Supplementary Table 1: Characteristics of the UK Biobank serology sub-cohort consisting of predominantly European ancestry participants.

Characteristic	Serology Data (N=7948)		No Serology Data (N=405,857)	
	N	(%)	N	(%)
Age at assessment				
Mean (SD)	56.74	(8.07)	56.74	(8.00)
Sex				
Male	3519	(44.3)	187685	(46.2)
Smoking status				
Never smoker	4348	(55.0)	218228	(54.0)
Former smoker	2774	(35.1)	143908	(35.6)
Current smoker	789	(14.48)	42285	(10.5)
Body-mass index (BMI) in kg/m^2				
Mean (SD)	27.36	(4.82)	27.41	(4.77)
Townsend deprivation index				
Mean (SD)	-1.52	(2.96)	-1.47	(2.99)
Autoimmune or chronic inflammatory condition	1033	(13.0)	50467	(12.4)
Any type of immune deficiency	1223	(0.3)	24	(0.3)
Cancer (prevalent or incident)	1069	(13.4)	52971	(13.1)

Included in genetic association analyses (N=7985)		
Human Herpes viruses	Seropositive	(%)
Cytomegalovirus (CMV)	4437	(56.2)
CMV pp28	4461	(56.5)
CMV pp52	5000	(63.3)
CMV pp150	4526	(57.3)
Epstein-Barr virus (EBV)	7470	(94.6)
EBV EA-D	6806	(86.2)
EBV EBNA	7003	(88.7)
EBV VCA p18	7492	(94.9)
EBV ZEBRA	7197	(91.2)
Human Herpesvirus-6 (HHV6)	7156	(90.6)
HHV6 IE1A	6077	(77.0)
HHV6 IE1B	6237	(79.0)
HHV6 p101 k	6188	(78.4)
Human Herpesvirus-7 (HHV7) U14	7481	(94.8)
Herpes Simplex virus-1 (HSV1) 1gG	5468	(69.3)
Herpes Simplex virus-2 (HSV2) 2mgG	1214	(15.4)
Kaposi’s Sarcoma-Associated Herpesvirus (KSHV)	607	(7.7)
KSHV K.81	219	(2.8)
KSHV LANA	432	(5.5)
VZV gE/Ig	7316	(92.3)

Human Polyomaviruses		
BKV	7523	(95.3)
JCV	4471	(56.6)
Merkel Cell Polyomavirus (MCV)	5219	(66.1)
Human Papillomaviruses		
HPV16 E6 or E7 (oncoproteins)	371	(4.7)
HPV16 L1	341	(4.3)
HPV18 L1	190	(2.4)
Hepatitis viruses		
Hepatitis B (HBV)	128	(1.6)
HBV HBc	158	(2.0)
HBV HBe	423	(5.4)
Hepatitis C (HCV)	23	(0.3)
HCV Core	164	(2.1)
HCV NS3	104	(1.3)
Human T-lymphotropic viruses		
Human T-lymphotropic Virus-1 (HTLV1)	128	(1.6)
HTLV1 env	70	(0.9)
HTLV1 gag	59	(0.3)

Supplementary Table 2: Baseline characteristics of UK Biobank participants with available results for SARS-CoV-2 testing up to April 14, 2020

	Tested for SARS-CoV-2						Not Tested	
	Negative: 805		Positive: 669		Total: 1474		Total: 501,062	
Participant-level characteristics	N	(%)	N	(%)	N	(%)	N	(%)
Age at assessment								
Mean (SD)	57.89	(8.68)	57.47	(8.67)	57.70	(8.68)	56.53	(8.09)
Sex								
Male	409	(50.8)	378	(56.5)	787	(53.4)	228347	(45.6)
Self-reported ethnicity								
White	741	(92.0)	565	(84.5)	1306	(88.6)	471419	(94.1)
Mixed (White, Black, Asian or other)	4	(0.5)	4	(0.6)	8	(0.5)	2950	(0.6)
Asian (Indian, Pakistani, Bangladeshi)	20	(2.5)	29	(4.3)	49	(3.3)	9833	(2.0)
Black (Caribbean, African, British, other)	22	(2.7)	46	(6.9)	68	(4.6)	7993	(1.6)
Chinese	0	(0)	4	(0.6)	4	(0.3)	1570	(0.3)
Other ethnic group	14	(1.7)	15	(2.2)	6	(0.4)	4530	(0.9)
Body-mass index (BMI) in kg/m^2								
Mean (SD)	28.33	(5.72)	29.15	(5.49)	28.70	(5.63)	27.43	(4.80)
Townsend deprivation index								
Mean (SD)	-0.33	(3.50)	0.05	(3.56)	-0.16	(3.53)	-1.30	(3.09)
Smoking status								
Never smoker	354	(44.1)	303	(45.9)	657	(44.9)	272880	(54.8)
Former smoker	307	(38.3)	285	(43.2)	592	(40.5)	172478	(34.6)
Current smoker	141	(17.6)	72	(10.9)	213	(14.6)	52766	(10.6)
Cigarette pack-years in smokers								
Mean (SD)	24.99	(15.52)	26.82	(18.32)	25.80	(16.84)	21.47	(13.77)
Alcohol intake frequency								
Never / non-drinker	85	(10.6)	84	(12.6)	169	(11.5)	40479	(8.1)
Special occasions only	114	(14.2)	97	(14.6)	211	(14.4)	57801	(11.6)
1-3 times a month	86	(10.7)	86	(12.9)	172	(11.7)	55686	(11.1)
1-2 times per week	191	(23.8)	157	(23.6)	348	(23.7)	128949	(25.8)
3-4 times per week	159	(19.8)	128	(19.2)	287	(19.6)	115158	(23.1)
Daily or almost daily	168	(20.9)	113	(17.0)	281	(19.1)	101493	(20.3)
Weekly alcohol intake (gr)								
Mean (SD)	153.25	(187.34)	142.32	(191.00)	148.30	(189.02)	146.58	(170.30)
UK Biobank assessment center								
Stockport (pilot)	9	(1.1)	12	(1.8)	21	(1.4)	3776	(0.8)
Manchester	30	(3.7)	25	(3.7)	55	(3.7)	13884	(2.8)
Oxford	28	(3.5)	15	(2.2)	43	(2.9)	14015	(2.8)
Cardiff	0	(0.0)	0	(0.0)	0	(0.0)	17878	(3.6)
Glasgow	0	(0.0)	0	(0.0)	0	(0.0)	18647	(3.7)
Edinburgh	0	(0.0)	0	(0.0)	0	(0.0)	17198	(3.4)

Stoke	31	(3.9)	16	(2.4)	47	(3.2)	19386	(3.9)
Reading	37	(4.6)	27	(4.0)	64	(4.3)	29347	(5.9)
Bury	37	(4.6)	36	(5.4)	73	(5.0)	28248	(5.6)
Newcastle	95	(11.8)	72	(10.8)	167	(11.3)	36835	(7.4)
Leeds	12	(1.5)	46	(6.9)	58	(3.9)	44140	(8.8)
Bristol	68	(8.4)	35	(5.2)	103	(7.0)	42909	(8.6)
Barts	30	(3.7)	32	(4.8)	62	(4.2)	12520	(2.5)
Nottingham	68	(8.4)	39	(5.8)	107	(7.3)	33769	(6.7)
Sheffield	92	(11.4)	51	(7.6)	143	(9.7)	30253	(6.0)
Liverpool	76	(9.4)	63	(9.4)	139	(9.4)	32677	(6.5)
Middlesborough	58	(7.2)	24	(3.6)	82	(5.6)	21204	(4.2)
Hounslow	44	(5.5)	56	(8.4)	100	(6.8)	28775	(5.7)
Croydon	47	(5.8)	66	(9.9)	113	(7.7)	27267	(5.4)
Birmingham	43	(5.3)	54	(8.1)	97	(6.6)	25404	(5.1)
Swansea	0	(0.0)	0	(0.0)	0	(0.0)	2281	(0.5)
Wrexham	0	(0.0)	0	(0.0)	0	(0.0)	649	(0.1)
Forced expiratory volume in 1-sec (FEV_1) in L	2.70	(0.76)	2.72	(0.80)	2.71	(0.78)	2.84	(0.79)
Forced vital capacity (FVC) in L	3.61	(0.96)	3.61	(1.01)	3.61	(0.98)	3.74	(1.01)
FEV_1/FVC	0.75	(0.08)	0.76	(0.08)	0.75	(0.08)	0.76	(0.07)
Charlson comorbidity index								
0	397	(49.3)	340	(50.8)	737	(50.0)	351798	(70.2)
1-2	289	(35.9)	245	(36.6)	534	(36.2)	126196	(25.2)
3-4	85	(10.6)	69	(10.3)	154	(10.4)	19100	(3.8)
5 or more	34	(4.2)	15	(2.2)	49	(3.3)	3968	(0.8)
Genetic association analyses								
European ancestry, pass quality control	633	(78.6)	480	(71.7)	1113	(75.5)	412692	(82.4)
Results from respiratory specimens	585	(72.7)	443	(64.7)	1028	(69.7)	-	-
Number of SARS-CoV-2 tests								
Tested once	421	(52.3)	239	(35.7)				
Tested multiple times	384	(47.7)	430	(64.3)				

Test-level characteristics: 2724 tests	Negative: 1564		Positive: 1160	
	N	(%)	N	(%)
Specimen type				
Respiratory	1388	(88.7)	1018	(87.8)
Serum	48	(3.1)	39	(3.4)
Unknown or other	128	(8.2)	103	(8.9)
Test origin				
Confirmed acute care / inpatient setting	750	(48.0)	451	(52.0)
Unknown	814	(38.9)	709	(61.1)

Supplementary Table 3: Odds ratios (OR) for lead variants associated with seropositivity for each antigen and SARS-Cov-2 test positive status. Linkage disequilibrium (LD) r^2 was calculated with respect to the lead variant for the continuous seroreactivity phenotype for the same antigen, if applicable.

Antigen		Chr	Position	Variant	Alleles		EAF	OR	P	Function	Nearest Gene	INFO	LD r^2 with Seroreactivity Variant	
					Effect	Other								
CMV	pp150	10	71789604	rs1181430303	CAAT	C	0.988	0.362	1.3×10^{-8}	intergenic	*RP11-262I2.2*	0.974	-	
EBV	EA-D	6	32447644	rs2395192	C	T	0.447	0.656	4.0×10^{-19}	intergenic	*HLA-DRB9*	0.983	rs34825357:	0.670
EBV	EBNA	6	32429303	rs9268848	G	A	0.449	1.598	1.2×10^{-18}	intronic	*HLA-DRB9*	0.992	rs9269233:	0.296
EBV	ZEBRA	6	32578323	rs17211342	A	G	0.542	0.623	1.6×10^{-15}	intergenic	*HLA-DRB1*	0.999	rs9274728:	0.388
HHV6	IE1B	4	111337175	rs72666167	G	A	0.952	1.588	3.2×10^{-8}	intronic	*ENPEP / ZNF969P*	0.950	-	
HHV6	p101k	6	31352446	rs7775759	G	A	0.730	0.785	2.1×10^{-8}	intergenic	*HLA-S*	1.000	-	
HSV2	2mgG	17	3707723	rs2116443	C	T	0.485	1.279	4.5×10^{-8}	upstream	*ITGAE*	0.993	-	
KSHV	K8.1	1	94134854	rs75175947	G	C	0.988	0.221	2.2×10^{-8}	intronic	*BCAR3*	0.924	-	
		7	67785001	rs553306098	ATATAT	A	0.983	0.242	4.1×10^{-8}	upstream	*LOC105375341*	0.790	-	
KSHV	LANA	22	19399297	rs138358091	A	C	0.983	0.344	1.2×10^{-8}	intronic	*HIRA*	0.938	-	
VZV	gE/Ig	6	32161034	rs3096688	C	T	0.301	0.701	3.7×10^{-8}	intronic	*GPSM3*	0.995	rs9273325:	0.076
HPV16	E6/E7	6	32573265	rs601148	G	T	0.805	0.603	3.3×10^{-9}	intergenic	*HLA-DRB1*	0.973	-	
		19	30611215	rs144341759	G	A	0.975	0.383	4.0×10^{-8}	intergenic	*CTC-448F2.6*	0.920	-	
HPV16	L1	9	1061974	rs200104414	A	ATG	0.981	0.295	4.9×10^{-8}	intergenic	*RPS27AP14*	0.822	-	
HPV18	L1	5	139338366	rs142237244	G	A	0.987	0.201	3.4×10^{-8}	intronic	*NRG2*	0.890	-	
		14	77060652	rs4243652	G	A	0.035	3.132	7.0×10^{-10}	intronic	*LOC105370576*	0.987	-	
		X	12493856	rs187318482	C	G	0.989	0.271	3.6×10^{-8}	intronic	*FRMPD4*	0.750	-	
HBV	HBc	19	22899930	rs111736095	C	T	0.984	0.217	8.3×10^{-9}	upstream	*CTC-457E21.9*	0.898	-	
HCV	Core	2	112655155	rs199913364	CAG	C	0.980	0.248	1.2×10^{-8}	upstream	*MERTK*	0.942	-	
		11	75259052	rs79794175	C	T	0.933	0.406	1.2×10^{-8}	intergenic	*SERPINH1*	1	-	
HCV	NS3	6	115406379	rs549795309	C	T	0.979	0.204	2.5×10^{-8}	intergenic	*RP11-282C5.1*	0.886	-	
		10	82580895	rs144432266	A	C	0.989	0.158	1.7×10^{-8}	intergenic	*FARSBP1*	0.874	-	
JCV	VP1	6	32577385	rs9271147	T	C	0.152	0.536	1.3×10^{-42}	intergenic	*HLA-DQA1*	0.998	rs9271525:	0.160
MCV	VP1	6	32621980	rs17613347	T	C	0.150	0.613	1.2×10^{-26}	intergenic	*HLA-DQB1*	0.995	rs9268847:	0.052
		5	138845045	rs1193730215	TTATC	T	0.259	1.259	7.2×10^{-9}	intergenic	*ECSCR*	0.985	rs7444313:	0.946
HTLV1[1]		9	15483425	rs16933318	G	C	0.990	0.153	3.3×10^{-8}	intronic	*PSIP1*	0.948	-	

[1] Case counts for HTLV1 env and HTLV1 gag antigens were <100, therefore results are presented for HTLV1 based on seropositivity for at least one antigen

Supplementary Table 4: Functional annotations for the top-ranking genetic variants associated with antibody response for antigens with at least 20% seroprevalence. Expression (eQTL) and splicing quantitative trait loci (sQTL) associations with FDR<0.05 were obtained in GTEx v8 and DICE (Database of Immune Cell Expression). Plasma protein (pQTL) associations with $P<5.0\times10^{-8}$ were obtained from the Human Plasma Proteome atlas.

Phenotype		Chr	Position	Variant	Alleles		CADD[1]	RegulomeDB		eQTL (GTEx)		eQTL (DICE)		sQTL (GTEx)	pQTL
					Effect	Other		Score[2]	Rank[3]	Genes	Tissues	Genes	Cells	Genes	Proteins
CMV	pp52	6	32301427	rs115378818	C	T	4.55	0.29	5	-	-	-	-	-	-
EBV	EA-D	6	32665840	rs34825357	T	TC	10.63	0.63	5	25	49	-	-	-	12
EBV	EBNA	3	151114852	rs67886110	G	T	1.55	0.20	6	2	29	1	1	-	-
		6	32451762	rs9269233	A	C	0.60	0.13	5	27	48	4	10	13	4
EBV	p18	6	31486158	6:31486158	GT	G	0.02	-	-	-	-	1	5		-
EBV	ZEBRA	6	32637772	rs9274728	A	G	7.92	0.95	5	22	49	8	15	9	5
HHV6	IE1A	7	139985625	rs2429218	T	C	0.64	0.61	4	1	1	-	-	-	-
HHV7	U14	6	32602665	rs139299944	C	CT	12.15	0.72	5	15	48	-	-	9	-
		11	118767564	rs75438046	G	A	7.00	0.61	4	2	6	-	-		-
		17	45794706	rs1808192	A	G	4.18	0.55	1f	6	35	2	11	5	-
HSV1	1gG	6	32627852	rs1130420	G	A	9.73	0.74	2b	-	-	8	15	-	2
		10	91189187	rs11203123	A	C	1.41	0.53	5	-	-	-	-	-	-
VZV	gE/Ig[1]	6	32623193	rs9273325	G	A	4.91	0.13	5	-	-	1	1	-	15
BKV	VP1	19	49206462	rs681343	C	T	0.06	0.13	5	8	40	1	7	3	16
JCV	VP1	6	32589842	rs9271525	G	A	10.73	0.15	3a	35	49	8	15	14	4
MCV	VP1	3	18238783	rs776170649	CT	C	15.61	0.35	6	-	-	-	-	-	-
		5	138865423	rs7444313	G	A	1.89	0.36	6	7	31	-	-	3	-
		6	32429277	rs9268847	A	G	5.57	0.18	7	16	28	-	-	8	-
SARS-CoV-2		18	13466908	rs7231584	G	A	3.54	0.88	2b	1	14	-	-	-	-

[1] Combined Annotation Dependent Depletion (CADD) score: >10 corresponds to the top 10% most deleterious substitutions in the genome

[2] Score: ranges from 0 to 1, with 1 being most likely to be a regulatory variant. This score is based on a model that integrates functional genomics features with continuous values such as ChIP-seq signal, DNase-seq signal, information content change, and DeepSEA scores

[3] Rank: 1f = eQTL + TF binding / DNase peak; 2b = TF binding + any motif + DNase Footprint + DNase peak; 3a = TF binding + any motif + DNase peak; 4= TF binding + DNase peak; 5= TF binding or DNase peak; 6 or greater = minimal evidence

Supplementary Table 5: Significant effects ($P<5.0\times10^{-8}$) on plasma protein levels (pQTL) observed for lead genome-wide significant variants for viral antigen antibody response using data from the Human Plasma Proteome atlas.

Phenotype	Variant	Target Protein	P_{pQTL}	Source Dataset [PMID]
EBV EA-D	rs34825357	Glutamate receptor 4	1.5×10^{-28}	Sun et al. [29875488]
		T-cell surface protein tactile	6.5×10^{-21}	
		Complement C4	1.2×10^{-20}	
		cAMP-specific 3,5-cyclic phosphodiesterase 4D	2.8×10^{-20}	
		HLA class II histocompatibility antigen, DQ alpha 2 chain	1.1×10^{-19}	
		Vesicle-fusing ATPase	5.9×10^{-12}	
		Beta-defensin 119	1.0×10^{-10}	
		Killer cell immunoglobulin-like receptor 2DS2	4.0×10^{-10}	
		Interleukin-21	4.6×10^{-10}	
		GDH/6PGL endoplasmic bifunctional protein	5.9×10^{-10}	
		MHC class I polypeptide-related sequence B	8.3×10^{-10}	
		Trypsin-3	2.9×10^{-8}	
EBV EBNA	rs9269233	HLA class II histocompatibility antigen, DQ alpha 2 chain	2.0×10^{-21}	Sun et al. [29875488]
		GDH/6PGL endoplasmic bifunctional protein	3.2×10^{-13}	
		Killer cell immunoglobulin-like receptor 2DS2	1.3×10^{-10}	
		Ameloblastin	3.7×10^{-8}	
EBV ZEBRA	rs9274728	Complement C4	6.9×10^{-16}	Sun et al. [29875488]
		MHC class I polypeptide-related sequence B	6.6×10^{-11}	
		Interleukin-21	2.2×10^{-10}	
		Ubiquitin carboxyl-terminal hydrolase 25	8.9×10^{-10}	
		T-cell surface protein tactile	3.8×10^{-8}	
HSV1	rs1130420	Trypsin-3	7.2×10^{-15}	Sun et al. [29875488]
		Rac GTPase-activating protein 1	1.7×10^{-13}	
VZV	rs9273325	HLA class II histocompatibility antigen, DQ alpha 2 chain	4.9×10^{-38}	Sun et al. [29875488]
		Glutamate receptor 4	6.8×10^{-26}	
		cAMP-specific 3,5-cyclic phosphodiesterase 4D	1.7×10^{-24}	
		MHC class I polypeptide-related sequence B	8.3×10^{-22}	
		Complement C4	2.0×10^{-18}	
		T-cell surface protein tactile	7.6×10^{-16}	
		Trypsin-3	2.0×10^{-13}	
		Rac GTPase-activating protein 1	4.5×10^{-11}	
		Beta-defensin 119	3.6×10^{-10}	
		Interleukin-21	1.9×10^{-9}	
		Tenascin-X	2.0×10^{-9}	
		Ubiquitin-like protein ISG15	3.9×10^{-9}	
		Palmitoyl-protein thioesterase 1	4.5×10^{-9}	
		Polypeptide N-acetylgalactosaminyltransferase 1	4.6×10^{-9}	
		Coiled-coil domain-containing protein 134	4.6×10^{-8}	

BKV	rs681343	Protein FAM3D	1.8×10^{-110}	Sun et al. [29875488]
		Golgi membrane protein 1	1.5×10^{-28}	
		C-C motif chemokine 15	2.2×10^{-27}	
		Transcobalamin-1	1.8×10^{-21}	
		Secreted and transmembrane protein 1	7.2×10^{-20}	
		Lithostathine-1-alpha	2.3×10^{-18}	Yao et al. [30111768]
		Protein FAM177A1	5.5×10^{-18}	Sun et al. [29875488]
		Galactoside 3(4)-L-fucosyltransferase	4.0×10^{-16}	
		Intestinal-type alkaline phosphatase	1.3×10^{-15}	
		C-C motif chemokine 25	1.4×10^{-13}	
		Fibroblast growth factor 19 (FGF19)	2.6×10^{-13}	
		BPI fold-containing family B member 1 (BPIFB1)	5.4×10^{-10}	
		N-acetyllactosaminide beta-1,3-N-acetylglucosaminyltransferase 2 (FUT3)	6.8×10^{-9}	Sun et al. [29875488]
		Lactase-phlorizin hydrolase	1.2×10^{-8}	
		Tissue factor	8.7×10^{-9}	Folkersen et al. [28369058]
		Stromelysin-2	3.5×10^{-8}	
JCV	rs9271525	GDH/6PGL endoplasmic bifunctional protein	4.2×10^{-26}	Sun et al. [29875488]
		Killer cell immunoglobulin-like receptor 2DS2	2.2×10^{-11}	
		Osteocalcin	6.5×10^{-9}	
		Complement factor B	3.1×10^{-8}	

Supplementary Table 6: Odds ratios (OR) for the effect of lead seroreactivity variants on selected cancers, schizophrenia, and Alzheimer's disease (AD). Associations with $P<7.3\times10^{-4}$ were considered statistically significant after Bonferroni correction for the number of genetic variants and phenotypes tested.

Antigen		Chr	Position	Variant	Alleles		Effect on antibody response (MFI)		Hematologic cancers[1] 3262 cases / 410,350 controls		Melanoma 6777 cases / 410,350 controls		Schizophrenia[2] 33,640 cases / 43,456 controls		AD[3] 17,536 cases / 53,711 controls
					Effect	Other	Beta	(SE)	OR	P	OR	P	OR	P	P
CMV	pp52	6	32301427	rs115378818	C	T	0.633	(0.095)	0.809	0.058	0.886	0.12	0.989	0.84	0.44
EBV	EA-D	6	32665840	rs34825357†	T	TC	-0.114	(0.017)	0.978	0.45	1.054	0.017	0.960	2.7×10^{-4}	0.75
EBV	EBNA	3	151114852	rs67886110*	G	T	0.103	(0.017)	0.960	0.11	0.993	0.68	1.023	0.037	0.068
		6	32451762	rs9269233†	A	C	0.315	(0.019)	0.878	2.7×10^{-4}	1.078	2.8×10^{-3}	1.034	6.2×10^{-3}	0.28
EBV	VCA p18	6	31486158	6:31486158†	GT	G	0.197	(0.018)	0.921	6.1×10^{-3}	0.993	0.75	1.030	0.020	0.016
EBV	ZEBRA	6	32637772	rs9274728	A	G	-0.315	(0.018)	0.975	0.35	1.060	3.3×10^{-3}	0.993	0.59	1.7×10^{-3}
HHV6	IE1A	7	139985625	rs2429218	T	C	0.106	(0.019)	1.035	0.19	0.990	0.58	1.024	0.041	0.24
HHV7	U14	6	32602665	rs139299944	C	CT	0.114	(0.017)	1.079	4.1×10^{-3}	0.986	0.43	0.990	0.38	-
		11	118767564	rs75438046	G	A	0.280	(0.049)	0.913	0.22	0.919	0.11	0.955	0.18	4.1×10^{-3}
		17	45794706	rs1808192†	A	G	-0.099	(0.017)	0.989	0.69	0.981	0.32	1.000	0.99	0.029
HSV1	1gG	6	32627852	rs1130420†	G	A	-0.122	(0.019)	0.888	3.5×10^{-6}	1.023	0.22	1.055	1.8×10^{-5}	1.2×10^{-4}
		10	91189187	rs11203123*†	A	C	0.512	(0.093)	0.948	0.71	0.966	0.75	0.985	0.70	0.85
VZV	gE/Ig[1]	6	32623193	rs9273325	G	A	-0.232	(0.021)	0.876	4.4×10^{-5}	0.965	0.12	1.131	4.3×10^{-15}	0.16
BKV	VP1	19	49206462	rs681343	C	T	-0.125	(0.016)	1.004	0.87	1.037	0.040	0.960	2.5×10^{-4}	0.16
JCV	VP1	6	32589842	rs9271525	G	A	-0.318	(0.031)	0.925	0.026	1.015	0.53	1.060	6.8×10^{-5}	4.7×10^{-3}
MCV	VP1	3	18238783	rs776170649†	CT	C	-0.134	(0.024)	1.006	0.86	0.975	0.23	1.045	9.0×10^{-4}	0.83
		5	138865423	rs7444313	G	A	0.169	(0.021)	0.957	0.13	1.026	0.21	1.019	0.12	0.033
		6	32429277	rs9268847	A	G	-0.195	(0.022)	1.018	0.54	0.949	8.3×10^{-3}	0.968	8.4×10^{-3}	0.14

[1] Cancer types included: non-Hodgkin lymphoma and lymphocytic leukemia

[2] Estimates obtained from a meta-analysis of the UK Biobank and Genetic Epidemiology Research on Aging cohorts [Rashkin et al. (2019) *bioRxiv* 635367]

[3] Summary statistics for European ancestry subjects were obtained from Lam, Chen et al. *Nat Genet.* (2019) 51(12):1670-1678 [PMID: 31740837]

[4] Summary statistics obtained from Jun et al. *Mol Psychiatry.* (2016) 21(1):108-17 [PMID: 25778476]

† Proxies for unavailable variants: rs2647006 for rs34825357 (schizophrenia and AD; LD r^2=0.99); rs7755774 for rs9269233 (AD; LD r^2=0.71); rs3093986 for 6:31486158_GT_G (AD; LD r^2=0.74); rs7219420 for rs1808192 (AD; LD r^2=0.87); rs4713572 for rs1130420 (AD; LD r^2=0.91); rs11203124 for rs11203123 (AD; LD r^2=1.00); rs7618405 for rs776170649 (AD; LD r^2=0.99)

* Multi-allelic variants: rs67886110 (G/T and G/C) and rs11203123 (A/C and A/AC)

Supplementary Table 7: Independent sentinel variants in the HLA region identified by clumping (LD r^2<0.05 ±500kb) associations with $P<5\times10^{-8}$ for each antigen response phenotype.

Antigen	Chr	Position	Variant	Alleles		EAF	Beta	(SE)	P	INFO	Clump Size[1]
				Effect	Other						
CMV pp52	6	32301427	rs115378818	C	T	0.986	0.633	(0.095)	2.8×10^{-11}	0.731	2
EBV EA-D	6	32665840	rs34825357	T	TC	0.409	-0.114	(0.017)	2.0×10^{-11}	0.998	779
	6	31451370	rs3132470	A	G	0.855	0.159	(0.024)	3.4×10^{-11}	1.000	207
	6	29842444	rs1611657	G	A	0.458	0.105	(0.017)	6.9×10^{-10}	0.996	19
	6	32583876	rs117503706	G	A	0.986	-0.423	(0.072)	4.8×10^{-9}	0.912	15
	6	30764907	rs1264377	G	A	0.818	0.119	(0.022)	4.7×10^{-8}	1	0
EBV EBNA	6	32451762	rs9269233	A	C	0.249	0.315	(0.019)	3.5×10^{-61}	0.961	3885
	6	32628432	rs9273507	A	G	0.570	0.167	(0.017)	7.5×10^{-23}	0.994	228
	6	31884823	rs3130682	T	C	0.148	0.220	(0.023)	3.0×10^{-21}	0.993	269
	6	32390436	rs143810596	T	G	0.977	-0.538	(0.058)	1.3×10^{-20}	0.989	51
	6	31297772	rs9265517	C	T	0.233	0.172	(0.020)	4.5×10^{-18}	0.975	967
	6	33048628	rs1042136	A	C	0.838	0.176	(0.023)	1.3×10^{-14}	0.991	158
	6	31835164	rs693906	G	C	0.842	0.177	(0.023)	2.0×10^{-14}	0.984	130
	6	31892641	rs9267677	T	C	0.905	0.206	(0.028)	3.6×10^{-13}	1	58
	6	32201469	rs41315395	C	A	0.855	-0.167	(0.023)	1.2×10^{-12}	0.997	3
	6	32387809	rs2395163	T	C	0.779	0.144	(0.020)	2.0×10^{-12}	1	25
	6	29822779	6:29822779	AAAAC	A	0.365	0.114	(0.017)	4.1×10^{-11}	0.999	113
	6	33083096	rs6457714	T	A	0.789	-0.132	(0.020)	6.8×10^{-11}	0.997	35
	6	32609147	rs12722051	A	T	0.795	0.127	(0.021)	1.3×10^{-9}	0.989	7
	6	31198786	rs3130935	A	G	0.621	0.098	(0.017)	1.5×10^{-8}	1.000	7
	6	32623017	rs28468461	T	C	0.969	-0.256	(0.046)	2.9×10^{-8}	0.993	0
	6	32542378	rs116206645	T	A	0.979	0.403	(0.074)	5.0×10^{-8}	0.699	0
EBV p18	6	31486158	6:31486158	GT	G	0.245	0.197	(0.018)	7.1×10^{-27}	0.994	1651
	6	32589978	rs9271536	A	T	0.179	0.200	(0.020)	3.9×10^{-23}	0.999	2455
	6	32069806	rs3096695	G	C	0.145	0.208	(0.022)	1.6×10^{-20}	0.997	16
	6	30921417	6:30921417	GA	G	0.119	0.165	(0.025)	2.7×10^{-11}	0.975	42
	6	30727983	rs3095339	A	G	0.722	0.112	(0.017)	7.3×10^{-11}	1.000	24
	6	32797876	rs241436	A	G	0.549	0.099	(0.016)	2.4×10^{-10}	1	2
	6	31379391	rs3828879	C	T	0.876	0.147	(0.024)	5.1×10^{-10}	1.000	3
	6	32206539	rs3134937	C	T	0.751	0.112	(0.018)	6.3×10^{-10}	0.981	20
	6	33073440	rs2064475	G	A	0.768	0.111	(0.019)	2.2×10^{-9}	1.000	21
	6	32045864	rs781341398	GAA	G	0.966	-0.277	(0.046)	2.7×10^{-9}	0.922	2
	6	32754876	rs116309362	T	C	0.976	-0.335	(0.057)	3.5×10^{-9}	0.895	1
	6	26370707	rs9379862	T	C	0.743	0.103	(0.018)	5.6×10^{-9}	1.000	1
	6	31448564	rs3099843	G	T	0.855	0.126	(0.022)	1.1×10^{-8}	1.000	12
	6	31362207	rs1052409	T	C	0.845	0.125	(0.022)	1.2×10^{-8}	0.978	7
	6	28039586	rs4713135	G	A	0.761	0.102	(0.019)	3.4×10^{-8}	1	0
	6	32637772	rs9274728	A	G	0.718	-0.315	(0.018)	4.7×10^{-67}	0.995	3836

EBV ZEBRA	6	32045864	rs781341398	GAA	G	0.966	-0.428	(0.048)	5.1×10^{-19}	0.922	20
	6	32211085	rs412657	T	G	0.622	0.145	(0.017)	1.0×10^{-17}	1	321
	6	32774954	rs6917611	G	C	0.608	0.142	(0.017)	1.9×10^{-17}	1.000	198
	6	32634588	rs113140854	C	T	0.983	-0.534	(0.067)	1.5×10^{-15}	0.827	253
	6	31672242	rs28366157	A	G	0.937	-0.266	(0.034)	2.3×10^{-15}	0.997	374
	6	31418810	rs3131623	T	A	0.817	0.167	(0.021)	2.6×10^{-15}	0.992	610
	6	29923351	rs2904758	G	A	0.280	0.144	(0.018)	5.0×10^{-15}	0.990	97
	6	32635948	rs541213498	C	T	0.987	-0.586	(0.078)	4.8×10^{-14}	0.780	5
	6	32626702	rs35779483	A	G	0.693	-0.135	(0.018)	6.1×10^{-14}	0.999	33
	6	30820373	rs2263298	C	T	0.849	0.154	(0.023)	2.4×10^{-11}	1.000	200
	6	33017502	rs3130177	G	A	0.717	-0.121	(0.018)	3.1×10^{-11}	0.996	5
	6	31150844	rs138206303	A	AGT	0.883	-0.167	(0.025)	4.8×10^{-11}	0.975	22
	6	31928799	rs419788	T	C	0.324	-0.113	(0.017)	1.0×10^{-10}	1	8
	6	32581008	rs3129747	T	C	0.698	-0.108	(0.018)	1.2×10^{-9}	0.989	8
	6	30434999	rs2516670	G	A	0.160	0.132	(0.022)	3.3×10^{-9}	1	2
	6	33045823	rs2073520	A	G	0.868	0.145	(0.025)	5.7×10^{-9}	0.972	1
	6	32707395	rs28371351	G	A	0.988	-0.519	(0.095)	4.2×10^{-8}	0.647	0
HHV7	6	32602665	rs139299944	C	CT	0.655	0.114	(0.017)	1.5×10^{-11}	0.998	437
HSV1	6	32627852	rs1130420	G	A	0.583	-0.122	(0.019)	2.5×10^{-10}	0.976	61
VZV	6	32623193	rs9273325	G	A	0.831	-0.232	(0.021)	8.2×10^{-28}	0.998	2708
	6	31323506	rs4990036	C	T	0.851	-0.240	(0.023)	4.5×10^{-26}	0.997	972
	6	32014828	rs433061	G	A	0.869	-0.249	(0.024)	6.5×10^{-26}	0.999	69
	6	30743729	rs3130668	G	A	0.855	-0.228	(0.023)	1.9×10^{-22}	0.978	271
	6	29986324	rs3115631	T	A	0.873	-0.229	(0.025)	4.1×10^{-20}	0.955	1442
	6	29356331	rs9257809	A	G	0.875	-0.216	(0.024)	1.5×10^{-18}	1	147
	6	28734676	rs1233604	G	A	0.882	-0.215	(0.025)	2.5×10^{-17}	1	291
	6	28214698	rs17720293	C	T	0.866	-0.191	(0.024)	2.1×10^{-15}	1	192
	6	27556141	rs13201294	A	T	0.870	-0.182	(0.024)	7.1×10^{-14}	0.996	94
	6	26743531	rs13211434	G	C	0.878	-0.188	(0.025)	1.1×10^{-13}	0.938	241
	6	26189356	rs13204572	G	C	0.896	-0.166	(0.027)	5.8×10^{-10}	0.996	37
	6	32589842	rs9271525	G	A	0.163	-0.137	(0.022)	1.0×10^{-9}	0.977	229
	6	30020252	rs546626159	A	ATT	0.749	0.108	(0.020)	3.0×10^{-8}	0.968	0
JCV	6	32589842	rs9271525	G	A	0.163	-0.318	(0.031)	3.9×10^{-24}	0.977	2335
	6	32080146	rs3130342	A	C	0.149	-0.245	(0.032)	1.3×10^{-14}	1	43
	6	31574306	rs372079459	T	TAA	0.198	-0.163	(0.028)	5.0×10^{-9}	0.972	2
MCV	6	32429277	rs9268847	A	G	0.750	-0.195	(0.022)	2.4×10^{-19}	0.995	2450
	6	32760665	rs113322198	C	CACTT	0.224	-0.196	(0.024)	2.3×10^{-16}	0.996	328
	6	32232358	rs9268070	T	C	0.149	-0.216	(0.029)	5.0×10^{-14}	0.999	38
	6	29924127	rs148584120	T	C	0.958	0.375	(0.052)	7.7×10^{-13}	0.972	160
	6	30475514	6:30475514	TGTGC	T	0.959	0.320	(0.052)	9.6×10^{-10}	0.966	10
	6	31561211	rs2736190	T	C	0.269	-0.134	(0.022)	2.1×10^{-9}	0.993	5
	6	27763714	rs76148407	C	G	0.966	0.299	(0.055)	4.8×10^{-8}	0.971	0

Supplementary Table 8: Conditionally independent genome-wide significant ($P_{cond}<5\times10^{-8}$) variants in the HLA identified through forward iterative conditional analyses for each antigen response phenotype.

Antigen	Round[1]	Chr	Position	Variant	Alleles		EAF	Beta	(SE)	P_{cond}	INFO
					Effect	Other					
EBV EBNA	0	6	32451762	rs9269233	A	C	0.249	0.315	(0.019)	3.5×10^{-61}	0.961
	1	6	32602665	rs139299944	C	CT	0.655	-0.160	(0.017)	5.9×10^{-21}	0.998
	2	6	33045272	rs6457711	C	A	0.752	-0.129	(0.019)	1.3×10^{-11}	0.994
	3	6	32626019	rs9273358	C	T	0.548	0.110	(0.017)	9.0×10^{-11}	0.996
	4	6	32626451	rs28414666	G	A	0.789	0.221	(0.035)	4.8×10^{-10}	0.997
	5	6	33047612	rs3097671	G	C	0.835	0.133	(0.022)	2.1×10^{-9}	1
EBV ZEBRA	0	6	32637772	rs9274728	A	G	0.718	-0.315	(0.018)	4.7×10^{-67}	0.995
	1	6	29923351	rs2904758	G	A	0.280	0.115	(0.018)	2.2×10^{-10}	0.990
	2	6	33034507	rs35683320	G	A	0.825	0.129	(0.022)	1.9×10^{-9}	0.982
	3	6	32783405	rs1383258	C	T	0.962	0.235	(0.042)	3.3×10^{-8}	1.000
EBV p18	0	6	31486158	6:31486158	GT	G	0.245	0.197	(0.018)	7.1×10^{-27}	0.994
	1	6	31247169	rs6917363	G	A	0.431	0.102	(0.016)	2.7×10^{-10}	0.999
	2	6	32582513	rs9271325	C	G	0.527	0.099	(0.016)	7.3×10^{-10}	1.000
	3	6	31356536	rs66479476	A	G	0.784	0.110	(0.020)	3.9×10^{-8}	0.963
MCV	0	6	32429277	rs9268847	A	G	0.750	-0.195	(0.022)	2.4×10^{-19}	0.995
	1	6	29924127	rs148584120	T	C	0.958	0.350	(0.052)	1.6×10^{-11}	0.972
	2	6	32797488	rs4148874	C	T	0.264	-0.158	(0.022)	1.1×10^{-12}	1
EBV EA-D	0	6	32665840	rs34825357	T	TC	0.409	-0.114	(0.017)	2.0×10^{-11}	0.998
	1	6	32655730	rs3129783	A	G	0.471	0.100	(0.017)	8.4×10^{-9}	0.980
CMV pp52	0	6	32301427	rs115378818	C	T	0.978	0.633	(0.095)	2.8×10^{-11}	0.731
HHV7	0	6	32602665	rs139299944	C	CT	0.655	0.114	(0.017)	1.5×10^{-11}	0.998
HSV1	0	6	32627852	rs1130420	G	A	0.583	-0.122	(0.019)	2.5×10^{-10}	0.976
VZV	0	6	32589842	rs9271525	G	A	0.831	-0.318	(0.031)	3.9×10^{-24}	0.977
JCV	0	6	32623193	rs9273325	G	A	0.163	-0.232	(0.021)	8.2×10^{-28}	0.998

[1] Conditional analysis round. Round 0 corresponds to results from unconditional analyses (not adjusted for any SNPs/indels).

Supplementary Table 9: Forty independent sentinel variants in the HLA region identified by clumping (LD $r^2<0.05$ ±500kb) associations with $P<5\times10^{-8}$ across 10 antigen response phenotypes.

Primary Phenotype	Chr	Position	Variant	Alleles		EAF	Beta	(SE)	P	INFO	Clump Size[1]
				Effect	Other						
EBV ZEBRA	6	32637772	rs9274728	G	A	0.718	-0.315	(0.018)	4.7×10^{-67}	0.995	14065
EBV EBNA	6	32633879	rs9274490	G	A	0.742	0.259	(0.019)	1.6×10^{-40}	0.997	4788
EBV EBNA	6	32608521	rs6907155	A	C	0.907	-0.317	(0.029)	2.9×10^{-27}	0.945	152
EBV p18	6	31486158	6:31486158	G	GT	0.245	0.197	(0.018)	7.1×10^{-27}	0.994	4087
VZV	6	31323506	rs4990036	T	C	0.851	-0.240	(0.023)	4.5×10^{-26}	0.997	1022
VZV	6	32014828	rs433061	A	G	0.869	-0.249	(0.024)	6.5×10^{-26}	0.999	323
VZV	6	30743729	rs3130668	A	G	0.855	-0.228	(0.023)	1.9×10^{-22}	0.978	509
EBV EBNA	6	32006317	rs6468	T	C	0.197	0.195	(0.021)	1.4×10^{-20}	0.963	353
VZV	6	29986324	rs3115631	A	T	0.873	-0.229	(0.025)	4.1×10^{-20}	0.955	1499
EBV ZEBRA	6	32045864	rs781341398	G	GAA	0.966	-0.428	(0.048)	5.1×10^{-19}	0.922	9
VZV	6	29356331	rs9257809	G	A	0.875	-0.216	(0.024)	1.5×10^{-18}	1	147
EBV p18	6	32786917	rs3763354	A	G	0.225	0.160	(0.018)	4.6×10^{-18}	1	687
VZV	6	28734676	rs1233604	A	G	0.882	-0.215	(0.025)	2.5×10^{-17}	1	291
EBV ZEBRA	6	32634588	rs113140854	T	C	0.983	-0.534	(0.067)	1.5×10^{-15}	0.827	257
VZV	6	28214698	rs17720293	T	C	0.866	-0.191	(0.024)	2.1×10^{-15}	1	193
EBV ZEBRA	6	31672242	rs28366157	G	A	0.937	-0.266	(0.034)	2.3×10^{-15}	0.997	197
EBV EBNA	6	33048628	rs1042136	C	A	0.838	0.176	(0.023)	1.3×10^{-14}	0.991	185
MCV	6	32630837	6:32630837	T	G	0.891	-0.233	(0.030)	1.5×10^{-14}	0.959	162
EBV EBNA	6	32551368	rs138008524	G	A	0.985	-0.625	(0.081)	1.9×10^{-14}	0.666	0
EBV ZEBRA	6	32635948	rs541213498	T	C	0.987	-0.586	(0.078)	4.8×10^{-14}	0.780	2
VZV	6	27556141	rs13201294	T	A	0.870	-0.182	(0.024)	7.1×10^{-14}	0.996	94
VZV	6	26743531	rs13211434	C	G	0.878	-0.188	(0.025)	1.1×10^{-13}	0.938	243
EBV ZEBRA	6	29796768	rs1632940	C	T	0.227	0.145	(0.020)	2.3×10^{-13}	0.991	268
EBV EBNA	6	31892641	rs9267677	C	T	0.905	0.206	(0.028)	3.6×10^{-13}	1	53
EBV p18	6	30921417	6:30921417	G	GA	0.119	0.165	(0.025)	2.7×10^{-11}	0.975	40
EBV EBNA	6	32598090	rs1281943	C	T	0.913	0.211	(0.032)	4.0×10^{-11}	0.919	16
EBV ZEBRA	6	31150844	rs138206303	AGT	A	0.883	-0.167	(0.025)	4.8×10^{-11}	0.975	31
MCV	6	30364587	rs2516687	T	A	0.960	0.341	(0.052)	5.3×10^{-11}	1	26
EBV EBNA	6	33083096	rs6457714	A	T	0.789	-0.132	(0.020)	6.8×10^{-11}	0.997	39
VZV	6	32853288	rs2244447	G	C	0.592	-0.106	(0.017)	2.9×10^{-10}	0.995	3
EBV EBNA	6	32965942	rs176248	A	G	0.707	0.115	(0.018)	3.2×10^{-10}	1	1
EBV p18	6	31379391	rs3828879	T	C	0.876	0.147	(0.024)	5.1×10^{-10}	1.000	0
VZV	6	26189356	rs13204572	C	G	0.896	-0.166	(0.027)	5.8×10^{-10}	0.996	37
EBV EA-D	6	32583876	rs117503706	A	G	0.986	-0.423	(0.072)	4.8×10^{-9}	0.912	15
EBV EBNA	6	32587835	rs71542419	A	C	0.916	-0.168	(0.029)	9.5×10^{-9}	0.973	6
EBV p18	6	31362207	rs1052409	C	T	0.845	0.125	(0.022)	1.2×10^{-8}	0.978	7
EBV EBNA	6	32722961	rs71565347	A	G	0.983	0.374	(0.067)	2.7×10^{-8}	0.991	3

EBV ZEBRA	6	32707395	rs28371351	A	G	0.988	-0.519	(0.095)	4.2×10^{-8}	0.647	0
MCV	6	27763714	rs76148407	G	C	0.966	0.299	(0.055)	4.8×10^{-8}	0.971	0
EBV EBNA	6	32542378	rs116206645	A	T	0.979	0.403	(0.074)	5.0×10^{-8}	0.699	0

[1] Clump size refers to the number of non-independent (LD r^2>0.05) variants clumped together with the sentinel variant

Supplementary Table 10: Associations from conditional analyses of classical HLA alleles associated with EBV ZEBRA antigen response at the Bonferroni-corrected threshold of $P<5\times10^{-4}$. Independent alleles identified at each round are in bold.

Allele	Unconditional (Round 0)			Conditional Round 1			Conditional Round 2			Conditional Round 3			Conditional Round 4			Conditional Round 5		
	Beta	(SE)	P	Beta	(SE)	P_{cond}	Beta	(S)E	P_{cond}	Beta	(SE)	P_{cond}	Beta	(SE)	P_{cond}	Beta	(SE)	P_{cond}
DRB4*99:01	**-0.246**	**(0.017)**	**1.4×10^{-46}**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DQB1*04:02	0.415	(0.056)	1.3×10^{-13}	**0.504**	**(0.055)**	**1.0×10^{-19}**	-	-	-	-	-	-	-	-	-	-	-	-
DRB1*04:04	0.508	(0.042)	6.8×10^{-34}	0.378	(0.043)	1.1×10^{-18}	**0.376**	**(0.042)**	**1.1×10^{-18}**	-	-	-	-	-	-	-	-	-
DQA1*02:01	0.254	(0.023)	4.9×10^{-27}	0.096	(0.028)	6.3×10^{-4}	0.098	(0.028)	4.4×10^{-4}	**0.187**	**(0.029)**	**1.1×10^{-10}**	-	-	-	-	-	-
A*03:01	0.107	(0.024)	6.2×10^{-6}	0.125	(0.023)	8.4×10^{-8}	0.128	(0.023)	3.2×10^{-8}	0.125	(0.023)	5.8×10^{-8}	**0.129**	**(0.023)**	**1.9×10^{-8}**	-	-	-
DRB3*99:01	0.202	(0.017)	7.4×10^{-32}	0.100	(0.020)	6.7×10^{-7}	0.067	(0.020)	9.5×10^{-4}	0.063	(0.020)	2.0×10^{-3}	0.060	(0.020)	2.7×10^{-3}	0.043	(0.020)	0.036
DRB1*07:01	0.251	(0.023)	1.3×10^{-26}	0.093	(0.028)	9.2×10^{-4}	0.094	(0.028)	7.1×10^{-4}	0.184	(0.029)	2.4×10^{-10}	-0.038	(0.185)	0.84	-0.050	(0.184)	0.79
DQB1*02:02	0.300	(0.030)	4.5×10^{-23}	0.128	(0.034)	1.5×10^{-4}	0.135	(0.034)	6.1×10^{-5}	0.217	(0.034)	2.8×10^{-10}	0.115	(0.053)	0.029	0.120	(0.053)	0.022
DRB4*01:01	0.293	(0.030)	7.9×10^{-22}	0.137	(0.033)	3.2×10^{-5}	0.139	(0.033)	2.3×10^{-5}	0.200	(0.033)	1.9×10^{-9}	0.114	(0.040)	4.7×10^{-3}	0.112	(0.040)	5.7×10^{-3}
DQB1*03:02	0.251	(0.027)	5.2×10^{-21}	0.103	(0.029)	4.4×10^{-4}	0.107	(0.029)	2.6×10^{-4}	-0.057	(0.035)	0.10	0.060	(0.040)	0.13	0.057	(0.040)	0.15
DRB4*01:03	0.173	(0.019)	7.0×10^{-20}	-0.142	(0.032)	1.1×10^{-5}	-0.144	(0.032)	8.1×10^{-6}	-0.194	(0.032)	2.2×10^{-9}	-0.112	(0.039)	3.9×10^{-3}	-0.110	(0.039)	4.7×10^{-3}
DQA1*05:01	-0.169	(0.019)	5.7×10^{-18}	-0.067	(0.021)	1.4×10^{-3}	-0.043	(0.021)	0.043	-0.039	(0.021)	0.066	-0.038	(0.021)	0.074	-0.019	(0.021)	0.36
DQA1*03:01	0.168	(0.020)	1.3×10^{-16}	-0.044	(0.027)	0.10	-0.047	(0.027)	0.080	-0.145	(0.028)	2.8×10^{-7}	0.153	(0.073)	0.036	0.148	(0.073)	0.043
DRB1*03:01	-0.172	(0.023)	5.1×10^{-14}	-0.077	(0.024)	1.2×10^{-3}	-0.058	(0.024)	0.015	-0.055	(0.024)	0.020	-0.055	(0.024)	0.019	-0.037	(0.024)	0.12
DQB1*02:01	-0.170	(0.023)	9.8×10^{-14}	-0.078	(0.024)	9.3×10^{-4}	-0.059	(0.024)	0.012	-0.057	(0.023)	0.016	-0.057	(0.023)	0.014	-0.039	(0.024)	0.097
DRB3*01:01	-0.154	(0.022)	1.3×10^{-12}	-0.054	(0.023)	0.018	-0.033	(0.023)	0.15	-0.031	(0.023)	0.17	-0.031	(0.023)	0.17	-0.014	(0.023)	0.52
DQA1*04:01	0.402	(0.057)	1.9×10^{-12}	0.506	(0.057)	4.2×10^{-19}	0.114	(0.232)	0.62	0.107	(0.231)	0.64	0.064	(0.230)	0.78	0.073	(0.230)	0.75
DRB1*08:01	0.409	(0.059)	3.9×10^{-12}	0.519	(0.058)	7.2×10^{-19}	0.118	(0.204)	0.56	0.125	(0.203)	0.54	0.093	(0.203)	0.65	0.088	(0.202)	0.66
B*08:01	-0.157	(0.023)	2.1×10^{-11}	-0.080	(0.024)	7.3×10^{-4}	-0.062	(0.024)	9.2×10^{-3}	-0.062	(0.024)	9.0×10^{-3}	-0.062	(0.024)	8.8×10^{-3}	-0.040	(0.024)	0.093
C*07:01	-0.135	(0.021)	2.6×10^{-10}	-0.072	(0.022)	8.0×10^{-4}	-0.057	(0.022)	7.9×10^{-3}	-0.055	(0.021)	9.9×10^{-3}	-0.053	(0.021)	0.013	-0.034	(0.022)	0.12
B*44:03	0.215	(0.034)	4.4×10^{-10}	0.101	(0.035)	3.8×10^{-3}	0.102	(0.035)	3.5×10^{-3}	0.140	(0.035)	6.1×10^{-5}	0.076	(0.037)	0.039	0.089	(0.037)	0.016
DPB1*06:01	0.550	(0.091)	1.7×10^{-9}	0.386	(0.091)	2.1×10^{-5}	0.379	(0.090)	2.7×10^{-5}	0.019	(0.101)	0.85	0.027	(0.101)	0.79	0.028	(0.101)	0.78
DRB3*02:02	-0.142	(0.024)	4.3×10^{-9}	-0.055	(0.025)	0.026	-0.034	(0.025)	0.17	-0.031	(0.025)	0.21	-0.029	(0.025)	0.24	-0.020	(0.025)	0.41
DQA1*01:02	-0.116	(0.021)	2.2×10^{-8}	-0.015	(0.022)	0.48	0.008	(0.022)	0.72	0.011	(0.022)	0.60	0.014	(0.022)	0.52	-0.002	(0.022)	0.92
C*16:01	0.219	(0.040)	3.0×10^{-8}	0.111	(0.040)	5.4×10^{-3}	0.109	(0.040)	6.1×10^{-3}	0.142	(0.040)	3.5×10^{-4}	0.082	(0.041)	0.045	0.092	(0.041)	0.024

A*29:02	0.209	(0.042)	6.6×10^{-7}	0.130	(0.042)	1.9×10^{-3}	0.127	(0.042)	2.4×10^{-3}	0.151	(0.042)	2.9×10^{-4}	0.109	(0.042)	9.5×10^{-3}	0.126	(0.042)	2.8×10^{-3}
DRB3*03:01	-0.181	(0.042)	1.5×10^{-5}	-0.092	(0.042)	0.028	-0.073	(0.042)	0.079	-0.069	(0.041)	0.097	-0.066	(0.041)	0.11	-0.069	(0.041)	0.096
DRB1*13:02	-0.178	(0.042)	2.0×10^{-5}	-0.090	(0.042)	0.032	-0.070	(0.042)	0.091	-0.066	(0.041)	0.11	-0.063	(0.041)	0.13	-0.065	(0.041)	0.11
B*40:01	0.150	(0.036)	3.7×10^{-5}	0.109	(0.036)	2.5×10^{-3}	0.092	(0.036)	0.010	0.011	(0.037)	0.77	0.024	(0.037)	0.52	0.031	(0.037)	0.39
DPA1*01:03	0.086	(0.021)	6.4×10^{-5}	0.094	(0.021)	8.6×10^{-6}	0.090	(0.021)	1.8×10^{-5}	0.079	(0.021)	1.6×10^{-4}	0.109	(0.021)	3.0×10^{-7}	0.107	(0.021)	5.3×10^{-7}
B*14:02	-0.205	(0.051)	6.5×10^{-5}	-0.140	(0.051)	5.9×10^{-3}	-0.126	(0.050)	0.013	-0.120	(0.050)	0.017	-0.119	(0.050)	0.018	-0.143	(0.050)	4.2×10^{-3}
DPB1*11:01	0.202	(0.051)	7.3×10^{-5}	0.082	(0.051)	0.11	0.075	(0.051)	0.14	0.101	(0.051)	0.047	0.027	(0.052)	0.60	0.027	(0.052)	0.61
DRB5*99:01	0.088	(0.023)	1.1×10^{-4}	-0.013	(0.024)	0.58	-0.035	(0.024)	0.14	-0.037	(0.023)	0.11	-0.038	(0.023)	0.10	-0.021	(0.024)	0.38
DPA1*02:01	-0.090	(0.023)	1.1×10^{-4}	-0.098	(0.023)	2.2×10^{-5}	-0.094	(0.023)	3.7×10^{-5}	-0.083	(0.023)	2.6×10^{-4}	-0.113	(0.023)	1.0×10^{-6}	-0.111	(0.023)	1.4×10^{-6}
DQB1*06:02	-0.090	(0.024)	1.4×10^{-4}	0.011	(0.024)	0.64	0.032	(0.024)	0.19	0.034	(0.024)	0.15	0.036	(0.024)	0.14	0.016	(0.024)	0.50
DQA1*01:01	-0.090	(0.024)	1.5×10^{-4}	0.005	(0.025)	0.84	0.024	(0.024)	0.32	0.026	(0.024)	0.29	0.026	(0.024)	0.28	0.020	(0.024)	0.40
DRB5*01:01	-0.086	(0.023)	2.1×10^{-4}	0.015	(0.024)	0.53	0.036	(0.0240	0.13	0.038	(0.024)	0.11	0.039	(0.024)	0.099	0.020	(0.024)	0.40
A*31:01	0.186	(0.050)	2.3×10^{-4}	0.116	(0.050)	0.020	0.117	(0.050)	0.018	0.038	(0.050)	0.45	0.049	(0.050)	0.33	0.070	(0.050)	0.16
C*03:04	0.112	(0.031)	2.5×10^{-4}	0.051	(0.030)	0.091	0.043	(0.030)	0.15	-0.010	(0.031)	0.76	0.018	(0.031)	0.56	0.023	(0.031)	0.46

Supplementary Table 11: Associations from conditional analyses of classical HLA alleles associated with EBV EBNA antigen response at the Bonferroni-corrected threshold of $P<5\times10^{-4}$. Independent alleles identified at each round are in bold.

Allele	Unconditional (Round 0)			Conditional Round 1			Conditional Round 2			Conditional Round 3			Conditional Round 4			Conditional Round 5		
	Beta	SE	P	Beta	SE	P_{cond}	Beta	SE	P_{cond}	Beta	SE	P_{cond}	Beta	SE	P_{cond}	Beta	SE	P_{cond}
DRB5*99:01	**-0.255**	**(0.022)**	**8.7×10^{-30}**	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
DRB3*02:02	0.224	(0.024)	2.2×10^{-20}	**0.276**	**(0.024)**	**6.8×10^{-30}**	-	-	-	-	-	-	-	-	-	-	-	-
DQB1*02:01	-0.217	(0.023)	2.4×10^{-20}	-0.174	(0.024)	2.0×10^{-13}	**-0.164**	**(0.023)**	**3.6×10^{-12}**	-	-	-	-	-	-	-	-	-
DRB4*99:01	0.198	(0.018)	6.6×10^{-29}	0.150	(0.018)	3.8×10^{-16}	0.092	(0.019)	2.1×10^{-6}	**0.176**	**(0.021)**	**8.3×10^{-17}**	-	-	-	-	-	-
DPB1*03:01	-0.215	(0.030)	5.7×10^{-13}	-0.199	(0.030)	1.8×10^{-11}	-0.201	(0.029)	6.9×10^{-12}	-0.206	(0.029)	1.7×10^{-12}	**-0.220**	**(0.029)**	**4.7×10^{-14}**	-	-	-
DRB1*15:01	0.253	(0.023)	7.8×10^{-28}	0.025	(0.079)	0.75	0.052	(0.079)	0.51	0.048	(0.078)	0.54	0.027	(0.078)	0.73	0.025	(0.078)	0.75
DQA1*01:02	0.221	(0.020)	4.1×10^{-27}	0.085	(0.039)	0.027	0.138	(0.038)	3.3×10^{-4}	0.110	(0.039)	4.5×10^{-3}	0.018	(0.040)	0.65	0.046	(0.040)	0.26
DRB5*01:01	0.248	(0.023)	5.2×10^{-27}	-0.049	(0.085)	0.57	-0.016	(0.085)	0.85	-0.016	(0.084)	0.85	-0.036	(0.084)	0.66	-0.036	(0.084)	0.67
DQB1*06:02	0.244	(0.023)	8.5×10^{-26}	-0.024	(0.067)	0.72	0.006	(0.066)	0.92	0.001	(0.066)	0.99	-0.028	(0.066)	0.67	-0.037	(0.065)	0.57
DQA1*02:01	-0.231	(0.024)	3.1×10^{-21}	-0.188	(0.025)	1.9×10^{-14}	-0.142	(0.025)	9.1×10^{-9}	-0.190	(0.025)	6.3×10^{-14}	-0.113	(0.029)	9.2×10^{-5}	-0.117	(0.029)	4.9×10^{-5}
DRB1*07:01	-0.230	(0.024)	3.8×10^{-21}	-0.188	(0.024)	1.9×10^{-14}	-0.142	(0.025)	9.8×10^{-9}	-0.189	(0.025)	6.4×10^{-14}	-0.113	(0.029)	9.1×10^{-5}	-0.117	(0.029)	4.7×10^{-5}
DRB1*03:01	-0.211	(0.023)	3.4×10^{-19}	-0.168	(0.024)	1.4×10^{-12}	-0.157	(0.024)	2.8×10^{-11}	0.119	(0.127)	0.35	0.003	(0.127)	0.98	-0.005	(0.126)	0.97
DRB4*01:03	-0.171	(0.020)	5.0×10^{-18}	-0.123	(0.020)	1.4×10^{-9}	-0.067	(0.021)	1.3×10^{-3}	-0.125	(0.022)	1.0×10^{-8}	0.029	(0.033)	0.38	0.035	(0.033)	0.29
DRB1*12:01	0.578	(0.071)	3.5×10^{-16}	0.617	(0.070)	1.6×10^{-18}	0.422	(0.073)	7.1×10^{-9}	0.393	(0.073)	6.9×10^{-8}	0.365	(0.072)	4.8×10^{-7}	0.360	(0.072)	6.4×10^{-7}
DQB1*02:02	-0.242	(0.031)	1.5×10^{-14}	-0.194	(0.032)	7.5×10^{-10}	-0.144	(0.032)	5.1×10^{-6}	-0.196	(0.032)	1.1×10^{-9}	-0.105	(0.035)	2.6×10^{-3}	-0.106	(0.035)	2.4×10^{-3}
B*07:02	0.162	(0.023)	5.4×10^{-12}	0.038	(0.027)	0.16	0.038	(0.027)	0.16	0.027	(0.027)	0.31	0.020	(0.027)	0.46	0.023	(0.026)	0.38
C*07:02	0.144	(0.023)	2.1×10^{-10}	0.030	(0.026)	0.24	0.031	(0.025)	0.23	0.020	(0.025)	0.43	0.007	(0.025)	0.77	0.012	(0.025)	0.62
DPB1*04:02	0.165	(0.027)	1.3×10^{-9}	0.187	(0.027)	4.2×10^{-12}	0.167	(0.027)	4.4×10^{-10}	0.159	(0.027)	2.7×10^{-9}	0.140	(0.027)	1.7×10^{-7}	0.116	(0.027)	1.6×10^{-5}
DRB1*11:01	0.264	(0.046)	8.1×10^{-9}	0.312	(0.045)	6.9×10^{-12}	0.082	(0.052)	0.11	0.051	(0.052)	0.32	0.034	(0.051)	0.51	0.024	(0.051)	0.64
B*08:01	-0.136	(0.024)	1.5×10^{-8}	-0.105	(0.024)	1.1×10^{-5}	-0.066	(0.024)	6.3×10^{-3}	0.112	(0.034)	1.1×10^{-3}	0.082	(0.034)	0.017	0.076	(0.034)	0.027
DQA1*03:01	-0.117	(0.021)	4.5×10^{-8}	-0.067	(0.022)	1.9×10^{-3}	-0.010	(0.022)	0.65	-0.054	(0.023)	0.018	0.084	(0.028)	2.6×10^{-3}	0.085	(0.028)	2.3×10^{-3}
A*03:01	0.130	(0.024)	4.6×10^{-8}	0.092	(0.024)	1.1×10^{-4}	0.100	(0.024)	2.5×10^{-5}	0.085	(0.024)	3.1×10^{-4}	0.073	(0.024)	2.1×10^{-3}	0.075	(0.023)	1.4×10^{-3}
DRB4*01:01	-0.168	(0.032)	9.4×10^{-8}	-0.126	(0.032)	6.9×10^{-5}	-0.078	(0.032)	0.014	-0.117	(0.032)	2.4×10^{-4}	-0.025	(0.034)	0.46	-0.032	(0.034)	0.35
DRB1*14:01	0.291	(0.060)	1.2×10^{-6}	0.315	(0.059)	1.2×10^{-7}	0.120	(0.062)	0.053	0.097	(0.062)	0.118	0.075	(0.062)	0.22	0.090	(0.061)	0.14
DRB3*01:01	-0.107	(0.022)	1.3×10^{-6}	-0.060	(0.022)	7.1×10^{-3}	-0.003	(0.023)	0.90	0.279	(0.035)	1.5×10^{-15}	0.197	(0.038)	1.6×10^{-7}	0.187	(0.037)	5.8×10^{-7}
DQB1*06:03	0.167	(0.036)	4.3×10^{-6}	0.207	(0.036)	9.0×10^{-9}	0.140	(0.036)	1.1×10^{-4}	0.112	(0.036)	2.1×10^{-3}	0.047	(0.037)	0.21	0.048	(0.037)	0.19

DRB1*04:01	-0.122	(0.027)	9.3×10^{-6}	-0.074	(0.028)	7.4×10^{-3}	-0.022	(0.028)	0.44	-0.061	(0.028)	0.031	0.045	(0.031)	0.15	0.035	(0.031)	0.26
DQB1*05:03	0.243	(0.055)	1.1×10^{-5}	0.266	(0.055)	1.3×10^{-6}	0.078	(0.057)	0.17	0.053	(0.057)	0.35	0.034	(0.057)	0.55	0.047	(0.057)	0.41
C*07:01	-0.094	(0.022)	1.7×10^{-5}	-0.065	(0.022)	3.0×10^{-3}	-0.039	(0.022)	0.07	0.086	(0.027)	1.7×10^{-3}	0.066	(0.027)	0.015	0.064	(0.027)	0.020
DPB1*05:01	0.243	(0.058)	2.9×10^{-5}	0.226	(0.057)	8.6×10^{-5}	0.219	(0.057)	1.2×10^{-4}	0.201	(0.057)	4.2×10^{-4}	0.169	(0.057)	2.8×10^{-3}	0.148	(0.057)	8.8×10^{-3}
DRB1*13:01	0.150	(0.037)	4.3×10^{-5}	0.198	(0.036)	5.6×10^{-8}	0.133	(0.037)	3.0×10^{-4}	0.104	(0.037)	4.7×10^{-3}	0.037	(0.038)	0.33	0.038	(0.038)	0.31
B*51:01	0.183	(0.045)	4.6×10^{-5}	0.194	(0.044)	1.2×10^{-5}	0.164	(0.044)	2.0×10^{-4}	0.144	(0.044)	1.1×10^{-3}	0.135	(0.044)	2.1×10^{-3}	0.144	(0.044)	1.0×10^{-3}
B*57:01	-0.165	(0.044)	1.7×10^{-4}	-0.133	(0.044)	2.3×10^{-3}	-0.110	(0.043)	0.011	-0.132	(0.043)	2.4×10^{-3}	-0.081	(0.044)	0.064	-0.085	(0.043)	0.050
DRB1*11:04	0.261	(0.074)	4.2×10^{-4}	0.311	(0.073)	2.3×10^{-5}	0.068	(0.076)	0.37	0.046	(0.076)	0.55	0.025	(0.076)	0.74	0.003	(0.075)	0.96
DRB3*99:01	-0.061	(0.018)	4.8×10^{-4}	-0.135	(0.018)	1.3×10^{-13}	-0.037	(0.021)	0.08	-0.230	(0.028)	1.2×10^{-16}	-0.151	(0.032)	2.8×10^{-6}	-0.158	(0.032)	8.9×10^{-7}

Supplementary Table 12: Associations from conditional analyses of classical HLA alleles associated with EBV p18 antigen response at the Bonferroni-corrected threshold of $P<5\times10^{-4}$. Independent alleles identified at each round are in bold.

Allele	Unconditional (Round 0)			Conditional Round 1			Conditional Round 2		
	Beta	(SE)	P	Beta	(SE)	P_{cond}	Beta	(SE)	P_{cond}
DRB5*99:01	**-0.210**	**(0.021)**	**1.7×10^{-22}**	-	-	-	-	-	-
DRB1*04:04	0.319	(0.041)	4.7×10^{-15}	**0.357**	**(0.040)**	**1.3×10^{-18}**	-	-	-
DRB5*01:01	0.211	(0.022)	1.4×10^{-21}	0.041	(0.083)	0.62	0.042	(0.082)	0.61
DRB1*15:01	0.209	(0.022)	4.2×10^{-21}	0.022	(0.077)	0.78	0.026	(0.077)	0.73
DQA1*01:02	0.181	(0.020)	2.7×10^{-20}	0.067	(0.037)	0.069	0.085	(0.037)	0.020
C*07:02	0.196	(0.022)	9.7×10^{-20}	0.125	(0.024)	2.9×10^{-7}	0.117	(0.024)	1.4×10^{-6}
DQB1*06:02	0.199	(0.022)	4.7×10^{-19}	-0.043	(0.064)	0.50	-0.039	(0.064)	0.54
B*07:02	0.195	(0.022)	2.2×10^{-18}	0.115	(0.026)	8.1×10^{-6}	0.106	(0.026)	3.3×10^{-5}
B*08:01	-0.119	(0.022)	8.3×10^{-8}	-0.094	(0.022)	2.4×10^{-5}	-0.079	(0.022)	3.6×10^{-4}
DPB1*03:01	-0.143	(0.028)	2.1×10^{-7}	-0.129	(0.027)	2.9×10^{-6}	-0.126	(0.027)	4.0×10^{-6}
DQB1*02:01	-0.105	(0.022)	1.3×10^{-6}	-0.069	(0.022)	1.7×10^{-3}	-0.047	(0.022)	0.031
DRB1*03:01	-0.102	(0.022)	2.2×10^{-6}	-0.067	(0.022)	2.2×10^{-3}	-0.045	(0.022)	0.040
DPB1*04:01	0.076	(0.016)	2.5×10^{-6}	0.046	(0.016)	5.0×10^{-3}	0.052	(0.016)	1.5×10^{-3}
C*07:01	-0.093	(0.020)	4.0×10^{-6}	-0.070	(0.020)	5.8×10^{-4}	-0.056	(0.020)	5.7×10^{-3}
DRB3*99:01	0.075	(0.016)	5.5×10^{-6}	0.031	(0.017)	0.074	0.001	(0.017)	0.95
DQA1*05:01	-0.084	(0.019)	6.0×10^{-6}	-0.045	(0.019)	0.017	-0.020	(0.019)	0.29
B*14:02	-0.212	(0.048)	8.8×10^{-6}	-0.199	(0.047)	2.7×10^{-5}	-0.183	(0.047)	1.1×10^{-4}
C*08:02	-0.181	(0.041)	9.2×10^{-6}	-0.165	(0.041)	4.8×10^{-5}	-0.149	(0.040)	2.2×10^{-4}
DPB1*06:01	0.379	(0.089)	2.0×10^{-5}	0.424	(0.088)	1.7×10^{-6}	0.077	(0.100)	0.44
DQA1*02:01	-0.096	(0.023)	2.5×10^{-5}	-0.059	(0.023)	0.010	-0.038	(0.023)	0.099
DRB1*07:01	-0.095	(0.023)	3.1×10^{-5}	-0.058	(0.023)	0.011	-0.037	(0.023)	0.11
C*04:01	-0.117	(0.028)	4.1×10^{-5}	-0.093	(0.028)	1.1×10^{-3}	-0.081	(0.028)	4.0×10^{-3}
C*03:03	-0.139	(0.034)	4.2×10^{-5}	-0.130	(0.034)	1.1×10^{-4}	-0.142	(0.034)	2.2×10^{-5}
DRB3*01:01	-0.083	(0.021)	4.9×10^{-5}	-0.046	(0.021)	0.026	-0.025	(0.021)	0.23
DPA1*02:01	-0.090	(0.022)	5.4×10^{-5}	-0.066	(0.022)	3.2×10^{-3}	-0.054	(0.022)	0.015
DQB1*02:02	-0.112	(0.029)	1.5×10^{-4}	-0.072	(0.030)	0.015	-0.047	(0.030)	0.11
DPB1*01:01	-0.124	(0.034)	2.3×10^{-4}	-0.097	(0.033)	3.8×10^{-3}	-0.084	(0.033)	0.012
B*35:01	-0.139	(0.038)	2.5×10^{-4}	-0.109	(0.038)	4.1×10^{-3}	-0.097	(0.038)	0.010
B*51:01	0.153	(0.042)	3.0×10^{-4}	0.164	(0.042)	1.0×10^{-4}	0.152	(0.042)	3.0×10^{-4}
B*15:01	-0.116	(0.033)	4.1×10^{-4}	-0.102	(0.033)	1.8×10^{-3}	-0.108	(0.032)	8.4×10^{-4}

Supplementary Table 13: Associations from conditional analyses of classical HLA alleles associated with antigen response at the Bonferroni-corrected threshold of $P<5\times10^{-4}$. Independent alleles identified at each round are in bold. Results are presented for antigens with a single conditionally independent classical allele.

Antigen	Allele	Unconditional (Round 0)			Conditional Round 1		
		Beta	(SE)	P	Beta	SE	P_{cond}
CMV pp52	**DRB1*01:03**	**-0.538**	**(0.075)**	$\mathbf{9.4\times10^{-13}}$	-	-	-
	C*07:01	-0.091	(0.025)	2.7×10^{-4}	-0.099	(0.025)	6.4×10^{-5}
	DPB1*03:01	0.121	(0.034)	3.7×10^{-4}	0.112	(0.034)	8.9×10^{-4}
EBV EA-D	**DQB1*02:01**	**-0.154**	**(0.024)**	$\mathbf{8.4\times10^{-11}}$	-	-	-
	DRB1*03:01	-0.147	(0.024)	5.5×10^{-10}	0.109	(0.124)	0.38
	B*08:01	-0.144	(0.024)	2.7×10^{-9}	-0.064	(0.035)	0.068
	DRB1*09:01	0.407	(0.073)	3.2×10^{-8}	0.383	(0.073)	1.9×10^{-7}
	DQA1*03:01	0.110	(0.021)	1.1×10^{-7}	0.085	(0.021)	6.6×10^{-5}
	DRB4*99:01	-0.088	(0.018)	5.8×10^{-7}	-0.058	(0.018)	1.5×10^{-3}
	C*07:01	-0.109	(0.022)	7.7×10^{-7}	-0.032	(0.028)	0.25
	DRB3*99:01	0.087	(0.018)	9.0×10^{-7}	0.033	(0.021)	0.12
	A*03:01	0.114	(0.024)	2.4×10^{-6}	0.098	(0.024)	5.6×10^{-5}
	DRB4*01:03	0.085	(0.019)	1.1×10^{-5}	0.057	(0.020)	4.4×10^{-3}
	DQA1*05:01	-0.088	(0.020)	1.4×10^{-5}	0.026	(0.031)	0.40
	DQB1*03:03	0.164	(0.038)	1.4×10^{-5}	0.142	(0.038)	1.9×10^{-4}
	DRB3*01:01	-0.096	(0.022)	2.0×10^{-5}	0.035	(0.034)	0.32
	DQB1*03:01	0.094	(0.022)	2.1×10^{-5}	0.069	(0.023)	2.2×10^{-3}
	DPB1*02:01	-0.103	(0.028)	1.9×10^{-4}	-0.110	(0.028)	6.3×10^{-5}
	A*01:01	-0.078	(0.021)	2.6×10^{-4}	-0.021	(0.024)	0.38
	A*02:01	-0.068	(0.019)	3.7×10^{-4}	-0.086	(0.019)	7.8×10^{-6}
HHV7	**DQB1*05:01**	**-0.139**	**(0.025)**	$\mathbf{2.8\times10^{-8}}$	-	-	-
	DQA1*01:01	-0.125	(0.023)	8.2×10^{-8}	-0.045	(0.053)	0.40
	DRB1*01:01	-0.146	(0.028)	2.3×10^{-7}	-0.049	(0.052)	0.35
	DRB4*99:01	-0.085	(0.017)	4.5×10^{-7}	-0.066	(0.017)	1.6×10^{-4}
	DPB1*04:02	-0.133	(0.026)	4.8×10^{-7}	-0.115	(0.027)	1.5×10^{-5}
	DRB1*04:01	0.128	(0.026)	7.3×10^{-7}	0.110	(0.026)	2.3×10^{-5}
	DRB4*01:03	0.077	(0.019)	3.0×10^{-5}	0.058	(0.019)	2.0×10^{-3}
HSV1	**DQB1*02:01**	**0.145**	**(0.026)**	$\mathbf{2.1\times10^{-8}}$	-	-	-
	DRB1*03:01	0.140	(0.026)	6.3×10^{-8}	-0.090	(0.147)	0.54
	DQA1*01:02	-0.110	(0.024)	3.1×10^{-6}	-0.086	(0.024)	3.7×10^{-4}
	DQB1*06:02	-0.115	(0.027)	1.7×10^{-5}	-0.091	(0.027)	7.9×10^{-4}
	DRB5*99:01	0.110	(0.026)	2.3×10^{-5}	0.086	(0.026)	1.2×10^{-3}
	DRB1*15:01	-0.110	(0.027)	3.6×10^{-5}	-0.086	(0.027)	1.5×10^{-3}
	DRB3*01:01	0.102	(0.025)	3.6×10^{-5}	-0.011	(0.038)	0.78
	DRB5*01:01	-0.109	(0.026)	3.7×10^{-5}	-0.085	(0.027)	1.5×10^{-3}

	B*08:01	0.106	(0.026)	6.2×10^{-5}	-0.003	(0.038)	0.93
VZV	**DRB1*03:01**	**0.236**	**(0.022)**	$\mathbf{7.3\times10^{-26}}$	-	-	-
	DQB1*02:01	0.236	(0.022)	7.5×10^{-26}	0.117	(0.126)	0.35
	B*08:01	0.238	(0.023)	4.7×10^{-25}	0.131	(0.034)	1.2×10^{-4}
	DRB3*01:01	0.197	(0.021)	3.7×10^{-20}	0.053	(0.034)	0.12
	C*07:01	0.194	(0.021)	4.6×10^{-20}	0.088	(0.027)	1.4×10^{-3}
	A*01:01	0.181	(0.021)	1.9×10^{-18}	0.104	(0.023)	6.9×10^{-6}
	DQA1*05:01	0.153	(0.019)	2.8×10^{-15}	-0.013	(0.031)	0.67
	DRB3*99:01	-0.114	(0.017)	3.2×10^{-11}	-0.013	(0.021)	0.54
	DRB5*99:01	0.136	(0.023)	2.3×10^{-9}	0.096	(0.023)	3.1×10^{-5}
	DRB5*01:01	-0.135	(0.023)	7.1×10^{-9}	-0.095	(0.023)	5.1×10^{-5}
	DQB1*06:02	-0.133	(0.023)	1.6×10^{-8}	-0.095	(0.024)	5.4×10^{-5}
	DRB1*15:01	-0.132	(0.023)	1.8×10^{-8}	-0.092	(0.024)	1.0×10^{-4}
	A*02:01	-0.103	(0.019)	4.1×10^{-8}	-0.079	(0.019)	3.0×10^{-5}
	DQA1*01:02	-0.099	(0.021)	1.4×10^{-6}	-0.057	(0.021)	6.7×10^{-3}
	DQB1*03:01	-0.089	(0.022)	4.9×10^{-5}	-0.046	(0.022)	0.040
	B*44:02	-0.108	(0.027)	5.8×10^{-5}	-0.074	(0.027)	5.7×10^{-3}
JCV	**DRB5*99:01**	**0.305**	**(0.032)**	$\mathbf{1.2\times10^{-21}}$	-	-	-
	DRB5*01:01	-0.309	(0.033)	4.8×10^{-21}	-0.097	(0.120)	0.42
	DQB1*06:02	-0.310	(0.033)	7.2×10^{-21}	-0.116	(0.093)	0.21
	DRB1*15:01	-0.309	(0.033)	9.0×10^{-21}	-0.082	(0.112)	0.46
	DQA1*01:02	-0.218	(0.028)	8.5×10^{-15}	0.006	(0.049)	0.89
	DQB1*03:01	0.133	(0.027)	1.1×10^{-6}	0.086	(0.028)	1.7×10^{-3}
	B*07:02	-0.132	(0.031)	2.8×10^{-5}	0.012	(0.035)	0.73
	DRB4*99:01	-0.087	(0.022)	5.1×10^{-5}	-0.033	(0.022)	0.14
	DPB1*04:01	-0.087	(0.021)	5.6×10^{-5}	-0.051	(0.022)	0.017
	DRB4*01:03	0.093	(0.024)	9.4×10^{-5}	0.044	(0.024)	0.068
	C*07:02	-0.115	(0.030)	1.5×10^{-4}	0.013	(0.033)	0.71
	DRB3*99:01	-0.082	(0.022)	1.6×10^{-4}	-0.029	(0.022)	0.19
	DQA1*03:01	0.096	(0.026)	2.0×10^{-4}	0.050	(0.026)	0.057
	DRB1*04:01	0.123	(0.033)	2.1×10^{-4}	0.079	(0.033)	0.018

Supplementary Table 14: Associations from conditional analyses of classical HLA alleles associated with MCV antigen response at the Bonferroni-corrected threshold of $P<5\times10^{-4}$. Independent alleles identified at each round are in bold.

Allele	Unconditional (Round 0)			Conditional Round 1			Conditional Round 2			Conditional Round 3			Conditional Round 4		
	Beta	(SE)	P	Beta	(SE)	P_{cond}	Beta	(SE)	P_{cond}	Beta	(SE)	P_{cond}	Beta	(SE)	P_{cond}
DQA1*01:01	**0.215**	**(0.027)**	**1.1×10^{-15}**	-	-	-	-	-	-	-	-	-	-	-	-
DRB1*04:04	-0.390	(0.054)	8.6×10^{-13}	**-0.362**	**(0.054)**	**3.0×10^{-11}**	-	-	-	-	-	-	-	-	-
A*29:02	-0.359	(0.052)	4.5×10^{-12}	-0.342	(0.052)	3.7×10^{-11}	**-0.350**	**(0.051)**	**1.0×10^{-11}**	-	-	-	-	-	-
DRB1*15:01	-0.213	(0.029)	2.1×10^{-13}	-0.178	(0.029)	1.1×10^{-9}	-0.199	(0.029)	1.0×10^{-11}	**-0.203**	**(0.029)**	**3.7×10^{-12}**	-	-	-
DQB1*05:01	0.220	(0.029)	1.6×10^{-14}	0.070	(0.066)	0.29	0.070	(0.066)	0.29	0.070	(0.065)	0.29	0.066	(0.065)	0.31
DQB1*06:02	-0.213	(0.029)	2.5×10^{-13}	-0.179	(0.029)	1.2×10^{-9}	-0.199	(0.029)	1.2×10^{-11}	-0.204	(0.029)	3.7×10^{-12}	-0.103	(0.124)	0.41
DRB5*01:01	-0.210	(0.029)	3.7×10^{-13}	-0.176	(0.029)	1.8×10^{-9}	-0.196	(0.029)	1.9×10^{-11}	-0.200	(0.029)	7.2×10^{-12}	0.067	(0.227)	0.77
DRB1*01:01	0.216	(0.032)	1.3×10^{-11}	0.046	(0.050)	0.35	0.044	(0.050)	0.38	0.044	(0.050)	0.37	0.041	(0.049)	0.41
DRB5*99:01	0.185	(0.028)	4.8×10^{-11}	0.152	(0.028)	7.4×10^{-8}	0.173	(0.028)	1.1×10^{-9}	0.177	(0.028)	3.8×10^{-10}	-0.094	(0.089)	0.29
DQA1*01:02	-0.151	(0.025)	1.9×10^{-9}	-0.113	(0.026)	9.8×10^{-6}	-0.136	(0.026)	1.1×10^{-7}	-0.143	(0.026)	2.5×10^{-8}	0.004	(0.044)	0.93
DPB1*06:01	-0.591	(0.122)	1.2×10^{-6}	-0.556	(0.121)	4.4×10^{-6}	-0.228	(0.137)	0.095	-0.208	(0.136)	0.13	-0.217	(0.136)	0.11
DRB3*02:02	0.129	(0.028)	3.0×10^{-6}	0.131	(0.028)	1.9×10^{-6}	0.118	(0.027)	1.9×10^{-5}	0.109	(0.027)	6.8×10^{-5}	0.081	(0.028)	3.4×10^{-3}
DQB1*03:01	0.108	(0.025)	1.9×10^{-5}	0.153	(0.026)	2.1×10^{-9}	0.139	(0.026)	6.0×10^{-8}	0.131	(0.025)	2.7×10^{-7}	0.096	(0.026)	2.3×10^{-4}
C*07:02	-0.118	(0.028)	2.7×10^{-5}	-0.116	(0.028)	3.0×10^{-5}	-0.117	(0.028)	2.5×10^{-5}	-0.128	(0.028)	3.7×10^{-6}	-0.051	(0.031)	0.096
B*07:02	-0.121	(0.029)	3.4×10^{-5}	-0.116	(0.029)	6.3×10^{-5}	-0.118	(0.029)	4.4×10^{-5}	-0.127	(0.029)	1.0×10^{-5}	-0.039	(0.033)	0.23
C*16:01	-0.178	(0.048)	2.1×10^{-4}	-0.154	(0.048)	1.3×10^{-3}	-0.164	(0.048)	5.7×10^{-4}	0.096	(0.064)	0.13	0.073	(0.064)	0.25
DQB1*03:02	-0.114	(0.033)	4.8×10^{-4}	-0.080	(0.033)	0.015	0.064	(0.040)	0.11	0.051	(0.040)	0.20	0.024	(0.040)	0.55

Supplementary Table 15: TWAS results for antigen response phenotypes that were analyzed using gene expression models based on whole blood and brain tissues. Associations with $P_{\mathrm{TWAS}}<4.2\times10^{-6}$ are considered statistically significant and genes with $P_{\mathrm{TWAS}}<4.5\times10^{-5}$ are considered suggestive.

Antigen	Region	Gene ID	Gene	Whole Blood		Brain (Frontal Cortex)	
				Z	P_{TWAS}	Z	P_{TWAS}
BKV	19q13.33	ENSG00000176909	*MAMSTR*	-4.22	2.4×10^{-5}	-	-
	7q21.2	ENSG00000004766	*VPS50*	4.09	4.4×10^{-5}	-0.33	0.74
	19q13.33	ENSG00000142233	*NTN5*	-2.33	0.020	6.09	1.1×10^{-9}
	19q13.33	ENSG00000176920	*FUT2*	-	-	7.16	8.1×10^{-13}
	20q13.2	ENSG00000054803	*CBLN4*	-	-	4.09	4.4×10^{-5}
CMV pp150	16p13.3	ENSG00000172366	*MCRIP2*	-0.44	0.66	-4.10	4.1×10^{-5}
CMV pp52	3q13.12	ENSG00000196776	*CD47*	-4.49	7.3×10^{-6}	-	-
HHV6 IE1A	6p21.32	ENSG00000196735	*HLA-DQA1*	4.29	1.8×10^{-5}	4.34	1.4×10^{-5}
	6p21.33	ENSG00000204525	*HLA-C*	-2.97	3.0×10^{-3}	-4.25	2.1×10^{-5}
HHV6 p101	4q13.3	ENSG00000163734	*CXCL3*	4.12	3.8×10^{-5}	4.12	3.8×10^{-5}
HHV7	6p21.32	ENSG00000232629	*HLA-DQB2*	5.38	7.3×10^{-8}	5.29	1.2×10^{-7}
	6p21.32	ENSG00000179344	*HLA-DQB1*	-5.07	3.9×10^{-7}	0.64	0.52
	22q13.2	ENSG00000273424	*CTA-223H9.9*	-4.71	2.5×10^{-6}	-4.71	2.5×10^{-6}
	22q13.2	ENSG00000167074	*TEF*	4.66	3.1×10^{-6}	-	-
	22q13.33	ENSG00000025708	*TYMP*	4.54	5.6×10^{-6}	3.98	6.8×10^{-5}
	6p21.32	ENSG00000204267	*TAP2*	-4.48	7.4×10^{-6}	1.90	0.058
	17q21.32	ENSG00000198933	*TBKBP1*	-4.41	1.0×10^{-5}	-4.21	2.6×10^{-5}
	22q13.33	ENSG00000177989	*ODF3B*	4.30	1.7×10^{-5}	3.01	2.6×10^{-3}
	22q13.2	ENSG00000100417	*PMM1*	-4.26	2.0×10^{-5}	-1.90	0.057
	6p21.33	ENSG00000204428	*LY6G5C*	4.24	2.3×10^{-5}	4.24	2.3×10^{-5}
	22q13.2	ENSG00000172346	*CSDC2*	4.14	3.4×10^{-5}	4.67	3.0×10^{-6}
	1q31.2	ENSG00000090104	*RGS1*	2.70	6.9×10^{-3}	-4.65	3.3×10^{-6}
	2q11.2	ENSG00000198885	*ITPRIPL1*	-2.66	7.9×10^{-3}	-4.09	4.4×10^{-5}
	6p21.32	ENSG00000204261	*PSMB8-AS1*	2.38	0.017	-5.06	4.1×10^{-7}
	6p21.32	ENSG00000241404	*EGFL8*	-0.83	0.41	-5.36	8.4×10^{-8}
HSV1	6p21.32	ENSG00000179344	*HLA-DQB1*	-5.46	4.8×10^{-8}	-4.62	3.9×10^{-6}
	6p21.32	ENSG00000232629	*HLA-DQB2*	5.11	3.3×10^{-7}	4.99	5.9×10^{-7}
	6p21.32	ENSG00000204257	*HLA-DMA*	4.93	8.2×10^{-7}	4.88	1.0×10^{-6}
	6p21.33	ENSG00000204444	*APOM*	-4.71	2.5×10^{-6}	-4.60	4.3×10^{-6}
	6p21.33	ENSG00000204386	*NEU1*	-4.44	9.1×10^{-6}	-	-
	6p21.33	ENSG00000231852	*CYP21A2*	4.41	1.0×10^{-5}	-	-
	6p21.33	ENSG00000224389	*C4B*	4.40	1.1×10^{-5}	-	-
	6p21.33	ENSG00000166278	*C2*	4.38	1.2×10^{-5}	-	-
	6p21.33	ENSG00000213719	*CLIC1*	-4.34	1.5×10^{-5}	-4.34	1.5×10^{-5}
	6p21.32	ENSG00000204305	*AGER*	4.13	3.6×10^{-5}	2.96	3.0×10^{-3}

	6p21.33	ENSG00000244731	*C4A*	-4.09	4.3×10^{-5}	-4.29	1.8×10^{-5}
	6p21.32	ENSG00000204308	*RNF5*	-1.92	0.055	-4.82	1.5×10^{-6}
	6p21.32	ENSG00000196735	*HLA-DQA1*	-1.80	0.072	-4.25	2.1×10^{-5}
	6p21.32	ENSG00000242574	*HLA-DMB*	-0.81	0.42	5.00	5.6×10^{-7}
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	-4.50	6.8×10^{-6}
JCV	6p21.32	ENSG00000237541	*HLA-DQA2*	7.09	1.3×10^{-12}	-	-
	6p21.33	ENSG00000204371	*EHMT2*	-6.95	3.7×10^{-12}	-	-
	6p21.32	ENSG00000204305	*AGER*	6.14	8.0×10^{-10}	7.45	9.5×10^{-14}
	6p21.32	ENSG00000232629	*HLA-DQB2*	6.11	9.9×10^{-10}	5.97	2.4×10^{-9}
	6p21.32	ENSG00000179344	*HLA-DQB1*	-5.88	4.2×10^{-9}	-0.31	0.76
	6p21.33	ENSG00000213722	*DDAH2*	-5.44	5.5×10^{-8}	-1.34	0.18
	6p21.32	ENSG00000204308	*RNF5*	-5.02	5.2×10^{-7}	-1.74	0.082
	6p21.32	ENSG00000204310	*AGPAT1*	-4.85	1.2×10^{-6}	5.07	4.1×10^{-7}
	6p21.33	ENSG00000198563	*DDX39B*	-4.84	1.3×10^{-6}	-0.43	0.67
	6p21.32	ENSG00000240065	*PSMB9*	4.47	7.7×10^{-6}	2.01	0.045
	6p21.33	ENSG00000213760	*ATP6V1G2*	2.80	5.1×10^{-3}	-4.46	8.3×10^{-6}
	11q13.4	ENSG00000214517	*PPME1*	2.22	0.026	4.31	1.6×10^{-5}
	6p21.32	ENSG00000204264	*PSMB8*	1.99	0.047	4.17	3.0×10^{-5}
	6p21.32	ENSG00000204252	*HLA-DOA*	-0.68	0.50	-4.56	5.2×10^{-6}
	6p21.32	ENSG00000204315	*FKBPL*	0.01	0.99	-4.53	6.0×10^{-6}
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	-7.50	6.5×10^{-14}
	6p21.33	ENSG00000204540	*PSORS1C1*	-	-	-4.69	2.8×10^{-6}
VZV	6p21.33	ENSG00000204444	*APOM*	-10.73	7.5×10^{-27}	-10.47	1.1×10^{-25}
	6p21.33	ENSG00000231852	*CYP21A2*	10.53	6.5×10^{-26}	-	-
	6p21.33	ENSG00000224389	*C4B*	10.47	1.2×10^{-25}	-	-
	6p21.33	ENSG00000166278	*C2*	10.29	8.1×10^{-25}	-	-
	6p21.33	ENSG00000204386	*NEU1*	-10.28	8.4×10^{-25}	-	-
	6p21.33	ENSG00000213719	*CLIC1*	-10.22	1.6×10^{-24}	-10.22	1.6×10^{-24}
	6p21.33	ENSG00000244731	*C4A*	-10.19	2.3×10^{-24}	-10.16	2.9×10^{-24}
	6p22.1	ENSG00000204613	*TRIM10*	-8.82	1.1×10^{-18}	-	-
	6p21.32	ENSG00000204305	*AGER*	8.69	3.6×10^{-18}	4.44	9.1×10^{-6}
	6p21.33	ENSG00000214894	*LINC00243*	8.01	1.1×10^{-15}	-	-
	6p22.1	ENSG00000281831	*HCP5B*	7.90	2.8×10^{-15}	1.53	0.13
	6p22.1	ENSG00000187626	*ZKSCAN4*	7.84	4.5×10^{-15}	7.24	4.4×10^{-13}
	6p22.1	ENSG00000204681	*GABBR1*	7.29	3.1×10^{-13}	1.02	0.31
	6p22.1	ENSG00000204657	*OR2H2*	7.09	1.3×10^{-12}	0.27	0.79
	6p22.1	ENSG00000204644	*ZFP57*	7.09	1.4×10^{-12}	-	-
	6p21.33	ENSG00000204435	*CSNK2B*	7.06	1.7×10^{-12}	-4.09	4.2×10^{-5}
	6p22.2	ENSG00000186470	*BTN3A2*	-6.91	4.8×10^{-12}	-6.72	1.8×10^{-11}
	6p21.32	ENSG00000204257	*HLA-DMA*	6.75	1.5×10^{-11}	6.76	1.3×10^{-11}

6p22.1	ENSG00000158691	*ZSCAN12*	-6.73	1.7×10^{-11}	5.45	5.0×10^{-8}
6p21.32	ENSG00000204304	*PBX2*	-6.28	3.5×10^{-10}	-1.48	0.14
6p22.1	ENSG00000189298	*ZKSCAN3*	6.20	5.7×10^{-10}	-2.35	0.019
6p22.1	ENSG00000206503	*HLA-A*	-6.14	8.2×10^{-10}	0.13	0.89
6p22.1	ENSG00000261353	*CTA-14H9.5*	-5.96	2.5×10^{-9}	-	-
6p21.32	ENSG00000179344	*HLA-DQB1*	-5.96	2.6×10^{-9}	-6.33	2.5×10^{-10}
6p22.1	ENSG00000137185	*ZSCAN9*	-5.86	4.7×10^{-9}	7.84	4.6×10^{-15}
6p21.32	ENSG00000232629	*HLA-DQB2*	5.79	7.0×10^{-9}	5.61	2.1×10^{-8}
6p21.33	ENSG00000204536	*CCHCR1*	5.72	1.1×10^{-8}	7.34	2.2×10^{-13}
6p22.1	ENSG00000197062	*ZSCAN26*	-5.57	2.5×10^{-8}	-5.71	1.1×10^{-8}
6p21.33	ENSG00000204463	*BAG6*	5.52	3.3×10^{-8}	-4.29	1.8×10^{-5}
6p22.2	ENSG00000180596	*HIST1H2BC*	-5.46	4.8×10^{-8}	-2.38	0.017
6p22.1	ENSG00000204655	*MOG*	5.42	5.9×10^{-8}	-	-
6p22.2	ENSG00000272462	*U91328.19*	5.02	5.1×10^{-7}	2.19	0.028
6p21.33	ENSG00000204396	*VWA7*	-4.90	9.5×10^{-7}	5.72	1.0×10^{-8}
6p21.33	ENSG00000204388	*HSPA1B*	4.89	1.0×10^{-6}	-	-
6p21.32	ENSG00000221988	*PPT2*	4.79	1.6×10^{-6}	-1.48	0.14
6p22.1	ENSG00000272468	*RP1-86C11.7*	-4.61	3.9×10^{-6}	1.12	0.26
6p22.1	ENSG00000234127	*TRIM26*	4.56	5.0×10^{-6}	1.58	0.11
6p22.1	ENSG00000137338	*PGBD1*	4.56	5.2×10^{-6}	1.34	0.18
6p22.2	ENSG00000010704	*HFE*	-4.42	9.8×10^{-6}	-1.15	0.25
6p22.1	ENSG00000241370	*RPP21*	4.41	1.0×10^{-5}	-3.91	9.3×10^{-5}
6p21.33	ENSG00000204371	*EHMT2*	-4.36	1.3×10^{-5}	-	-
6p22.1	ENSG00000204632	*HLA-G*	4.24	2.2×10^{-5}	-0.64	0.52
6p22.2	ENSG00000124508	*BTN2A2*	4.22	2.5×10^{-5}	-1.95	0.051
6p21.32	ENSG00000204310	*AGPAT1*	-3.70	2.2×10^{-4}	4.26	2.0×10^{-5}
6p21.33	ENSG00000204387	*C6orf48*	-2.96	3.1×10^{-3}	-4.18	3.0×10^{-5}
6p21.32	ENSG00000204264	*PSMB8*	2.89	3.8×10^{-3}	4.83	1.3×10^{-6}
6p21.33	ENSG00000213722	*DDAH2*	-2.46	0.014	-8.27	1.3×10^{-16}
6p21.32	ENSG00000204301	*NOTCH4*	-2.37	0.018	-6.98	3.0×10^{-12}
6p21.33	ENSG00000204420	*MPIG6B*	2.10	0.036	-5.68	1.4×10^{-8}
6p22.1	ENSG00000112812	*PRSS16*	2.03	0.043	4.94	7.7×10^{-7}
6p22.1	ENSG00000198315	*ZKSCAN8*	1.66	0.097	-4.90	9.5×10^{-7}
6p21.33	ENSG00000137411	*VARS2*	-1.64	0.10	-5.17	2.3×10^{-7}
6p21.33	ENSG00000204410	*MSH5*	-1.45	0.15	-7.81	5.7×10^{-15}
6p21.32	ENSG00000213676	*ATF6B*	-1.36	0.18	-4.38	1.2×10^{-5}
6p21.33	ENSG00000137312	*FLOT1*	1.22	0.22	6.32	2.6×10^{-10}
6p21.33	ENSG00000226979	*LTA*	-0.97	0.33	4.09	4.3×10^{-5}
6p21.33	ENSG00000213760	*ATP6V1G2*	0.83	0.40	-5.43	5.8×10^{-8}
6p21.32	ENSG00000204308	*RNF5*	-0.69	0.49	-9.65	5.2×10^{-22}

	6p21.32	ENSG00000242574	*HLA-DMB*	0.55	0.58	6.63	3.3×10^{-11}
	6p21.32	ENSG00000196735	*HLA-DQA1*	-0.37	0.71	-5.22	1.8×10^{-7}
	6p21.33	ENSG00000228022	*HCG20*	-	-	-5.62	1.9×10^{-8}
	6p21.33	ENSG00000204540	*PSORS1C1*	-	-	-5.09	3.6×10^{-7}
	6p21.33	ENSG00000204531	*POU5F1*	-	-	4.23	2.4×10^{-5}
	10p14	ENSG00000151657	*KIN*	-	-	4.14	3.5×10^{-5}

Supplementary Table 16: TWAS results for EBV antigen response phenotypes that were analyzed using gene expression models based on whole blood, brain tissues, and EBV-transformed lymphocytes. Associations with $P_{\mathrm{TWAS}}<4.2\times10^{-6}$ are considered statistically significant and genes with $P_{\mathrm{TWAS}}<4.5\times10^{-5}$ are considered suggestive.

Antigen	Region	Gene ID	Gene	Whole Blood		Brain (Frontal Cortex)		EBV Lymphocytes	
				Z	P_{WAS}	Z	P_{TWAS}	Z	P_{TWAS}
EBV EA-D	6p21.32	ENSG00000204257	*HLA-DMA*	-5.91	3.5×10^{-9}	-5.93	3.0×10^{-9}	5.88	4.0×10^{-9}
	6p21.33	ENSG00000204444	*APOM*	5.86	4.6×10^{-9}	5.73	1.0×10^{-8}	5.45	5.1×10^{-8}
	6p21.33	ENSG00000166278	*C2*	-5.70	1.2×10^{-8}	-	-	-	-
	6p21.33	ENSG00000244731	*C4A*	5.66	1.5×10^{-8}	5.55	2.9×10^{-8}	5.59	2.3×10^{-8}
	6p21.33	ENSG00000204386	*NEU1*	5.59	2.3×10^{-8}	-	-	-1.65	0.099
	6p21.33	ENSG00000213719	*CLIC1*	5.55	2.9×10^{-8}	5.55	2.9×10^{-8}	1.14	0.25
	6p21.33	ENSG00000224389	*C4B*	-5.43	5.6×10^{-8}	-	-	-	-
	6p21.33	ENSG00000231852	*CYP21A2*	-5.41	6.4×10^{-8}	-	-	-	-
	6p22.1	ENSG00000281831	*HCP5B*	-4.66	3.2×10^{-6}	-5.30	1.1×10^{-7}	-6.01	1.9×10^{-9}
	6p22.1	ENSG00000204625	*HCG9*	-4.52	6.2×10^{-6}	-	-	-	-
	6p22.1	ENSG00000204613	*TRIM10*	4.48	7.6×10^{-6}	-	-	-	-
	6p21.33	ENSG00000204388	*HSPA1B*	-4.43	9.3×10^{-6}	-	-	1.61	0.11
	6p21.33	ENSG00000214894	*LINC00243*	-4.38	1.2×10^{-5}	-	-	1.19	0.23
	6q22.1	ENSG00000188820	*FAM26F*	4.26	2.0×10^{-5}	4.68	2.8×10^{-6}	3.41	6.4×10^{-4}
	6p21.33	ENSG00000204536	*CCHCR1*	-3.77	1.7×10^{-4}	-4.75	2.1×10^{-6}	0.40	0.69
	20q11.23	ENSG00000080839	*RBL1*	-2.68	7.3×10^{-3}	-2.28	0.022	-4.10	4.2×10^{-5}
	12q23.1	ENSG00000139343	*SNRPF*	-2.46	0.014	-4.12	3.9×10^{-5}	-4.13	3.6×10^{-5}
	6p21.33	ENSG00000204410	*MSH5*	-2.40	0.016	5.71	1.2×10^{-8}	-1.32	0.19
	6p21.32	ENSG00000242574	*HLA-DMB*	2.00	0.046	-5.80	6.8×10^{-9}	-2.59	9.7×10^{-3}
	6p21.32	ENSG00000232629	*HLA-DQB2*	1.48	0.14	1.31	0.19	4.15	3.3×10^{-5}
	6p21.33	ENSG00000204482	*LST1*	0.87	0.39	-	-	-4.34	1.4×10^{-5}
	6p21.33	ENSG00000204560	*DHX16*	0.72	0.47	0.07	0.94	-4.17	3.1×10^{-5}
	6p21.32	ENSG00000198502	*HLA-DRB5*	-	-	-	-	-5.85	4.8×10^{-9}
	6p21.33	ENSG00000204531	*POU5F1*	-	-	-1.64	0.10	-5.40	6.7×10^{-8}
	6p21.33	ENSG00000204540	*PSORS1C1*	-	-	4.43	9.6×10^{-6}	4.67	3.0×10^{-6}
	6p21.33	ENSG00000228022	*HCG20*	-	-	4.10	4.2×10^{-5}	3.58	3.5×10^{-4}
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	-4.38	1.2×10^{-5}	-	-
EBV EBNA	6p21.32	ENSG00000179344	*HLA-DQB1*	13.30	2.2×10^{-40}	11.46	2.2×10^{-30}	10.67	1.4×10^{-26}
	6p21.32	ENSG00000232629	*HLA-DQB2*	-12.19	3.6×10^{-34}	-12.16	5.0×10^{-34}	-3.78	1.6×10^{-4}
	6p21.32	ENSG00000204305	*AGER*	-10.70	9.9×10^{-27}	-8.91	5.1×10^{-19}	-7.28	3.4^{-13}
	6p21.33	ENSG00000204371	*EHMT2*	9.43	4.0×10^{-21}	-	-	-	-
	6p21.33	ENSG00000213722	*DDAH2*	9.00	2.2×10^{-19}	7.76	8.6×10^{-15}	0.01	1.00
	6p21.33	ENSG00000204435	*CSNK2B*	-7.62	2.5×10^{-14}	3.36	7.8×10^{-4}	-1.61	0.11
	6p21.32	ENSG00000204308	*RNF5*	7.53	5.0×10^{-14}	9.45	3.6×10^{-21}	10.17	2.8×10^{-24}

EBV EBNA	6p21.32	ENSG00000204304	*PBX2*	7.31	2.7×10^{-13}	4.05	5.1×10^{-5}	4.05	5.1×10^{-5}
	6p21.33	ENSG00000204444	*APOM*	7.30	2.8×10^{-13}	7.16	7.8×10^{-13}	6.14	8.2×10^{-10}
	6p21.32	ENSG00000204310	*AGPAT1*	7.30	3.0×10^{-13}	-7.57	3.7×10^{-14}	-	-
	6p21.33	ENSG00000204463	*BAG6*	-7.07	1.5×10^{-12}	3.26	1.1×10^{-3}	2.51	0.012
	6p21.32	ENSG00000204315	*FKBPL*	-6.74	1.6×10^{-11}	4.81	1.5×10^{-6}	-	-
	6p21.33	ENSG00000224389	*C4B*	-6.43	1.3×10^{-10}	-	-	-	-
	6p21.33	ENSG00000231852	*CYP21A2*	-6.41	1.4×10^{-10}	-	-	-	-
	6p21.33	ENSG00000213719	*CLIC1*	6.21	5.3×10^{-10}	6.21	5.3×10^{-10}	6.98	3.0×10^{-12}
	6p21.33	ENSG00000166278	*C2*	-6.21	5.3×10^{-10}	-	-	-	-
	6p21.33	ENSG00000204386	*NEU1*	6.14	8.2×10^{-10}	-	-	-2.05	0.040
	6p21.33	ENSG00000204536	*CCHCR1*	-5.94	2.9×10^{-9}	-5.82	6.0×10^{-9}	3.30	9.7×10^{-4}
	6p21.33	ENSG00000227507	*LTB*	5.77	7.8×10^{-9}	-	-	-	-
	3q25.1	ENSG00000169313	*P2RY12*	5.53	3.3×10^{-8}	5.20	2.0×10^{-7}	5.20	2.0×10^{-7}
	6p21.33	ENSG00000244731	*C4A*	5.30	1.2×10^{-7}	5.83	5.6×10^{-9}	7.18	6.8×10^{-13}
	6p21.32	ENSG00000236104	*ZBTB22*	-5.13	2.9×10^{-7}	-3.73	1.9×10^{-4}	-	-
	6p21.32	ENSG00000204314	*PRRT1*	-5.02	5.1×10^{-7}	-	-	-9.99	1.6×10^{-23}
	6p21.33	ENSG00000204396	*VWA7*	4.96	7.0×10^{-7}	-6.57	4.9×10^{-11}	0.42	0.68
	6p21.32	ENSG00000204209	*DAXX*	4.94	7.8×10^{-7}	0.19	0.85	4.55	5.3×10^{-6}
	6p21.32	ENSG00000237541	*HLA-DQA2*	-4.84	1.3×10^{-6}	-	-	-	-
	6p21.32	ENSG00000204257	*HLA-DMA*	-4.69	2.7×10^{-6}	-4.54	5.5×10^{-6}	4.64	3.5×10^{-6}
	6p21.32	ENSG00000227057	*WDR46*	-4.54	5.6×10^{-6}	-1.86	0.063	-1.86	0.063
	6p21.33	ENSG00000204366	*ZBTB12*	-4.44	8.9×10^{-6}	3.02	2.5×10^{-3}	0.26	0.80
	6p21.33	ENSG00000204420	*MPIG6B*	-4.44	9.0×10^{-6}	2.89	3.8×10^{-3}	4.44	9.0×10^{-6}
	6p21.33	ENSG00000204344	*STK19*	4.44	9.1×10^{-6}	1.21	0.23	-	-
	6p21.32	ENSG00000231925	*TAPBP*	-4.37	1.2×10^{-5}	-5.18	2.3×10^{-7}	5.42	5.9×10^{-8}
	6p22.1	ENSG00000204625	*HCG9*	-4.25	2.1×10^{-5}	-	-	-	-
	6p21.32	ENSG00000196735	*HLA-DQA1*	4.18	2.9×10^{-5}	11.93	8.8×10^{-33}	0.87	0.38
	6p21.32	ENSG00000221988	*PPT2*	-3.72	2.0×10^{-4}	-0.59	0.55	-6.36	2.0×10^{-10}
	6p22.1	ENSG00000281831	*HCP5B*	-3.49	4.9×10^{-4}	-4.24	2.3×10^{-5}	-5.08	3.7×10^{-7}
	6p21.33	ENSG00000206344	*HCG27*	-3.22	1.3×10^{-3}	0.74	0.46	-5.86	4.6×10^{-9}
	6p21.33	ENSG00000232810	*TNF*	3.06	2.2×10^{-3}	3.06	2.2×10^{-3}	-7.43	1.1×10^{-13}
	6p21.33	ENSG00000213760	*ATP6V1G2*	-3.04	2.4×10^{-3}	3.58	3.5×10^{-4}	-4.89	9.9×10^{-7}
	6p21.32	ENSG00000204252	*HLA-DOA*	2.45	0.014	7.80	6.3×10^{-15}	1.84	0.066
	6p21.33	ENSG00000204410	*MSH5*	-2.04	0.041	5.27	1.4×10^{-7}	1.68	0.093
	6p21.32	ENSG00000231389	*HLA-DPA1*	-1.97	0.049	-5.49	4.1×10^{-8}	0.33	0.74
	6p21.32	ENSG00000223865	*HLA-DPB1*	1.96	0.050	-6.35	2.1×10^{-10}	-	-
	6p22.1	ENSG00000234127	*TRIM26*	1.34	0.18	-4.69	2.7×10^{-6}	1.34	0.18
	6p21.32	ENSG00000242574	*HLA-DMB*	1.22	0.22	-5.05	4.4×10^{-7}	-3.61	3.1×10^{-4}
	6p21.33	ENSG00000204469	*PRRC2A*	-1.20	0.23	0.62	0.53	-7.58	3.5×10^{-14}
	6p21.32	ENSG00000204228	*HSD17B8*	1.16	0.25	4.63	3.7×10^{-6}	1.14	0.26

EBV EBNA	6p21.33	ENSG00000204388	*HSPA1B*	1.05	0.30	-	-	4.46	8.4×10^{-6}
	6p21.33	ENSG00000226979	*LTA*	-0.75	0.45	-5.76	8.6×10^{-9}	-5.71	1.1×10^{-8}
	6p21.32	ENSG00000204231	*RXRB*	-0.67	0.50	4.54	5.7×10^{-6}	0.67	0.50
	3q25.1	ENSG00000181631	*P2RY13*	0.48	0.63	5.72	1.1×10^{-8}	-0.13	0.90
	6p21.32	ENSG00000204301	*NOTCH4*	0.36	0.72	4.41	1.0×10^{-5}	2.12	0.034
	6p21.33	ENSG00000204389	*HSPA1A*	-	-	-	-	8.81	1.3×10^{-18}
	6p21.33	ENSG00000204531	*POU5F1*			-4.32	1.5×10^{-5}	-6.23	4.7×10^{-10}
	6p21.32	ENSG00000198502	*HLA-DRB5*	-	-	-	-	5.24	1.6×10^{-7}
	6p21.33	ENSG00000168631	*DPCR1*	-	-	-	-	4.92	8.5×10^{-7}
	6p21.33	ENSG00000204540	*PSORS1C1*	-	-	4.89	1.0×10-6	4.91	9.3×10^{-7}
	6p21.33	ENSG00000137337	*MDC1*	-	-	-	-	4.73	2.2×10^{-6}
	6p21.32	ENSG00000204287	*HLA-DRA*	-	-	-	-	4.67	3.0×10^{-6}
	6p21.32	ENSG00000168477	*TNXB*	-	-	-	-	4.25	2.2×10^{-5}
	6p21.33	ENSG00000228789	*HCG22*	-	-	-4.47	7.7×10^{-6}	3.27	1.1×10^{-3}
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	13.05	6.7×10^{-39}	-	-
	6p22.1	ENSG00000270604	*HCG17*	-	-	4.16	3.3×10^{-5}	-	-
EBV p18	6p21.33	ENSG00000213722	*DDAH2*	9.74	2.0×10^{-22}	6.03	1.6×10^{-9}	1.85	0.064
	6p21.33	ENSG00000204371	*EHMT2*	9.56	1.2×10^{-21}	-	-	-	-
	6p21.32	ENSG00000204305	*AGER*	-8.39	4.8×10^{-17}	-8.90	5.4×10^{-19}	-5.02	5.1×10^{-7}
	6p21.33	ENSG00000204463	*BAG6*	-8.20	2.5×10^{-16}	-2.14	0.032	-1.18	0.24
	6p21.33	ENSG00000204536	*CCHCR1*	-6.66	2.7×10^{-11}	-5.05	4.4×10^{-7}	0.09	0.93
	6p21.33	ENSG00000227507	*LTB*	6.65	3.0×10^{-11}	-	-	-	-
	6p21.33	ENSG00000213760	*ATP6V1G2*	-6.36	2.0×10^{-10}	2.65	8.1×10^{-3}	-7.02	2.2×10^{-12}
	6p21.32	ENSG00000179344	*HLA-DQB1*	5.79	7.1×10^{-9}	5.74	9.8×10^{-9}	4.65	3.3×10^{-6}
	6p21.33	ENSG00000137310	*TCF19*	-5.76	8.6×10^{-9}	-3.44	5.9×10^{-4}	3.65	2.6×10^{-4}
	6p21.32	ENSG00000204310	*AGPAT1*	5.72	1.1×10^{-8}	-6.10	1.1×10^{-9}	-	-
	6p21.32	ENSG00000232629	*HLA-DQB2*	-5.61	2.1×10^{-8}	-5.64	1.7×10^{-8}	-1.74	0.082
	6p21.33	ENSG00000214894	*LINC00243*	-5.60	2.2×10^{-8}	-	-	-0.16	0.87
	6p21.32	ENSG00000237541	*HLA-DQA2*	-5.41	6.5×10^{-8}	-	-	-	-
	6p21.33	ENSG00000166278	*C2*	-5.35	8.9×10^{-8}	-	-	-	-
	6p22.2	ENSG00000186470	*BTN3A2*	5.33	9.9×10^{-8}	5.05	4.4×10^{-7}	5.25	1.5×10^{-7}
	6p21.33	ENSG00000213719	*CLIC1*	5.31	1.1×10^{-7}	5.31	1.1×10^{-7}	6.84	8.2×10^{-12}
	6p21.33	ENSG00000204386	*NEU1*	5.26	1.5×10^{-7}	-	-	-1.05	0.29
	6p21.33	ENSG00000204396	*VWA7*	5.21	1.9×10^{-7}	-6.23	4.8×10^{-10}	1.10	0.27
	6p21.33	ENSG00000204469	*PRRC2A*	-5.16	2.4×10^{-7}	0.77	0.44	-8.33	8.1×10^{-17}
	6p21.33	ENSG00000206344	*HCG27*	-5.11	3.3×10^{-7}	-1.61	0.11	-8.68	4.1×10^{-18}
	6p21.33	ENSG00000224389	*C4B*	-5.03	4.9×10^{-7}	-	-	-	-
	6p21.33	ENSG00000204444	*APOM*	4.97	6.6×10^{-7}	4.83	1.4-6	5.38	7.5×10^{-8}
	6p21.33	ENSG00000231852	*CYP21A2*	-4.95	7.3×10^{-7}	-	-	-	-
	6p21.32	ENSG00000204304	*PBX2*	4.83	1.4×10^{-6}	0.20	0.84	0.20	0.84

EBV p18	6p22.2	ENSG00000124508	*BTN2A2*	-4.70	2.6×10^{-6}	-0.72	0.47	5.06	4.2×10^{-7}
	6p22.1	ENSG00000261353	*CTA-14H9.5*	4.67	3.0×10^{-6}	-	-	-3.65	2.6×10^{-4}
	6p22.1	ENSG00000137185	*ZSCAN9*	4.53	6.0×10^{-6}	-4.40	1.1×10^{-5}	4.40	1.1×10^{-5}
	6p22.1	ENSG00000197279	*ZNF165*	-4.50	6.9×10^{-6}	-0.76	0.45	-2.03	0.042
	6p22.1	ENSG00000158691	*ZSCAN12*	4.45	8.6×10^{-6}	-3.27	1.1×10^{-3}	4.46	8.1×10^{-6}
	6p22.1	ENSG00000187626	*ZKSCAN4*	-4.42	1.0×10^{-5}	-4.79	1.7×10^{-6}	-4.79	1.7×10^{-6}
	19q13.12	ENSG00000126243	*LRFN3*	4.34	1.4×10^{-5}	4.14	3.5×10^{-5}	4.47	7.8×10^{-6}
	9q21.11	ENSG00000226337	*RP11-274B18.4*	-4.22	2.5×10^{-5}	-	-	-	-
	19q13.12	ENSG00000011600	*TYROBP*	-4.22	2.5×10^{-5}	4.22	2.5×10^{-5}	-	-
	6p22.1	ENSG00000197062	*ZSCAN26*	4.18	2.9×10^{-5}	4.33	1.5×10^{-5}	3.86	1.1×10^{-4}
	6p22.1	ENSG00000272468	*RP1-86C11.7*	4.17	3.1×10^{-5}	-0.93	0.35	-	-
	6p21.32	ENSG00000204257	*HLA-DMA*	-4.15	3.4×10^{-5}	-4.11	3.9×10-5	4.16	3.2×10^{-5}
	6p22.1	ENSG00000204613	*TRIM10*	4.10	4.2×10^{-5}	-	-	-	-
	6p21.33	ENSG00000244731	*C4A*	4.01	6.1×10^{-5}	4.24	2.2×10^{-5}	5.60	2.2×10^{-8}
	6p21.32	ENSG00000241106	*HLA-DOB*	3.97	7.1×10^{-5}	4.54	5.6×10^{-6}	-1.10	0.27
	6p21.33	ENSG00000204435	*CSNK2B*	-3.97	7.1×10^{-5}	6.41	1.4×10^{-10}	-3.45	5.5×10^{-4}
	6p21.32	ENSG00000204301	*NOTCH4*	-3.93	8.4×10^{-5}	4.70	2.6×10^{-6}	0.84	0.40
	6p21.32	ENSG00000204308	*RNF5*	3.66	2.5×10^{-4}	5.59	2.3×10^{-8}	5.96	2.5×10^{-9}
	6p21.33	ENSG00000204516	*MICB*	-3.62	3.0×10^{-4}	2.97	3.0×10^{-3}	-8.06	7.4×10^{-16}
	6p22.1	ENSG00000233822	*HIST1H2BN*	3.36	7.8×10^{-4}	0.83	0.41	4.69	2.8×10^{-6}
	6p21.32	ENSG00000204267	*TAP2*	-3.09	2.0×10^{-3}	-4.22	2.4×10^{-5}	-4.09	4.2×10^{-5}
	6p21.33	ENSG00000204387	*C6orf48*	3.04	2.3×10^{-3}	3.78	1.5×10^{-4}	4.85	1.2×10^{-6}
	6p21.33	ENSG00000204482	*LST1*	3.00	2.7×10^{-3}	-	-	-4.52	6.1×10^{-6}
	6p21.33	ENSG00000204520	*MICA*	2.52	0.012	1.90	0.057	5.60	2.1×10^{-8}
	6p21.33	ENSG00000272221	*XXbac-BPG181B23.7*	2.09	0.037	4.52	6.1×10^{-6}	-0.37	0.71
	6p21.32	ENSG00000204228	*HSD17B8*	1.87	0.062	4.81	1.5×10^{-6}	2.47	0.014
	5q31.1	ENSG00000164402	*SEPTIN8*	1.65	0.098	4.42	9.9×10^{-6}	-1.95	0.051
	6p21.32	ENSG00000204252	*HLA-DOA*	-1.34	0.18	6.56	5.5×10^{-11}	-1.13	0.26
	6p22.2	ENSG00000111801	*BTN3A3*	-0.93	0.35	-4.68	2.8×10^{-6}	0.25	0.80
	6p21.32	ENSG00000242574	*HLA-DMB*	-0.87	0.38	-4.40	1.1×10^{-5}	-3.24	1.2×10^{-3}
	6p21.33	ENSG00000204472	*AIF1*	0.86	0.39	-3.01	2.6×10^{-3}	-4.21	2.6×10^{-5}
	6p21.32	ENSG00000204314	*PRRT1*	0.68	0.50	-	-	-5.91	3.5×10^{-9}
	6p21.33	ENSG00000226979	*LTA*	-0.65	0.51	-6.72	1.8×10^{-11}	-6.64	3.1×10^{-11}
	6p22.1	ENSG00000198315	*ZKSCAN8*	0.62	0.53	5.15	2.7×10^{-7}	-0.01	1.00
	6p21.32	ENSG00000204248	*COL11A2*	-0.60	0.55	4.15	3.3×10^{-5}	1.64	0.10
	6p21.32	ENSG00000196735	*HLA-DQA1*	0.50	0.62	6.81	1.0×10^{-11}	1.01	0.31
	6p21.33	ENSG00000232810	*TNF*	0.48	0.63	0.48	0.63	-10.43	1.8×10^{-25}
	22q13.1	ENSG00000278195	*SSTR3*	0.23	0.82	-4.70	2.6×10^{-6}	1.23	0.22
	6p21.33	ENSG00000204531	*POU5F1*	-	-	-5.64	1.7×10^{-8}	-5.84	5.2×10^{-9}

EBV p18	6p21.33	ENSG00000228022	*HCG20*	-	-	5.10	3.4×10^{-7}	5.70	1.2×10^{-8}
	6p21.33	ENSG00000204389	*HSPA1A*	-	-	-	-	5.65	1.6×10^{-8}
	6p22.1	ENSG00000184357	*HIST1H1B*	-	-	-	-	-4.85	1.2×10^{-6}
	6p21.33	ENSG00000137337	*MDC1*	-	-	-	-	4.76	1.9×10^{-6}
	6p21.33	ENSG00000204540	*PSORS1C1*	-	-	4.99	6.0×10^{-7}	4.15	3.3×10^{-5}
	6p21.33	ENSG00000168631	*DPCR1*	-	-	-	-	4.10	4.1×10^{-5}
	6p21.33	ENSG00000228789	*HCG22*	-	-	-4.33	1.5×10^{-5}	3.03	2.4×10^{-3}
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	7.02	2.2×10^{-12}	-	-
EBV ZEBRA	6p21.32	ENSG00000232629	*HLA-DQB2*	8.87	7.6×10^{-19}	8.54	1.4×10^{-17}	5.29	1.3×10^{-7}
	6p21.32	ENSG00000179344	*HLA-DQB1*	-8.56	1.1×10^{-17}	1.04	0.30	-11.40	4.1×10^{-30}
	6p21.32	ENSG00000204257	*HLA-DMA*	-7.28	3.4×10^{-13}	-7.45	9.5×10^{-14}	7.32	2.6×10^{-13}
	6p21.33	ENSG00000214894	*LINC00243*	-6.89	5.6×10^{-12}	-	-	-0.22	0.82
	6p21.33	ENSG00000244731	*C4A*	6.80	1.1×10^{-11}	6.46	1.0×10^{-10}	6.54	6.0×10^{-11}
	6p21.33	ENSG00000166278	*C2*	-6.42	$1.4\times10-^{10}$	-	-	-	-
	6p21.33	ENSG00000204386	*NEU1*	6.39	1.6×10^{-10}	-	-	-2.35	0.019
	6p21.33	ENSG00000213719	*CLIC1*	6.20	5.6×10^{-10}	6.20	5.6×10^{-10}	-0.45	0.65
	6p21.33	ENSG00000224389	*C4B*	-6.17	7.0×10^{-10}	-	-	-	-
	6p21.33	ENSG00000231852	*CYP21A2*	-6.16	7.5×10^{-10}	-	-	-	-
	6p21.33	ENSG00000204444	*APOM*	6.13	8.6×10^{-10}	5.97	2.3×10^{-9}	6.18	6.6×10^{-10}
	6p21.33	ENSG00000228727	*SAPCD1*	-6.06	1.4×10^{-9}	-1.18	0.24	-6.06	1.4×10^{-9}
	6p21.33	ENSG00000146112	*PPP1R18*	-5.71	1.1×10^{-8}	0.84	0.40	-5.77	8.1×10^{-9}
	6p21.33	ENSG00000204351	*SKIV2L*	5.70	1.2×10^{-8}	5.76	8.2×10^{-9}	6.13	8.7×10^{-10}
	6p21.33	ENSG00000204396	*VWA7*	5.49	4.0×10^{-8}	-4.62	3.9×10^{-6}	4.31	1.6×10^{-5}
	6p21.33	ENSG00000204392	*LSM2*	-5.43	5.7×10^{-8}	-5.01	5.4×10^{-7}	-5.01	5.4×10^{-7}
	6p21.33	ENSG00000227507	*LTB*	5.28	1.3×10^{-7}	-	-	-	-
	6p21.33	ENSG00000204388	*HSPA1B*	-5.27	1.4×10^{-7}	-	-	-2.17	0.030
	6p21.33	ENSG00000204564	*C6orf136*	5.06	4.1×10^{-7}	0.38	0.70	5.05	4.4×10^{-7}
	6p21.32	ENSG00000204315	*FKBPL*	5.03	4.9×10^{-7}	-0.60	0.55	-	-
	6p21.32	ENSG00000204252	*HLA-DOA*	-4.98	6.5×10^{-7}	1.48	0.14	-4.95	7.5×10^{-7}
	6p21.33	ENSG00000204536	*CCHCR1*	-4.96	7.0×10^{-7}	-5.72	1.1×10^{-8}	-1.37	0.17
	6p21.33	ENSG00000204463	*BAG6*	-4.86	1.2×10^{-6}	0.80	0.42	1.20	0.23
	6p22.1	ENSG00000204592	*HLA-E*	-4.66	3.2×10^{-6}	-4.66	3.2×10^{-6}	-4.66	3.2×10^{-6}
	6p22.1	ENSG00000204613	*TRIM10*	4.60	4.2×10^{-6}	-	-	-	-
	6p21.33	ENSG00000204525	*HLA-C*	-4.60	4.3×10^{-6}	1.19	0.23	-5.39	7.1×10^{-8}
	6p21.32	ENSG00000196735	*HLA-DQA1*	-4.57	5.0×10^{-6}	-6.72	1.8×10^{-11}	-4.09	4.4×10^{-5}
	22q11.21	ENSG00000185608	*MRPL40*	4.49	7.1×10^{-6}	3.96	7.5×10^{-5}	4.48	7.5×10^{-6}
	4q24	ENSG00000109320	*NFKB1*	-4.37	1.2×10^{-5}	3.88	1.1×10^{-4}	0.94	0.35
	6p21.33	ENSG00000204394	*VARS*	4.32	1.5×10^{-5}	0.44	0.66	0.44	0.66
	6p22.1	ENSG00000281831	*HCP5B*	-4.29	1.8×10^{-5}	-5.24	1.6×10^{-7}	-4.40	1.1×10^{-5}
	6p21.32	ENSG00000241404	*EGFL8*	-4.26	2.0×10^{-5}	-2.58	9.8×10^{-3}	-4.90	9.6×10^{-7}

EBV ZEBRA	6p22.1	ENSG00000204625	*HCG9*	-4.16	3.1×10^{-5}	-	-	-	-
	6p21.33	ENSG00000204356	*NELFE*	-4.14	3.4×10^{-5}	0.77	0.44	-	-
	6p22.1	ENSG00000158691	*ZSCAN12*	4.10	4.1×10^{-5}	-0.49	0.63	3.19	1.4×10^{-3}
	6p21.33	ENSG00000204428	*LY6G5C*	-3.48	5.1×10^{-4}	-3.48	5.1×10^{-4}	-6.49	8.8×10^{-11}
	6p22.1	ENSG00000204619	*PPP1R11*	3.39	7.1×10^{-4}	0.08	0.94	5.08	3.8×10^{-7}
	6p21.33	ENSG00000204438	*GPANK1*	2.81	4.9×10^{-3}	2.21	0.027	4.36	1.3×10^{-5}
	6p21.32	ENSG00000242574	*HLA-DMB*	2.70	6.9×10^{-3}	-7.33	2.3×10^{-13}	0.72	0.47
	6p21.32	ENSG00000204261	*PSMB8-AS1*	-2.67	7.6×10^{-3}	2.36	0.018	4.26	2.0×10^{-5}
	6p21.32	ENSG00000204267	*TAP2*	-2.21	0.027	-4.76	2.0×10^{-6}	-3.92	9.0×10^{-5}
	6p21.33	ENSG00000226979	*LTA*	2.05	0.040	-6.15	7.6×10^{-10}	-5.29	1.3×10^{-7}
	6p22.1	ENSG00000198315	*ZKSCAN8*	2.00	0.046	4.54	5.7×10^{-6}	-0.78	0.44
	6p21.32	ENSG00000231389	*HLA-DPA1*	1.75	0.079	5.52	3.5×10^{-8}	2.44	0.015
	6p21.33	ENSG00000204482	*LST1*	1.53	0.13	-	-	-6.81	1.0×10^{-11}
	6p21.33	ENSG00000213760	*ATP6V1G2*	1.44	0.15	4.23	2.4×10^{-5}	2.55	0.011
	6p21.33	ENSG00000204435	*CSNK2B*	-1.25	0.21	4.91	9.3×10^{-7}	-3.55	3.9×10^{-4}
	6p21.33	ENSG00000204410	*MSH5*	-0.82	0.41	5.67	1.4×10^{-8}	-0.02	0.98
	6p21.32	ENSG00000221988	*PPT2*	-0.59	0.55	4.90	9.6×10^{-7}	-3.68	2.3×10^{-4}
	6p21.33	ENSG00000137312	*FLOT1*	0.54	0.59	-5.77	8.1×10^{-9}	-1.41	0.16
	6p21.32	ENSG00000198502	*HLA-DRB5*	-	-	-	-	-14.09	4.2×10^{-45}
	6p21.32	ENSG00000204287	*HLA-DRA*	-	-	-	-	8.48	2.2×10^{-17}
	6p21.33	ENSG00000204531	*POU5F1*	-	-	0.64	0.52	-6.11	9.9×10^{-10}
	6p21.33	ENSG00000204574	*ABCF1*	-	-	-	-	-5.74	9.3×10^{-9}
	6p21.33	ENSG00000204540	*PSORS1C1*	-	-	6.24	4.4×10^{-10}	5.25	1.5×10^{-7}
	6p21.32	ENSG00000168394	*TAP1*	-	-	-2.30	0.022	4.76	2.0×10^{-6}
	6p21.33	ENSG00000228022	*HCG20*	-	-	5.05	4.4×10^{-7}	3.92	8.9×10^{-5}
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	-12.01	3.3×10^{-33}	-	-
	6p22.1	ENSG00000271755	*RP1-153G14.4*	-	-	4.16	3.2×10^{-5}	-	-

Supplementary Table 17: TWAS results for MCV antigen response using gene expression models based on whole blood, brain, and skin tissues. Associations with $P_{\mathrm{TWAS}}<4.2\times10^{-6}$ are considered statistically significant and genes with $P_{\mathrm{TWAS}}<4.5\times10^{-5}$ are considered suggestive.

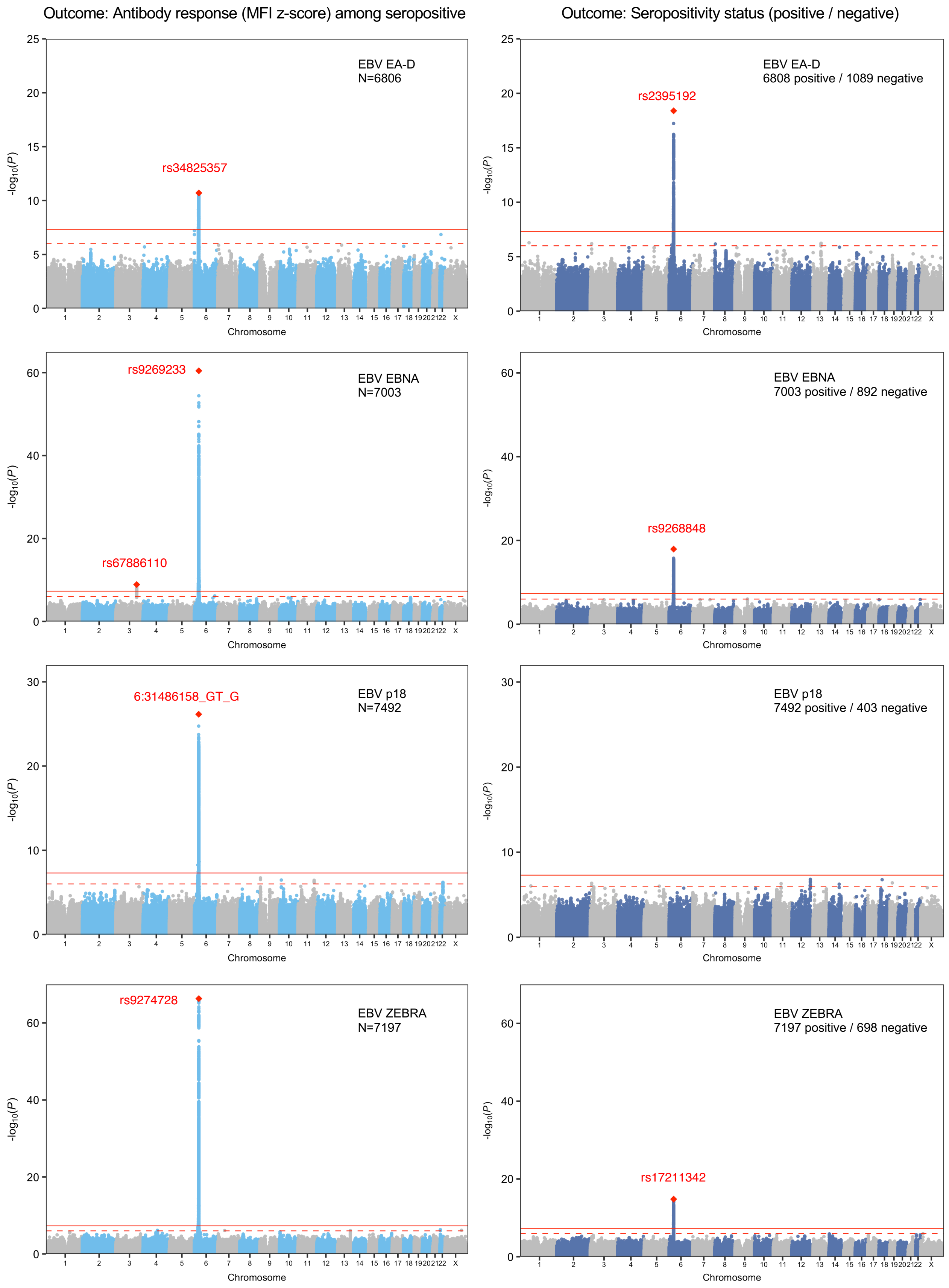
Region	Gene ID	Gene	Whole Blood		Brain (Frontal Cortex)		Skin (Sun Exposed)		Skin (Sun Unexposed)	
			Z	P_{TWAS}	Z	P_{TWAS}	Z	P_{TWAS}	Z	P_{TWAS}
6p21.33	ENSG00000204396	*VWA7*	-5.89	4.0×10^{-9}	5.42	6.0×10^{-8}	-4.91	9.0×10^{-7}	-4.85	1.2×10^{-6}
6p21.33	ENSG00000204371	*EHMT2*	-5.88	4.0×10^{-9}	-	-	-2.68	7.5×10^{-3}	-2.66	7.9×10^{-3}
6p21.33	ENSG00000204564	*C6orf136*	-5.76	8.2×10^{-9}	-0.97	0.33	-2.75	6.0×10^{-3}	-2.58	9.9×10^{-3}
6p21.33	ENSG00000213722	*DDAH2*	-5.68	1.4×10^{-8}	-1.49	0.14	-3.94	8.2×10^{-5}	-	-
5q31.2	ENSG00000170464	*DNAJC18*	4.82	1.5×10^{-6}	6.07	1.3×10^{-9}	3.39	6.9×10^{-4}	3.40	6.7×10^{-4}
6p21.33	ENSG00000227507	*LTB*	-4.72	2.3×10^{-6}	-	-	-	-	-	-
5q31.2	ENSG00000228672	*PROB1*	-4.64	3.6×10^{-6}	-3.29	1.0×10^{-3}	-	-	-6.75	1.5×10^{-11}
6p21.33	ENSG00000204388	*HSPA1B*	-4.48	7.4×10^{-6}	-	-	-	-	-	-
6p22.1	ENSG00000204599	*TRIM39*	-4.36	1.3×10^{-5}	-0.43	0.67	0.20	0.84	-0.11	0.91
5q31.2	ENSG00000170482	*SLC23A1*	-4.34	1.4×10^{-5}	-4.07	4.7×10^{-5}	4.39	1.1×10^{-5}	4.07	4.7×10^{-5}
5q31.2	ENSG00000170469	*SPATA24*	4.20	2.7×10^{-5}	-	-	4.30	1.7×10^{-5}	4.29	1.8×10^{-5}
6p22.1	ENSG00000204632	*HLA-G*	4.11	3.9×10^{-5}	-1.45	0.15	0.19	0.85	0.11	0.92
5q31.2	ENSG00000184584	*TMEM173*	-4.08	4.5×10^{-5}	-4.28	1.9×10^{-5}	-4.17	3.0×10^{-5}	-4.20	2.6×10^{-5}
6p21.32	ENSG00000241106	*HLA-DOB*	-3.84	1.2×10^{-4}	-5.30	1.2×10^{-7}	-3.59	3.3×10^{-4}	-4.73	2.3×10^{-6}
6p22.1	ENSG00000204619	*PPP1R11*	-3.46	5.4×10^{-4}	0.64	0.52	4.21	2.5×10^{-5}	4.20	2.7×10^{-5}
6p21.32	ENSG00000204267	*TAP2*	3.32	9.1×10^{-4}	3.11	1.9×10^{-3}	5.52	3.4×10^{-8}	3.18	1.5×10^{-3}
6p21.33	ENSG00000226979	*LTA*	2.94	3.3×10^{-3}	5.07	4.0×10^{-7}	0.88	0.38	1.33	0.18
6p21.32	ENSG00000204314	*PRRT1*	-2.80	5.1×10^{-3}	-	-	5.75	9.2×10^{-9}	5.72	1.1×10^{-8}
5q31.2	ENSG00000249751	*ECSCR*	2.38	0.018	7.83	5.0×10^{-15}	7.25	4.2×10^{-13}	7.83	$5.0\times10\text{-}^{15}$
6p22.1	ENSG00000234127	*TRIM26*	-2.24	0.025	-1.64	0.10	-6.21	5.3×10^{-10}	-5.47	4.6×10^{-8}
6p21.33	ENSG00000204498	*NFKBIL1*	-2.19	0.029	-1.94	0.052	-4.16	3.2×10^{-5}	-3.32	9.0×10^{-4}
6p21.32	ENSG00000204305	*AGER*	0.91	0.36	5.83	5.6×10^{-9}	1.87	0.062	0.28	0.78
5q31.2	ENSG00000131508	*UBE2D2*	-	-	4.33	1.5×10^{-5}	-	-	-	-

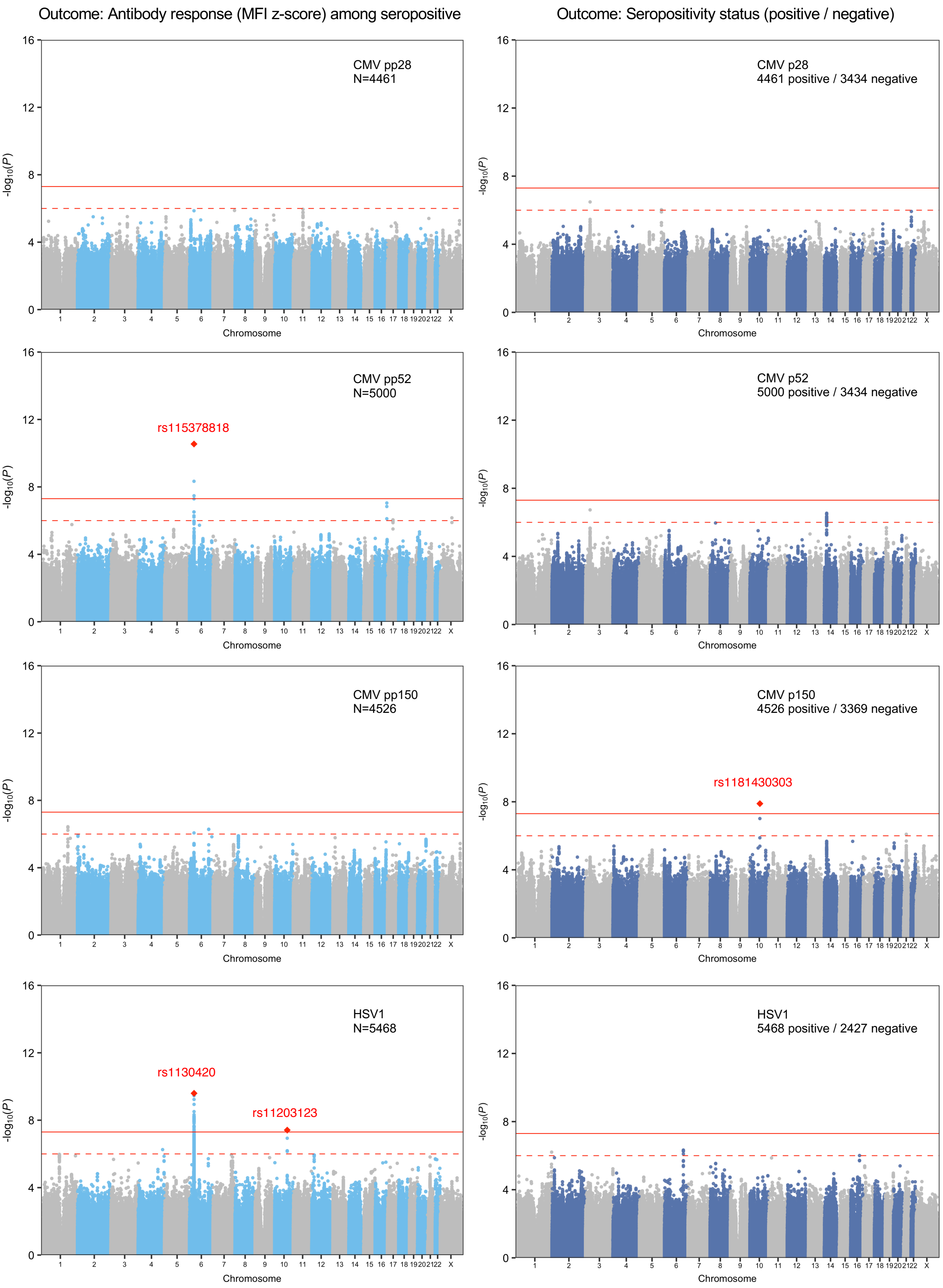
Supplementary Table 18: TWAS results for seropositivity using gene expression models based on whole blood, brain, and skin tissues. Only statistically significant associations with $P_{\mathrm{TWAS}}<4.2\times10^{-6}$ are presented.

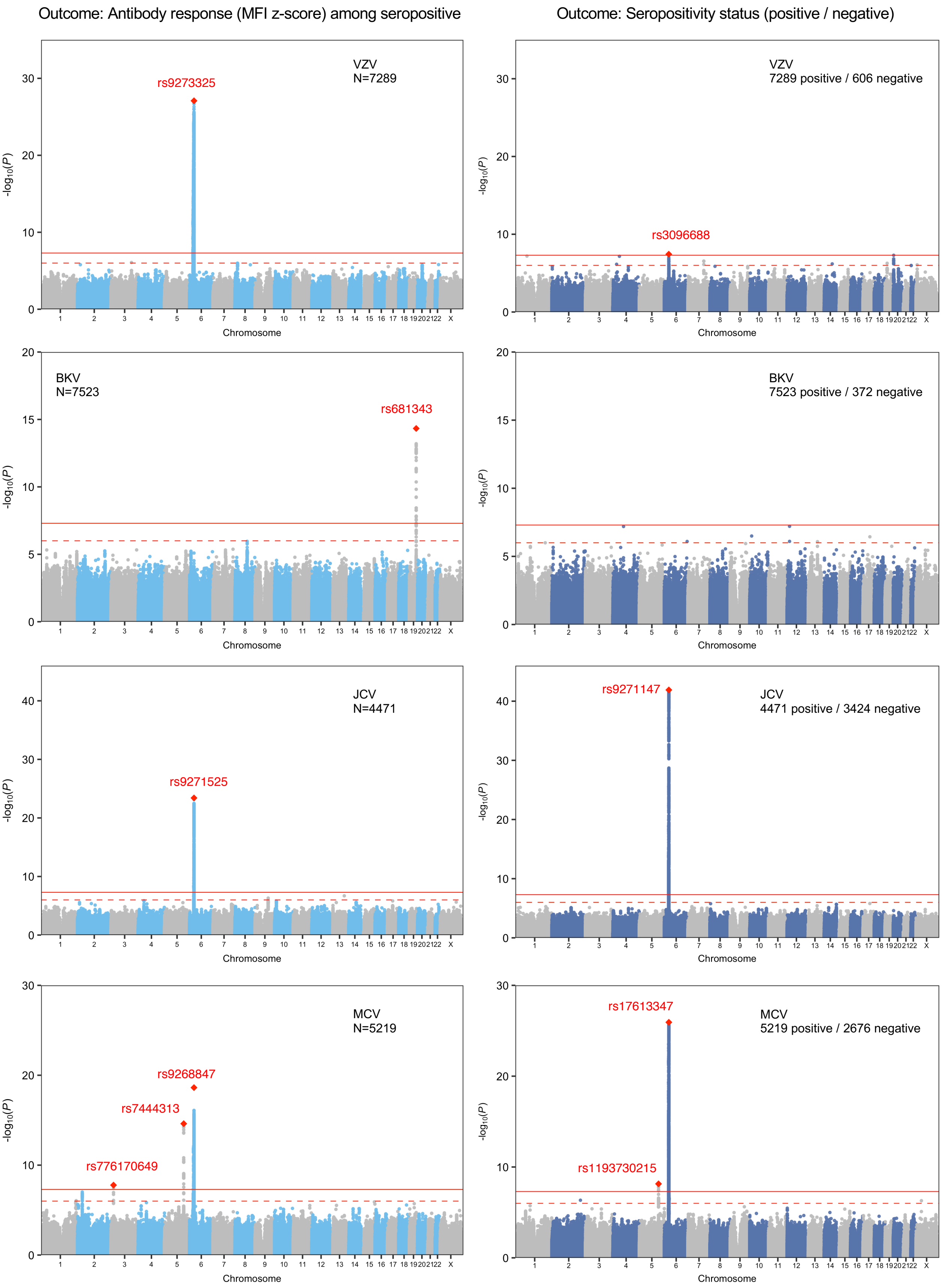
Antigen	Region	Gene ID	Gene	Whole Blood		Brain (Frontal Cortex)	
				Z	P_{TWAS}	Z	P_{TWAS}
EBV EA-D[1]	6p21.33	ENSG00000204388	*HSPA1B*	-6.33	2.5×10^{-10}	-	-
	6p21.33	ENSG00000204371	*EHMT2*	-5.77	8.0×10^{-9}	-	-
	6p21.33	ENSG00000244731	*C4A*	5.58	2.4×10^{-8}	5.27	1.4×10^{-7}
	6p21.33	ENSG00000166278	*C2*	-4.88	1.0×10^{-6}	-	-
	6p21.33	ENSG00000204469	*PRRC2A*	4.84	1.3×10^{-6}	-	-
	6p21.33	ENSG00000231852	*CYP21A2*	-4.78	1.7×10^{-6}	-	-
	6p21.33	ENSG00000213719	*CLIC1*	4.76	2.0×10^{-6}	4.76	2.0×10^{-6}
	6p21.33	ENSG00000224389	*C4B*	-4.76	2.0×10^{-6}	-	-
	6p21.33	ENSG00000204386	*NEU1*	4.75	2.1×10^{-6}	-	-
	6p22.3	ENSG00000137177	*KIF13A*	-4.65	3.3×10^{-6}	-	-
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	-6.87	6.4×10^{-12}
	6p21.32	ENSG00000204305	*AGER*	-	-	5.77	8.1×10^{-9}
	6p21.33	ENSG00000204420	*MPIG6B*	-	-	4.71	2.5×10^{-6}
	6p21.32	ENSG00000213676	*ATF6B*	-	-	4.80	1.6×10^{-6}
EBV EBNA[1]	6p21.32	ENSG00000179344	*HLA-DQB1*	8.37	5.6×10^{-17}	-	-
	6p21.32	ENSG00000232629	*HLA-DQB2*	-8.10	5.7×10^{-16}	-7.95	1.9×10^{-15}
	6p21.32	ENSG00000237541	*HLA-DQA2*	-5.46	4.8×10^{-8}	-	-
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	7.78	7.0×10^{-15}
	6p21.32	ENSG00000196735	*HLA-DQA1*	-	-	6.91	4.7×10^{-12}
	6p21.32	ENSG00000204252	*HLA-DOA*	-	-	4.79	1.7×10^{-6}
	6p21.32	ENSG00000231389	*HLA-DPA1*	-	-	-5.20	2.0×10^{-7}
EBV ZEBRA[1]	6p21.33	ENSG00000244731	*C4A*	4.64	3.5×10^{-6}	-	-
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	-5.95	2.7×10^{-9}
VZV[1]	4p15.2	ENSG00000109680	*TBC1D19*	-4.96	7.2×10^{-7}	-	-
JCV	6p21.32	ENSG00000237541	*HLA-DQA2*	9.68	3.5×10^{-22}	-	-
	6p21.33	ENSG00000204371	*EHMT2*	-9.30	1.4×10^{-20}	-	-
	6p21.32	ENSG00000179344	*HLA-DQB1*	-8.05	8.4×10^{-16}	-	-
	6p21.32	ENSG00000232629	*HLA-DQB2*	7.98	1.5×10^{-15}	7.85	4.3×10^{-15}
	6p21.32	ENSG00000204305	*AGER*	7.82	5.3×10^{-15}	10.39	2.8×10^{-25}
	6p21.33	ENSG00000213722	*DDAH2*	-7.46	8.5×10^{-14}	-	-
	6p21.32	ENSG00000204310	*AGPAT1*	-6.80	1.0×10^{-11}	7.80	6.0×10^{-15}
	6p21.32	ENSG00000204308	*RNF5*	-6.13	9.0×10^{-10}	-	-
	6p21.33	ENSG00000204396	*VWA7*	-5.64	1.7×10^{-8}	4.98	6.4×10^{-7}
	6p21.33	ENSG00000227507	*LTB*	-5.56	2.8×10^{-8}	-	-
	6p21.33	ENSG00000204463	*BAG6*	5.30	1.2×10^{-7}	-	-
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	-9.995	1.6×10^{-23}

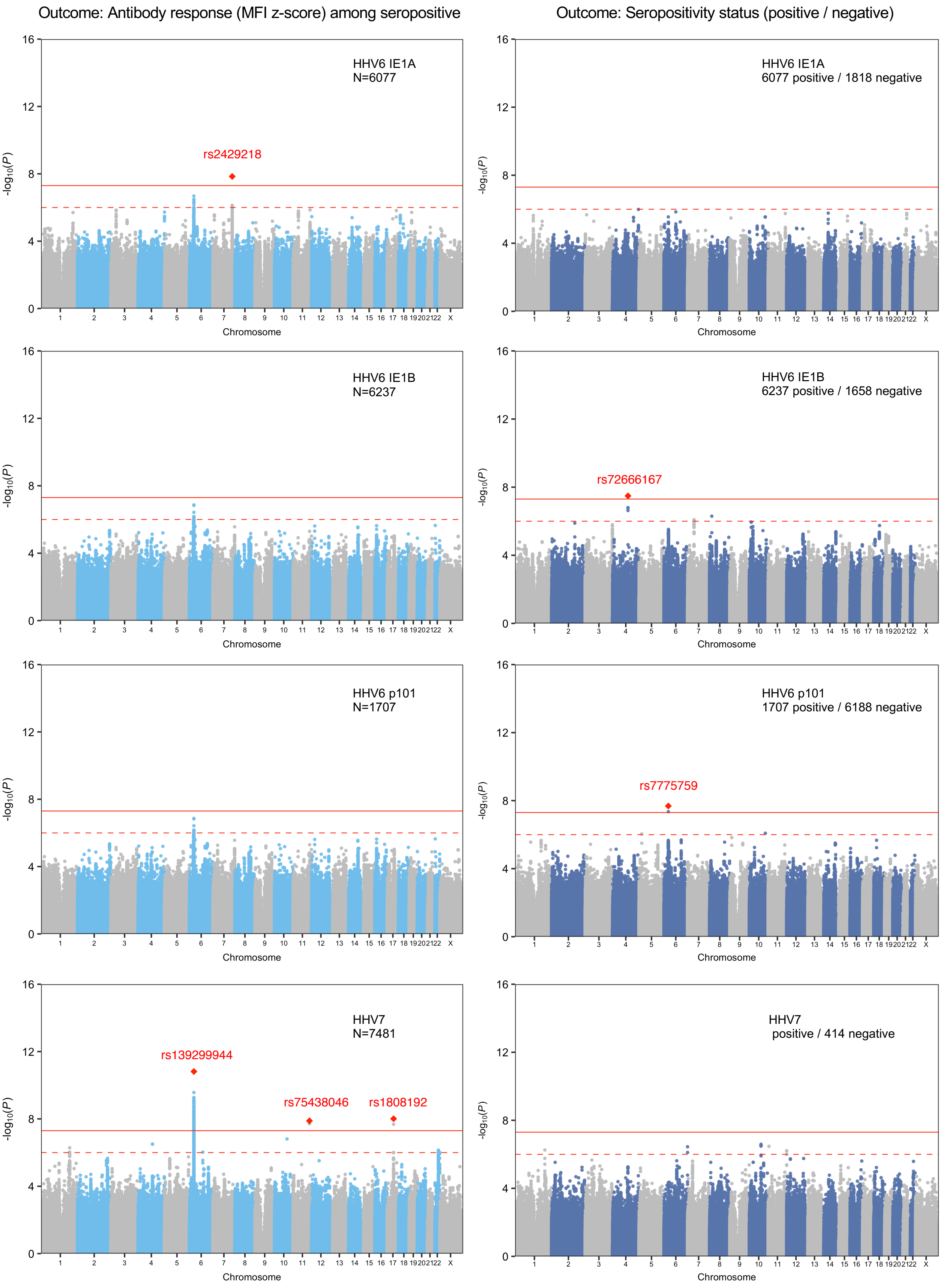
	6p21.32	ENSG00000196735	*HLA-DQA1*	-	-	-5.73	9.8×10^{-9}
	6p21.32	ENSG00000204252	*HLA-DOA*	-	-	-5.90	3.6×10^{-9}
	6p21.32	ENSG00000204261	*PSMB8-AS1*	-	-	-5.36	8.1×10^{-8}
	6p21.32	ENSG00000204264	*PSMB8*	-	-	5.71	1.2×10^{-8}
	6p21.32	ENSG00000204301	*NOTCH4*	-	-	-5.85	5.0×10^{-9}
	6p21.33	ENSG00000213760	*ATP6V1G2*	-	-	-4.98	6.2×10^{-7}
	6p21.33	ENSG00000226979	*LTA*	-	-	5.81	6.2×10^{-9}
MCV	6p21.33	ENSG00000204371	*EHMT2*	-8.64	5.8×10^{-18}	-	-
	6p21.33	ENSG00000213722	*DDAH2*	-8.49	2.2×10^{-17}	-4.69	2.7×10^{-6}
	6p21.33	ENSG00000227507	*LTB*	-8.24	1.7×10^{-16}	-	-
	6p21.33	ENSG00000204396	*VWA7*	-6.20	5.7×10^{-10}	5.40	6.7×10^{-8}
	6p21.32	ENSG00000204305	*AGER*	5.27	1.4×10^{-7}	9.35	9.0×10^{-21}
	6p21.32	ENSG00000240065	*PSMB9*	5.18	2.2×10^{-7}	-	-
	6p21.33	ENSG00000146112	*PPP1R18*	5.11	3.2×10^{-7}	-	-
	6p21.32	ENSG00000241106	*HLA-DOB*	-4.75	2.0×10^{-6}	-5.79	7.1×10^{-9}
	6p21.32	ENSG00000237541	*HLA-DQA2*	4.72	2.3×10^{-6}	-	-
	6p21.32	ENSG00000179344	*HLA-DQB1*	-	-	-6.79	1.1×10^{-11}
	6p21.32	ENSG00000196126	*HLA-DRB1*	-	-	-5.41	6.4×10^{-8}
	6p21.32	ENSG00000196735	*HLA-DQA1*	-	-	-6.48	9.4×10^{-11}
	6p21.32	ENSG00000204310	*AGPAT1*	-	-	4.92	8.5×10^{-7}
	6p21.33	ENSG00000226979	*LTA*	-	-	8.84	9.9×10^{-19}
	6p21.33	ENSG00000228789	*HCG22*	-	-	5.40	6.5×10^{-8}
	5q31.2	ENSG00000249751	*ECSCR*	-	-	5.63	1.8×10^{-8}

Supplementary Figure 1: Manhattan plots visualizing genome-wide association results for continuous antibody response phenotypes (MFI z-scores) and dichotomous seropositivity phenotypes for each antigen.

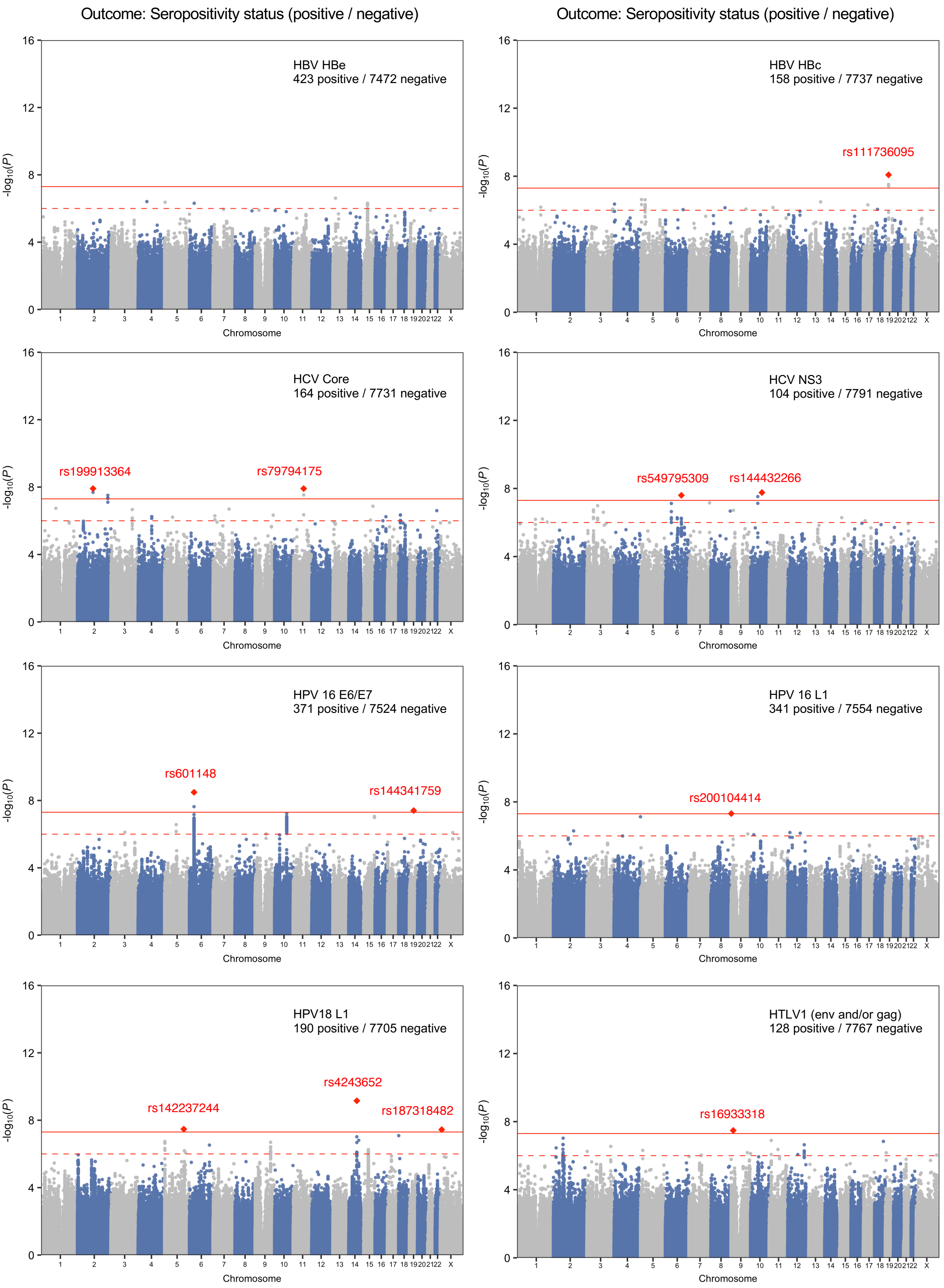


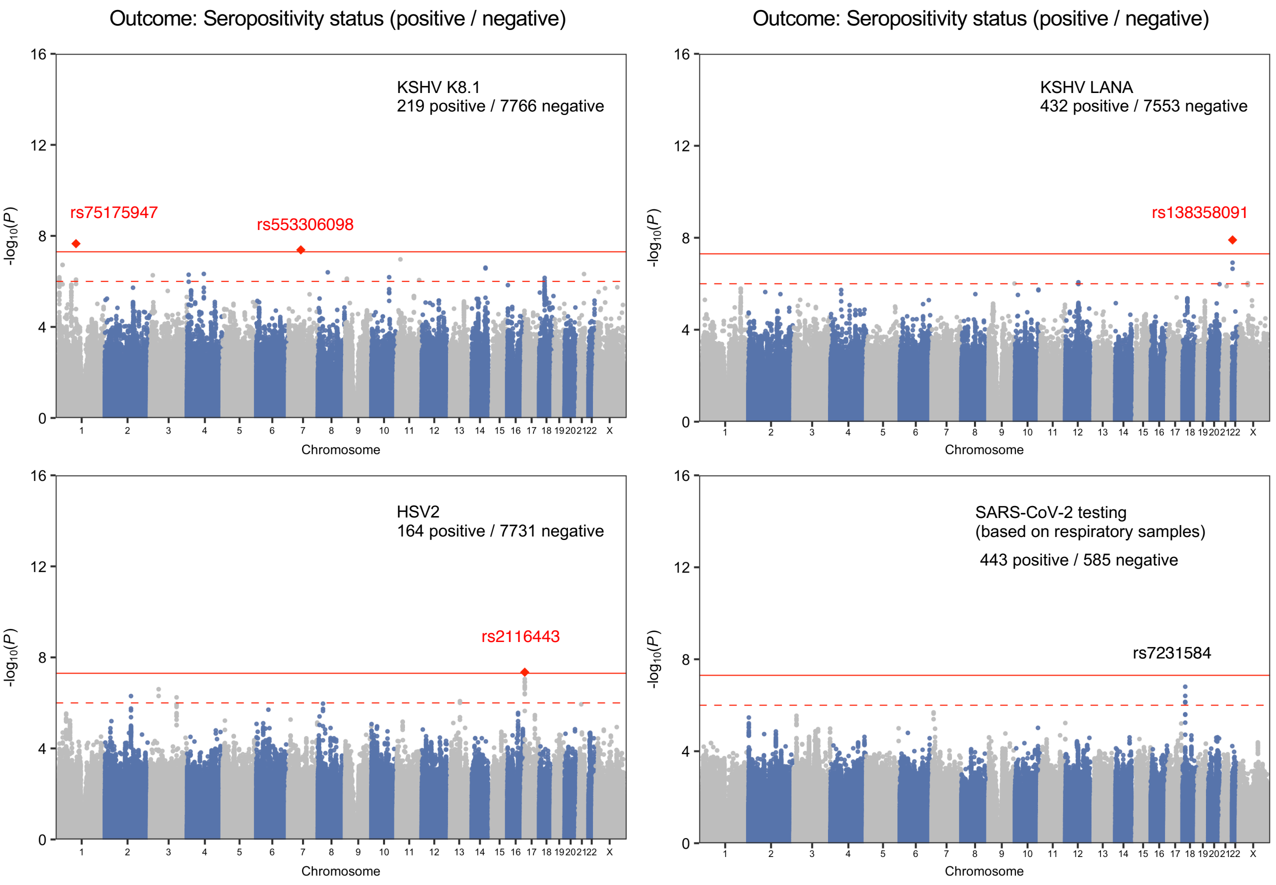

Outcome: Antibody response (MFI z-score) among seropositive
Outcome: Seropositivity status (positive / negative)
CMV pp28
N=4461
CMV p28
4461 positive / 3434 negative
CMV pp52
N=5000
rs115378818
CMV p52
5000 positive / 3434 negative
CMV pp150
N=4526
CMV p150
4526 positive / 3369 negative
rs1181430303
HSV1
N=5468
rs1130420
rs11203123
HSV1
5468 positive / 2427 negative
-log10(P)
0
4
8
12
16
Chromosome
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X


Outcome: Antibody response (MFI z-score) among seropositive
Outcome: Seropositivity status (positive / negative)
VZV
N=7289
rs9273325
VZV
7289 positive / 606 negative
rs3096688
BKV
N=7523
rs681343
BKV
7523 positive / 372 negative
JCV
N=4471
rs9271525
JCV
4471 positive / 3424 negative
rs9271147
MCV
N=5219
rs9268847
rs7444313
rs776170649
MCV
5219 positive / 2676 negative
rs17613347
rs1193730215
$-\log_{10}(P)$
Chromosome
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X
0
5
10
15
20
30
40

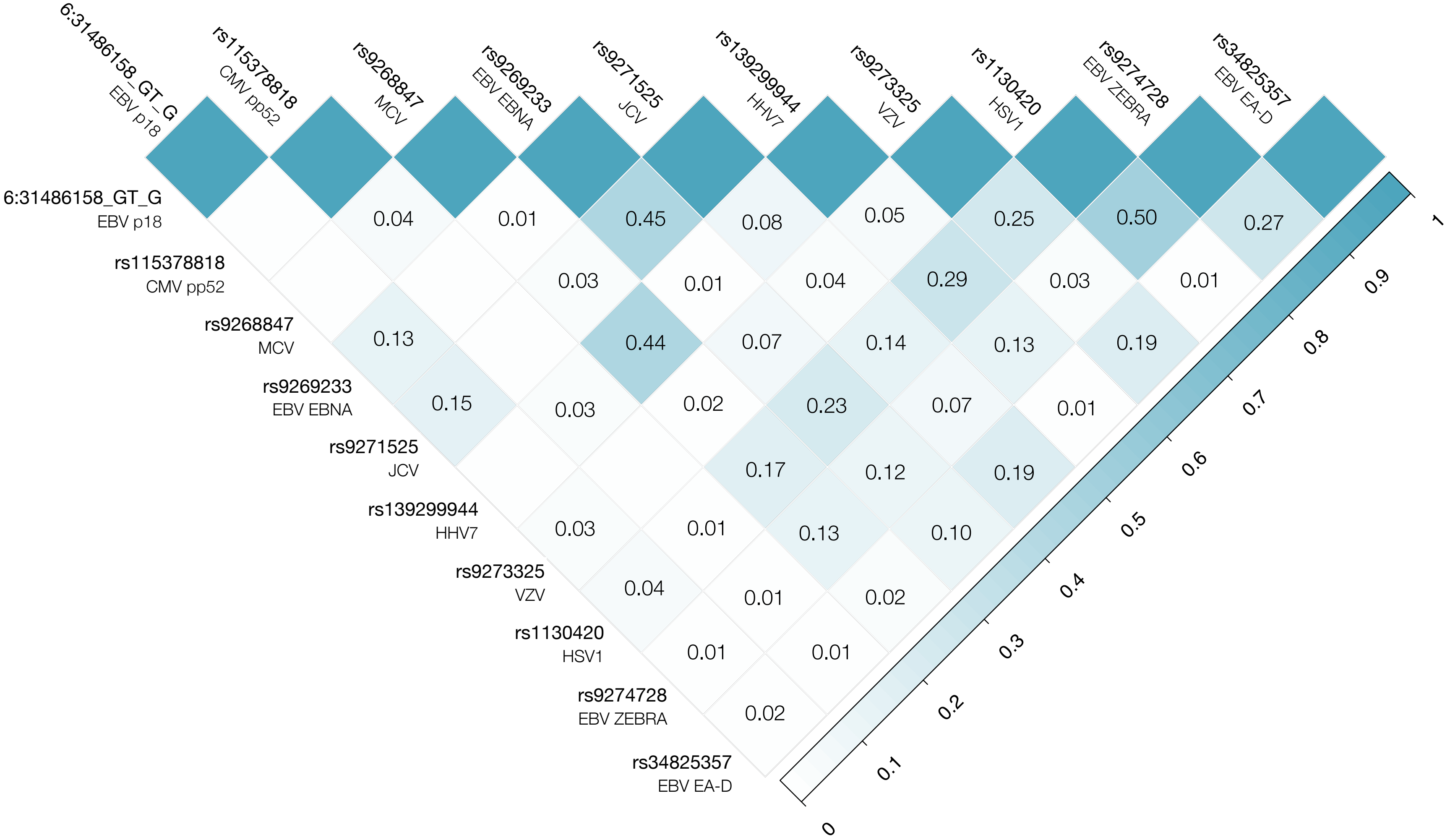

Outcome: Antibody response (MFI z-score) among seropositive

Outcome: Seropositivity status (positive / negative)

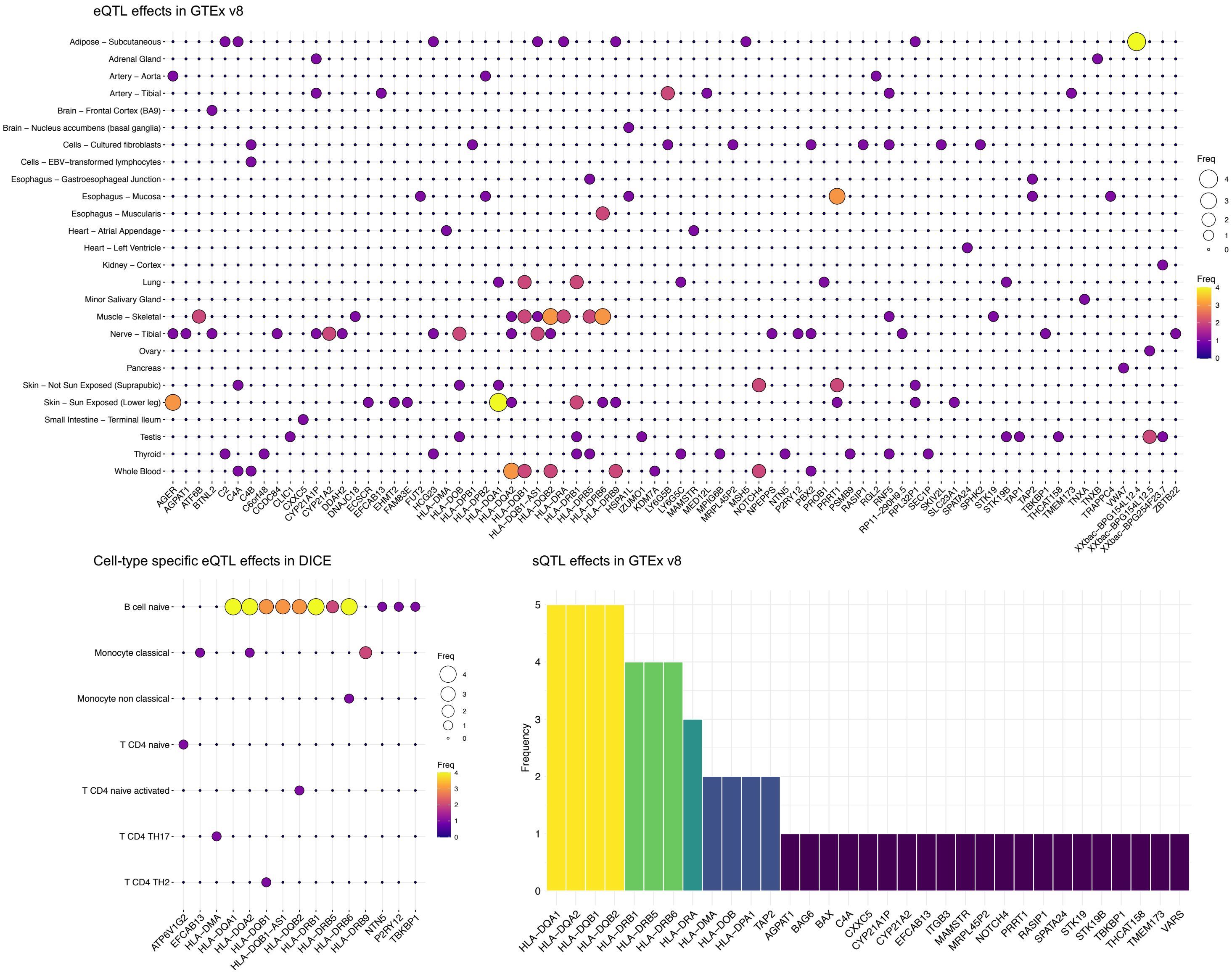

Outcome: Seropositivity status (positive / negative)
Outcome: Seropositivity status (positive / negative)
HBV HBe
423 positive / 7472 negative
HBV HBc
158 positive / 7737 negative
rs111736095
HCV Core
164 positive / 7731 negative
rs199913364
rs79794175
HCV NS3
104 positive / 7791 negative
rs549795309
rs144432266
HPV 16 E6/E7
371 positive / 7524 negative
rs601148
rs144341759
HPV 16 L1
341 positive / 7554 negative
rs200104414
HPV18 L1
190 positive / 7705 negative
rs142237244
rs4243652
rs187318482
HTLV1 (env and/or gag)
128 positive / 7767 negative
rs16933318
$-\log_{10}(P)$
0
4
8
12
16
Chromosome
1
2
3
4
5
6
7
8
9
10
11
12
13
14
15
16
17
18
19
20
21
22
X


Outcome: Seropositivity status (positive / negative)
Outcome: Seropositivity status (positive / negative)
KSHV K8.1
219 positive / 7766 negative
rs75175947
rs553306098
KSHV LANA
432 positive / 7553 negative
rs138358091
HSV2
164 positive / 7731 negative
rs2116443
SARS-CoV-2 testing
(based on respiratory samples)
443 positive / 585 negative
rs7231584
-log10(P)
0
4
8
12
16
1 2 3 4 5 6 7 8 9 10 11 12 13 14 15 16 17 18 19 20 21 22 X
Chromosome

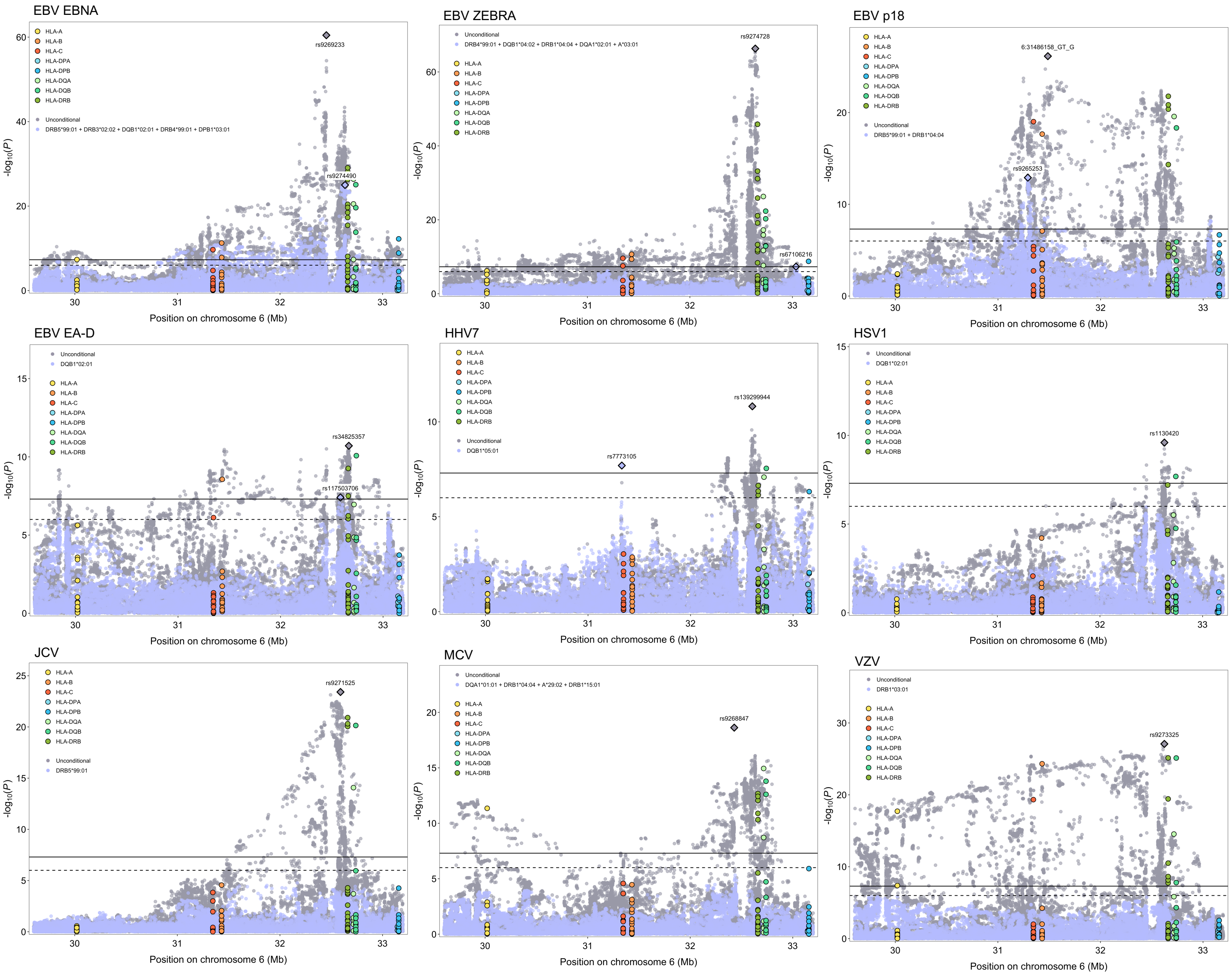
Supplementary Figure 2: Linkage disequilibrium (LD) structure between the top-ranking variants in HLA associated with continuous antibody response phenotypes (MFI z-scores) for each antigen



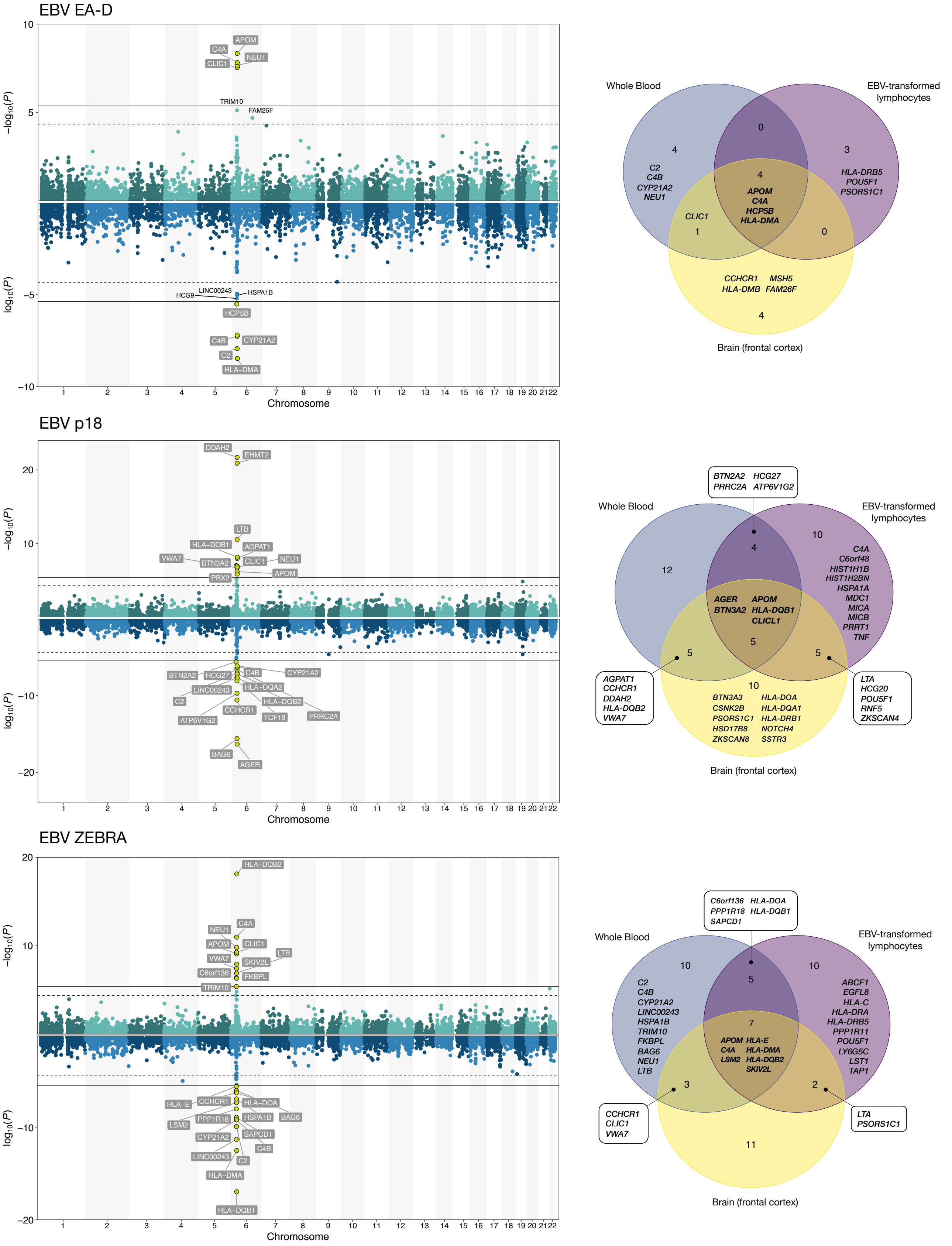
Supplementary Figure 3: Summary of expression (eQTL) and splicing quantitative trait loci (sQTL) associations obtained in GTEx v8 and DICE (Database of Immune Cell Expression) for the genome-wide significant variants ($P<5.0\times10^{-8}$) for continuous antibody response phenotypes. In each panel, frequency corresponds to the number of variants with a specific gene-tissue or gene-cell combination.

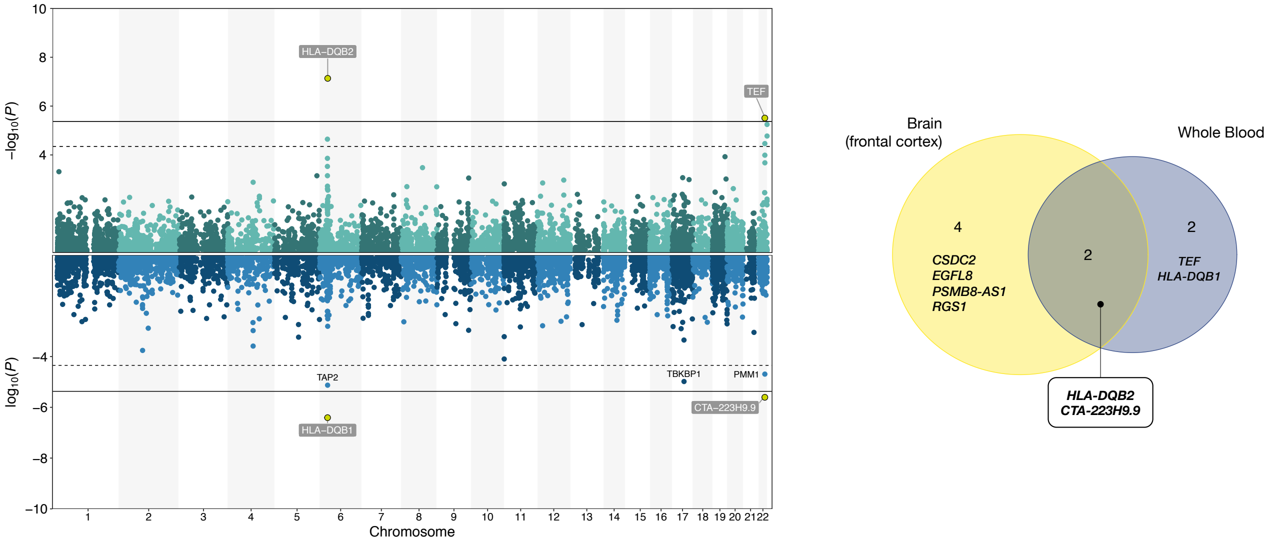


Supplementary Figure 4: Regional association plots depicting results based on analyses conditional on statistically independent classical HLA all

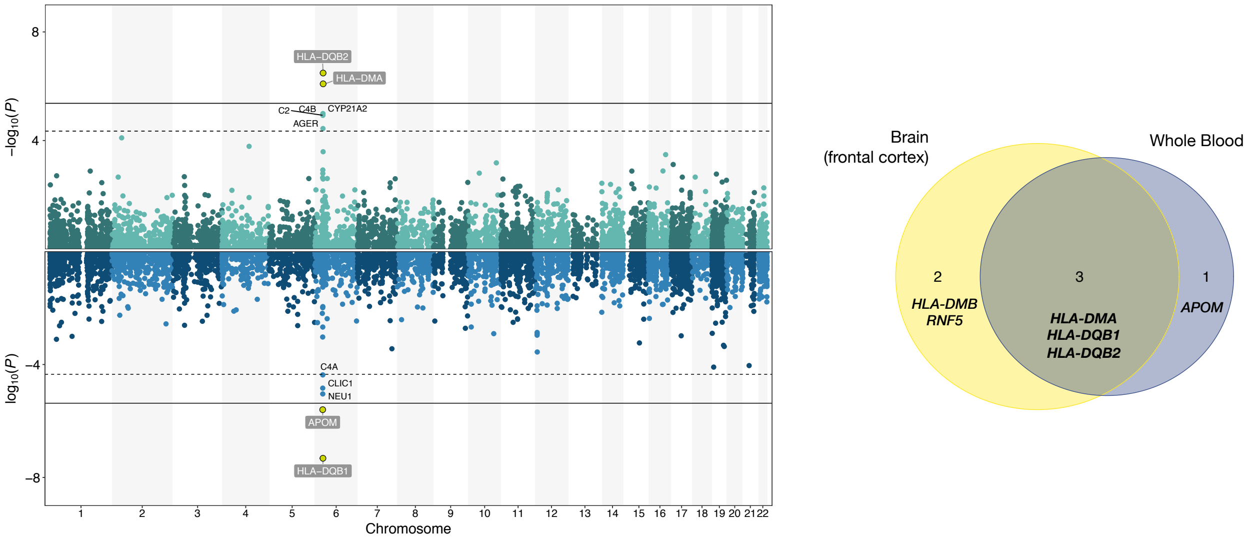


Supplementary Figure 5: TWAS associations with continuous antigen response phenotypes. Two Manhattan plots depicting the transcriptome-wide associations for genes with a positive direction of effect (increased expression leads to higher antibody response) and genes with a negative direction of effect (increased expression associated with a decreasing.

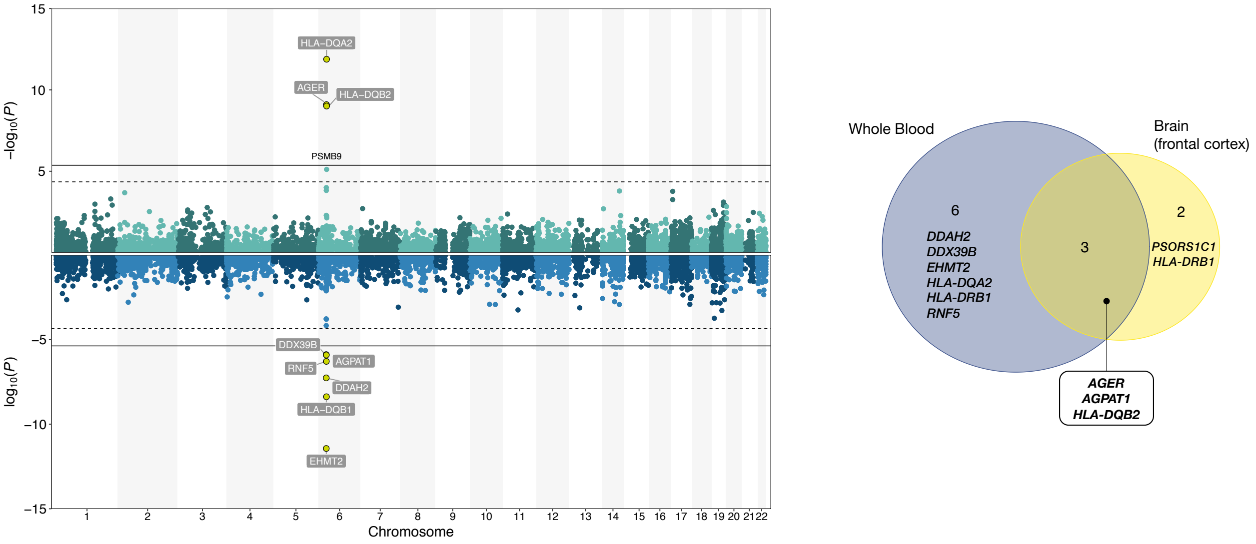




HHV7

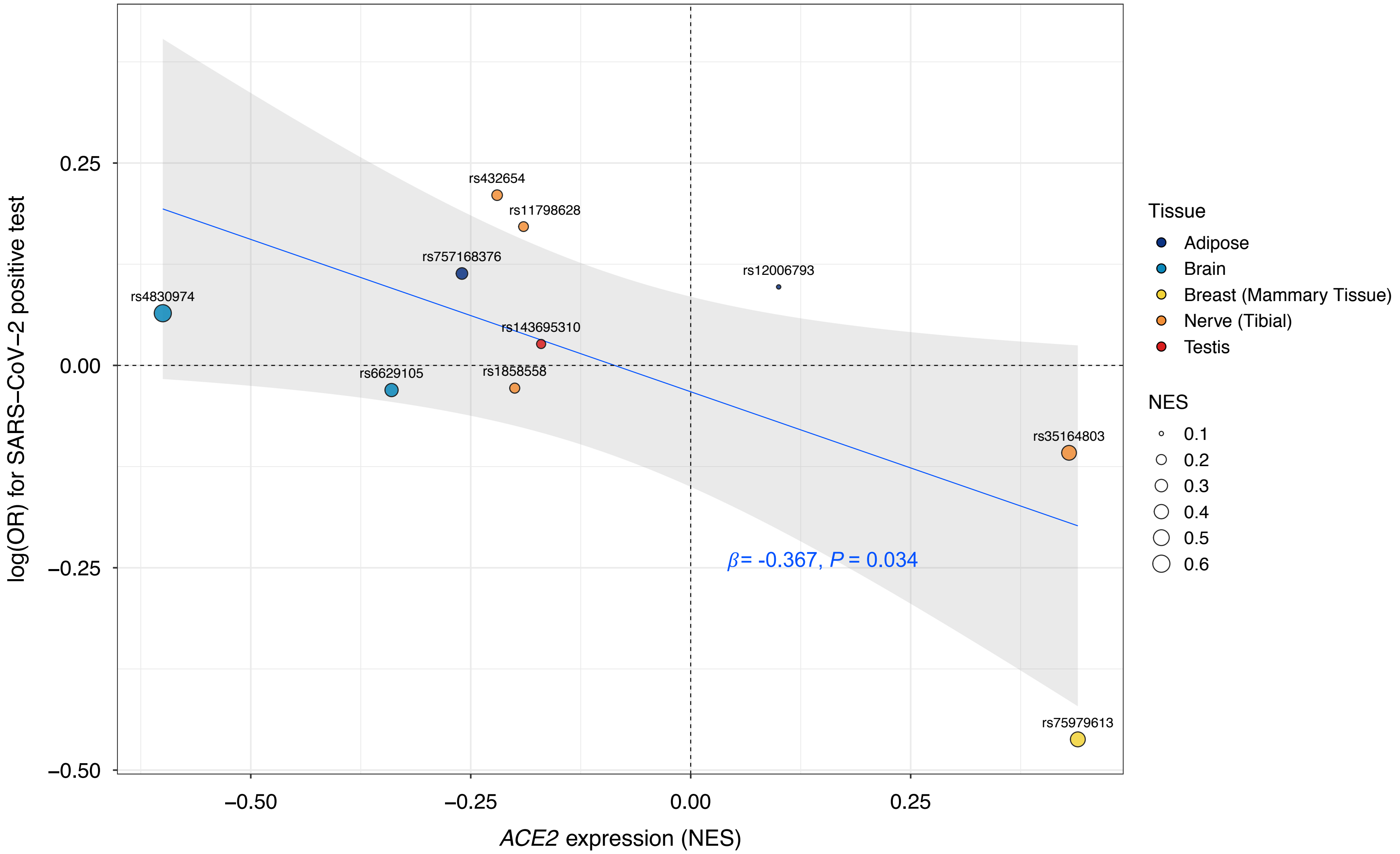


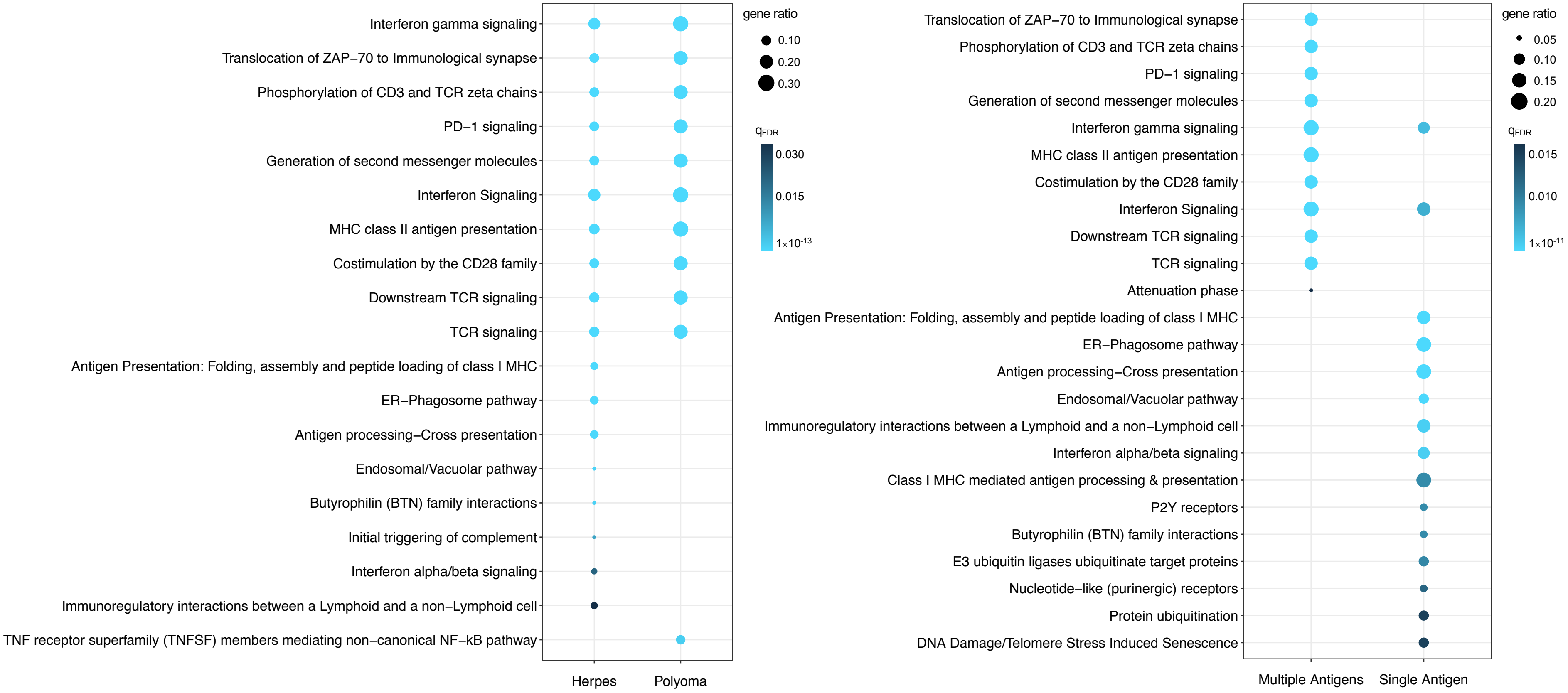
HSV1



JCV

Supplementary Figure 6: Variant-specific effects on *ACE2* gene expression normalized effect size (NES) and the log odds ratio (OR) for having a positive for SARS-CoV-2 test for significant, independent (q_{FDR}<0.05, LD r^2>0.10) expression quantitative trait loci identified in GTEx v8. Association between *ACE2* expression and SARS-CoV-2 log(OR) was estimated using a linear generalized estimating equations model, with a cluster term for tissue type.





Supplementary Figure 7: Visualization of significantly ($q_{FDR}<0.05$) enriched Reactome pathways for TWAS-identified genes grouped by virus family (human herpes viruses vs. human polyoma viruses) and specificity of association (multiple antigens vs. single antigen). Gene ratio corresponds to the size of the overlap between the input gene list with a specific gene set to the size of the overlap between the input gene list with all the members of the collection of gene sets.

Supplementary Figure 8: Significant protein interactions identified in the STRING database for genes associated with multiple antigens. The color of each node corresponds to the lowest -log$_{10}$(P_{TWAS}) observed across phenotypes and tissues. This analysis considered unidirectional functional interactions with confidence scores ≥400 (medium confidence) at the q_{FDR}<0.05 threshold. Interactions were limited to the input genes.