1

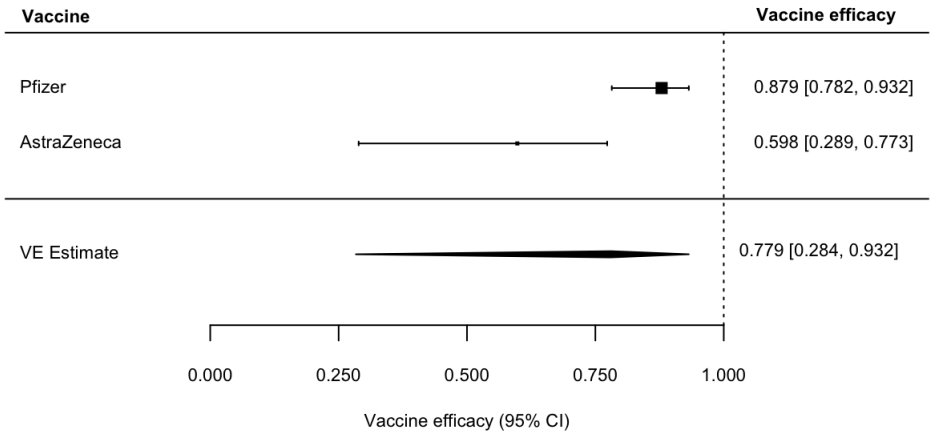

Figure 15: Forest plot of vaccine efficacy against δ (B.1.617.2) after dose 2

Discussion

We have presented the relevant VE estimates for the COVID-19 vaccines that are being rolled out on a global scale and for which there is sufficient quality data. We provide estimates of VE against disease with confirmed infection, infection, and transmission to others. The VE estimates against disease are stratified by disease severity, hospitalization and death. We have also provided VE estimates for three of the VOC.

These estimates should be useful for constructing mathematical models for vaccination impact and for making policy decisions involving vaccination. We plan to keep updating this report as more information becomes available.

Methods

For each vaccine efficacy measure (e.g., severe disease, infection), we first obtained log odds ratios and corresponding sampling variances from each vaccine efficacy estimate and 95% confidence interval (CI). We then fit random-effects models to these data to estimate average log odds ratios, which we back-transformed to obtain VE summary estimates and 95% CIs. All analyses were done in R version 4.0.2 using the package metafor (R Project for Statistical Computing) [2, 3].

Funding

This work was partially funded by NIH grants R01AI139761 and R56AI148284.

Appendix

Here we give the details about the studies and data that are summarized in the figures.
Note: * indicates that the VE estimate is based on double-blinded, randomized trials.

Table 1: Vaccine efficacy to prevent any disease after dose 2, VE_{SP}

Company	**Efficacy%, (95% CI), time frame of estimate**	**References**
Moderna	94.5*, (86.5, 97.8), 14 or more days after dose 2	[4]
Pfizer	94.2*, (88.7, 97.2), 14 or more days after dose 2	[5]
Johnson & Johnson	One dose vaccine	n/a
AstraZeneca	81.5*, (67.9, 89.4), 14 or more days after dose 2	[6]
Novavax	89.3*, (75.2, 95.4), 7 or more days after dose 2	[7]
Sputnik V	Not reported	n/a
Sinovac	50.7*, (35.7, 62.2), time frame not reported	[8]
Sinopharm	78.1*, (64.9, 86.3), median follow-up time 112 days	[9]

Table 2: Vaccine efficacy to prevent any disease after dose 1, VE_{SP}

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	92.1*, (68.8, 99.1), more than 14 days after dose 1	[4]
Pfizer	82.0*, (75.6, 86.9), after dose 1	[5]
	57.0, (50.0, 60.0), 14-20 day period after dose 1	[10]
Johnson & Johnson	66.9*, (59.1, 73.4), 14 or more days after vaccination	[11, 12]
	66.5*, (55.5, 75.1), 28 or more days after vaccination	[11, 12]
AstraZeneca	76.0*, (59.0, 86.0), 22-90 day period after dose 1	[7]
Novavax	83.4*, (73.6, 89.5), 14 or more days after dose 1	[13]
Sputnik V	91.6*, (85.6, 95.2), 21 days after dose 1	[14]
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

Table 3: Vaccine efficacy to prevent severe disease after dose 2, VE_{SP}^{S}

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	100.0*, (CI not reported), 14 or more days after dose 2	[4]
Pfizer	92.0, (75.0, 100.0), 7 or more days after dose 2	[10]
Johnson & Johnson	One dose vaccine	n/a
AstraZeneca	100.0*, (CI not reported), time frame not reported	[7]
Novavax	100.0*, (CI not reported), time frame not reported	[7]
Sputnik V	Not reported	n/a
Sinovac	100.0*, (53.4, 100.0)[a], time frame not reported	[8]
Sinopharm	Not reported	n/a

[a] Combined estimate of VE against hospitalization, severe disease, and death

Table 4: Vaccine efficacy to prevent severe disease after dose 1, VE^{S}_{SP}

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	42.6*, (-300.8, 94.8), 14 or more days after dose 1	[4]
Pfizer	88.9*, (20.1, 99.7), after dose 1	[5]
	62.0, (39.0, 80.0), 14-20 day period after dose 1	[10]
Johnson & Johnson	76.7*, (54.6, 89.9), 14 or more days after vaccination	[11, 12]
	85.4*, (54.2, 96.9), 28 or more days after vaccination	[11, 12]
AstraZeneca	100.0*, (CI not reported), more than 22 days after dose 1	[15]
Novavax	Not reported	n/a
Sputnik V	100.0*, (94.4, 100.0), 21 or more days after dose 1	[16]
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

Table 5: Vaccine efficacy to prevent hospitalization, VE_{SP}^{H}

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	89.0, (13.0, 99.0), time frame not reported	[17]
Pfizer	87.0, (55.0, 100.0), 7 or more days after dose 2	[10]
	74.0, (56.0, 86.0), 14-20 days after dose 1	[10]
	91.0, (85.0, 94.0), 28-34 days after a single dose	[18]
Johnson & Johnson	93.1⋆, (72.7, 99.2), 14 or more days after vaccination	[11, 12]
	100.0⋆, (74.3, 100.0), 28 or more days after vaccination	[11, 12]
AstraZeneca	100.0⋆, (CI not reported), more than 22 days after dose 1	[15]
	88.0, (75.0, 94.0), 28-34 days after a single dose	[18]
Novavax	100.0⋆, (CI not reported), time frame not reported	[13]
Sputnik V	Not reported	n/a
Sinovac	83.7⋆, (58.0, 93.7), time frame not reported	[8]
Sinopharm	78.7⋆, (26.0, 93.9), median follow-up time 112 days	[9]

Table 6: Vaccine efficacy to prevent death, VE^{D}_{SP}

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	Not reported	n/a
Pfizer	72.0, (19.0, 100.0), 14-20 days after dose 1	[10]
Johnson & Johnson	100.0*, (CI not reported), time frame not reported	[11]
AstraZeneca	100.0*, (CI not reported), time frame not reported	[6]
Novavax	100.0*, (CI not reported), time frame not reported	[13]
Sputnik V	Not reported	n/a
Sinovac	100.0*, (53.4, 100.0)^{a}, time frame not reported	[8]
Sinopharm	Not reported	n/a

^{a} Combined estimate of VE against hospitalization, severe disease, and death

Table 7: Vaccine efficacy to prevent infection, VE_S

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	90.0, (68.0, 97.0)[c], 14 or more days after dose 2	[19]
	80.0, (59.0, 90.0)[c], 14 or more days after dose 1 but before dose 2	[19]
Pfizer	70.0, (55.0, 85.0)[d], 21 days after dose 1	[20]
	85.0, (74.0, 96.0)[d], 7 days after dose 2	[20]
	90.0, (68.0, 97.0)[c], 14 or more days after dose 2	[19]
	80.0, (59.0, 90.0)[c], 14 or more days after dose 1 but before dose 2	[19]
	51.4, (16.3, 71.8)[d], 13-24 day period after dose 1 compared to the preceding 1-12 days	[21]
Johnson & Johnson	Not reported	n/a
AstraZeneca	77.3*, (65.4, 85.0)[e], more than 14 days after dose 2	[6]
	51.9, (42.0, 60.1)[d], time frame not reported	[20]
Novavax	Not reported	n/a
Sputnik V	Not reported	n/a
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

[c] mRNA vaccine effectiveness for prevention of infection.

[d] VE against all (symptomatic and asymptomatic) infection.

[e] VE against all (symptomatic and asymptomatic) infection caused by non-B.1.1.7 variants. Asymptomatic infections were detected by weekly swabbing.

Table 8: Vaccine efficacy to prevent infectiousness to others, VE_I

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	Not reported	n/a
Pfizer	51.0, (44.0, 56.0), after dose 2	[22]
Johnson & Johnson	Not reported	n/a
AstraZeneca	47.0, (37.0, 56.0), after dose 2	[22]
Novavax	Not reported	n/a
Sputnik V	Not reported	n/a
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

Table 9: Vaccine efficacy against α (B.1.1.7) after dose 1

Company	**Efficacy%, (95% CI), time frame of estimate**	**References**
Moderna	Not reported[m]	[23]
Pfizer	29.5, (22.9, 35.5)[n], after dose 1	[23, 24]
	54.1, (26.1, 71.9)[u], after dose 1	[24]
	49.2, (42.6, 55.0)[q], after dose 1	[25]
Johnson & Johnson	Not reported[p]	[23]
AstraZeneca	51.4, (47.3, 55.2)[q], after dose 1	[25]
Novavax	85.6*[q], (CI not reported), time frame not reported	[23, 26]
Sputnik V	Not reported	n/a
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

[m] Although a VE estimate is unknown, numerous studies have reported that the Moderna vaccine offers protection against the α (B.1.1.7) variant [26–28].

[n] VE against PCR-confirmed infection with the α (B.1.1.7) variant.

[u] VE against severe, critical, or fatal disease caused by the α (B.1.1.7) variant.

[p] There is no VE estimate reported, but it is important to note that the Johnson & Johnson vaccine was tested in the US after the α (B.1.1.7) variant was circulating.

[q] VE against symptomatic COVID-19

[r] VE against all (symptomatic and asymptomatic) infection caused by the α (B.1.1.7) variant. Asymptomatic infections were detected by weekly swabbing.

Table 10: Vaccine efficacy against α (B.1.1.7) after dose 2

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	Not reported[m]	[23]
Pfizer	89.5, (85.9, 92.3)[n], 14 or more days after dose 2	[24]
	100.0, (81.7, 100.0)[u], 14 or more days after dose 2	[24]
	93.4, (90.4, 95.5)[q], after dose 2	[25]
Johnson & Johnson	One dose vaccine	n/a
AstraZeneca	66.1, (54.0, 75.0)[q], after dose 2	[25]
	61.7*, (36.7, 76.9)[r], time frame not reported	[6]
Novavax	85.6$^{\star q}$, (CI not reported), time frame not reported	[23, 26]
Sputnik V	Not reported	n/a
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

[m] Although a VE estimate is unknown, numerous studies have reported that the Moderna vaccine offers protection against the B.1.1.7 variant [26–28].

[n] VE against PCR-confirmed infection with the α (B.1.1.7) variant.

[u] VE against severe, critical, or fatal disease caused by the α (B.1.1.7) variant.

[q] VE against symptomatic COVID-19

[r] VE against all (symptomatic and asymptomatic) infection caused by the α (B.1.1.7) variant. Asymptomatic infections were detected by weekly swabbing.

Table 11: Vaccine efficacy against γ (P.1)

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	Not reported	n/a
Pfizer	Not reported	n/a
Johnson & Johnson	66.2*, (51.0, 77.1)^s, 14 or more days after vaccination	[12]
	68.1*, (48.8, 80.7)^s, 28 or more days after vaccination	[12]
AstraZeneca	Not reported	n/a
Novavax	Not reported	n/a
Sputnik V	Not reported	n/a
Sinovac	49.6, (11.3, 71.4)^t, 14 or more days after dose 1	[29]
Sinopharm	Not reported	n/a

^{s} VE against moderate to severe Covid-19 caused by the variant from the P.2 lineage carrying the E484K mutation.

^{t} VE against symptomatic infection

Table 12: Vaccine efficacy against β (B.1.351) after dose 1

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	Not reported	n/a
Pfizer	16.9, (10.4, 23.0)[n], after dose 1	[23, 24]
	0.0, (0.0, 19.0)[u], after dose 1	[24]
Johnson & Johnson	52.0⋆, (30.3, 67.4)[w], 14 or more days after vaccination	[12]
	64.0⋆, (41.2, 78.7)[w], 28 or more days after vaccination	[12]
AstraZeneca	21.9⋆[q], (-49.9, 59.8), time frame not reported	[23, 30]
Novavax	Not reported	n/a
Sputnik V	Not reported	n/a
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

[n] VE against PCR-confirmed infection with the β (B.1.351) variant.

[u] VE against severe, critical, or fatal disease caused by the β (B.1.351) variant.

[w] VE against moderate to severe COVID-19

[q] VE against symptomatic COVID-19

Table 13: Vaccine efficacy against β (B.1.351) after dose 2

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	Not reported	n/a
Pfizer	75.0, (70.5, 78.9)[n], 14 or more days after dose 2	[24]
Johnson & Johnson	One dose vaccine	n/a
AstraZeneca	21.9*, (-49.9, 59.8)[q], time frame not reported	[23, 30]
Novavax	49.4*, (6.1, 72.8)[q], 7 days after dose 2	[23, 31]
Sputnik V	Not reported	n/a
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

[n] VE against PCR-confirmed infection with the β (B.1.351) variant.

[q] VE against symptomatic COVID-19

Table 14: Vaccine efficacy against δ (B.1.617.2) after dose 1

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	Not reported	n/a
Pfizer	33.2, (8.3, 51.4)[q], after dose 1	[25]
Johnson & Johnson	Not reported	n/a
AstraZeneca	32.9, (19.3, 44.3)[q], after dose 1	[25]
Novavax	Not reported	n/a
Sputnik V	Not reported	n/a
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

[q] VE against symptomatic COVID-19

Table 15: Vaccine efficacy against δ (B.1.617.2) after dose 2

Company	Efficacy%, (95% CI), time frame of estimate	References
Moderna	Not reported	n/a
Pfizer	87.9, (78.2, 93.2)[q], after dose 2	[25]
Johnson & Johnson	Not reported	n/a
AstraZeneca	59.8, (28.9, 77.3)[q], after dose 2	[25]
Novavax	Not reported	n/a
Sputnik V	Not reported	n/a
Sinovac	Not reported	n/a
Sinopharm	Not reported	n/a

[q] VE against symptomatic COVID-19

Table 16: Viral neutralization of the variants of concern as compared with pre-existing variants

Company	Variant of concern	Neutralization by pseudovirion or live viral plaque assay	References
Moderna	B.1.1.7 (α)	Decrease by 1.8x	[23]
	P.1 (γ)	Decrease by 4.5x	[23]
	B.1.351 (β)	Decrease by $\leq$ 8.6x	[23]
	B.1.617.2 (δ)	Not reported	n/a
Pfizer	B.1.1.7 (α)	Decrease by 2x	[23]
	P.1 (γ)	Decrease by 6.7x	[32]
	B.1.351 (β)	Decrease by $\leq$ 6.5x	[23]
	B.1.617.2 (δ)	Not reported	n/a
Johnson & Johnson	B.1.1.7 (α)	Not reported	n/a
	P.1 (γ)	Not reported	n/a
	B.1.351 (β)	Not reported	n/a
	B.1.617.2 (δ)	Not reported	n/a
AstraZeneca	B.1.1.7 (α)	Decrease by 9x	[6]
	P.1 (γ)	Not reported	n/a
	B.1.351 (β)	Decrease by $\leq$ 86%	[23]
	B.1.617.2 (δ)	Not reported	n/a
Novavax	B.1.1.7 (α)	Decrease by 1.8x	[23]
	P.1 (γ)	Not reported	n/a
	B.1.351 (β)	Not reported	n/a
	B.1.617.2 (δ)	Not reported	n/a
Sputnik V	B.1.1.7 (α)	Not reported	n/a
	P.1 (γ)	Not reported	n/a
	B.1.351 (β)	Not reported	n/a
	B.1.617.2 (δ)	Not reported	n/a
Sinovac	B.1.1.7 (α)	Not reported	n/a
	P.1 (γ)	Not reported	n/a
	B.1.351 (β)	Not reported	n/a
	B.1.617.2 (δ)	Not reported	n/a
Sinopharm	B.1.1.7 (α)	Not reported	n/a
	P.1 (γ)	Not reported	n/a
	B.1.351 (β)	Not reported	n/a
	B.1.617.2 (δ)	Not reported	n/a

References

[1] Halloran ME, Longini IM, Struchiner CJ. Design and Analysis of Vaccine Studies. Springer; 2010.

[2] Viechtbauer W. Conducting Meta-Analyses in R with the metafor Package. Journal of Statistical Software, Articles. 2010;36(3):1–48. Available from: https://www.jstatsoft.org/v036/i03.

[3] R Core Team. R: a language and environment for statistical computing;. Available from: https://www.gbif.org/tool/81287/r-a-language-and-environment-for-statistical-computing.

[4] ModernaTX; 2020. Available from: https://www.fda.gov/media/144434/download.

[5] Pfizer; 2020. Available from: https://www.fda.gov/media/144246/download.

[6] Emary KR, Golubchik T, Aley PK, Ariani CV, Angus BJ, Bibi S, et al. Efficacy of ChAdOx1 nCoV-19 (AZD1222) vaccine against SARS-CoV-2 VOC 202012/01 (B. 1.1. 7). The Lancet. 2021.

[7] Vizient; 2021. Available from: https://www.vizientinc.com/-/media/documents/sitecorepublishingdocuments/public/covid19_sidebyside_vaccinecompare.pdf.

[8] Supply Vaccines to Eliminate Human Diseases;. Available from: http://www.sinovacbio.com/news/shownews.php?id=1154&lang=en.

[9] Evidence Assessment: Sinopharm/bbibp Covid-19 Vaccine. Sage Working Group;. Available from: https://cdn.who.int/media/docs/default-source/immunization/sage/2021/april/2_sage29apr2021_critical-evidence_sinopharm.pdf.

[10] Dagan N, Barda N, Kepten E, Miron O, Perchik S, Katz MA, et al. BNT162b2 mRNA Covid-19 vaccine in a nationwide mass vaccination setting. New England Journal of Medicine. 2021.

[11] Janssen Biotech, Inc; 2021. Available from: https://www.fda.gov/media/146217/download.

[12] Sadoff J, Gray G, Vandebosch A, Cárdenas V, Shukarev G, Grinsztejn B, et al. Safety and Efficacy of Single-Dose Ad26. COV2. S Vaccine against Covid-19. New England Journal of Medicine. 2021.

[13] Novavax Confirms High Levels of Efficacy Against Original and Variant COVID-19 Strains in United Kingdom and South Africa Trials;. Available from: https://ir.novavax.com/news-releases/news-release-details/novavax-confirms-high-levels-efficacy-against-original-and.

[14] Jones I, Roy P. Sputnik V COVID-19 vaccine candidate appears safe and effective. The Lancet. 2021;397(10275):642–643.

[15] COVID-19 Vaccine AstraZeneca confirms 100% protection against severe disease, hospitalisation and death in the primary analysis of Phase III trials; 2021. Available from: https://www.astrazeneca.com/media-centre/press-releases/2021/covid-19-vaccine-astrazeneca-confirms-protection-against-severe-disease-hospitalisation-and-death-in-the-primary-analysis-of-phase-iii-trials.html.

[16] Logunov DY, Dolzhikova IV, Shcheblyakov DV, Tukhvatulin AI, Zubkova OV, Dzharullaeva AS, et al. Safety and efficacy of an rAd26 and rAd5 vector-based heterologous prime-boost COVID-19 vaccine: an interim analysis of a randomised controlled phase 3 trial in Russia. The Lancet. 2021;397(10275):671–681.

[17] GRADE: Moderna COVID-19 Vaccine. Centers for Disease Control and Prevention; 2020. Available from: https://www.cdc.gov/vaccines/acip/recs/grade/covid-19-moderna-vaccine.html.

[18] 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. The Lancet. 2021.

[19] 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 2021. Centers for Disease Control and Prevention; 2021. Available from: https://www.cdc.gov/mmwr/volumes/70/wr/mm7013e3.htm.

[20] Hall VJ, Foulkes S, Saei A, Andrews N, Oguti B, Charlett 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. The Lancet. 2021.

[21] K; CGLTSTAD. Assessment of Effectiveness of 1 Dose of BNT162b2 Vaccine for SARS-CoV-2 Infection 13 to 24 Days After Immunization. U.S. National Library of Medicine;. Available from: https://pubmed.ncbi.nlm.nih.gov/34097044/.

[22] Harris RJ, Hall JA, Zaidi A, Andrews NJ, Dunbar JK, Dabrera G. Impact of vaccination on household transmission of SARS-COV-2 in England. medRxiv. 2021.

[23] Abdool Karim SS, de Oliveira T. New SARS-CoV-2 Variants - Clinical, Public Health, and Vaccine Implications. New England Journal of Medicine. Available from: https://doi.org/10.1056/NEJMc2100362.

[24] 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. New England Journal of Medicine. Available from: https://doi.org/10.1056/NEJMc2104974.

[25] 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. medRxiv. 2021. Available from: https://www.medrxiv.org/content/early/2021/05/24/2021.05.22.21257658.

[26] Stieg C. How the different Covid vaccines will handle new variants of the virus. CNBC; 2021. Available from: https://www.cnbc.com/2021/03/05/how-the-different-covid-vaccines-will-handle-variants.html#:~:text=If%20a%20fully%20vaccinated%20person,as%20Moderna's%20original%20Covid%20vaccine.

[27] Collier DA, De Marco A, Ferreira IA, Meng B, Datir R, Walls AC, et al. Sensitivity of SARS-CoV-2 B. 1.1. 7 to mRNA vaccine-elicited antibodies. Nature. 2021:1–8.

[28] Wu K, Werner AP, Koch M, Choi A, Narayanan E, Stewart-Jones GB, et al. Serum Neutralizing Activity Elicited by mRNA-1273 Vaccine. New England Journal of Medicine. 2021.

[29] Hitchings M, Ranzani OT, Torres MS, de Oliveira SB, Almiron M, Said R, et al. Effectiveness of CoronaVac in the setting of high SARS-CoV-2 P. 1 variant transmission in Brazil: A test-negative case-control study. medRxiv. 2021.

[30] Madhi SA, Baillie V, Cutland CL, Voysey M, Koen AL, Fairlie L, et al. Efficacy of the ChAdOx1 nCoV-19 Covid-19 Vaccine against the B. 1.351 Variant. New England Journal of Medicine. 2021.

[31] Shinde V, Bhikha S, Hoosain Z, Archary M, Bhorat Q, Fairlie L, et al. Efficacy of NVX-CoV2373 Covid-19 Vaccine against the B.1.351 Variant. New England Journal of Medicine. Available from: https://doi.org/10.1056/NEJMoa2103055.

[32] Science Brief: Background Rationale and Evidence for Public Health Recommendations for Fully Vaccinated People. Centers for Disease Control and Prevention;. Available from: https://www.cdc.gov/coronavirus/2019-ncov/science/science-briefs/fully-vaccinated-people.html#ref4.