

Antibody response after vaccination against SARS-CoV-2 in adults with hematological malignancies: a systematic review and meta-analysis

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Supplemental Material

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Supplemental Table 1. Search query.

((SARSCOV2[Title/Abstract] OR covid[Title/Abstract] OR 2019 novel coronavirus[Title/Abstract] OR COVID19[Title/Abstract] OR COVID-19[Title/Abstract] OR SARS-CoV-2[Title/Abstract] OR 2019-nCoV[Title/Abstract] OR coronavirus disease 2019[Title/Abstract] OR coronavirus disease-19[Title/Abstract]) AND (cancer[Title/Abstract] OR hematologic*[Title/Abstract] OR leukemia[Title/Abstract] OR leukaemia[Title/Abstract] OR myeloma[Title/Abstract] OR lymphoma[Title/Abstract] OR myeloproliferative[Title/Abstract] OR myelodysplastic syndrome*[Title/Abstract] OR myelofibrosis[Title/Abstract] OR transplantation[Title/Abstract] OR chimeric antigen[Title/Abstract] OR cellular therapy[Title/Abstract] OR CART[Title/Abstract] OR allogeneic[Title/Abstract] OR autologous[Title/Abstract] OR stem cell transplantation[Title/Abstract] OR haematologic*[Title/Abstract])) AND (vaccin*[Title/Abstract] OR BNT162b2[Title/Abstract] OR AZD1222[Title/Abstract] OR mRNA-1273[Title/Abstract] OR Ad26.COV2.S[Title/Abstract] OR ChAdOx1*[Title/Abstract])

Supplemental Table 2. Study characteristics.

Study	N	Vaccine	Dose	Disease	HCT/ CAR-T	Control	Assay	Median age, years	Median follow-up, days
Kastritis et al.	177	BNT162b2, AZD1222	1 st	Amyloidosis	None	Healthy	GenScript	62	22
Ehmsen et al.	424	BNT162b2, mRNA-1273	2 nd	CLL, MM, Lymphoma	54	Solid cancer	AdviseDx, Abbott	72	55
Thakkar et al.	201	BNT162b2, mRNA-1273, Ad26.COVS.S	2 nd or 1 st	Lymphoid, myeloid, MM	26/3	Solid cancer, healthy	AdviseDx Abbott	67	50
Monin et al.	151	BNT162b2	1 st + 2 nd	Lymphoid, myeloid, MM, MPN	NR	Solid cancer, healthy	Jackson	73	22
Addeo et al.	131	BNT162b2, mRNA-1273	1 st + 2 nd	Lymphoid, MM, MPN	NR	Solid cancer	Elecsys	63	50
Maneikis et al.	953	BNT162b2	1 st + 2 nd	Lymphoid, myeloid, MM, MPN	314	Matched healthy	Abbott Architect	65	94
Iacono et al.	36	BNT162b2	2 nd	NS (>80 years)	NR	Solid cancer	Abbott Alinity	82	NR
Gurion et al.	162	BNT162b2	2 nd	Lymphoma	NR	None	AdviseDx Abbott	65	14-42 after 2 nd dose
Gavriatopoulou et al.	271	BNT162b2, AZD1222	1 st	WM, CLL, NHL	NR	Healthy	GenScript	75	22
Herishanu et al.	219	BNT162b2	2 nd	CLL	NR	Matched healthy	Elecsys	71	75
Roeker et al.	44	BNT162b2, mRNA-1273	2 nd	CLL	NR	None	Liason	71	50
Benjamini et al.	373	BNT162b2	2 nd	CLL	NR	None	AdviseDx,	70	40

							Abbott		
Parry et al.	356	BNT162b2, AZD1222	1 st + 2 nd	CLL	NR	Matched healthy	DBS	69	50
Herzog Tzarfati et al.	423	BNT162b2	2 nd	Lymphoid, myeloid, MM, MPN	21	Matched healthy	DiaSorin	71	63
Malard et al.	225	BNT162b2	1 st + 2 nd	Lymphoid, myeloid, CLL, MM, MPN	82/1	Healthy	Abbott Alinity	68	52
Agha et al.	67	BNT162b2, mRNA-1273	2 nd	Lymphoid, myeloid, CLL, MM	1	None	Beckman Coulter	72	51
Benda et al.	259	BNT162b2	1 st + 2 nd	Lymphoid, myeloid, CLL, MM, WM	20	Solid cancer	Elecsys	65	49
Greenberger et al.	1445	BNT162b2, mRNA-1273	2 nd	Lymphoid, myeloid, CLL, MM, WM	73/12	None	Elecsys	66	35
Ghione et al.	287	BNT162b2, mRNA-1273	2 nd	Lymphoma, MM	NR	Healthy	Platelia	70	14-56 after final dose
Lim et al.	129	BNT162b2, AZD1222	1 st + 2 nd	Lymphoma	15	Healthy	Meso Scale Discovery	67 NHL, 46 HL	14-28 days after 2 nd dose
Pimpinelli et al.	128	BNT162b2	1 st + 2 nd	MM, MPN	NR	Healthy	Liaison	72	35
Terpos et al.	152	BNT162b2	1 st	MM	NR	Healthy		83	22
Van Oekelen et al.	320	BNT162b2, mRNA-1273	2 nd	MM	165/23	None	Sero-Klir Kantaro	68	51
Stampfer et al.	168	BNT162b2, mRNA-1273	1 st + 2 nd	MM	NR	Matched	Sino	68	50

						healthy	Biological		
Terpos et al.	502	BNT162b2, AZD1222	1 st + 2 nd	MM	NR	Matched healthy	GenScript	74	28 post 2 nd BNT162b2 or 49 post 1 st AZD1222
Bird et al.	93	BNT162b2, AZD1222	1 st	MM	77	None	Ortho Clinical Diagnostics	67	33
Ghandili et al.	82	BNT162b2, mRNA-1273, AZD1222	1 st	MM	NR	None	Liaison	67	25
Avivi et al.	235	BNT162b2	2 nd	MM	96	Healthy	Elecsys	70	107
Pimpinelli et al.	42	BNT162b2	2 nd	MPN		None	Liason	72	35
Caocci et al.	20	BNT162b2	2 nd	Myelofibrosis		None	Liason	68	107
Ram et al.	80	BNT162b2	2 nd	Lymphoid, myeloid, MPN	66/14	None	Elecsys	65	35
Ali et al.	113	BNT162b2, mRNA-1273	1 st + 2 nd	Lymphoid, myeloid, MPN	113	None	NR	66	40
Easdale et al.	55	BNT162b2, AZD1222	1 st	Lymphoid, myeloid, MPN	55	None	Ortho Clinical Diagnostics	50	NR
Dhakal et al.	130	BNT162b2, mRNA-1273, Ad26.COVS.S	2 nd or 1 st	Lymphoid, myeloid, MM, MPN	116/14	None	Euroimmun	64	NR, at least 14 after 2 nd dose
Redjoul et al.	88	BNTB162b2	2 nd	Lymphoid, myeloid	88	None	Abbott	60	84
Mairhofer et al.	116	BNT162b2, mRNA-1273	2 nd	Lymphoid, myeloid, MM,	NR	Solid cancer, healthy	Abbott	66	51

				MPN					
Chung et al.	620	BNT162b2, mRNA-1273	2 nd	Lymphoid, myeloid, MM	NR	Healthy	AdviseDx, Abbott	65	90
Del Poeta et al.	46	BNT162b2	2 nd	CLL	NR	None	Maglumi	70	48
Jurgens et al.	102	BNT162b2, mRNA-1273	2 nd	Lymphoid		Healthy	NR	71	47
Perry et al.	214	BNT162b2	2 nd	Lymphoid	NR	Healthy	Elecsys	64	95
Tamari et al.	271	BNT162b2, mRNA-1273	2 nd	Lymphoid, myeloid, MM, MPN	217	Healthy	AdviseDx, Abbott	66	90
Terpos et al.	346	BNT162b2	2 nd	Lymphoid	NR	Healthy	GenScript	65	50
Ollila et al.	160	BNT162b2, mRNA-1273, Ad26.COVS.S	2 nd or 1 st	Lymphoid, myeloid, MM	NR	None	AdviseDx Abbott	72	56
Peeters et al.	240	BNT162b2	1 st + 2 nd	Lymphoid, myeloid	11	Solid cancer, healthy	Wantai	61	50
Harrington et al.	16	BNT162b2	1 st	CLL	None	None	Miltenyi	45	21
Harrington et al.	21	BNT162b2	1 st	MPN	None	None	Miltenyi	55	21
Marchesi et al.	218	BNT162b2	2 nd	MPN, MM, NHL	NR	Healthy	Dia.pro	68	84
Le Bourgeois et al.	117	BNT162b2	1 st + 2 nd	Myeloid, lymphoid	117	None	Roche	57	58
Gastinne et al.	58	BNT162b2	1 st + 2 nd	Lymphoid	23	None	Roche		77
Abbreviations: MM, multiple myeloma; MPN, myeloproliferative neoplasms; CLL, chronic lymphocytic leukemia; HCT, haematopoietic cell transplantation; CAR-T, chimeric antigen receptor T cell therapy; NHL, non-Hodgkin lymphoma; WM, Waldenström's macroglobulinemia; HL, Hodgkin's lymphoma; NHL, non-Hodgkin's lymphoma; NR, not reported.									

Supplemental Table 3. Risk of bias assessment.¹

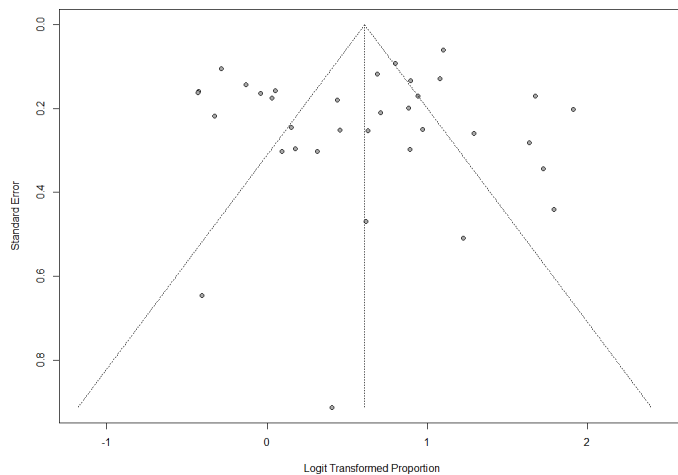
Study	Patient selection (1)	Ascertainment (2)	Causality (4)	Reporting (1)	Risk
Kaстрitis et al. ²	1	2	4	1	Low
Ehmsen et al. ³	1	2	4	1	Low
Thakkar et al. ⁴	1	2	4	1	Low
Monin et al. ⁵	1	2	4	1	Low
Addeo et al. ⁶	1	2	4	1	Low
Iacono et al. ⁷	1	2	2	0	Moderate
Gurion et al. ⁸	1	2	4	1	Low
Gavriatopoulou et al. ⁹	1	2	4	0	Low
Herishanu et al. ¹⁰	1	2	4	1	Low
Roeker et al. ¹¹	1	2	4	1	Low
Benjamini et al. ¹²	1	2	4	1	Low
Parry et al. ¹³	1	2	4	1	Low
Herzog Tzarfati et al. ¹⁴	1	2	4	1	Low
Malard et al. ¹⁵	1	2	4	0	Low
Agha et al. ¹⁶	0	1	4	0	Moderate
Benda et al. ¹⁷	1	2	4	1	Low
Greenberger et al. ¹⁸	1	2	4	1	Low
Ghione et al. ¹⁹	0	2	3	0	Moderate
Lim et al. ²⁰	1	2	4	1	Low
Pimpinelli et al. ²¹	1	2	2	0	Moderate
Terpos et al. ²²	1	2	4	1	Low
Van Oekelen et al. ²³	1	2	4	1	Low
Stampfer et al. ²⁴	1	2	4	1	Low
Terpos et al. ²⁵	1	2	4	1	Low
Bird et al. ²⁶	1	2	4	1	Low
Ghandili et al. ²⁷	1	1	3	0	Moderate
Pimpinelli et al. ²⁸	1	2	3	0	Moderate
Caocci et al. ²⁹	1	2	3	0	Moderate
Ram et al. ³⁰	1	2	4	1	Low
Ali et al. ³¹	1	2	4	1	Low
Easdale et al. ³²	1	2	4	1	Low
Dhokal et al. ³³	1	2	4	1	Low
Maneikis et al. ³⁴	1	2	4	1	Low
Redjoul et al. ³⁵	1	2	4	1	Low

Mairhofer et al. ³⁶	1	2	4	0	Low
Chung et al. ³⁷	1	2	4	0	Low
Del Poeta et al. ³⁸	1	2	2	0	Moderate
Jurgens et al. ³⁹	0	2	4	0	Moderate
Perry et al. ⁴⁰	1	2	4	1	Low
Tamari et al. ⁴¹	1	2	4	1	Low
Terpos et al. ⁴²	1	2	4	1	Low
Ollila et al. ⁴³	1	2	4	1	Low
Avivi et al. ⁴⁴	1	2	4	1	Low
Gastinne et al. ⁴⁵	1	2	4	1	Low
Le Bourgeois et al. ⁴⁶	1	2	4	1	Low
Harrington et al. ⁴⁷	1	2	4	1	Low
Peeters et al. ⁴⁸	1	2	4	1	Low
Marchesi et al. ⁴⁹	1	2	3	0	Moderate
Harrington et al. ⁵⁰	1	2	4	1	Low

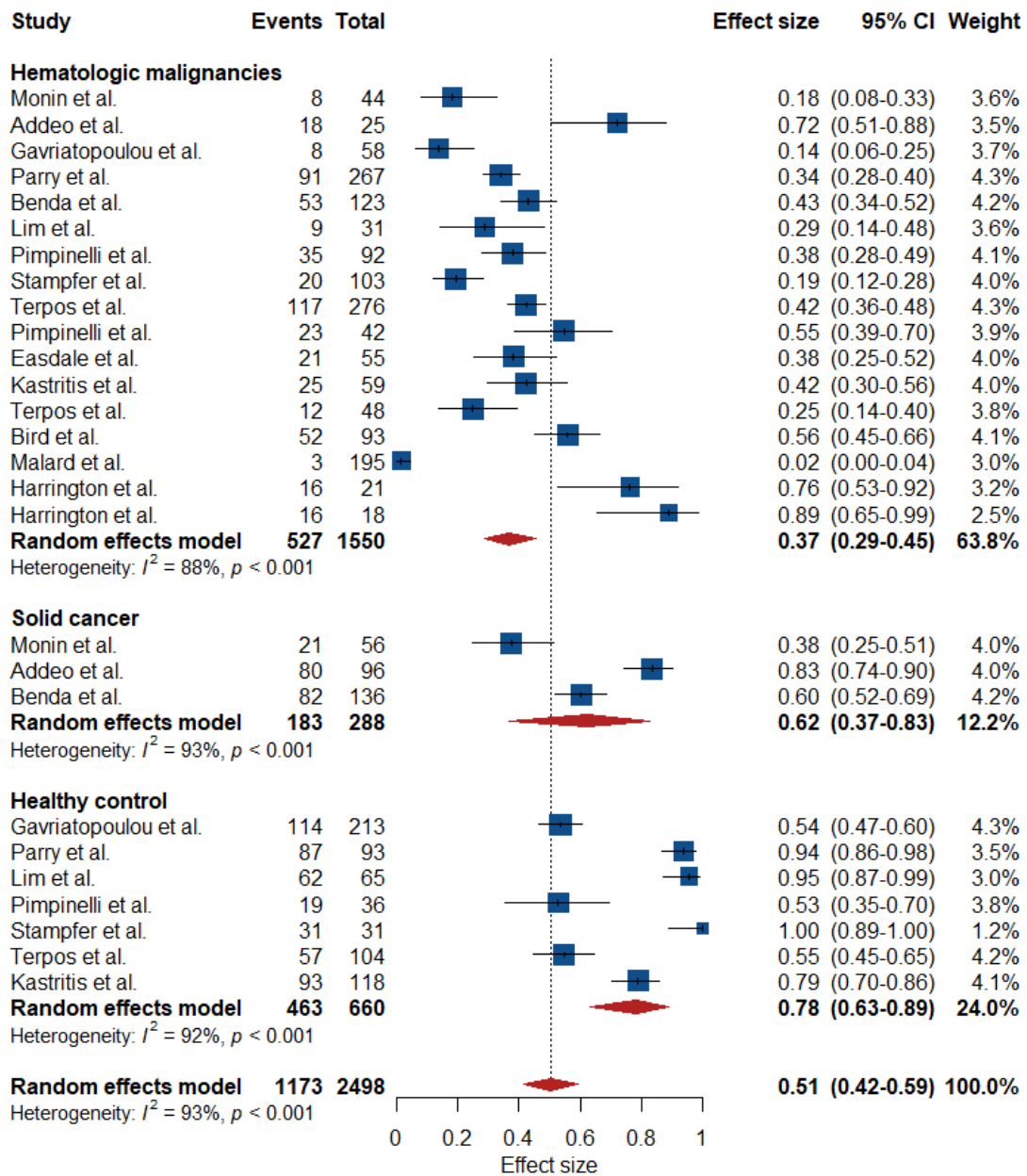
Supplemental Table 4. Adverse events in % across evaluable studies.

Study	Local	Weakness	Headache	Fever	Muscle pain
1st dose					
Monin et al. ⁵	21	17	10	0	6
Thakkar et al. ⁴	35	2	0	6	10
Herishanu et al. ¹⁰	30	8	7	4	3
Terpos et al. ²⁵	33	13	NR	NR	13
Benda et al. ¹⁷	32	12	7	1	2
Pimpinelli et al. ²¹	30	5	1	0	1
Ram et al. ³⁰		4	6	1	4
Ali et al. ³¹	40	15		5	8
Malard et al. ¹⁵	42	22	7	3	12
2nd dose					
Thakkar et al. ⁴	30	6		12	14
Herishanu et al. ¹⁰	34	9	5	7	5
Benjamini et al. ¹²				8	4
Benda et al. ¹⁷	15	18	10	6	7
Pimpinelli et al. ²¹	26	1	2	3	16
Terpos et al. ²⁵	31	21	NR	NR	21
Ram et al. ³⁰	NR	11	11	3	4
Malard et al. ¹⁵	25	19	NR	NR	17
Avivi et al. ⁴⁴	43	16	11	5	10
Ali et al. ³¹	44	30	NR	4	30
Mairhofer et al. ³⁶	NR	19	NR	23	NR
Perry et al. ⁴⁰	37	20	10	7	9

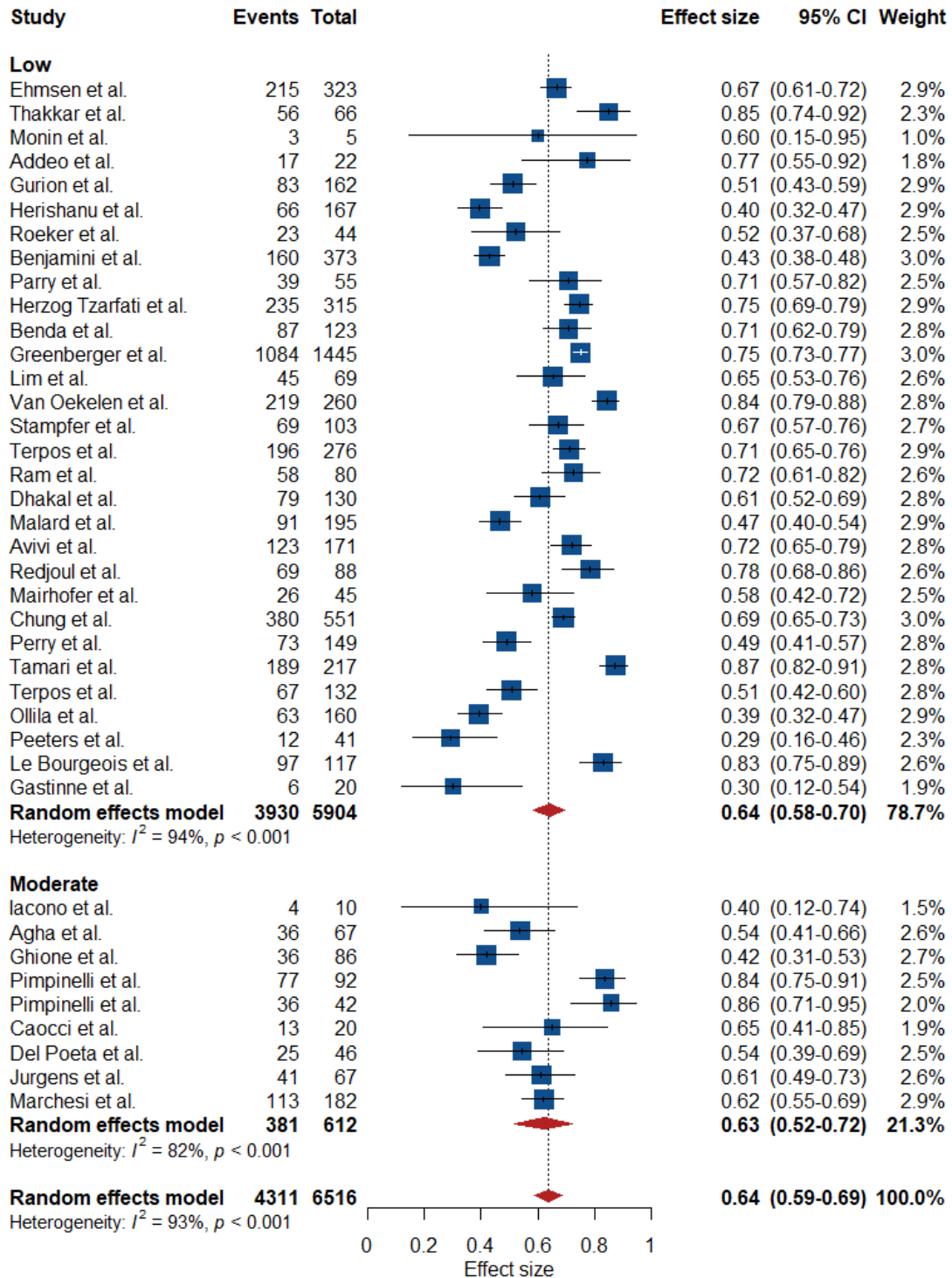
Supplemental Figure 1. Funnel plot of studies assessing antibody response in hematologic malignancies after full vaccination.



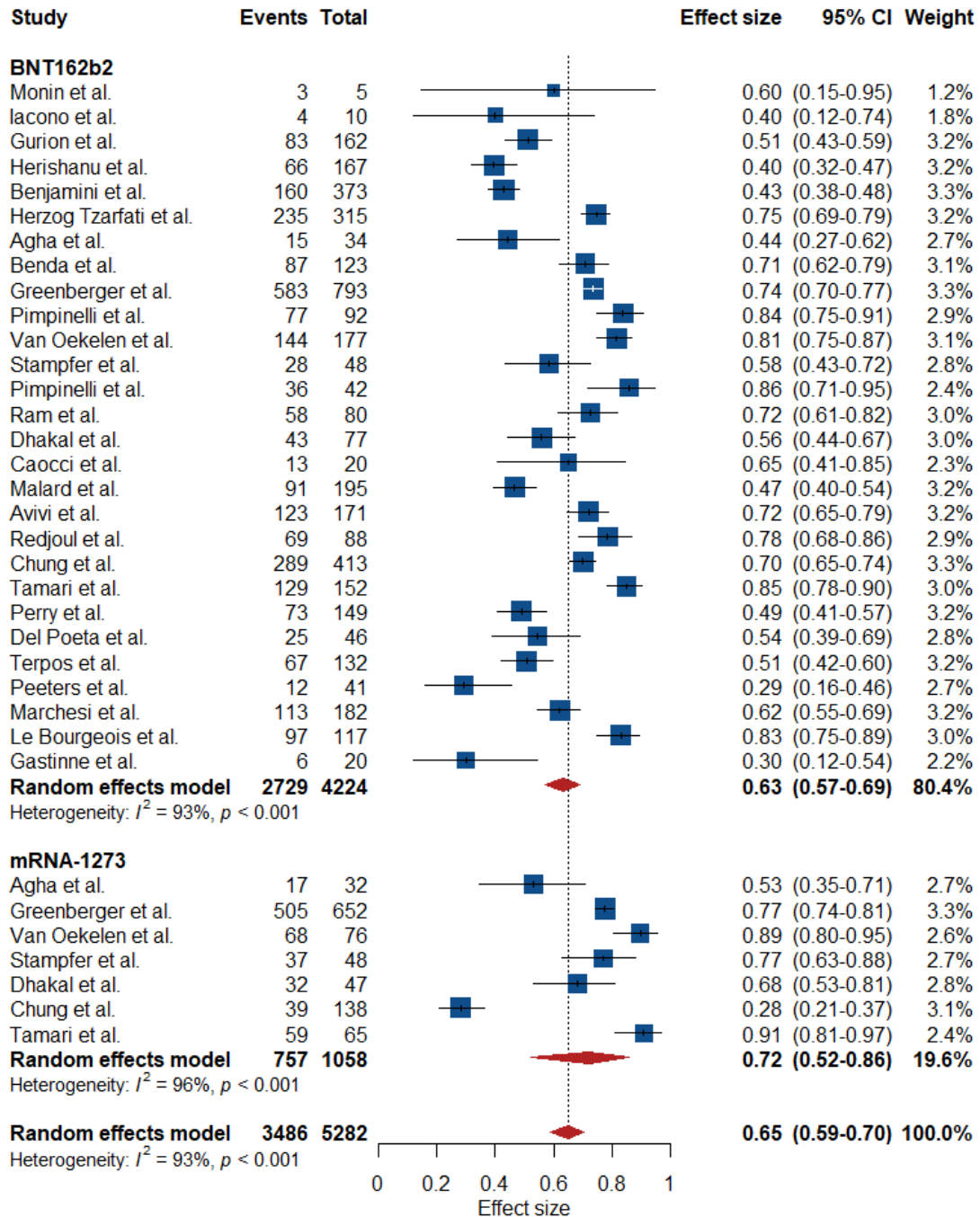
Supplemental Figure 2. Overall response after 1st dose of vaccine.



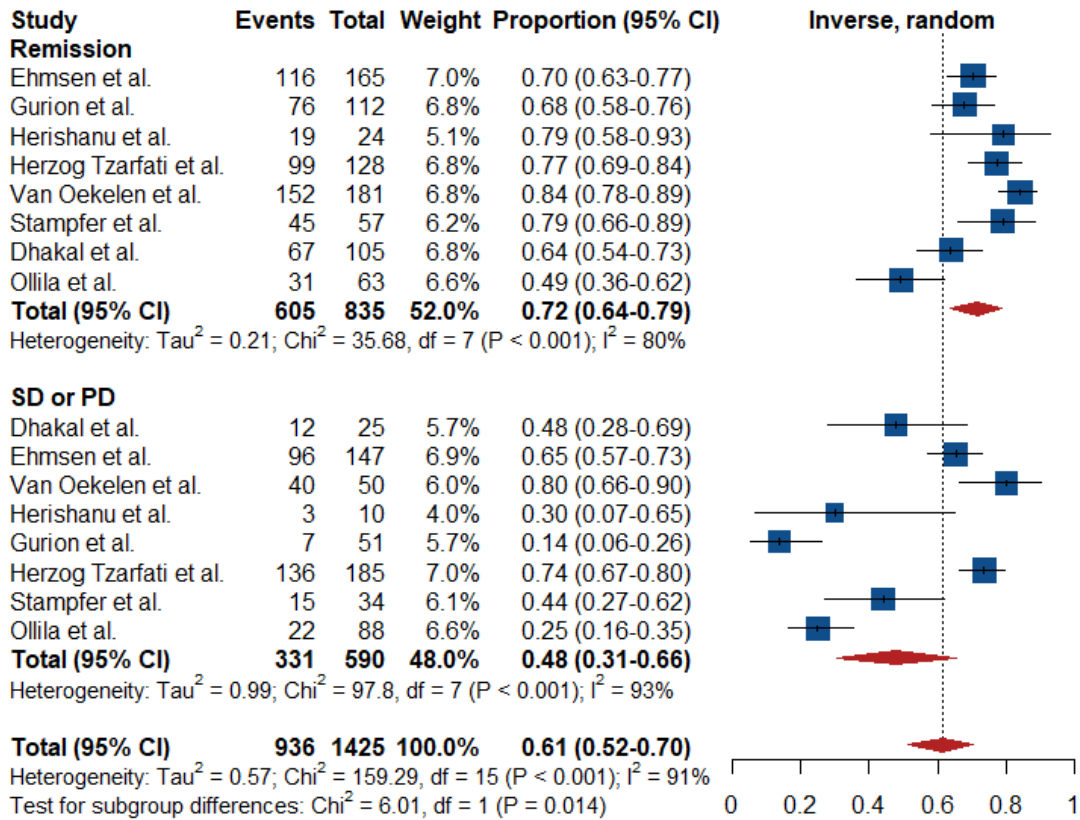
Supplemental Figure 3. Antibody response after full vaccination according to risk of bias of included studies.



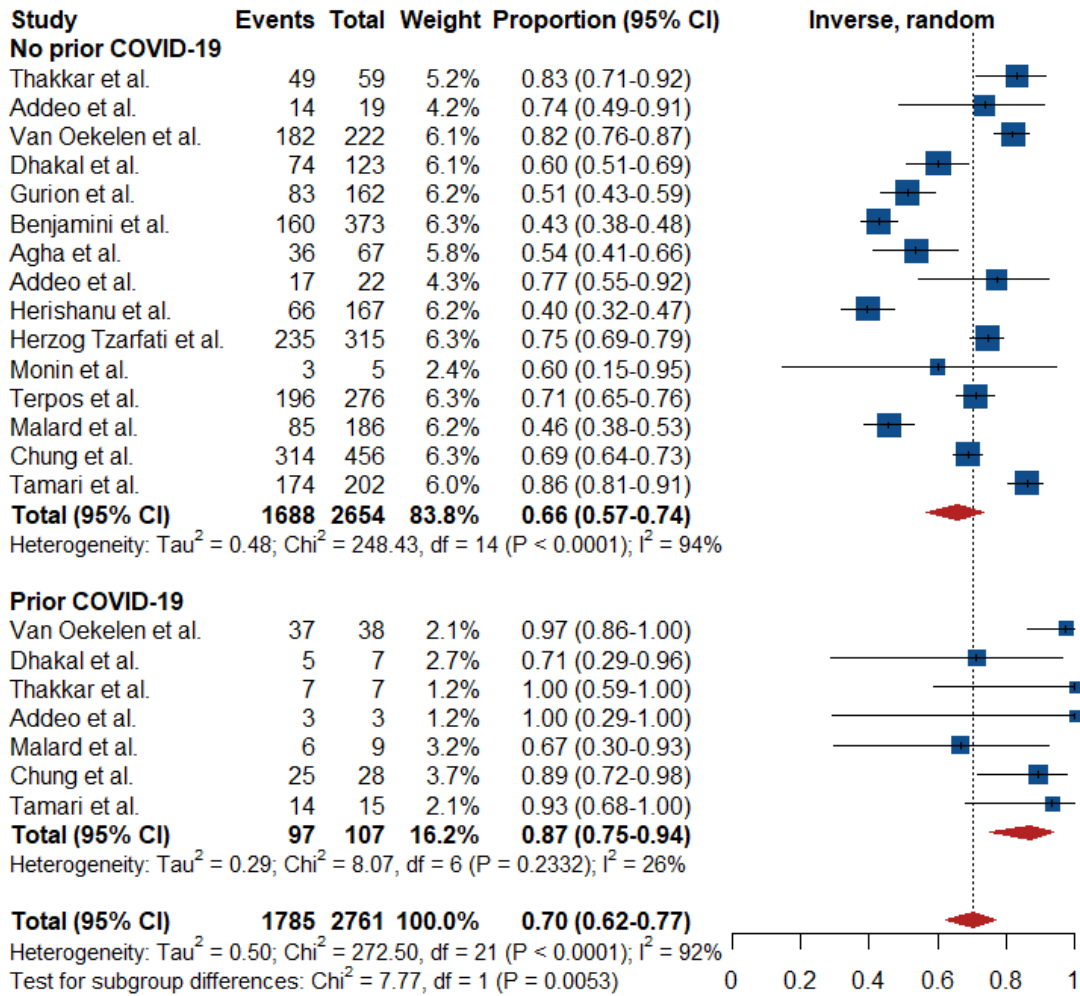
Supplemental Figure 4. Antibody response after full vaccination according to type of mRNA vaccine in haematological malignancies.



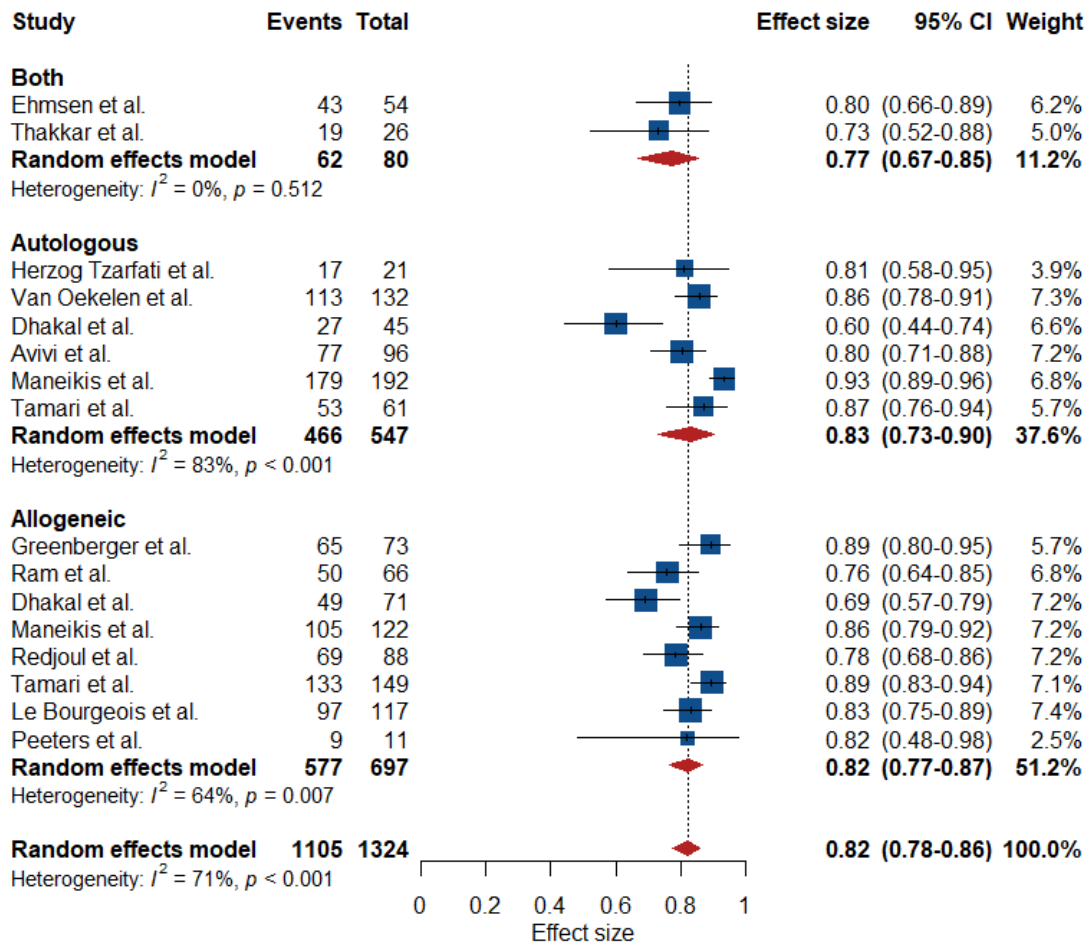
Supplemental Figure 5. Antibody response after full vaccination according to remission.



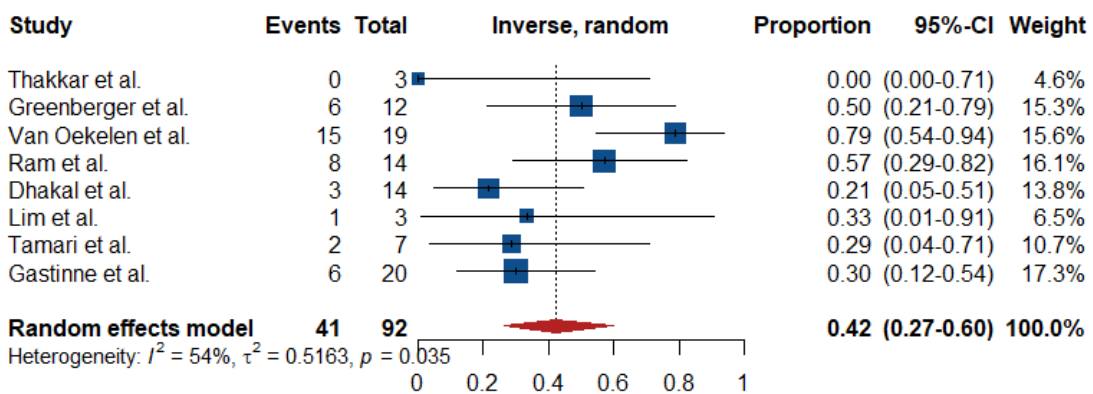
Supplemental Figure 6. Antibody response after full vaccination according to history of COVID-19.



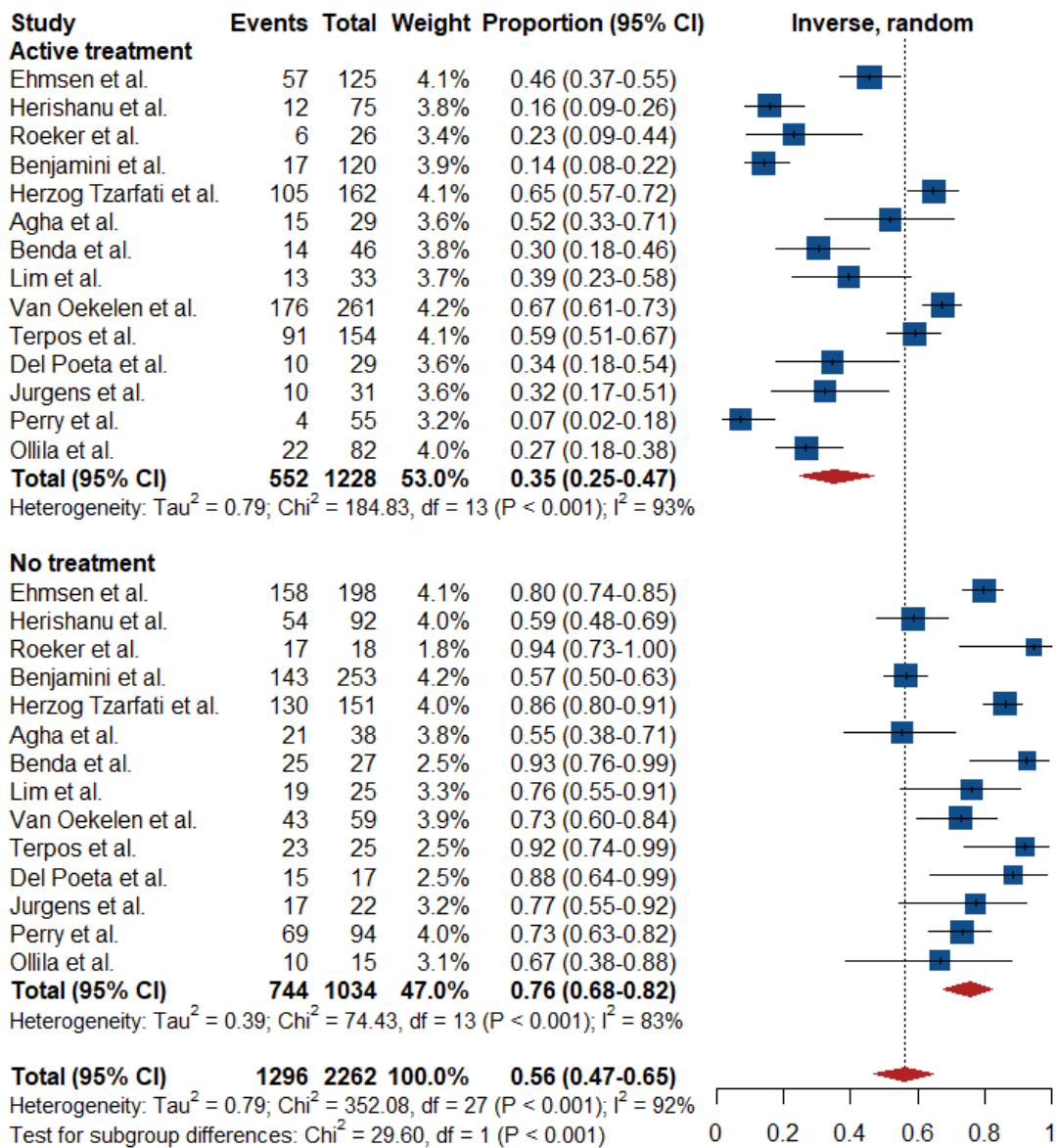
Supplemental Figure 7. Antibody response after full vaccination in haematopoietic cell transplantation.



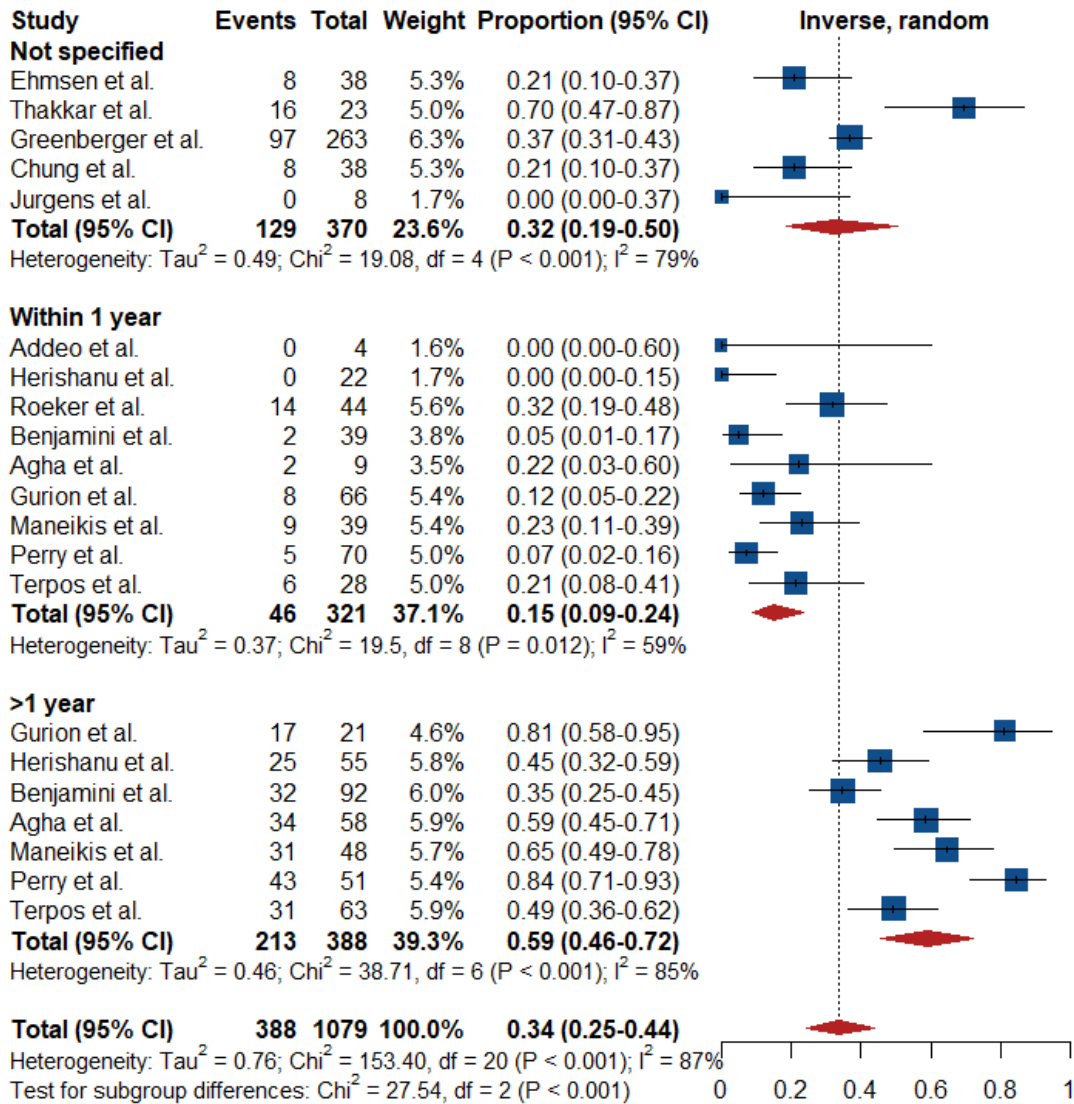
Supplemental Figure 8. Antibody response after full vaccination in CAR-T.



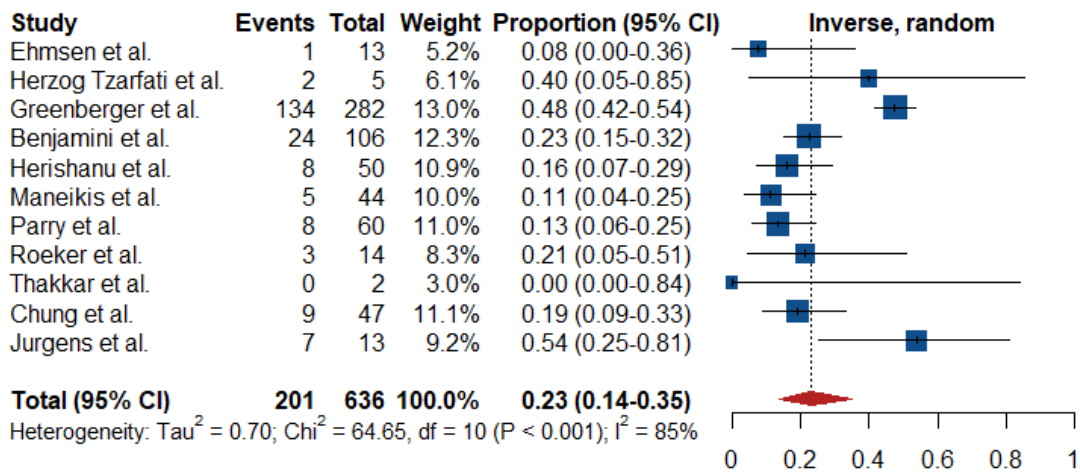
Supplemental Figure 9. Antibody response after full vaccination according to active or no treatment.



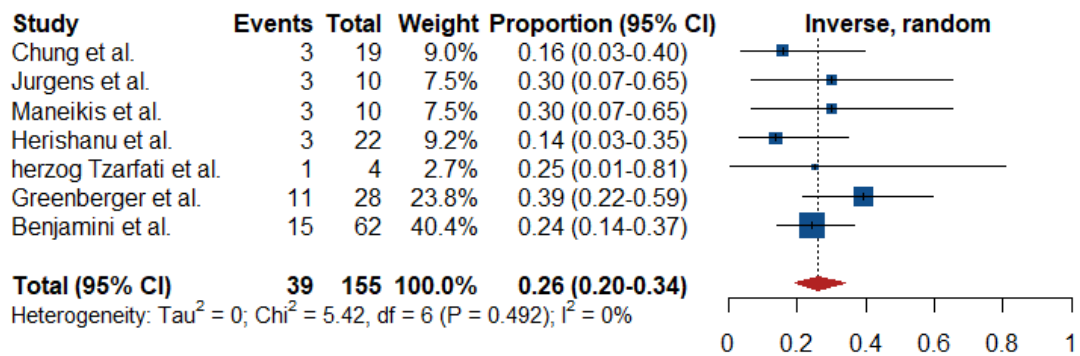
Supplemental Figure 10. Antibody response after full vaccination according to anti-CD20 therapy.



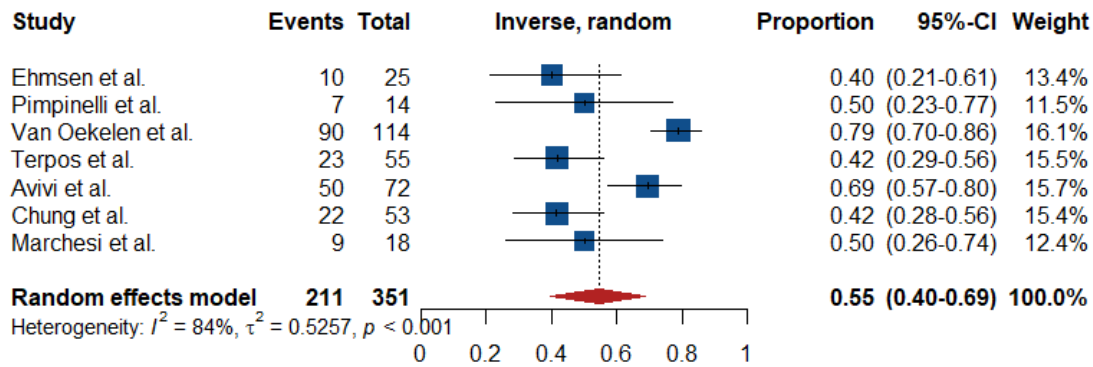
Supplemental Figure 11. Antibody response after full vaccination in BTK inhibitor therapy.



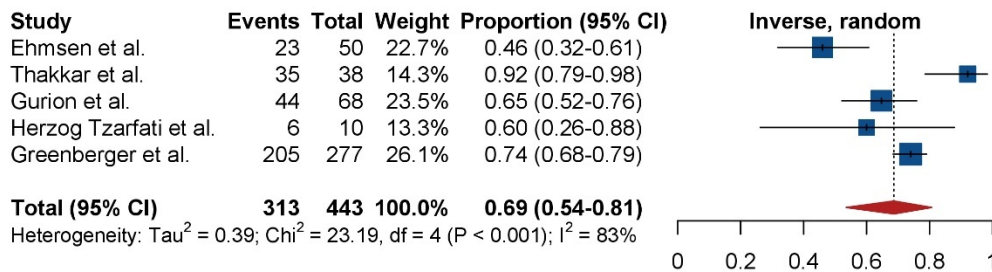
Supplemental Figure 12. Antibody response after full vaccination in venetoclax therapy.



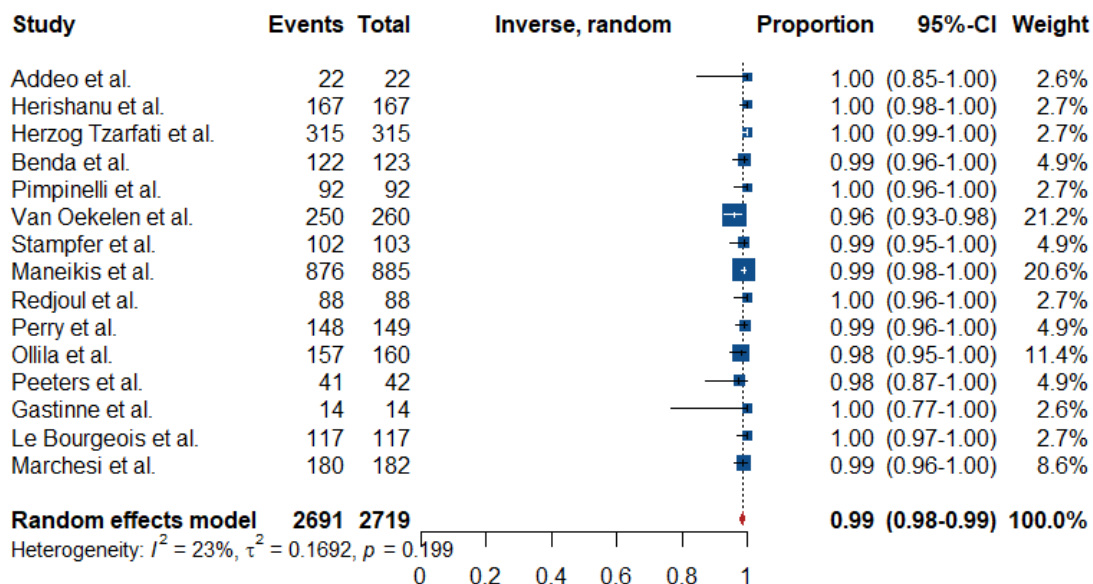
Supplemental Figure 13. Antibody response after full vaccination in anti-CD38 therapy.



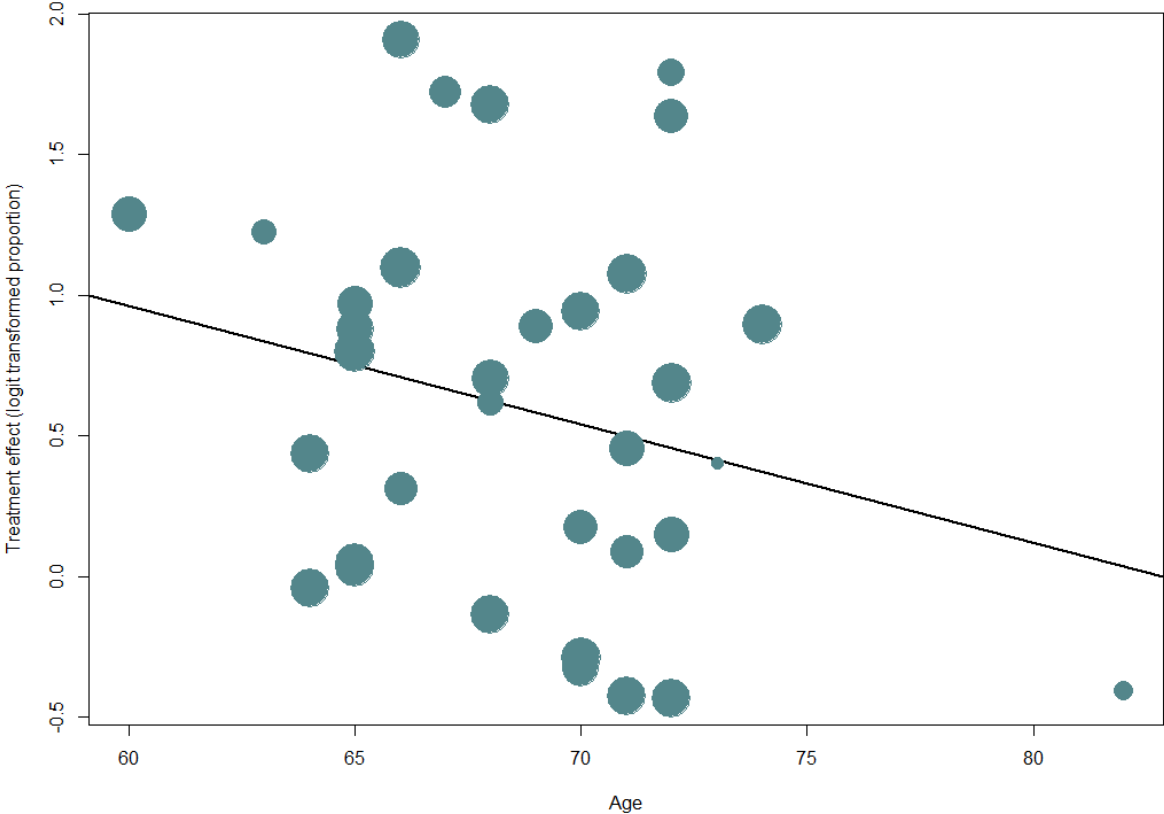
Supplemental Figure 14. Antibody response after full vaccination in chemotherapy.



Supplemental Figure 15. Efficacy.



Supplemental Figure 16. Meta-regression on the effect of age.



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