

Supplementary Materials

Cancers and COVID-19 Risk: A Mendelian Randomization Study

Zengbin Li ¹, Yudong Wei ¹, Guixian Zhu ¹, Mengjie Wang ¹ and Lei Zhang ^{1,2,3,4,*}

¹ China-Australia Joint Research Center for Infectious Diseases, School of Public Health, Xi'an Jiaotong University Health Science Center, Xi'an 710061, China; zengbinli@stu.xjtu.edu.cn (Z.L.); weiyudong@stu.xjtu.edu.cn (Y.W.); xianxianshell@stu.xjtu.edu.cn (G.Z.); mjwang0211@stu.xjtu.edu.cn (M.W.)

² Melbourne Sexual Health Centre, Alfred Health, Melbourne, VIC 3053, Australia

³ Central Clinical School, Faculty of Medicine, Nursing and Health Sciences, Monash University, Melbourne, VIC 3800, Australia

⁴ Department of Epidemiology and Biostatistics, College of Public Health, Zhengzhou University, Zhengzhou 450001, China

*Correspondence: lei.zhang1@monash.edu; Tel.: +86-29-82655135

Table S1. Excluded cancers with insufficient SNPs

	Cancer		GWAS ID	Year	Cases	Controls
Discovery	Stomach cancer	Benign neoplasm: Stomach	finn-b-CD2_BENIGN_STOMACH	2021	1252	217,540
		Malignant neoplasm of stomach	finn-b-C3_STOMACH_EXALLC	2021	633	174,006
	Pancreatic cancer	Pancreatic cancer	ieu-a-822	2009	1896	1939
		Pancreas benign neoplasm	finn-b-CD2_BENIGN_PANCREAS_EXALLC	2021	163	180,666
	Oesophagus cancer	Malignant neoplasm of oesophagus	finn-b-C3_OESOPHAGUS	2021	144	218,648
		Benign neoplasm: Oesophagus	finn-b-CD2_BENIGN_OESOPHAGUS	2021	232	218,560
	Kidney cancer	Malignant neoplasm of kidney, except renal pelvis	ukb-b-1316	2018	1114	461,896
		Malignant neoplasm of kidney, except renal pelvis	finn-b-C3_KIDNEY_NOTRENALPELVIS_EXALLC	2021	971	174,006
		Benign neoplasm: Kidney	finn-b-CD2_BENIGN_KIDNEY_EXALLC	2021	381	180,506
		Malignant neoplasm of kidney, except renal pelvis	finn-b-C3_KIDNEY_NOTRENALPELVIS_EXALLC	2021	971	217,821
		Secondary malignant neoplasm of liver	ukb-b-16713	2018	1139	461,871
		Liver & bile duct cancer	ieu-b-4915	2021	350	372,016
	Liver cancer	Liver cell carcinoma	ieu-b-4953	2021	168	372,016
		Benign neoplasm: Liver	finn-b-CD2_BENIGN_LIVER	2021	232	218,560
		Benign neoplasm: Liver/bile ducts	finn-b-CD2_BENIGN_LIVE_BILE	2021	264	218,528
		Malignant neoplasm of liver and intrahepatic bile ducts	finn-b-C3_LIVER_INTRAHEPATIC_BILE_DUCTS	2021	304	218,488
	Biliary tract cancer	Malignant neoplasm of other and unspecified parts of biliary tract	finn-b-C3_BILIARY_TRACT	2021	109	218,683
	Head and neck cancer	Gallbladder cancer	ieu-a-1057	2012	41	866
		Head and neck cancer	ieu-b-4912	2021	1106	372,016
		Benign lipomatous neoplasm of skin and subcutaneous tissue of head, face and neck	finn-b-CD2_BENIGN_LIPO_SKIN_HEADFACENECK	2021	915	217,877

Validati on	Bladder cancer	Benign neoplasm: Connective and other soft tissue of head, face and neck	finn-b- CD2_BENIGN_CONNSOFT_HEADFACETRUNK	2021	262	218,530
		Bladder cancer	ukb-b-8193	2018	1101	461,832
	Testis cancer	Malignant neoplasm of bladder	ukb-d-C67	2018	1554	359,640
		Benign neoplasm: Bladder	finn-b-CD2_BENIGN_BLADDER	2021	109	218,683
	Brain cancer	Malignant neoplasm of bladder	finn-b-C3_BLADDER	2021	1115	217,677
		Malignant neoplasm of testis	finn-b-C3_TESTIS	2021	199	95,014
	Multiple myeloma	Brain cancer	ieu-b-4875	2021	606	372,016
		Malignant neoplasm of brain	finn-b-C3_BRAIN	2021	464	218,328
	Bone cancer	Malignant neoplasm of eye, brain and central nervous system	finn-b-C3_EYE_BRAIN_NEURO	2021	1446	217,346
		Benign neoplasm: Brain, supratentorial	finn-b-CD2_BENIGN_BRAIN_SUPRATENT	2021	218	218,574
	Lung cancer	Multiple myeloma	ieu-b-4957	2021	601	372,016
		Malignant neoplasm of bone and articular cartilage	finn-b-C3_BONE_CARTILAGE_EXALLC	2021	119	174,006
		Benign neoplasm: Short bones of lower limb	finn-b-CD2_BENIGN_BONE_SHORT_LOWER	2021	128	218,664
		Benign neoplasm: Scapula and long bones of upper limb	finn-b- CD2_BENIGN_BONE_SCAPULA_LONG_UPPER	2021	125	218,667
		Benign neoplasm: Long bones of lower limb	finn-b-CD2_BENIGN_BONE_LONG_LOWER	2021	443	218,349
		Benign neoplasm: Bones of skull and face	finn-b-CD2_BENIGN_BONE_SKULL_FACE	2021	120	218,672
	Lung cancer	Non-small cell lung cancer	finn-b-C3_LUNG_NONSMALL	2021	1627	217,165
		Lung adenocarcinoma	ieu-a-965	2014	3442	14,894
		Non-small cell lung cancer, adenocarcinoma	finn-b-C3_NSCLC_ADENO	2021	571	218,221
		Non-small cell lung cancer, squamous	finn-b-C3_NSCLC_SQUAM_EXALLC	2021	365	174,004

Ovarian cancer	Ovarian cancer	ieu-b-4963	2021	1218	198,523
Endometrial cancer	Uterine/endometrial cancer	ukb-b-13545	2018	1151	461,782
Thyroid cancer	Benign neoplasm of thyroid gland	finn-b-CD2_BENIGN_THYROID	2021	455	218,337
Melanoma	Malignant melanoma of skin	finn-b-C3_MELANOMA_SKIN	2021	98	218,694
	Melanoma in situ	finn-b-CD2_INSITU_MELANOMA	2021	393	218,399
Colorectal cancer	Colorectal cancer	finn-b-C3_COLORECTAL	2021	3022	215,770
	Malignant neoplasm of colon	finn-b-C3_COLON	2021	1803	216,989
	Hodgkin lymphoma	finn-b-CD2_HODGKIN_LYMPHOMA	2021	369	218,423
	Other and unspecified types of non-Hodgkin lymphoma	finn-b-CD2_NONHODGKIN_NAS	2021	533	218,259
Lymphoma	Diffuse large B-cell lymphoma	finn-b-C3_DLBCL	2021	209	218,583
	Mature T/NK-cell lymphomas	finn-b-CD2_TNK_LYMPHOMA	2021	150	218,642
	Non-follicular lymphoma	finn-b-CD2_NONFOLLICULAR_LYMPHOMA	2021	1283	217,509
	Follicular lymphoma	finn-b-CD2_FOLLICULAR_LYMPHOMA_EXALLC	2021	522	180,756
Oropharyngeal cancer	Oropharyngeal cancer	ieu-b-96	2016	1090	2928
	cin/pre-cancer cells cervix	ukb-b-17507	2018	1604	461,329
Cervix cancer	Carcinoma in situ of cervix uteri	finn-b-CD2_INSITU_CERVIX_UTERI	2021	298	123,281
	Carcinoma in situ of cervix uteri, exocervix	finn-b-CD2_INSITU_CERVIX_UTERI_EXOCERVIX	2021	107	123,472

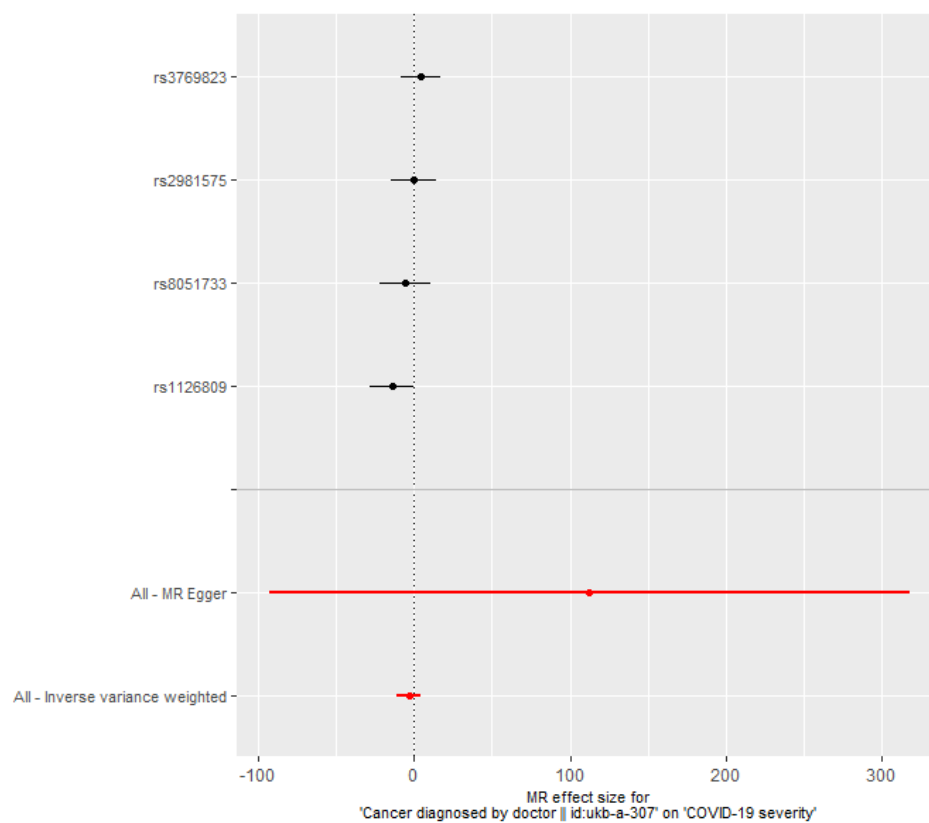


Figure S1A. The effect of each SNP in overall cancer on COVID-19 severity.

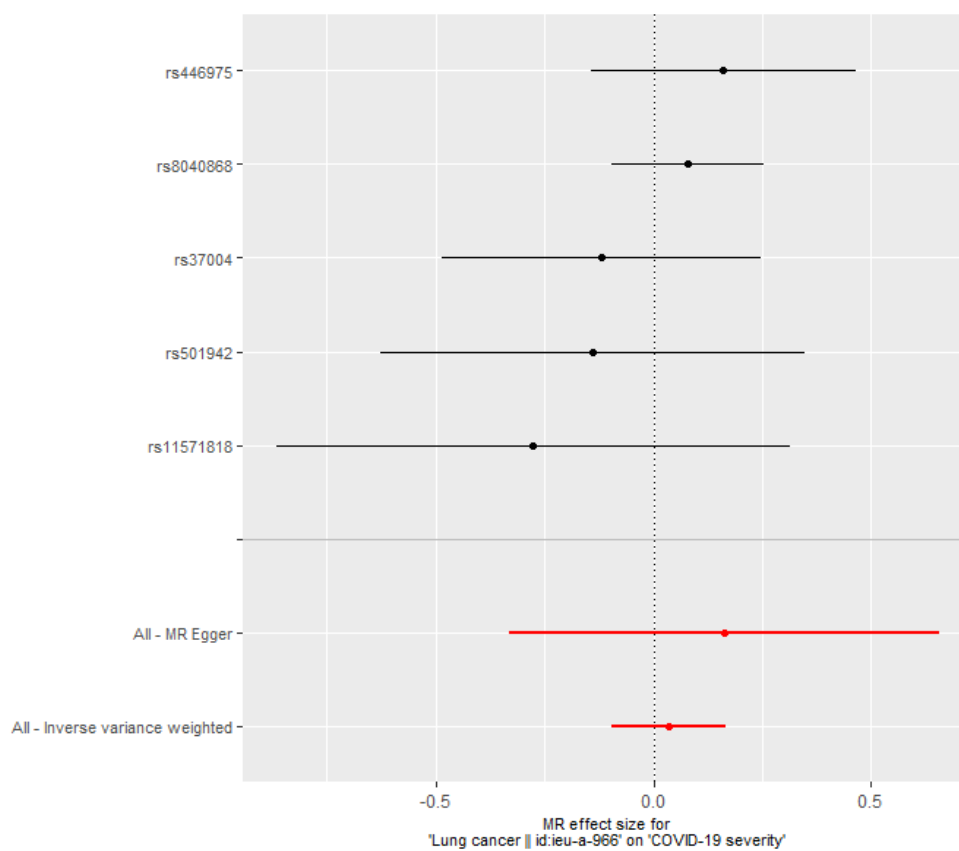


Figure S1B. The effect of each SNP in lung cancer on COVID-19 severity.

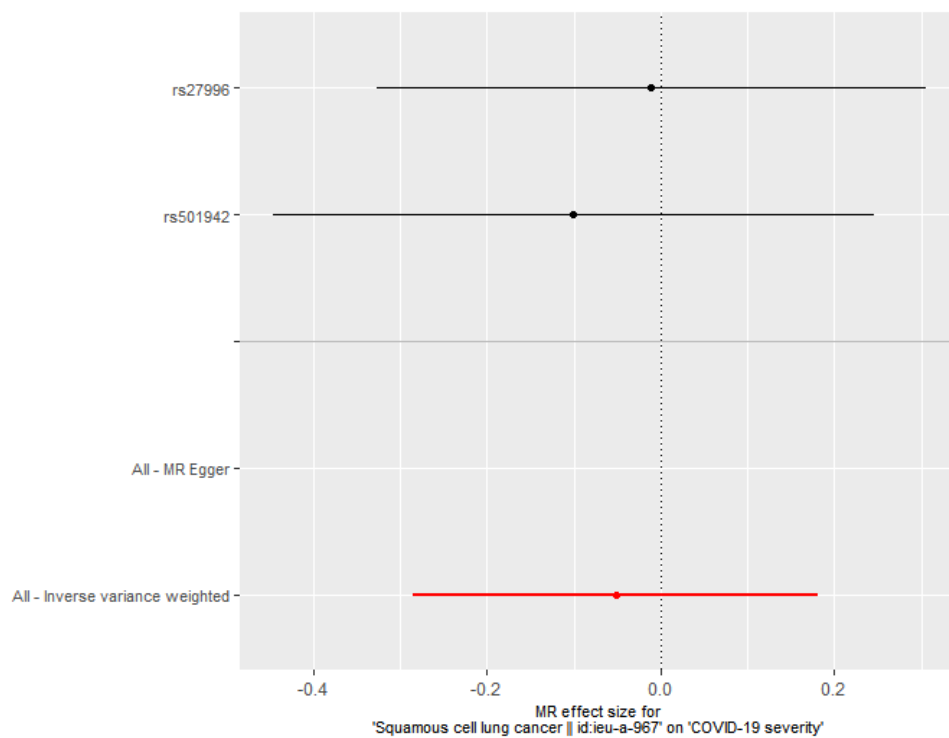


Figure S1C. The effect of each SNP in squamous cell lung cancer on COVID-19 severity.

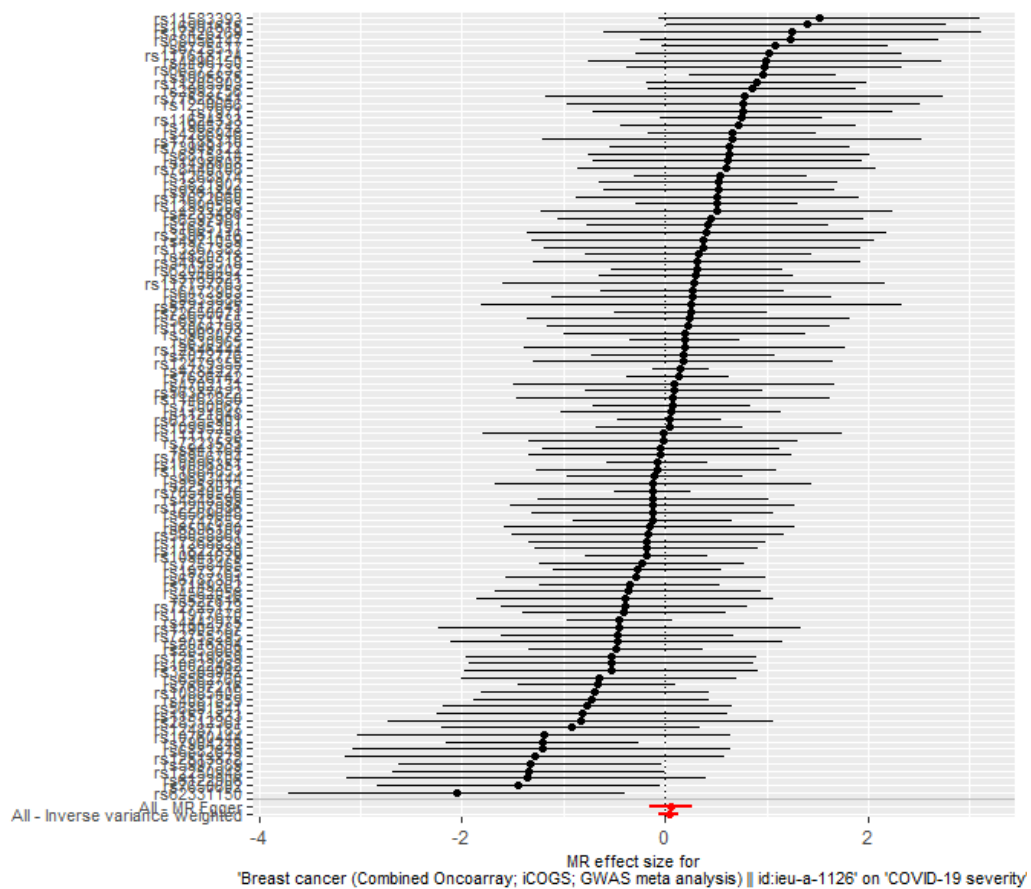


Figure S1D. The effect of each SNP in breast cancer on COVID-19 severity.

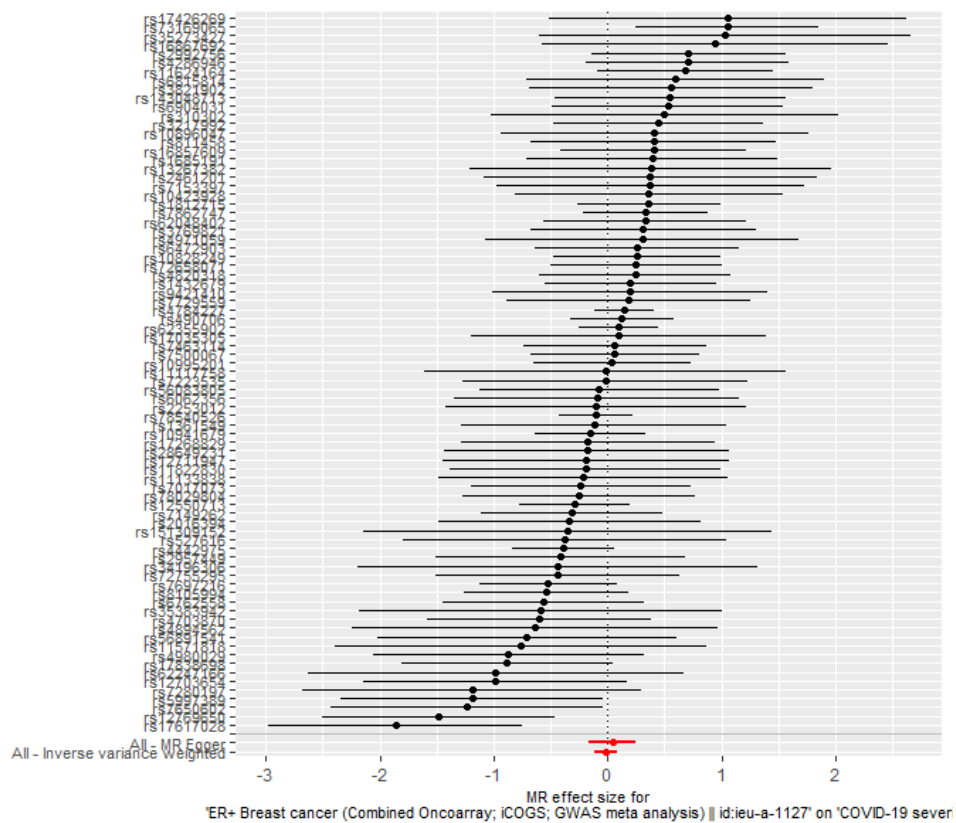


Figure S1E. The effect of each SNP in ER+ breast cancer on COVID-19 severity.

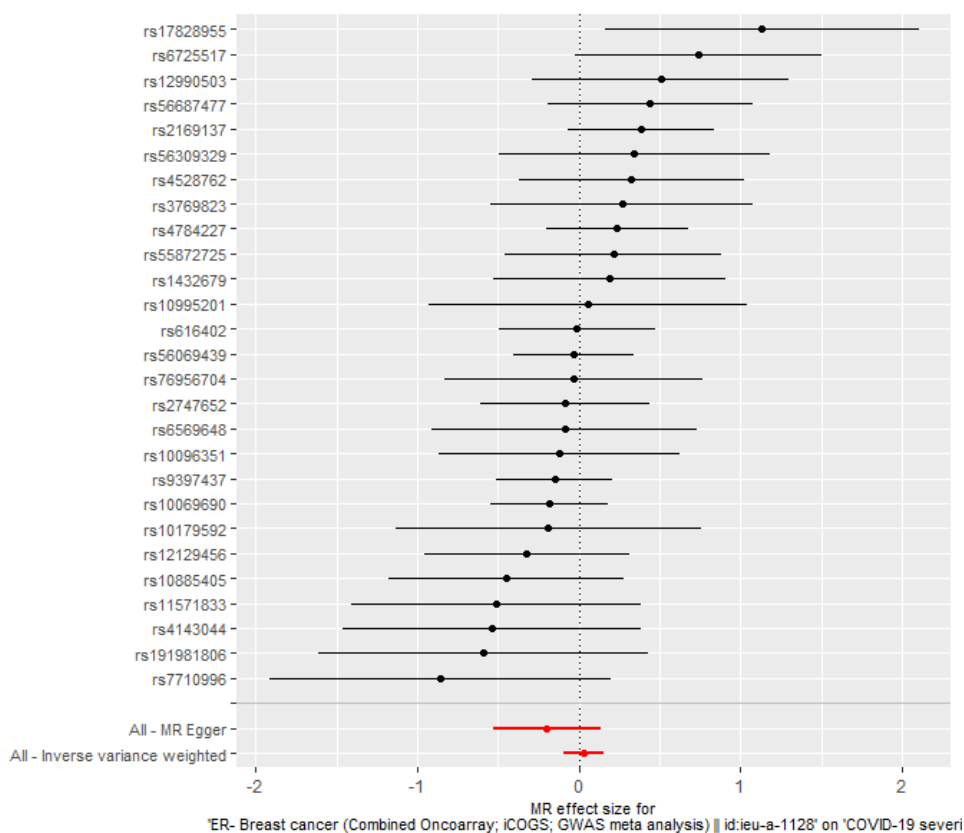


Figure S1F. The effect of each SNP in ER- breast cancer on COVID-19 severity.

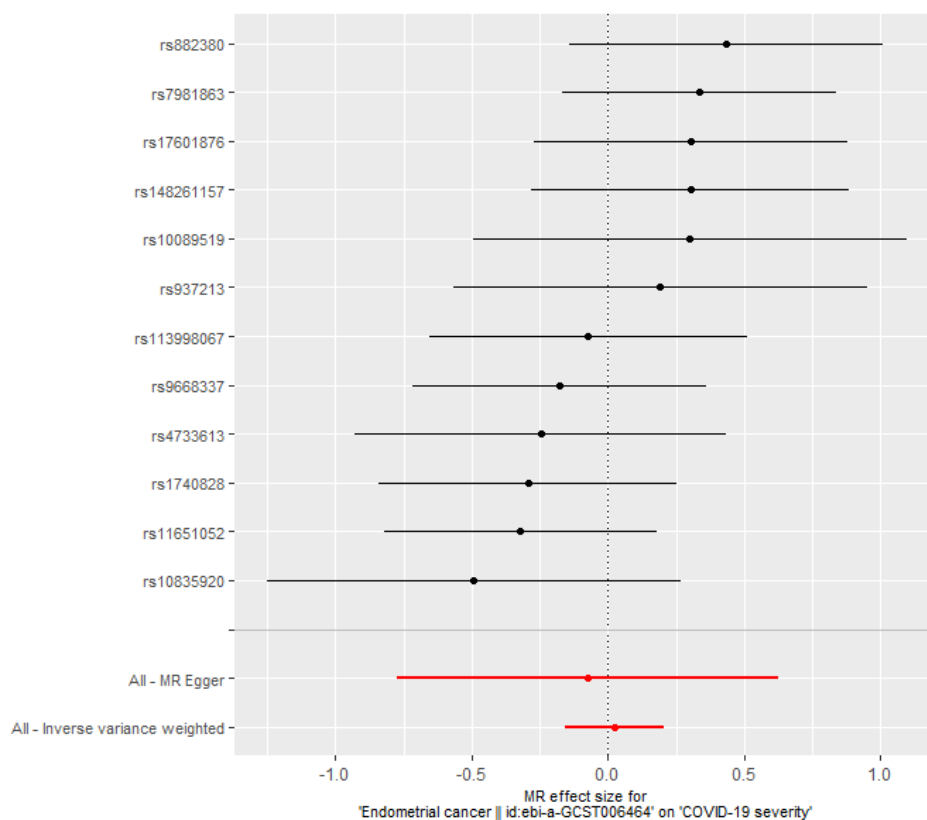


Figure S1G. The effect of each SNP in endometrial cancer on COVID-19 severity.

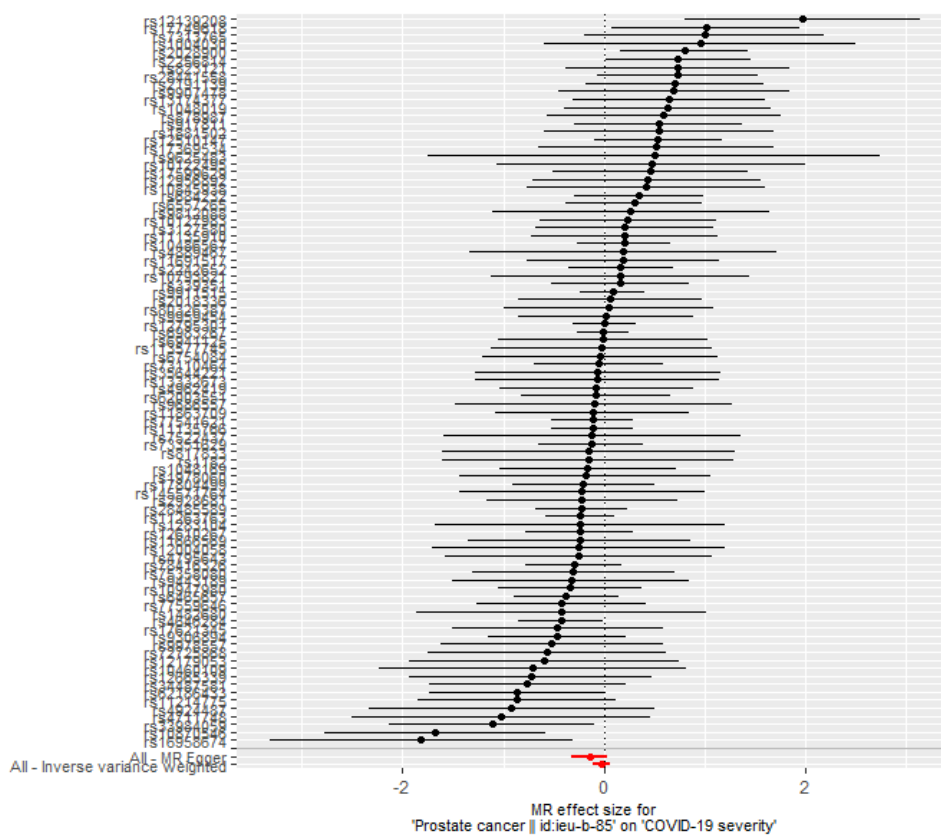


Figure S1H. The effect of each SNP in prostate cancer on COVID-19 severity.

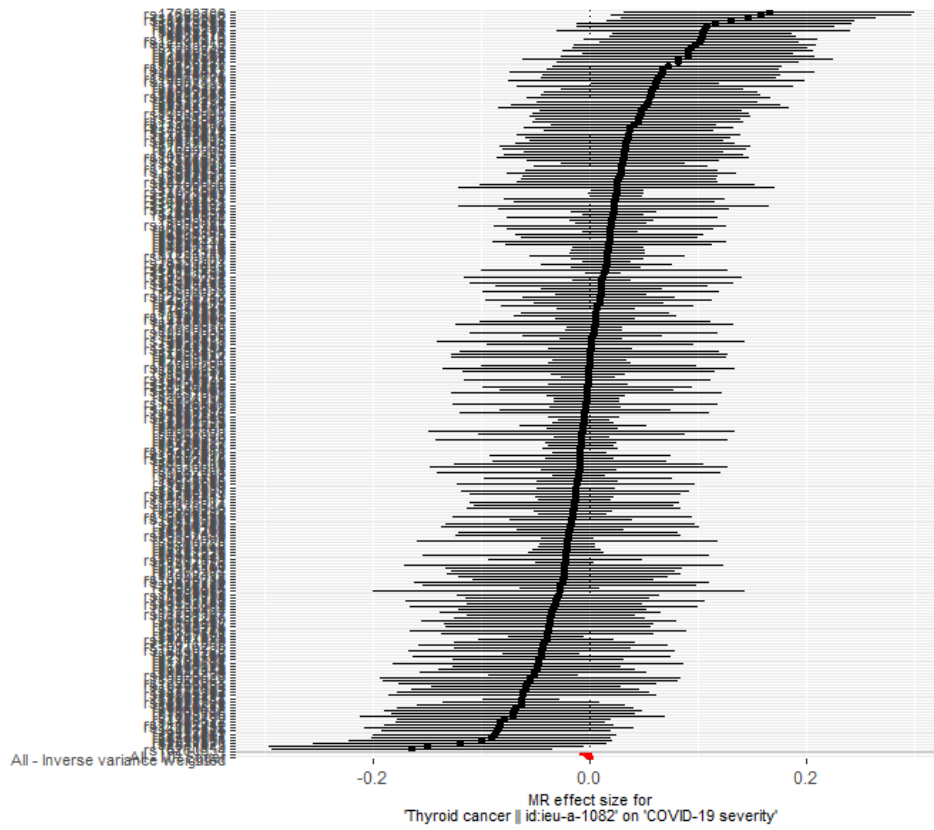


Figure S1I. The effect of each SNP in thyroid cancer on COVID-19 severity.

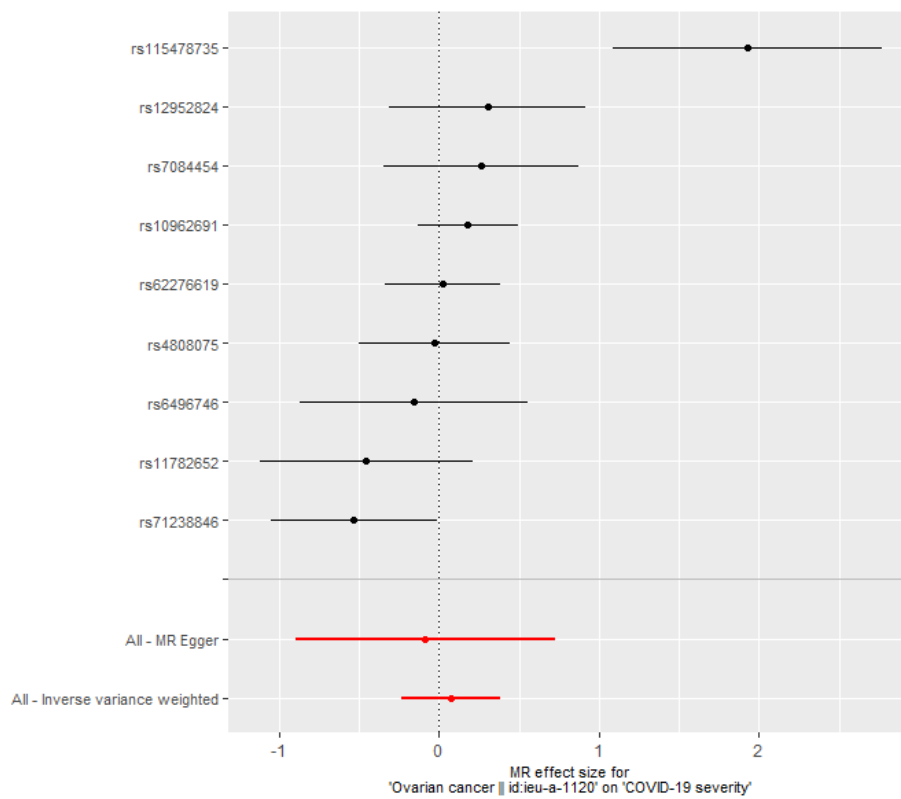


Figure S1J. The effect of each SNP in ovarian cancer on COVID-19 severity.

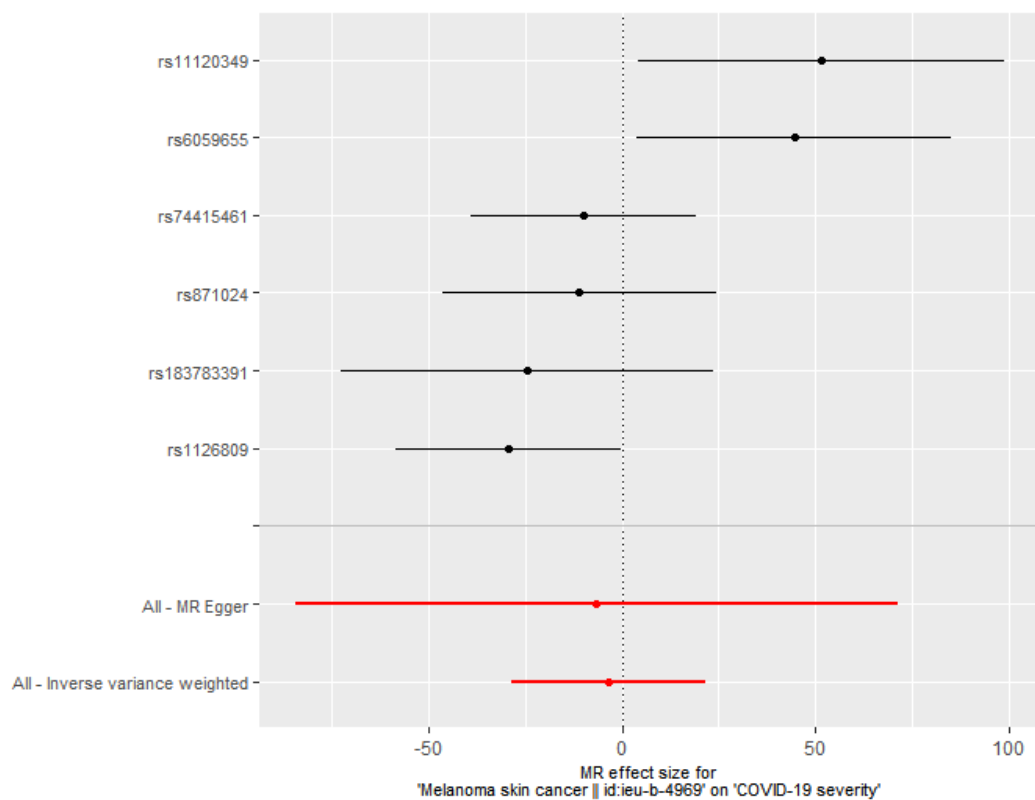


Figure S1K. The effect of each SNP in melanoma on COVID-19 severity.

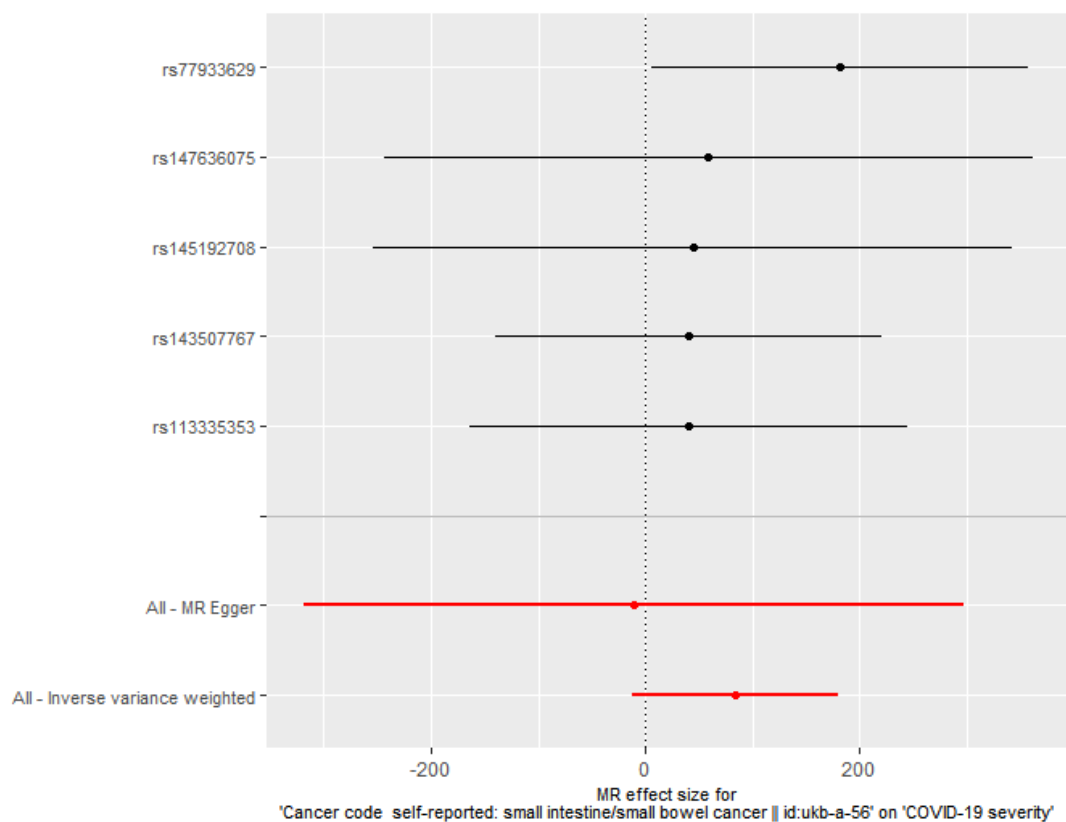


Figure S1L. The effect of each SNP in small bowel cancer on COVID-19 severity.

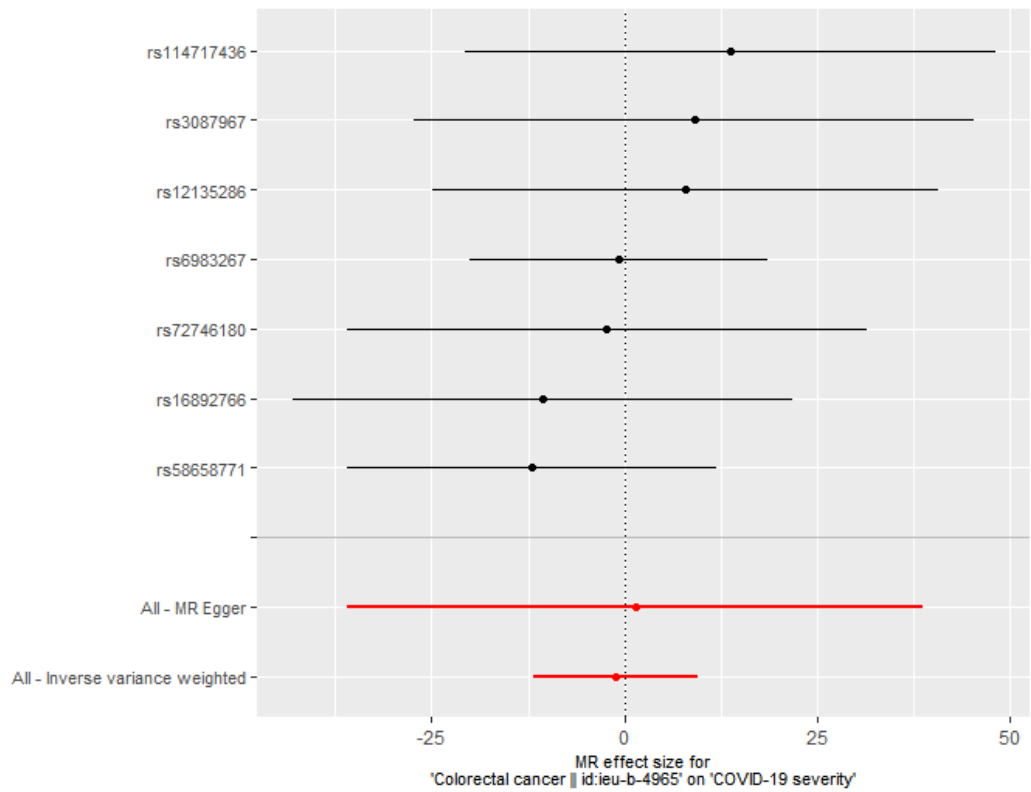


Figure S1M. The effect of each SNP in colorectal cancer on COVID-19 severity.

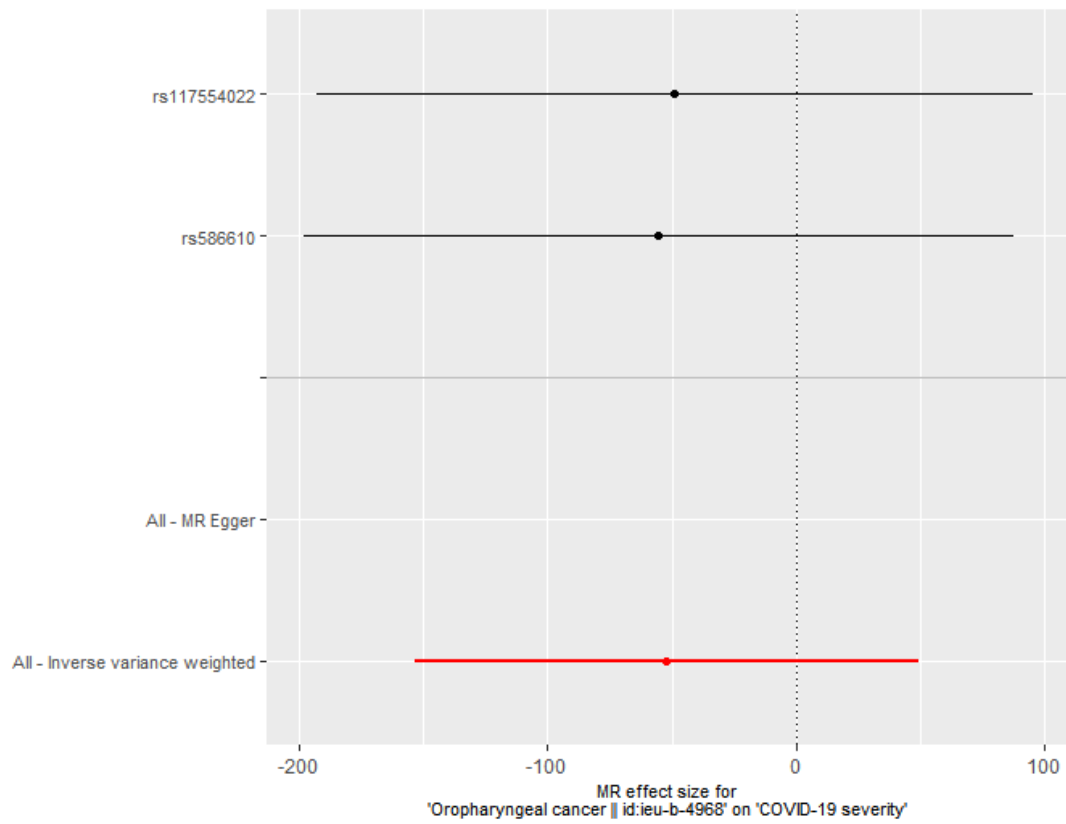


Figure S1N. The effect of each SNP in oropharyngeal cancer on COVID-19 severity.

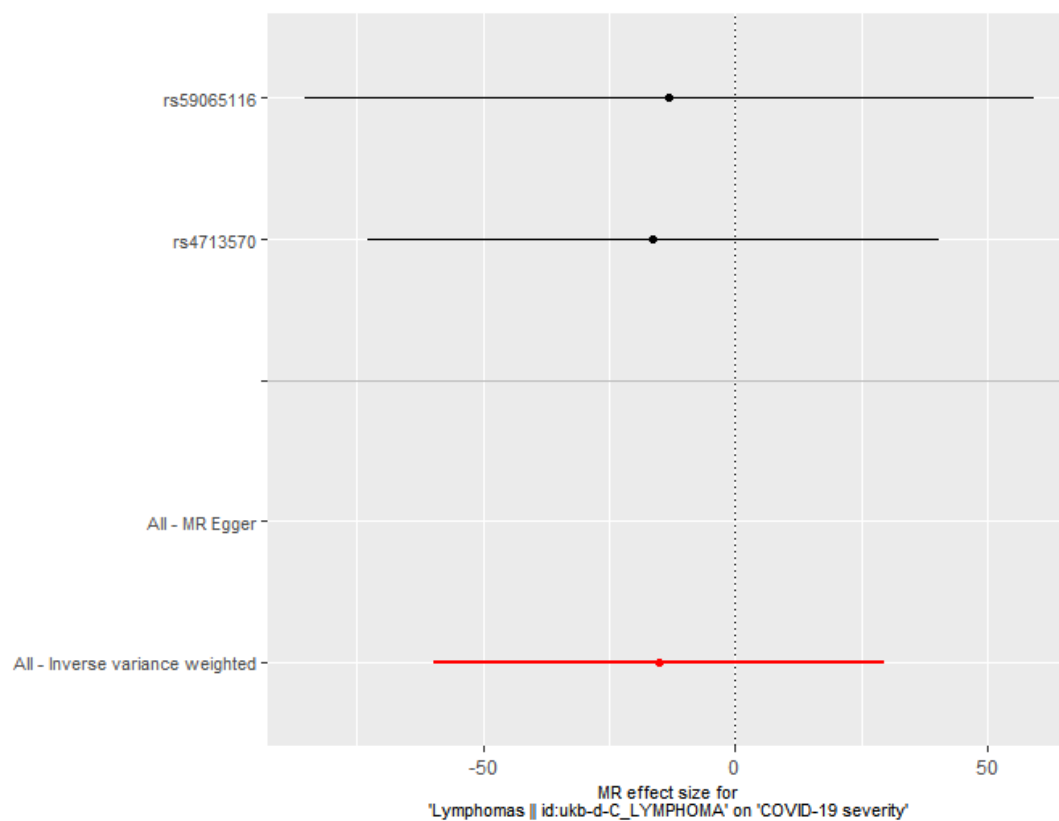


Figure S1O. The effect of each SNP in lymphoma on COVID-19 severity.

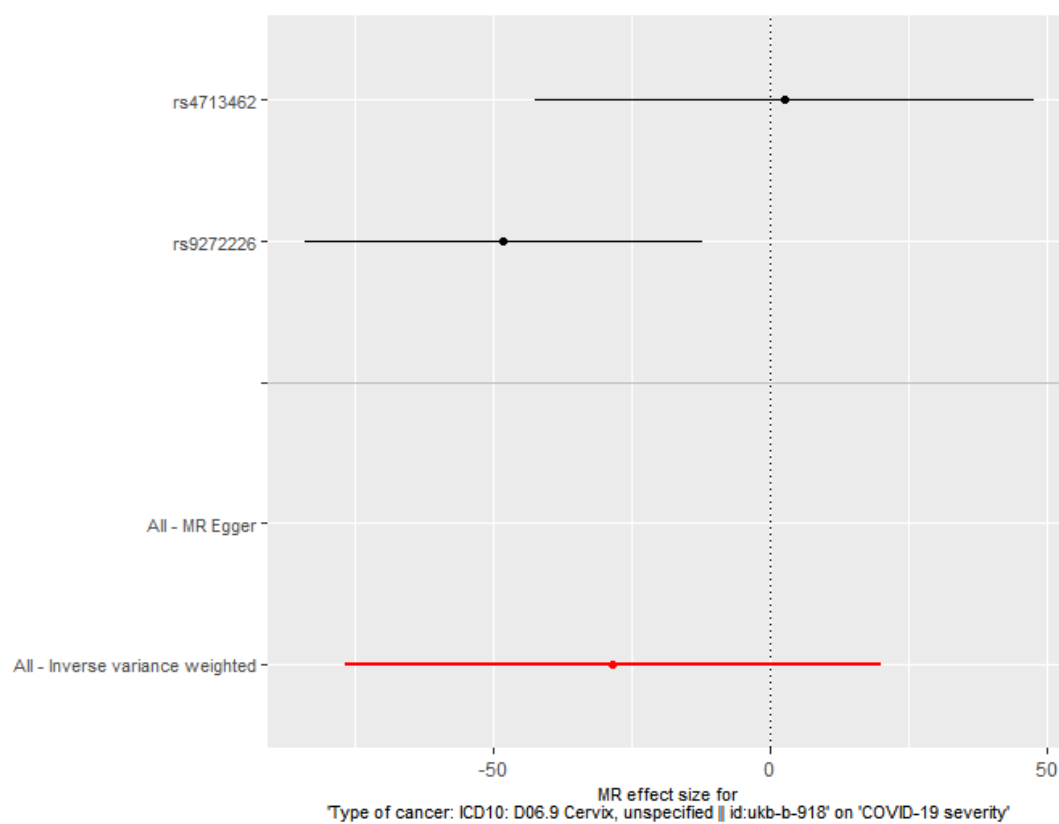


Figure S1P. The effect of each SNP in cervix cancer on COVID-19 severity.

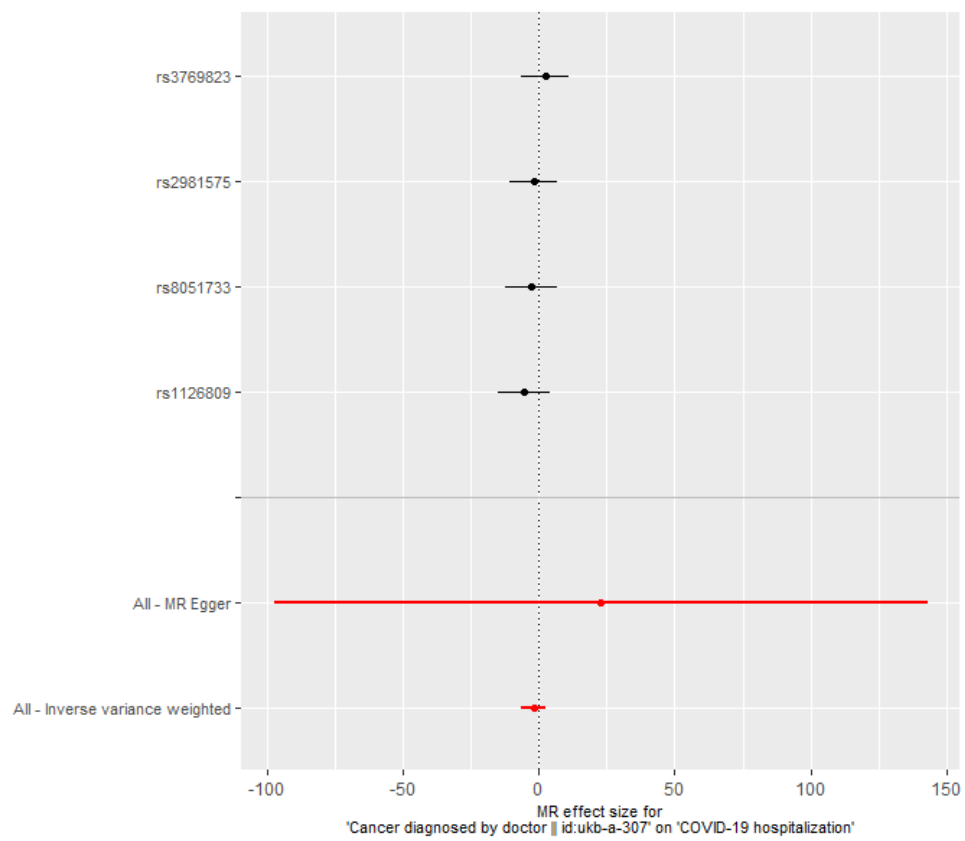


Figure S2A. The effect of each SNP in overall cancer on COVID-19 hospitalization.

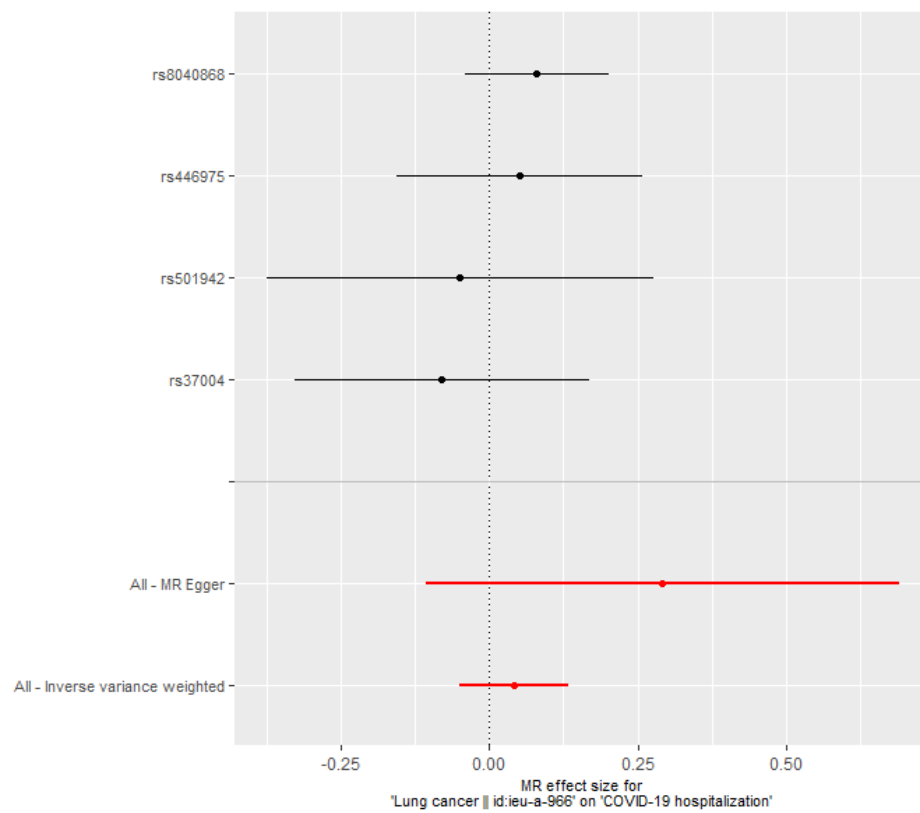


Figure S2B. The effect of each SNP in lung cancer on COVID-19 hospitalization.

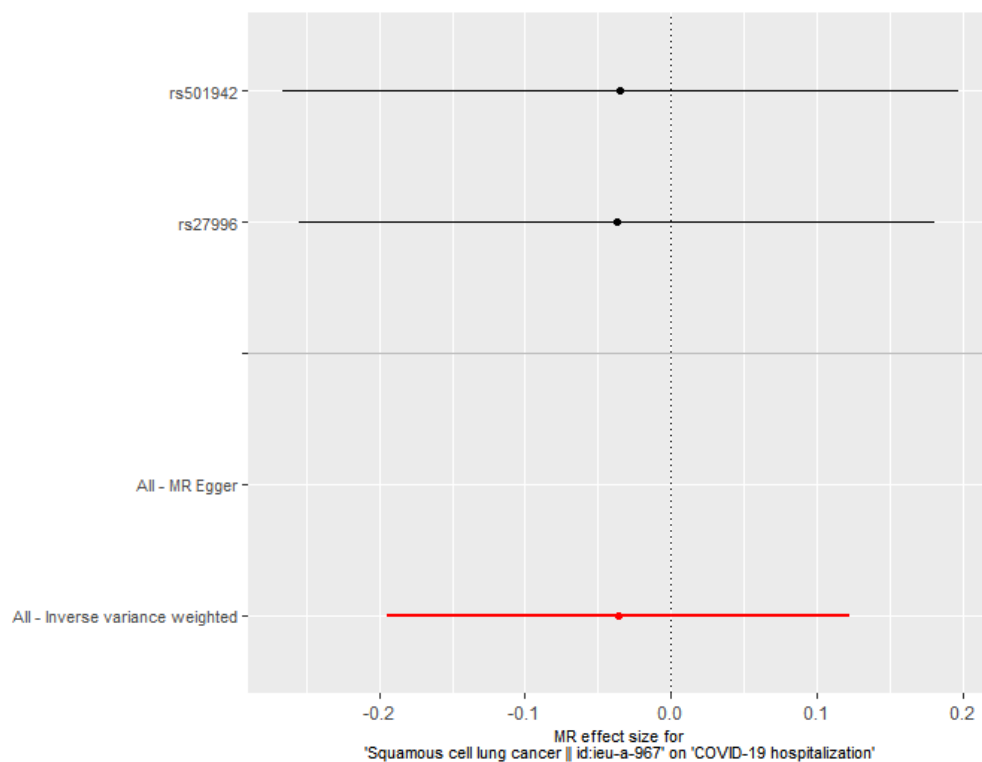


Figure S2C. The effect of each SNP in squamous cell lung cancer on COVID-19 hospitalization.

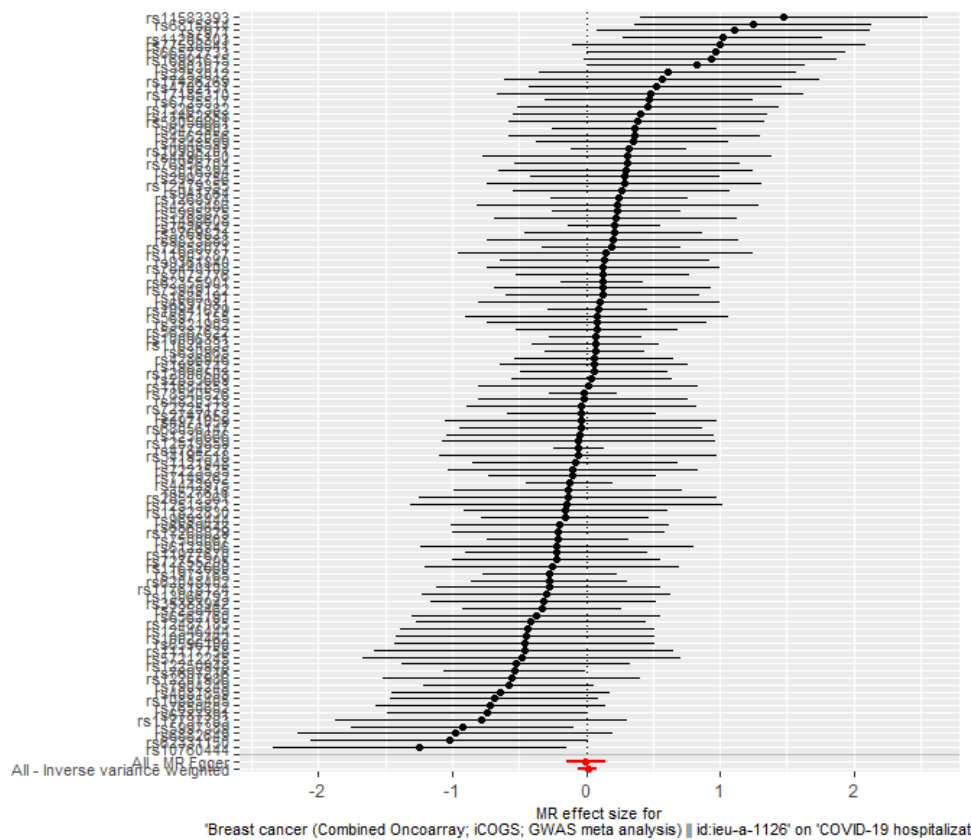


Figure S2D. The effect of each SNP in breast cancer on COVID-19 hospitalization.

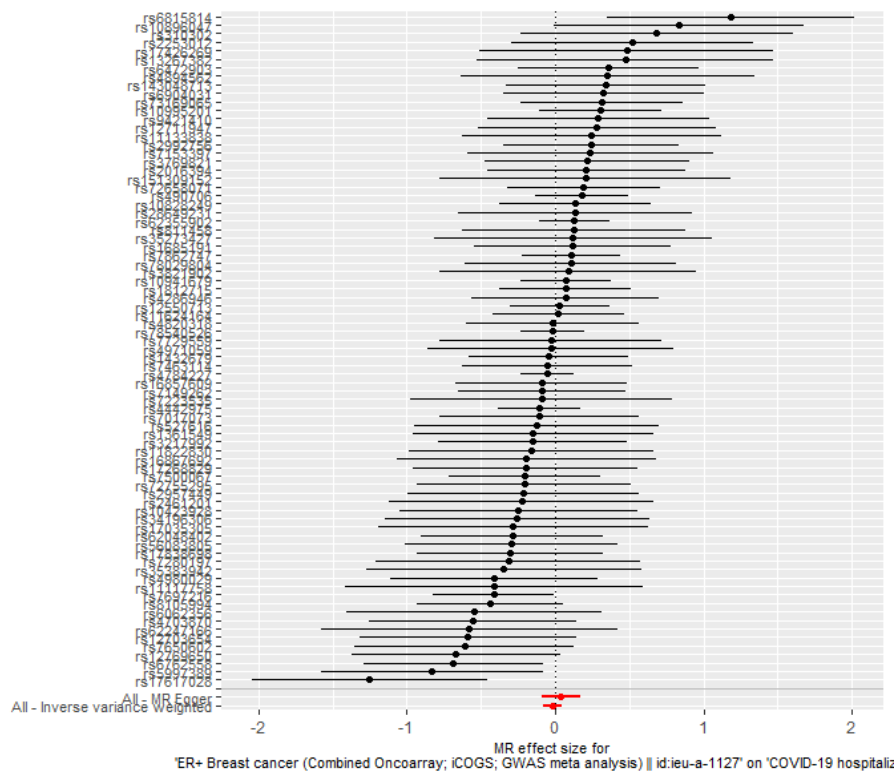


Figure S2E. The effect of each SNP in ER+ breast cancer on COVID-19 hospitalization.

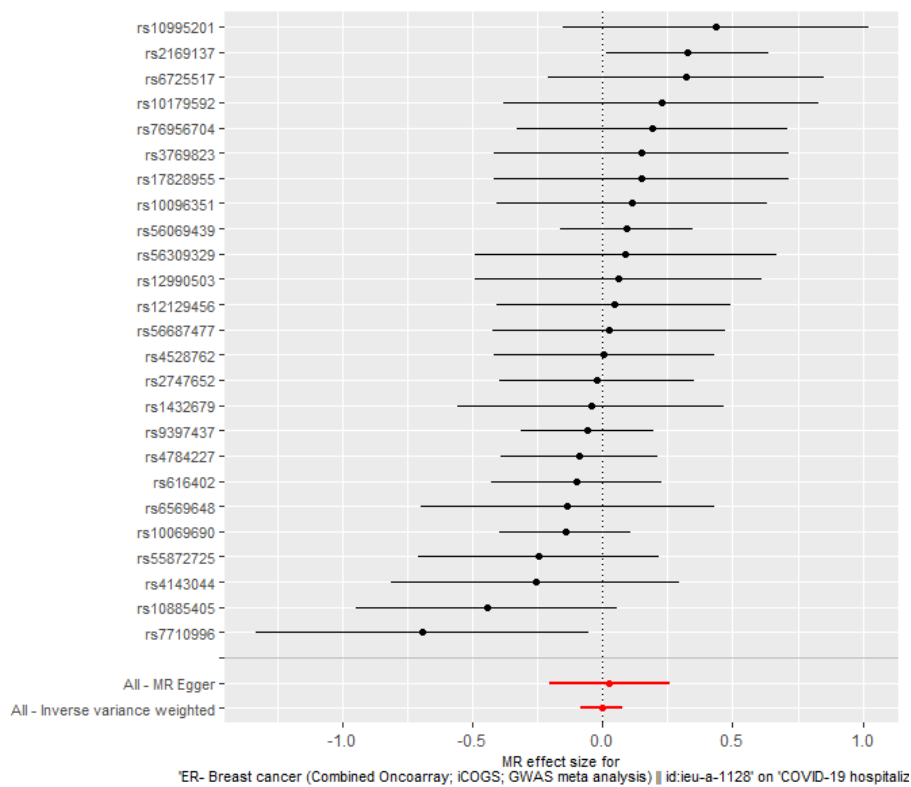


Figure S2F. The effect of each SNP in ER- breast cancer on COVID-19 hospitalization.

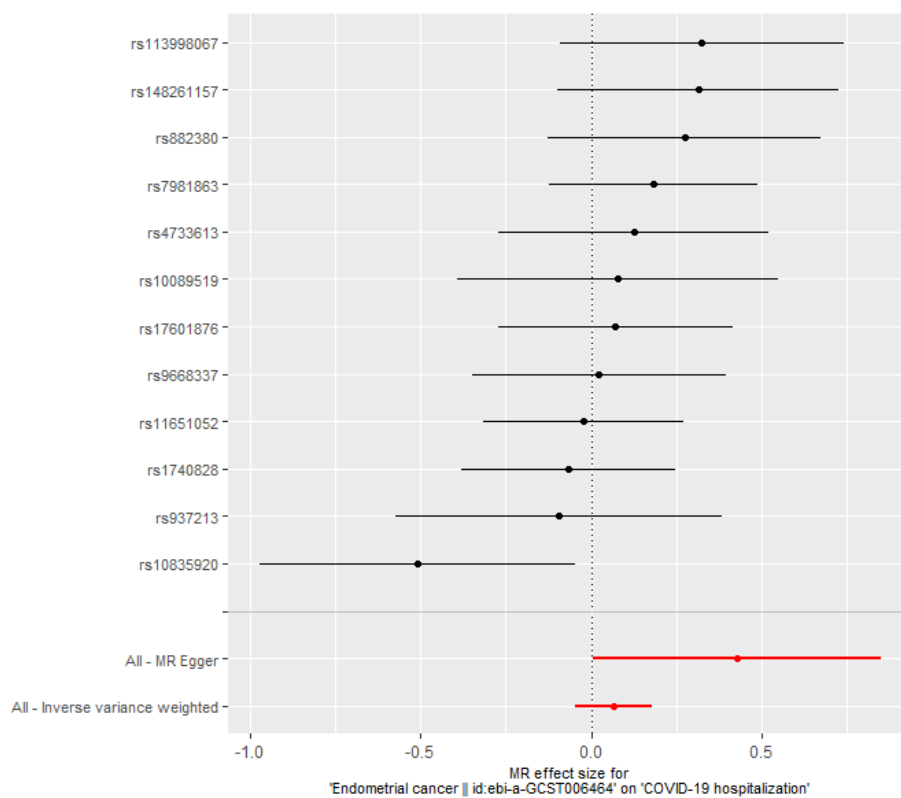


Figure S2G. The effect of each SNP in endometrial cancer on COVID-19 hospitalization.

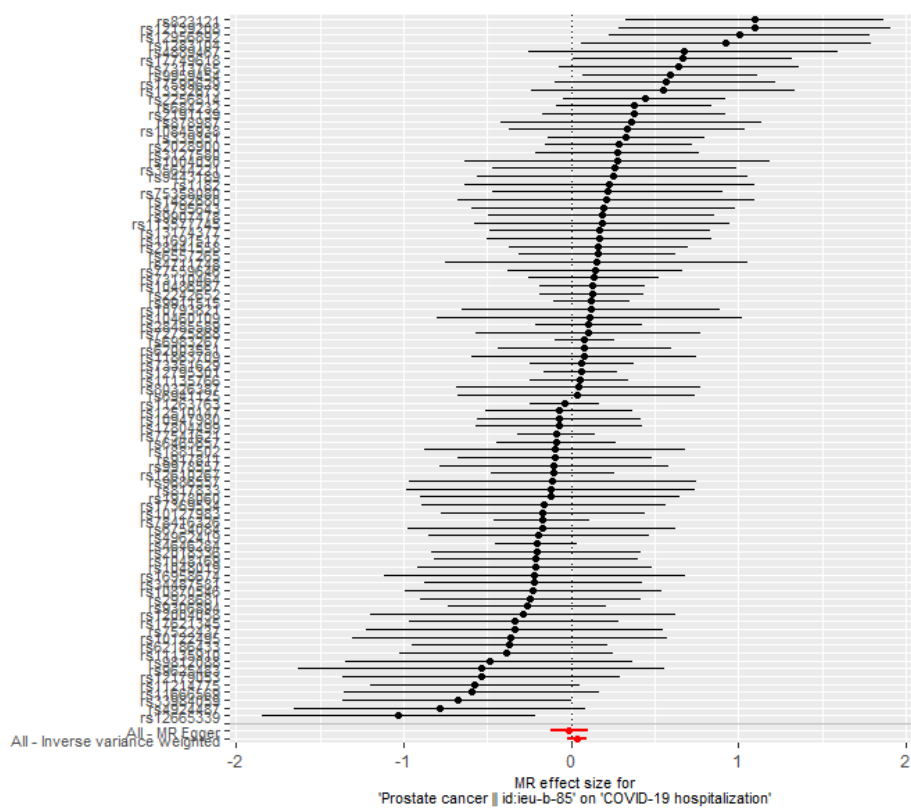


Figure S2H. The effect of each SNP in prostate cancer on COVID-19 hospitalization.

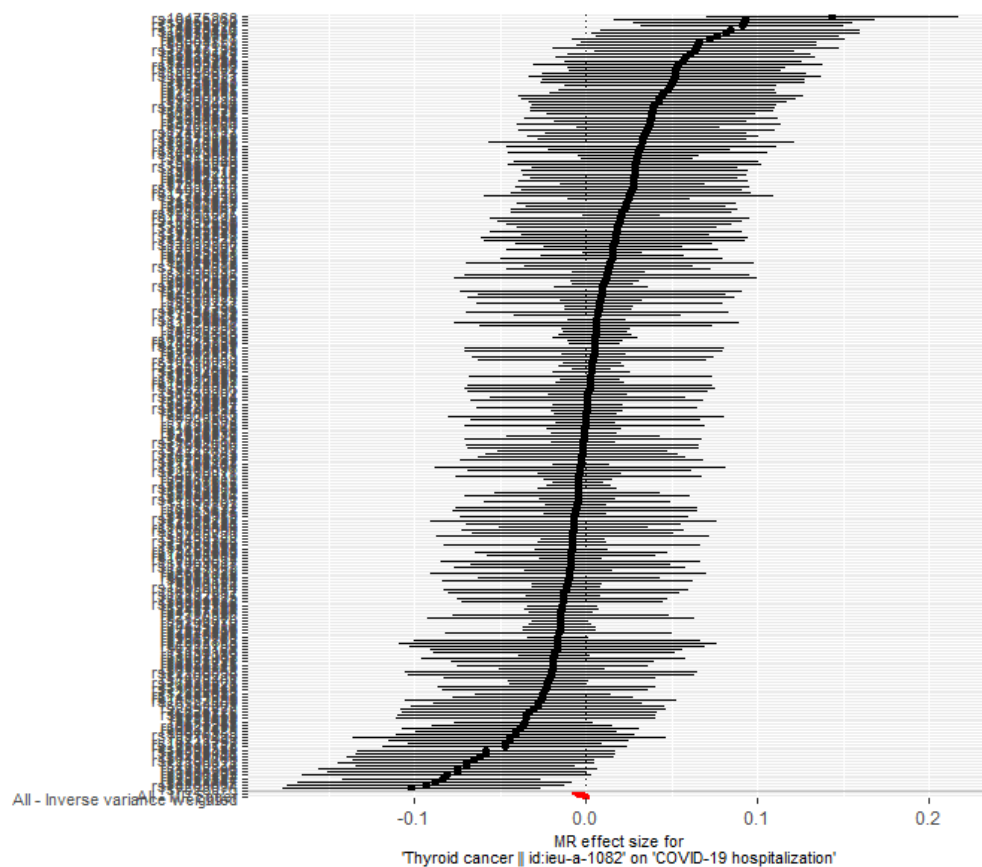


Figure S2I. The effect of each SNP in thyroid cancer on COVID-19 hospitalization.

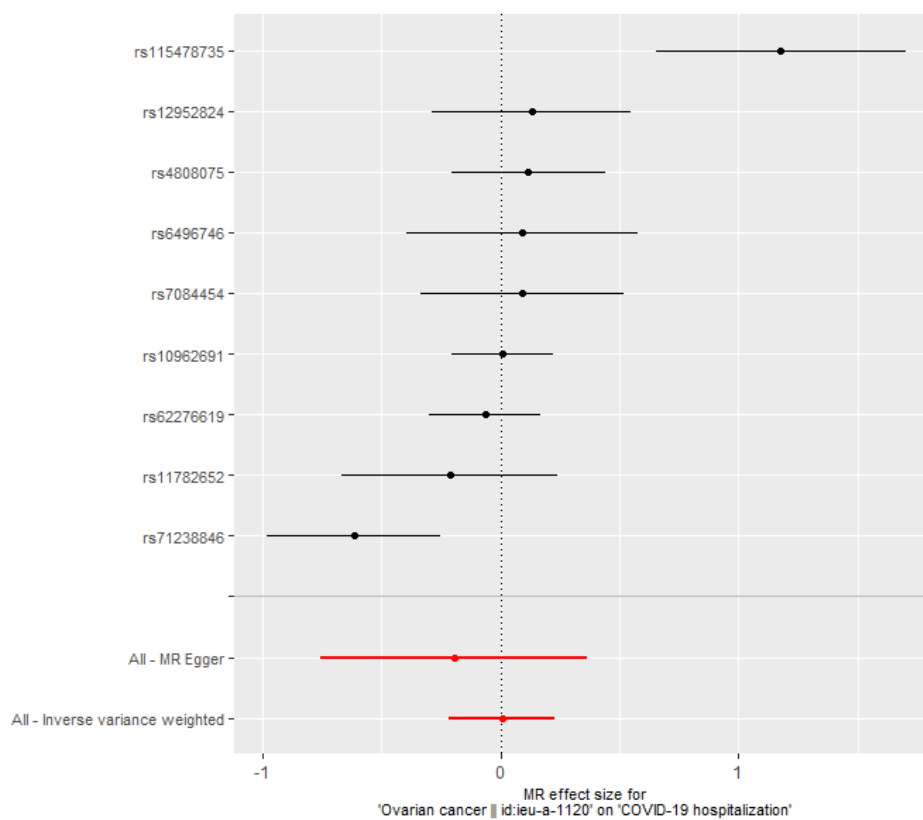


Figure S2J. The effect of each SNP in ovarian cancer on COVID-19 hospitalization.

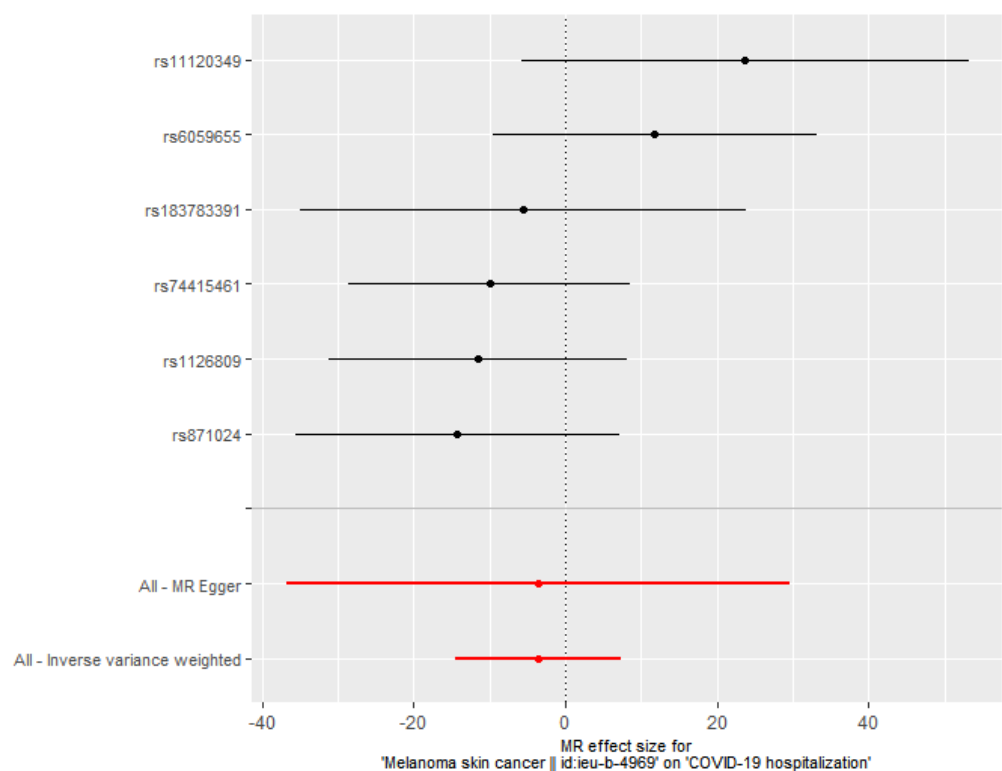


Figure S2K. The effect of each SNP in melanoma on COVID-19 hospitalization.

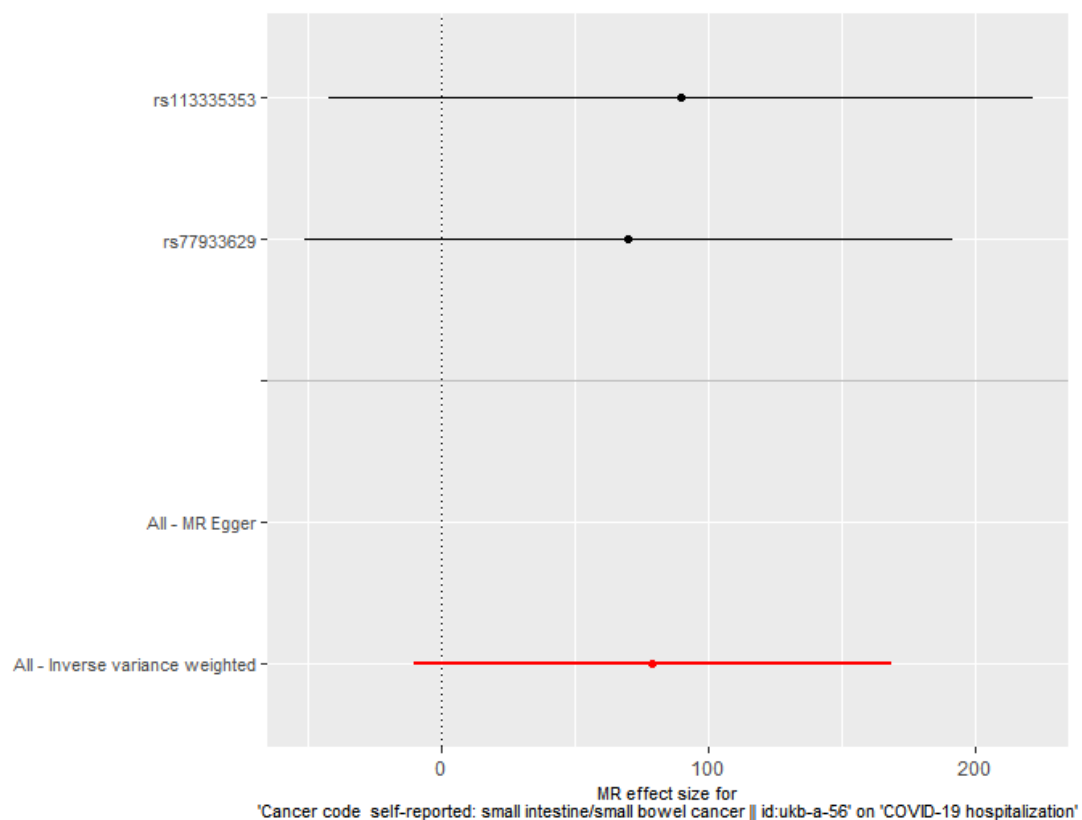


Figure S2L. The effect of each SNP in small bowel cancer on COVID-19 hospitalization.

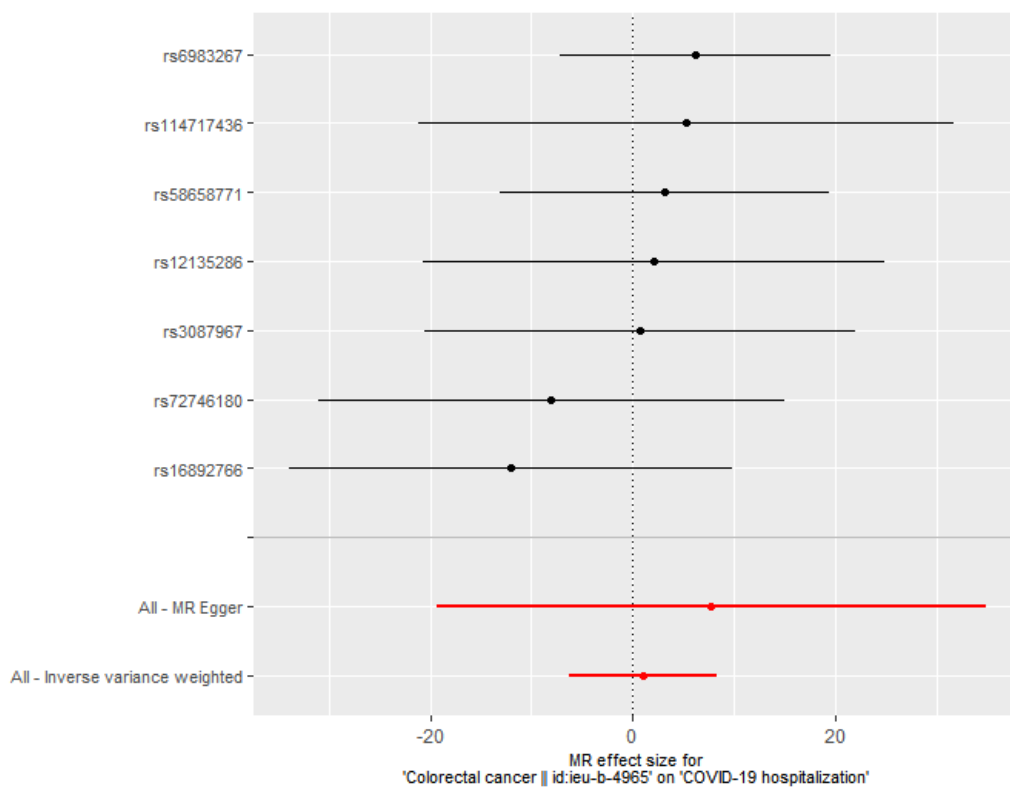


Figure S2M. The effect of each SNP in colorectal cancer on COVID-19 hospitalization.



Figure S2N. The effect of each SNP in oropharyngeal cancer on COVID-19 hospitalization.



Figure S2O. The effect of each SNP in lymphoma on COVID-19 hospitalization.

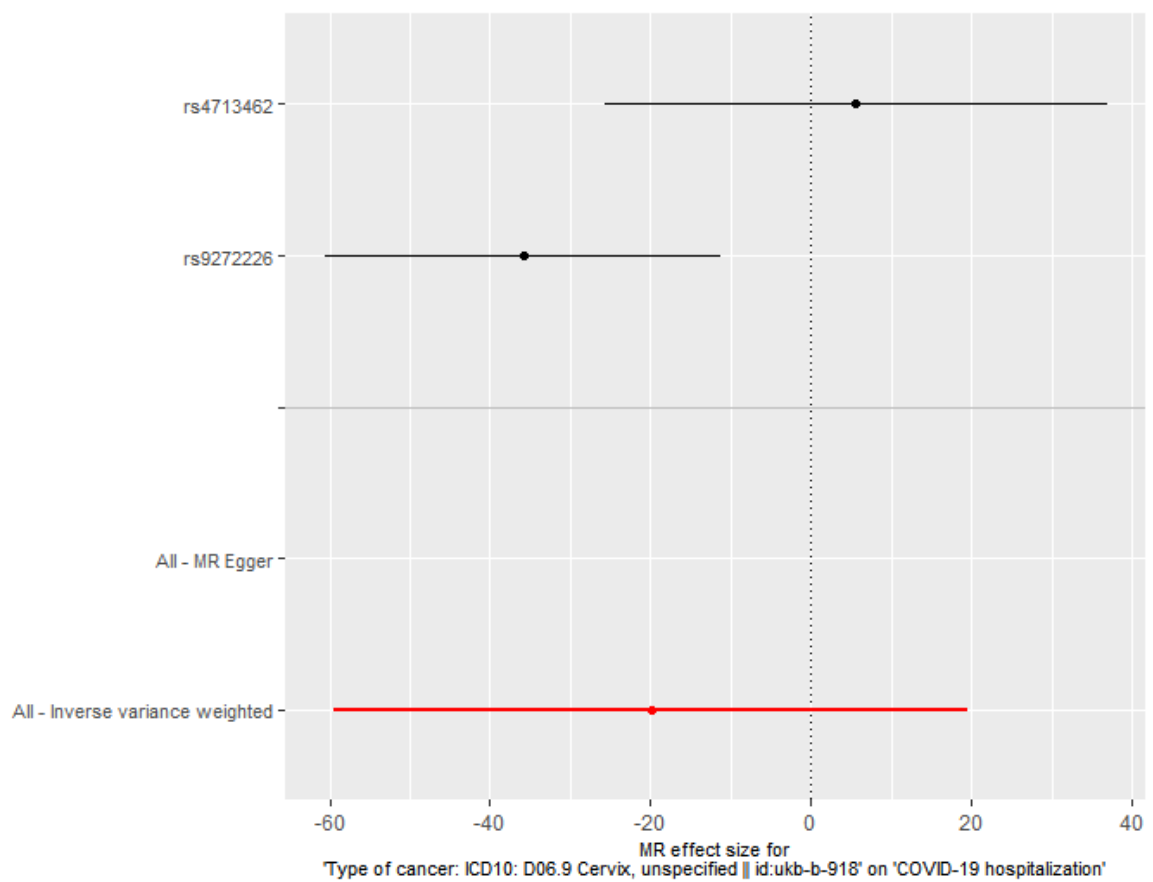


Figure S2P. The effect of each SNP in cervix cancer on COVID-19 hospitalization.

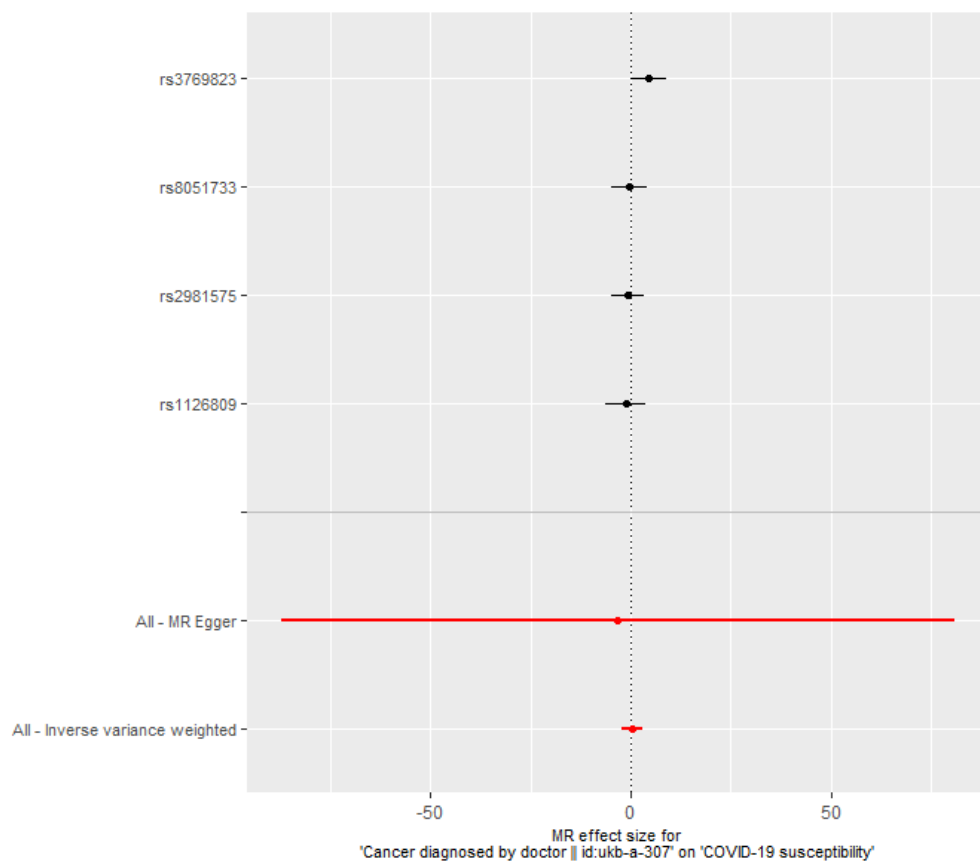


Figure S3A. The effect of each SNP in overall cancer on COVID-19 susceptibility.

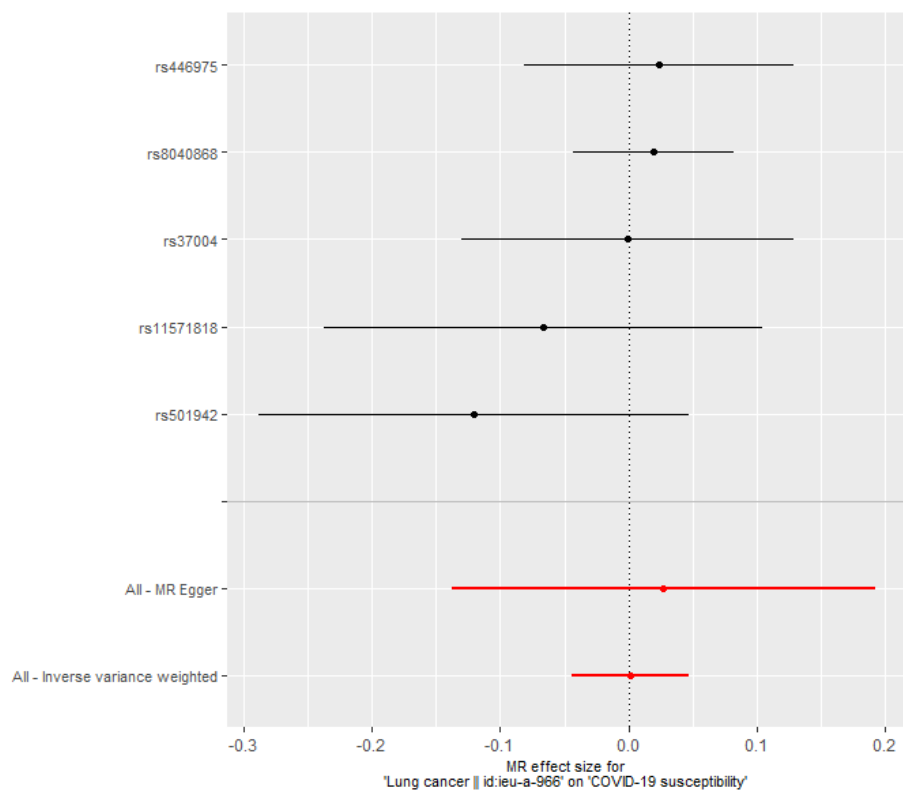


Figure S3B. The effect of each SNP in lung cancer on COVID-19 susceptibility.

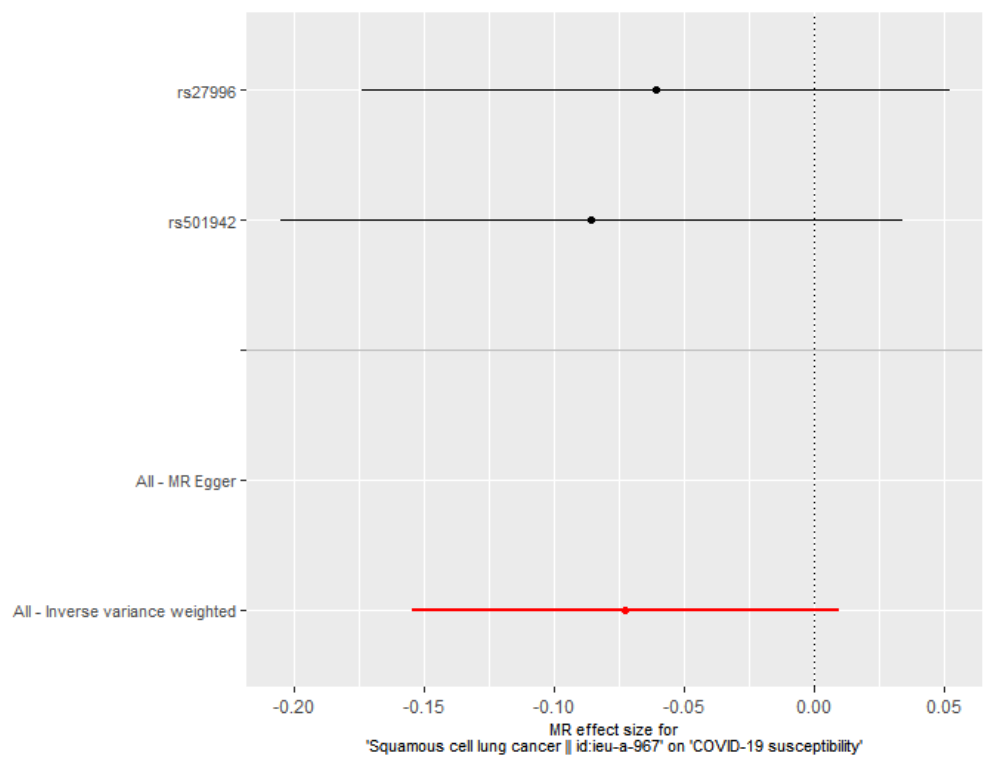


Figure S3C. The effect of each SNP in squamous cell lung cancer on COVID-19 susceptibility.

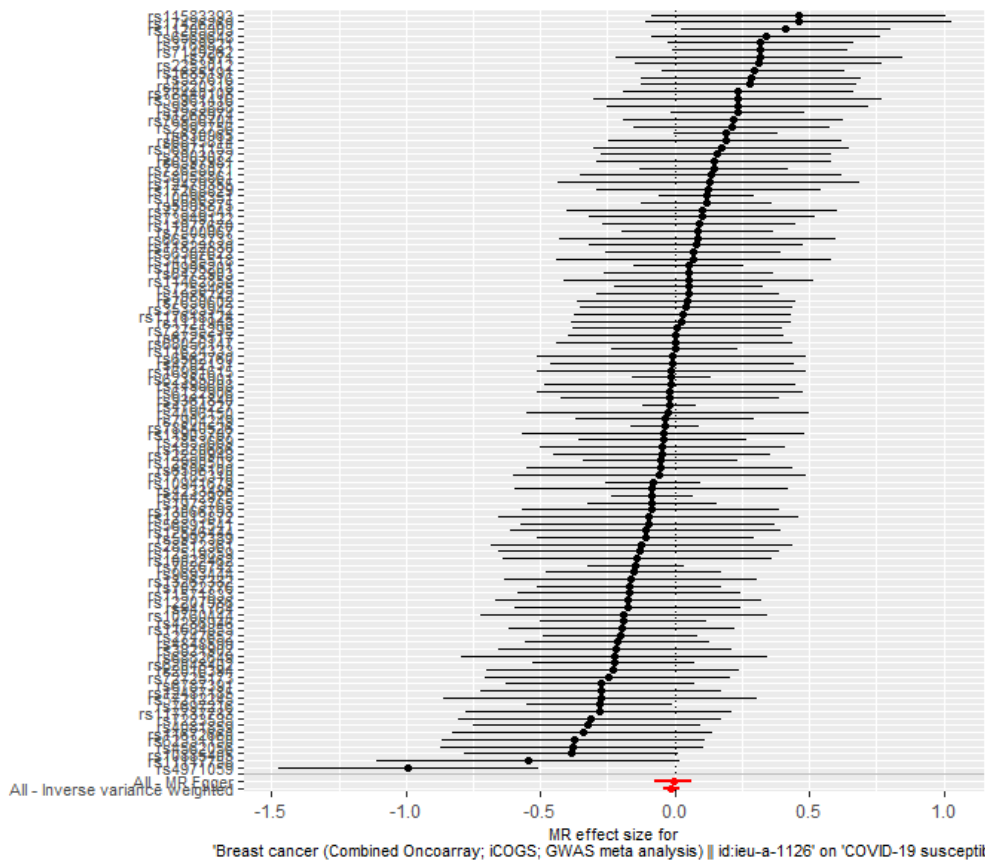


Figure S3D. The effect of each SNP in breast cancer on COVID-19 susceptibility.

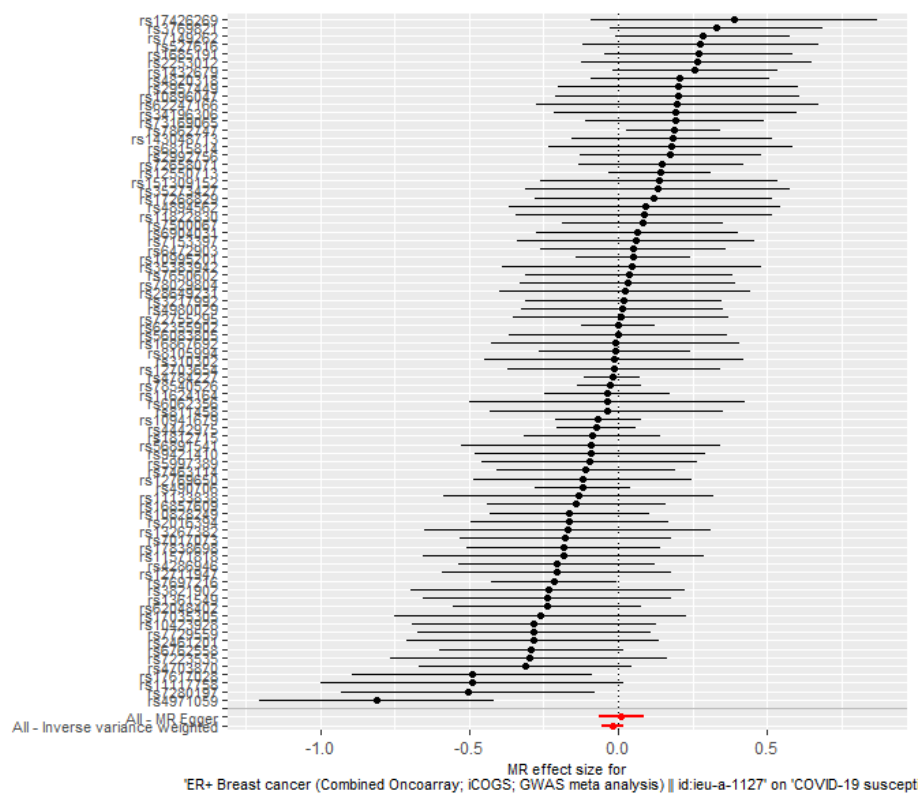


Figure S3E. The effect of each SNP in ER+ breast cancer on COVID-19 susceptibility.

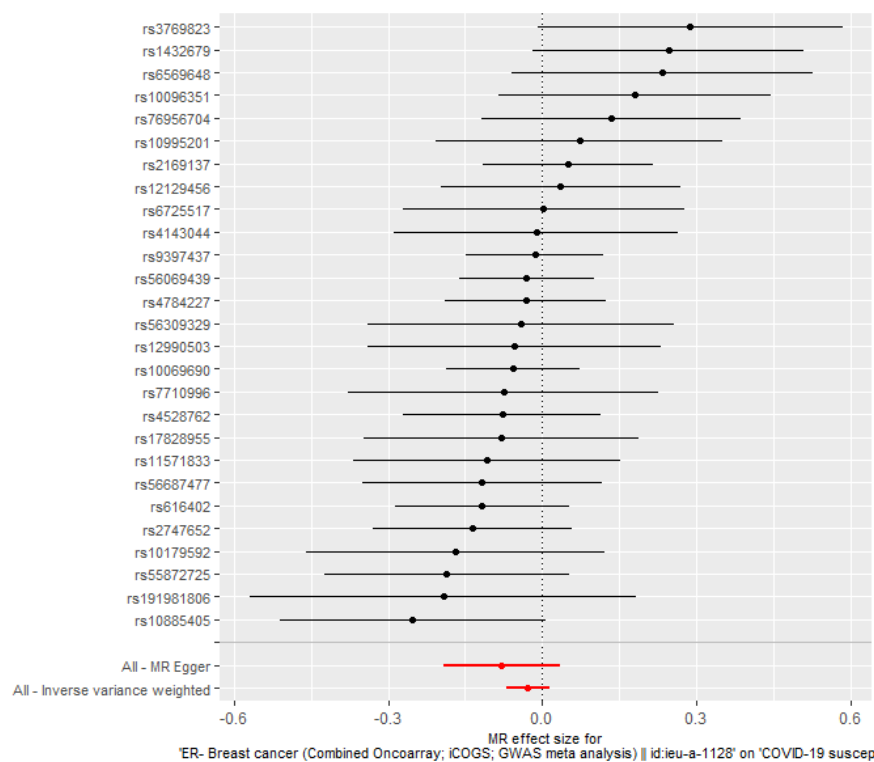


Figure S3F. The effect of each SNP in ER- breast cancer on COVID-19 susceptibility.

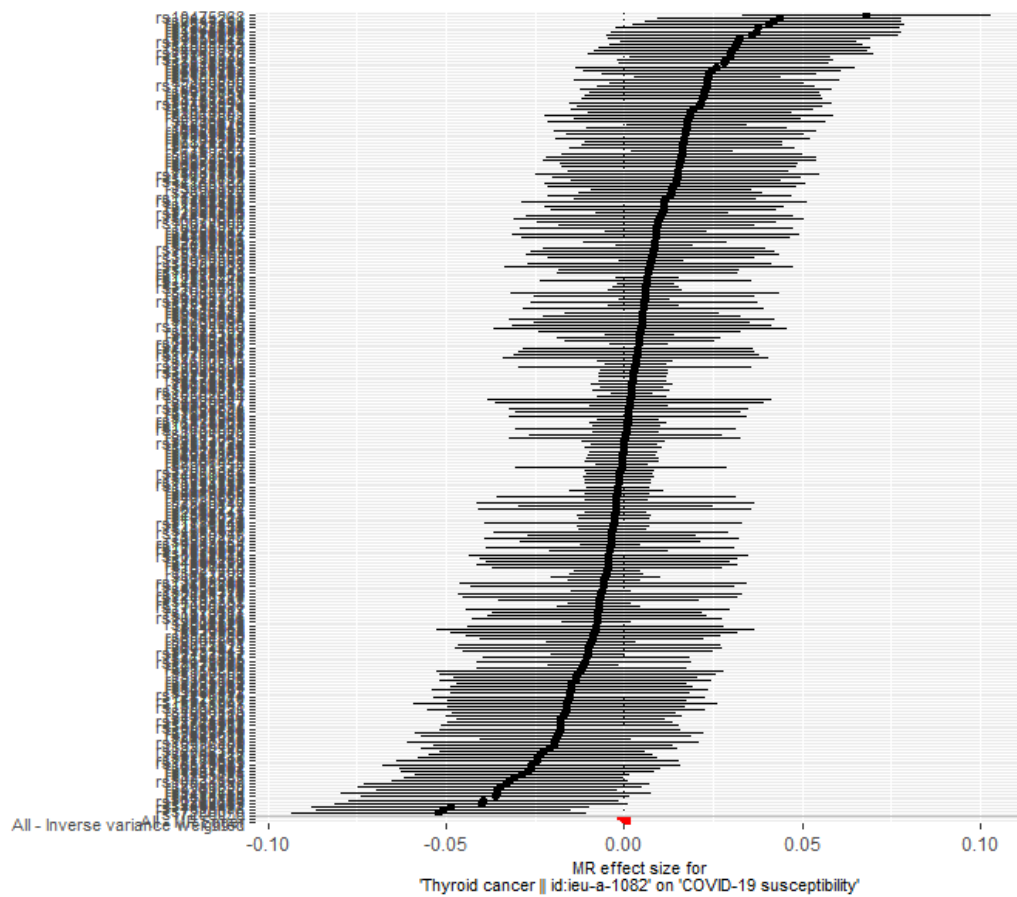


Figure S3I. The effect of each SNP in thyroid cancer on COVID-19 susceptibility.

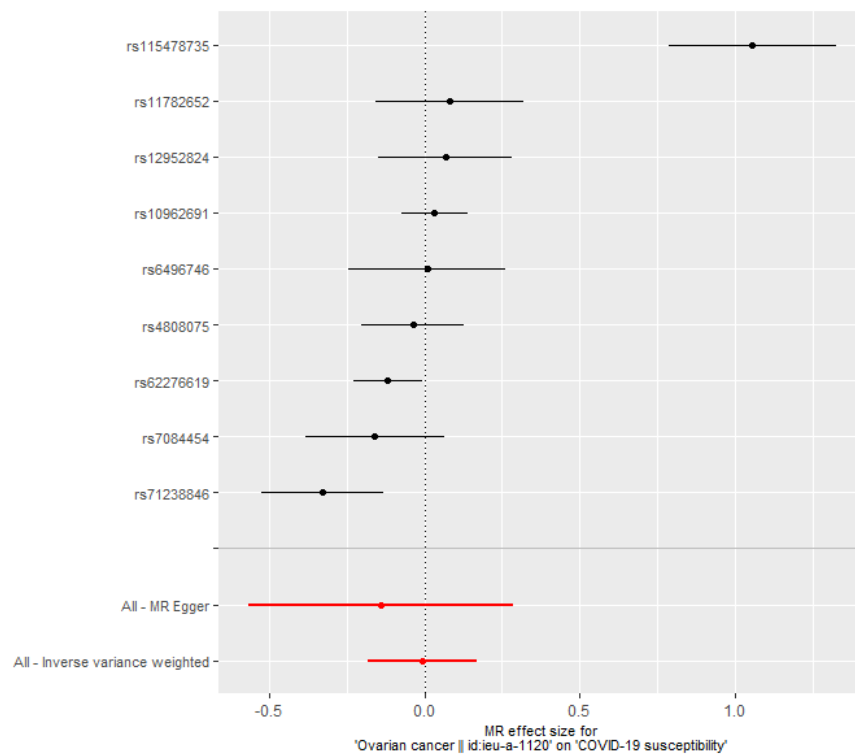


Figure S3J. The effect of each SNP in ovarian cancer on COVID-19 susceptibility.

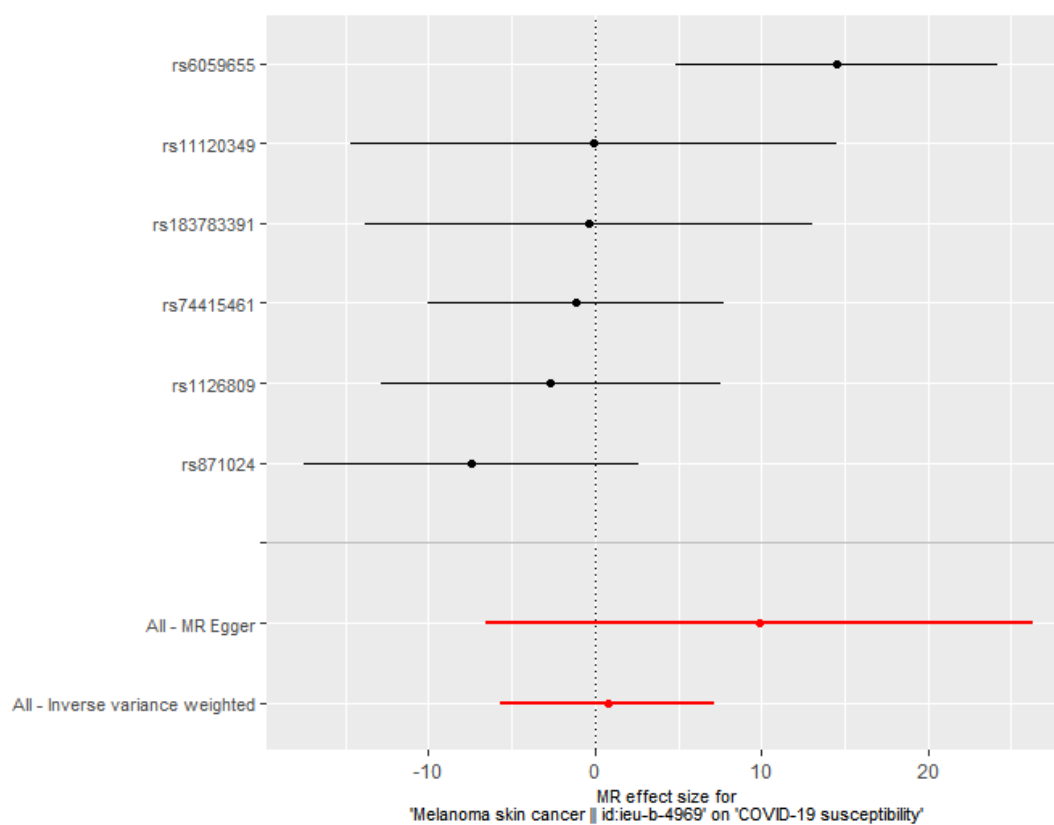


Figure S3K. The effect of each SNP in melanoma on COVID-19 susceptibility.

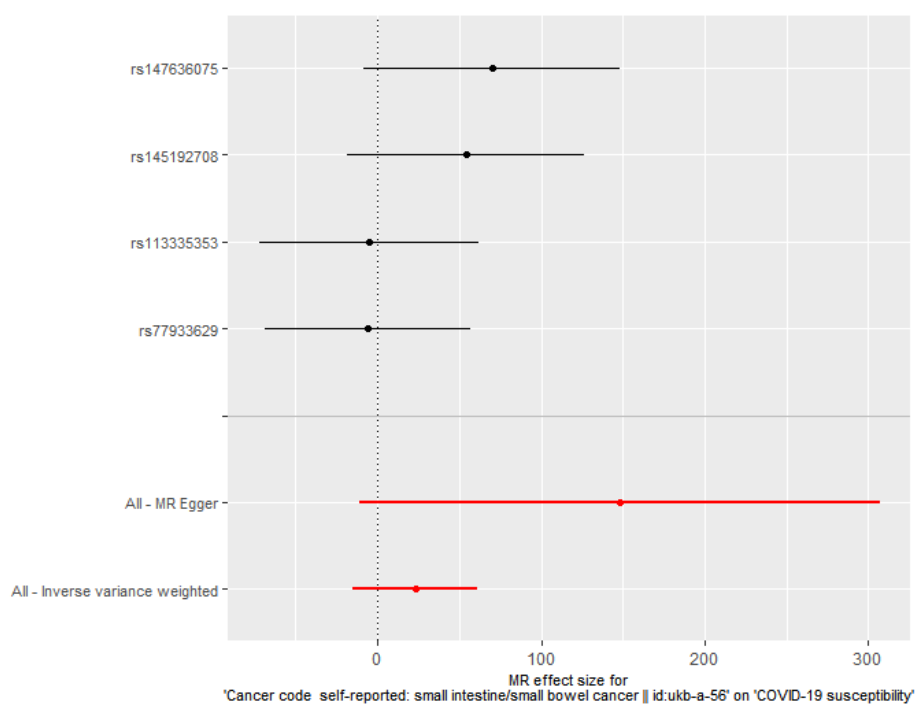


Figure S3L. The effect of each SNP in small bowel cancer on COVID-19 susceptibility.

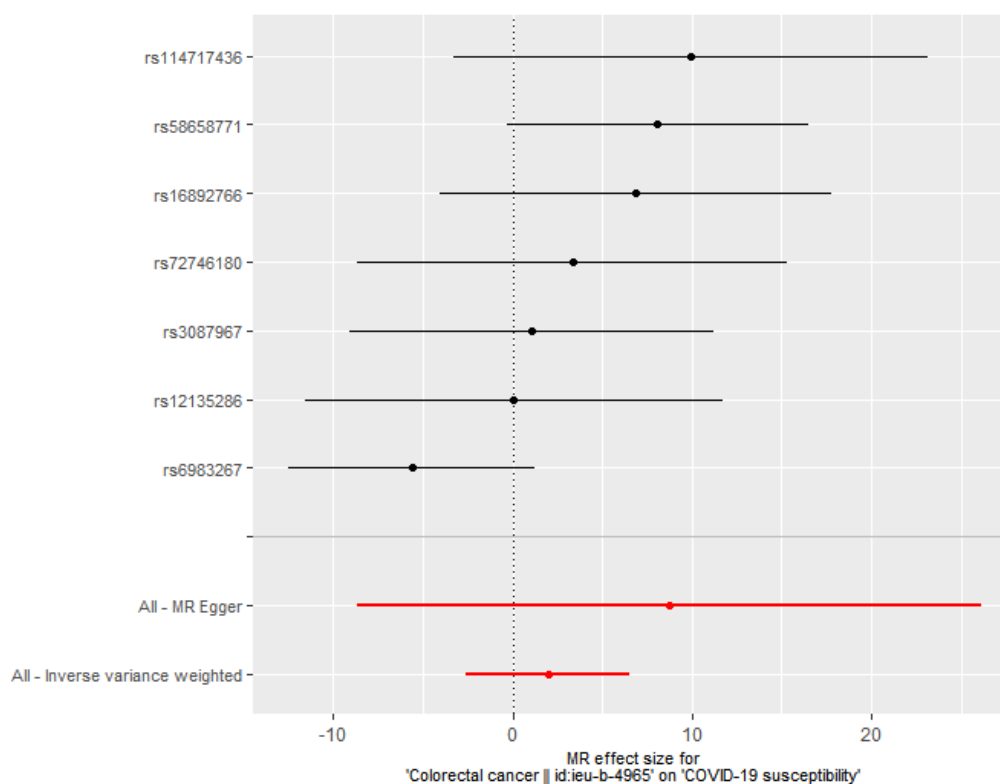


Figure S3M. The effect of each SNP in colorectal cancer on COVID-19 susceptibility.

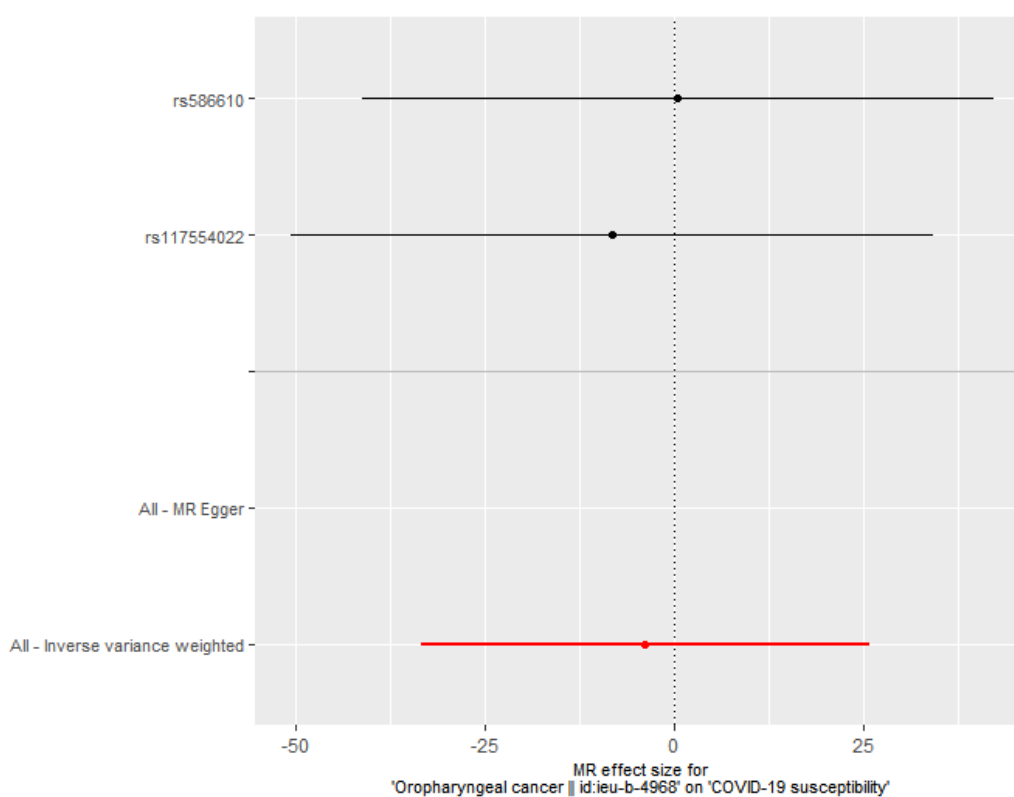


Figure S3N. The effect of each SNP in oropharyngeal cancer on COVID-19 susceptibility.

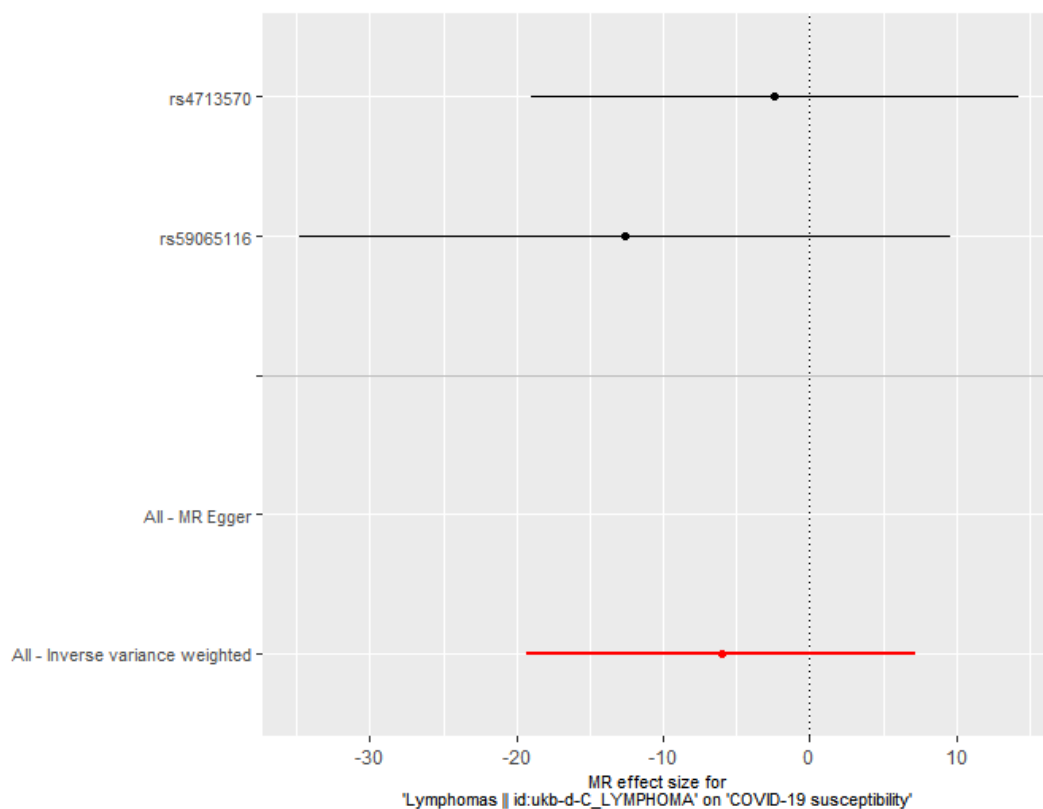


Figure S3O. The effect of each SNP in lymphoma on COVID-19 susceptibility.

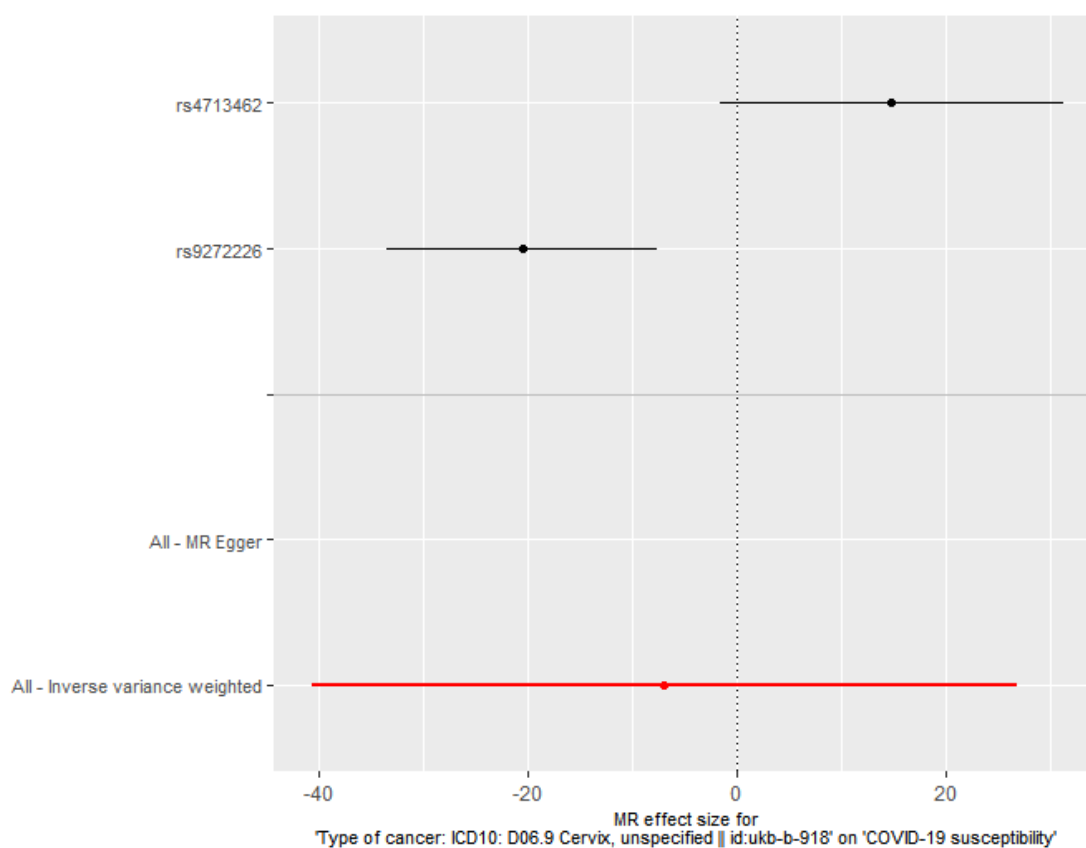


Figure S3P. The effect of each SNP in cervix cancer on COVID-19 susceptibility.

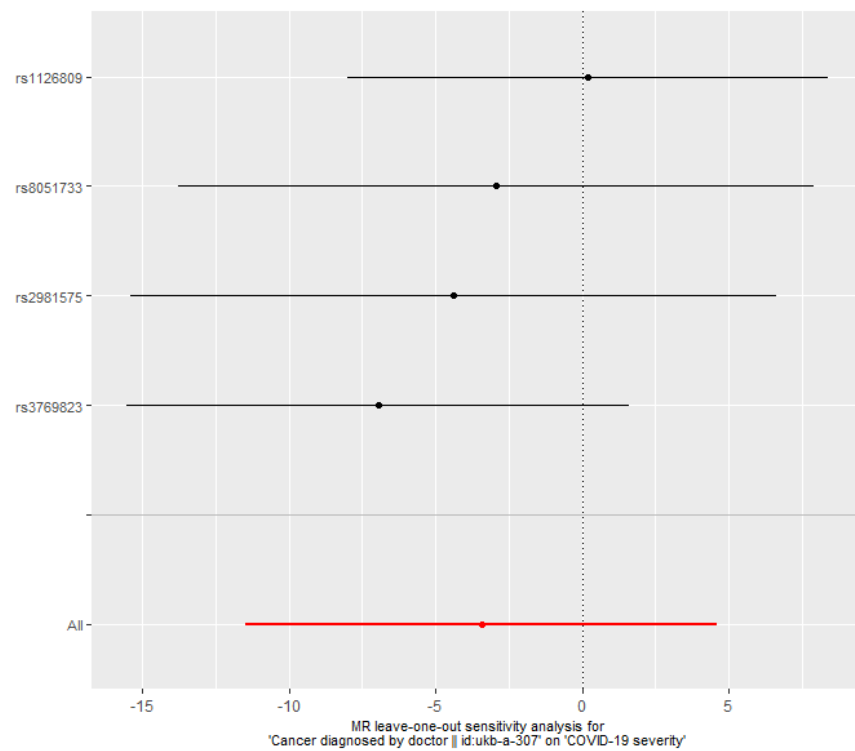


Figure S4A. The leave-one-out sensitivity analysis of the causal effect of overall cancer on COVID-19 severity.

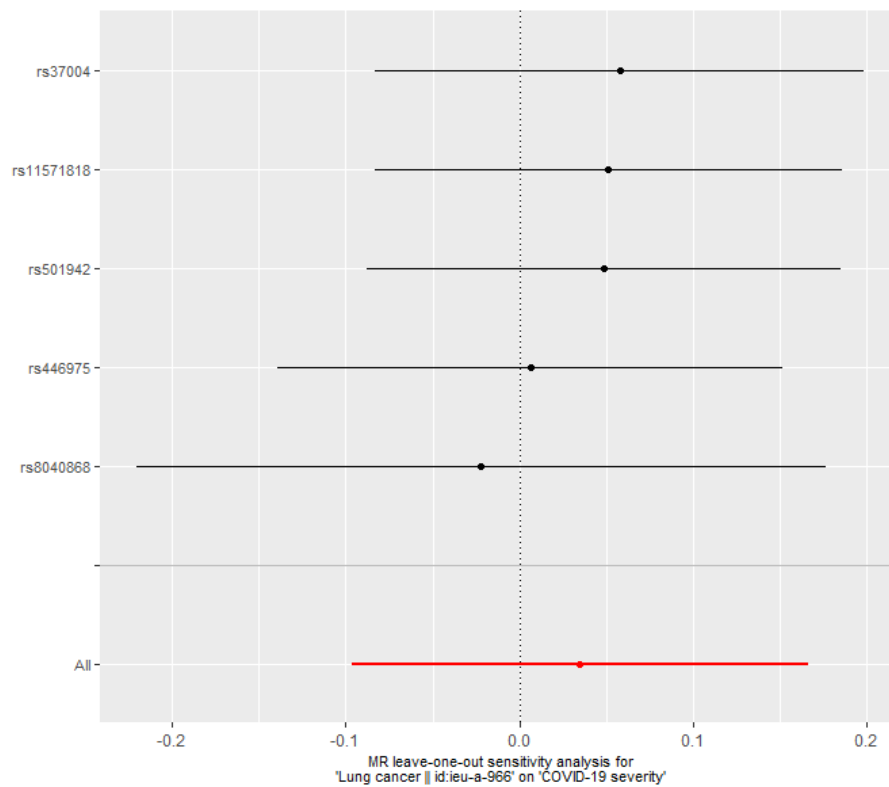


Figure S4B. The leave-one-out sensitivity analysis of the causal effect of lung cancer on COVID-19 severity.



Figure S4C. The leave-one-out sensitivity analysis of the causal effect of squamous cell lung cancer on COVID-19 severity.

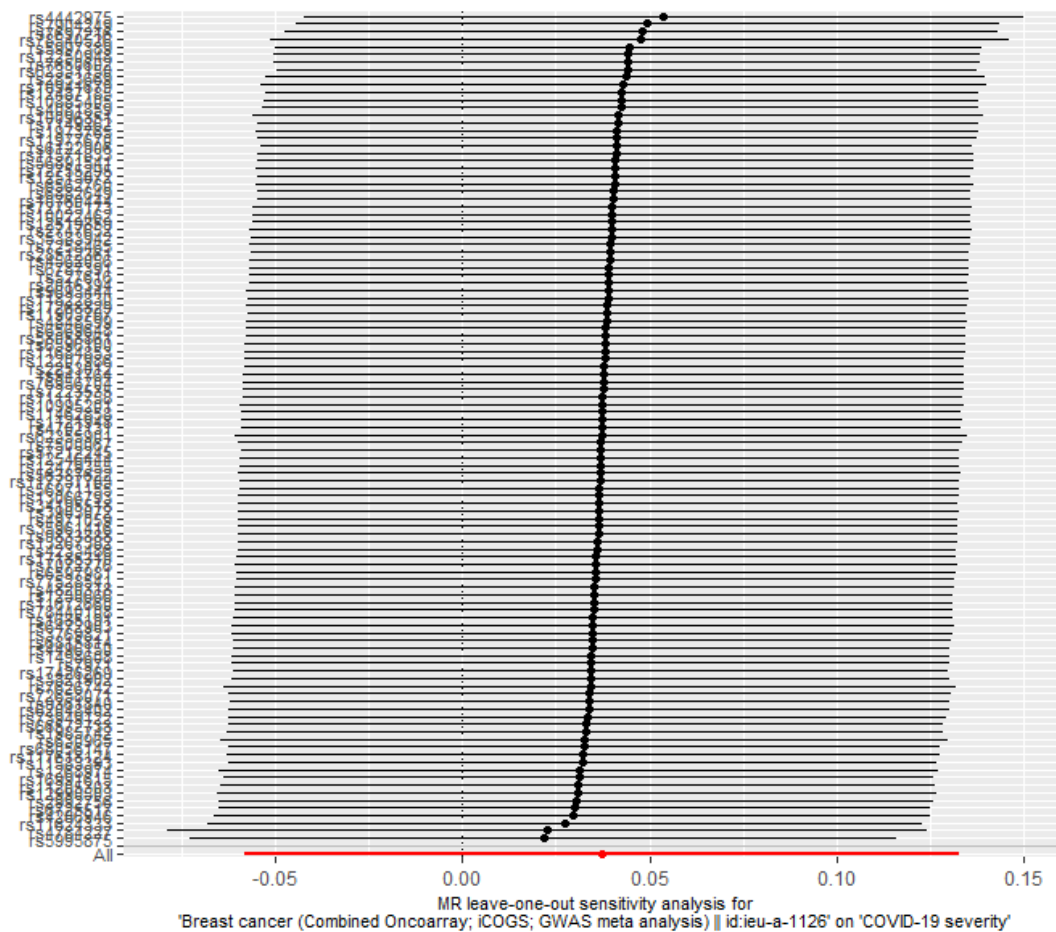


Figure S4D. The leave-one-out sensitivity analysis of the causal effect of breast cancer on COVID-19 severity.

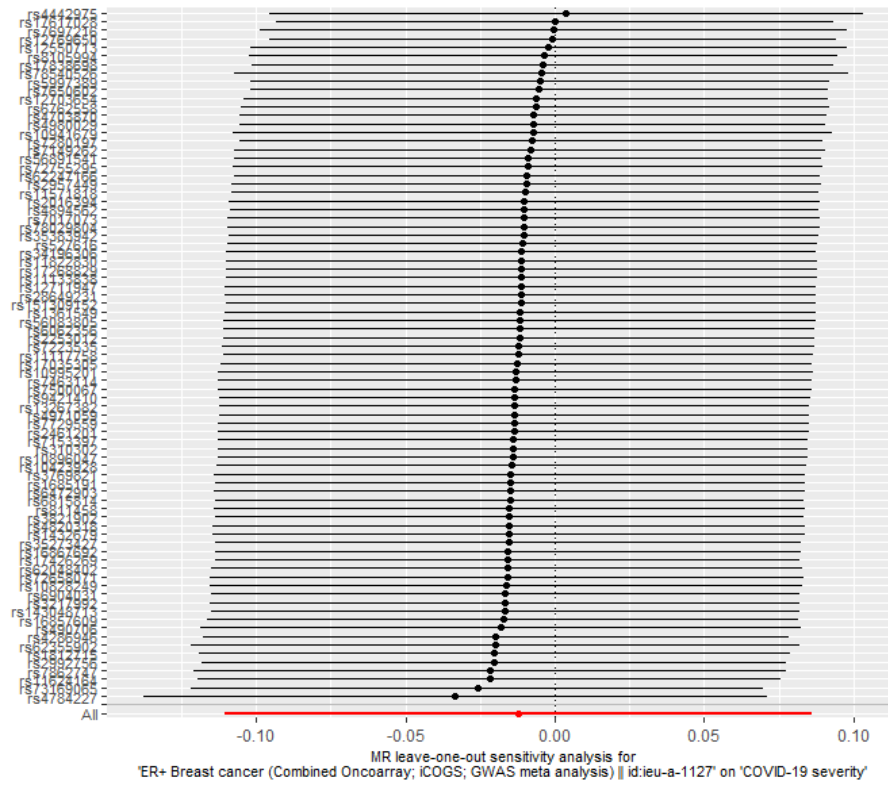


Figure S4E. The leave-one-out sensitivity analysis of the causal effect of ER+ breast cancer on COVID-19 severity.

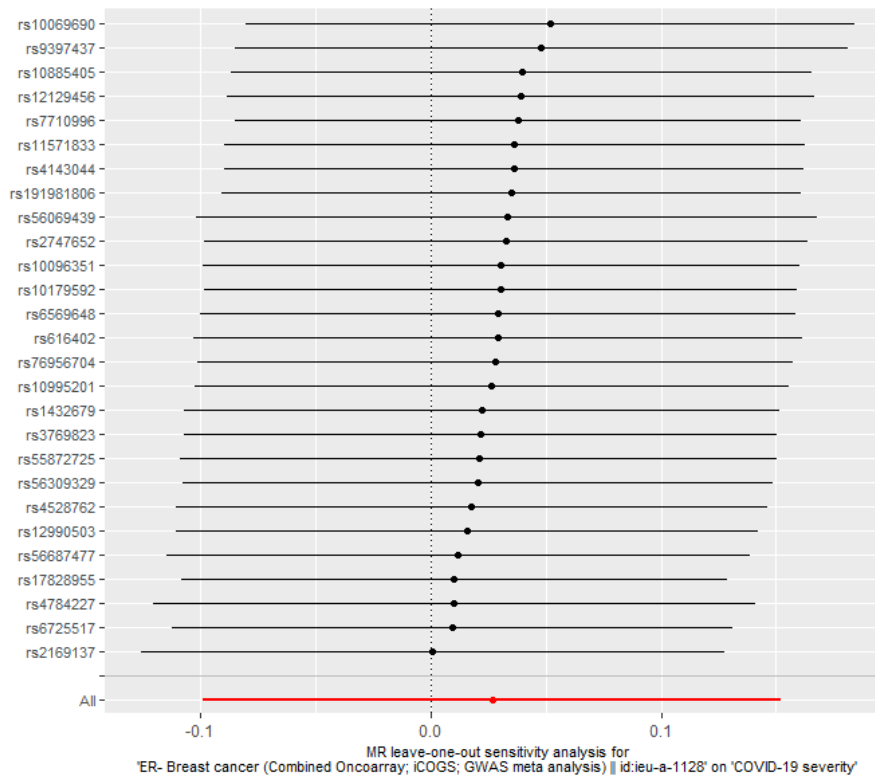


Figure S4F. The leave-one-out sensitivity analysis of the causal effect of ER- breast cancer on COVID-19 severity.

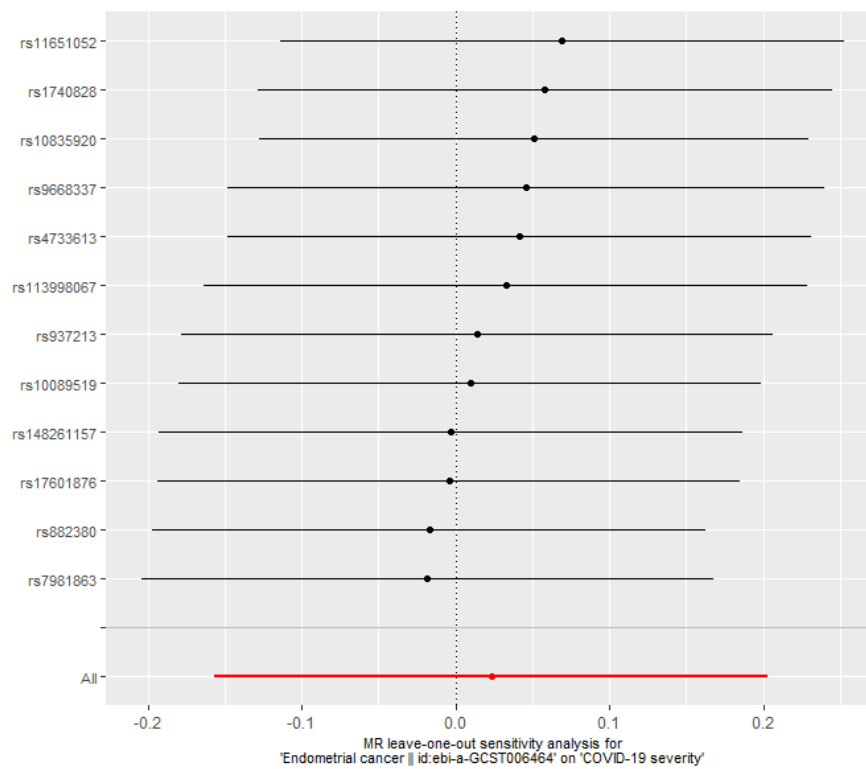


Figure S4G. The leave-one-out sensitivity analysis of the causal effect of endometrial cancer on COVID-19 severity.

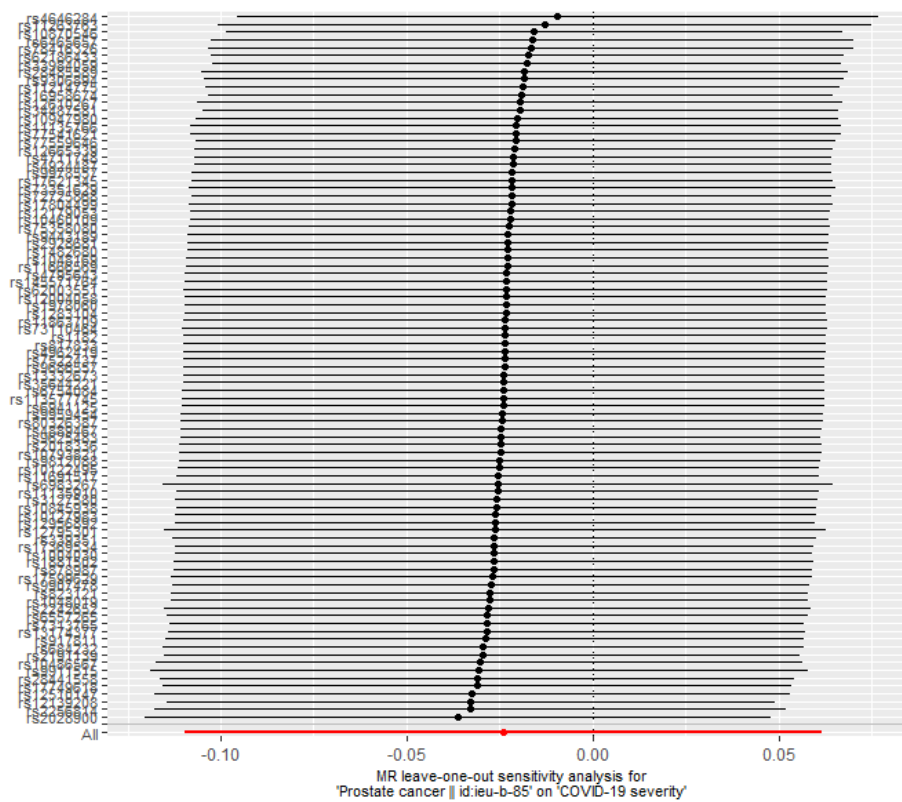


Figure S4H. The leave-one-out sensitivity analysis of the causal effect of prostate cancer on COVID-19 severity.

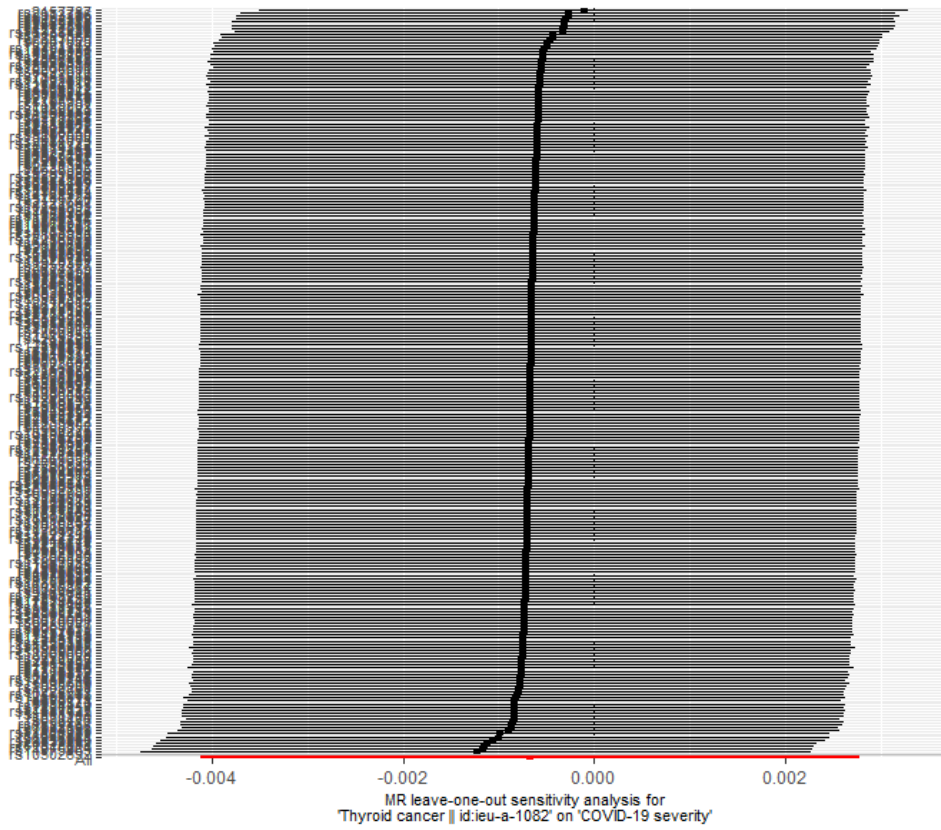


Figure S4I. The leave-one-out sensitivity analysis of the causal effect of thyroid cancer on COVID-19 severity.

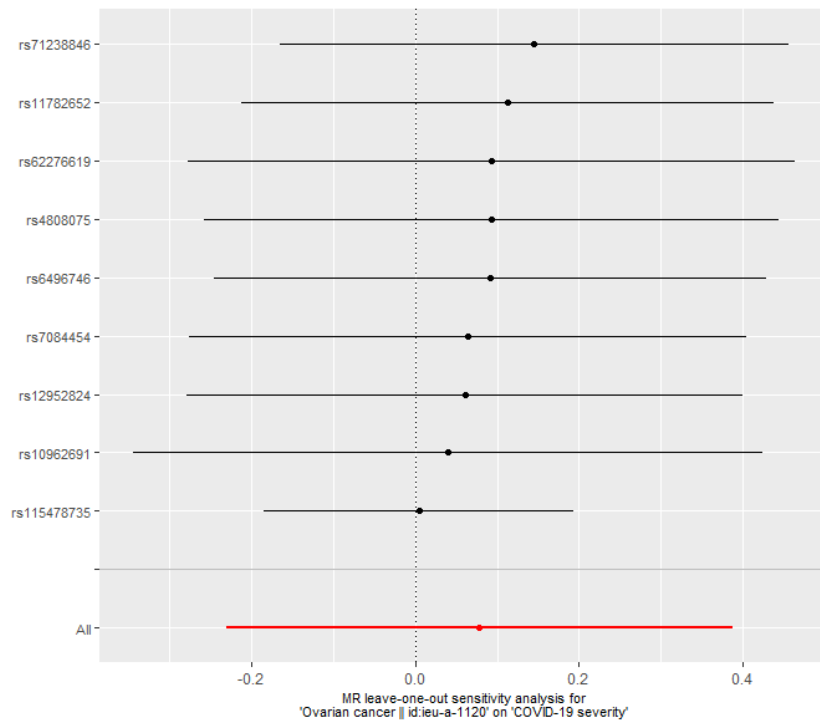


Figure S4J. The leave-one-out sensitivity analysis of the causal effect of ovarian cancer on COVID-19 severity.

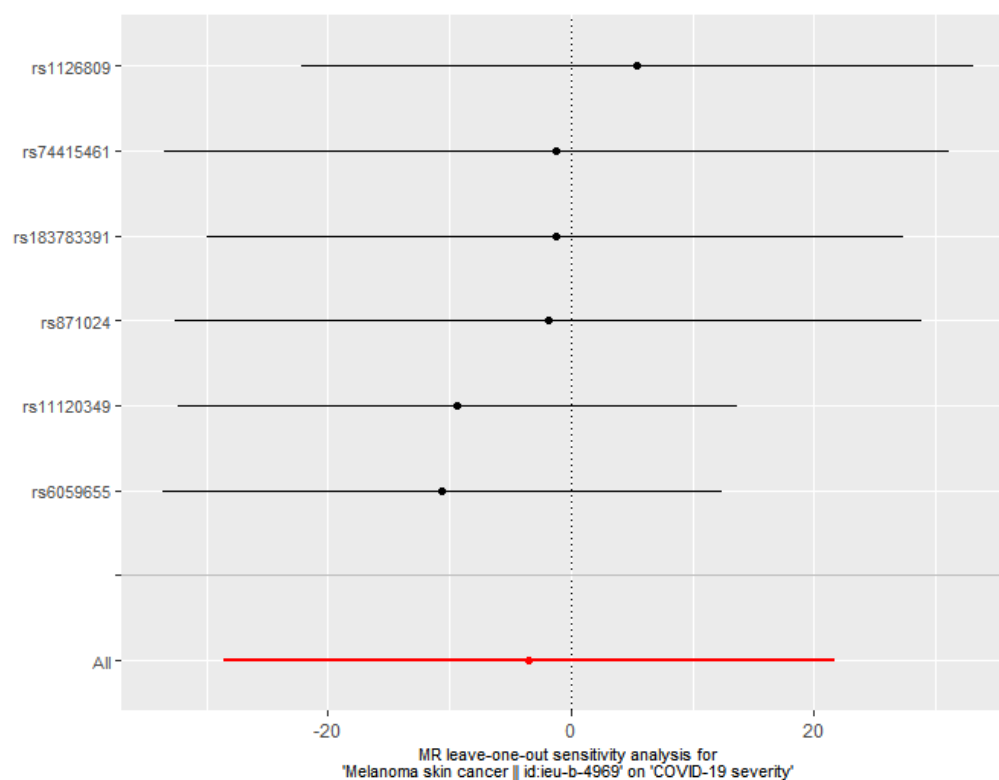


Figure S4K. The leave-one-out sensitivity analysis of the causal effect of melanoma on COVID-19 severity.

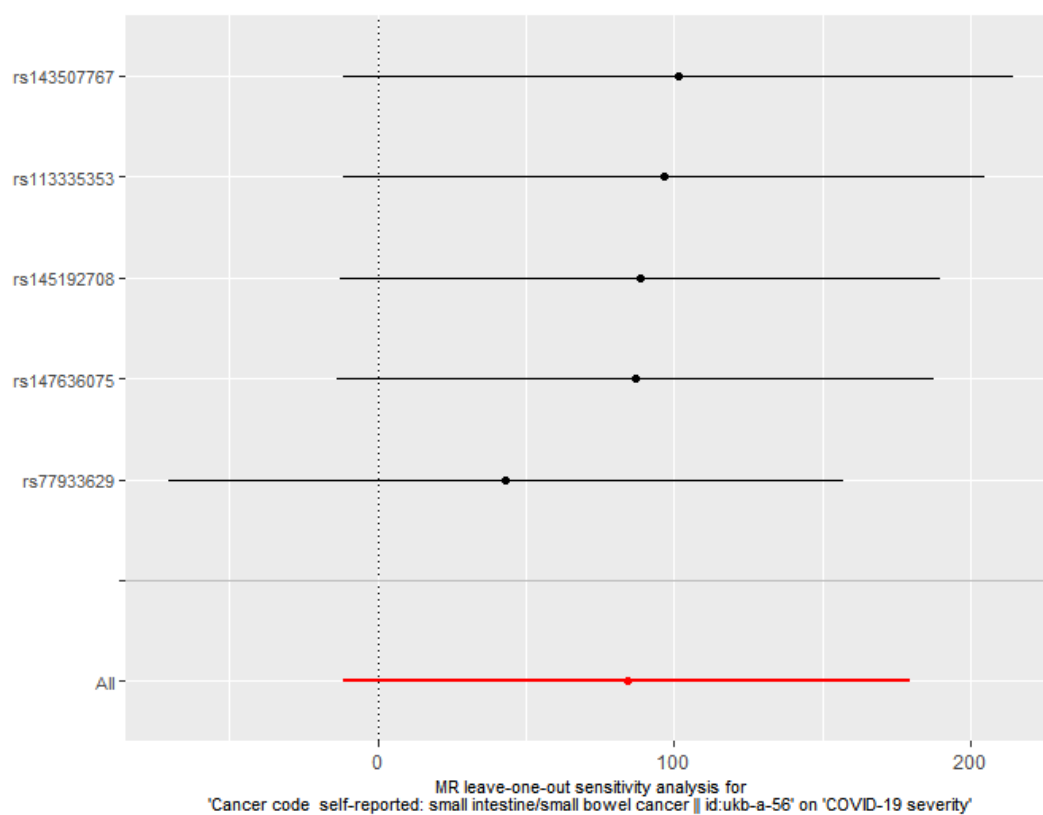


Figure S4L. The leave-one-out sensitivity analysis of the causal effect of small bowel cancer on COVID-19 severity.

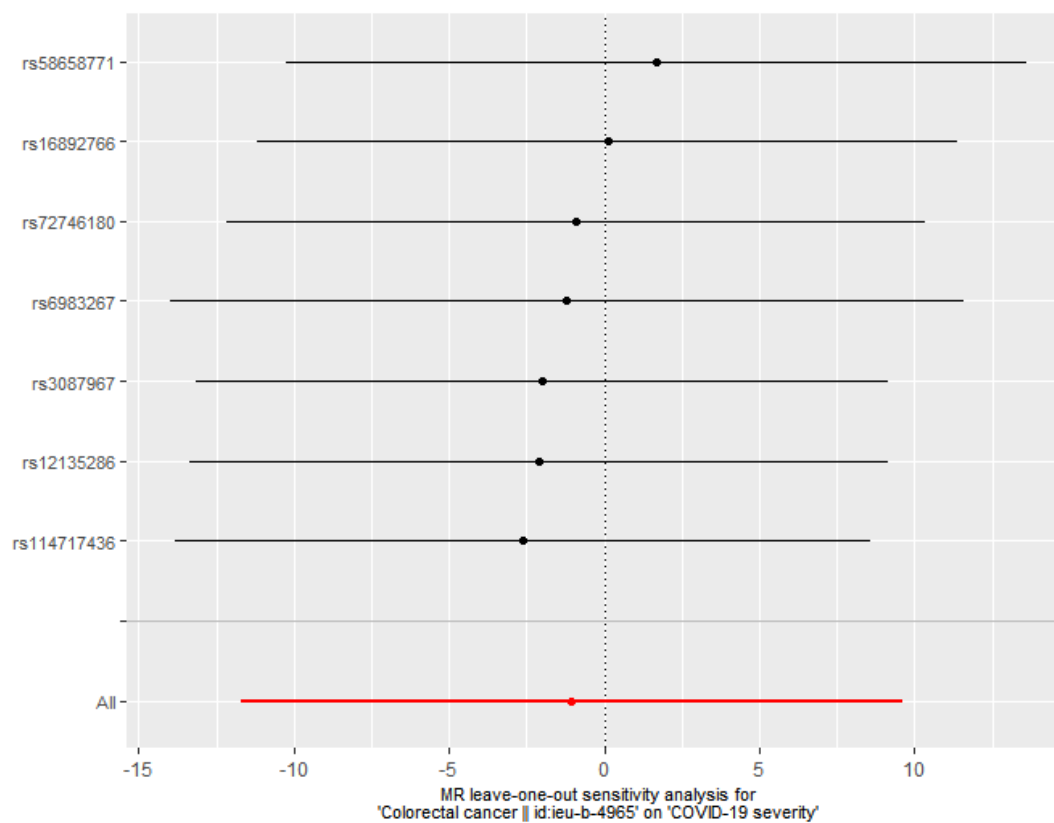


Figure S4M. The leave-one-out sensitivity analysis of the causal effect of colorectal cancer on COVID-19 severity.

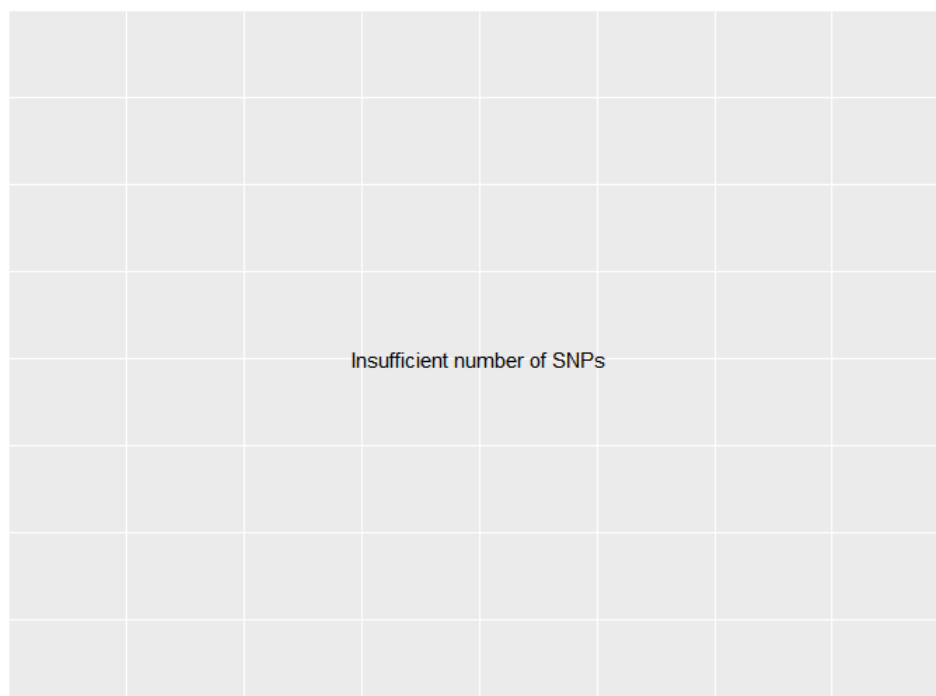


Figure S4N. The leave-one-out sensitivity analysis of the causal effect of oropharyngeal cancer on COVID-19 severity.



Figure S4O. The leave-one-out sensitivity analysis of the causal effect of lymphoma on COVID-19 severity.



Figure S4P. The leave-one-out sensitivity analysis of the causal effect of cervix cancer on COVID-19 severity.

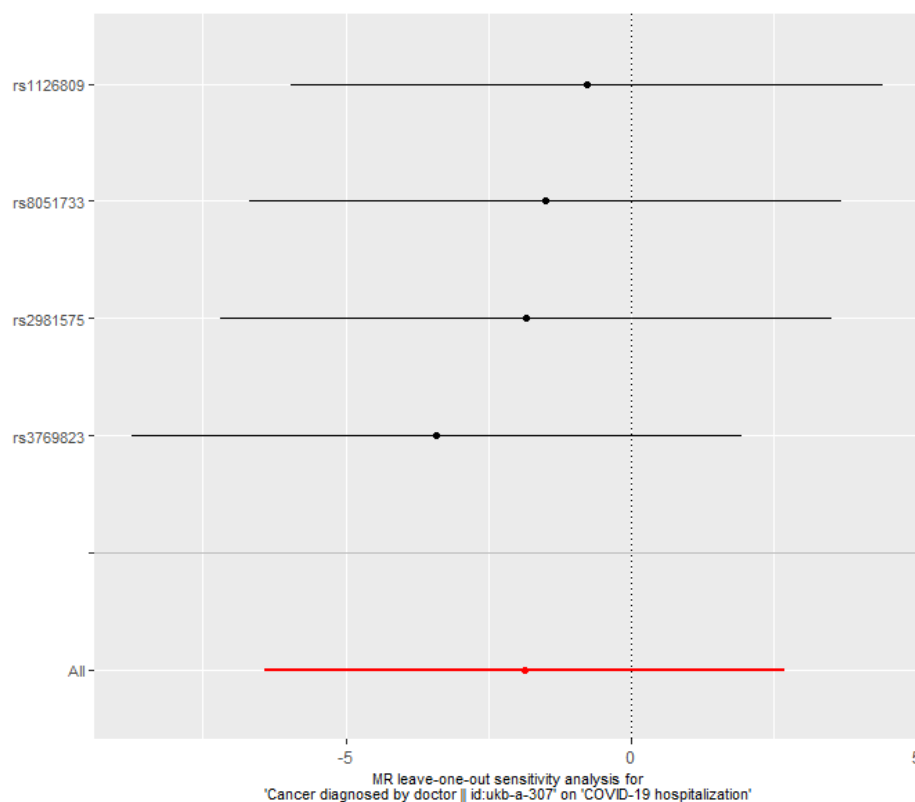


Figure S5A. The leave-one-out sensitivity analysis of the causal effect of overall cancer on COVID-19 hospitalization.

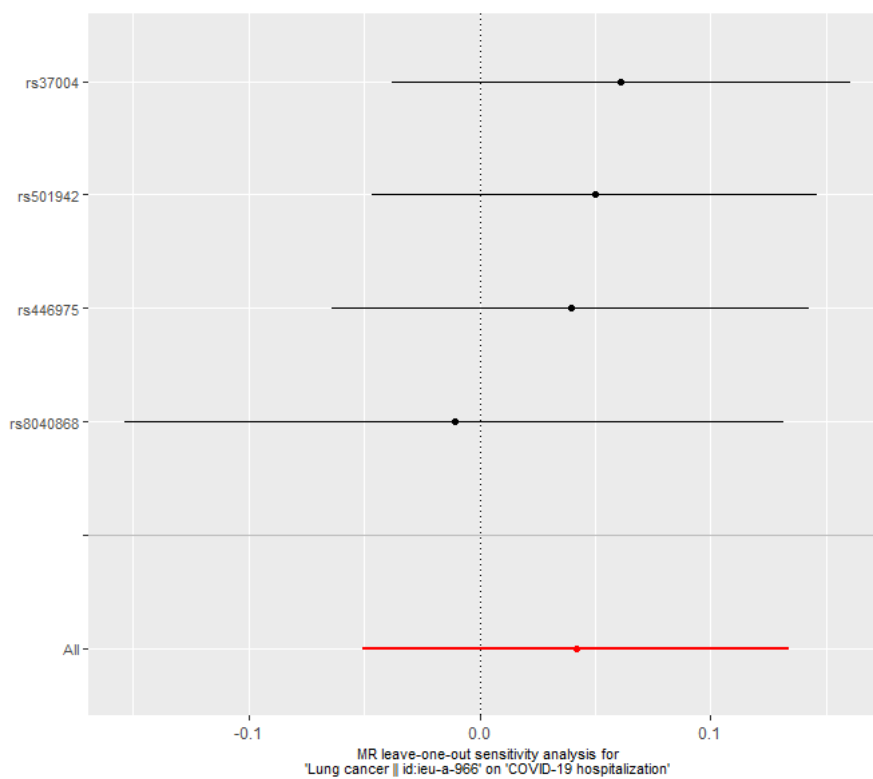


Figure S5B. The leave-one-out sensitivity analysis of the causal effect of lung cancer on COVID-19 hospitalization.



Figure S5C. The leave-one-out sensitivity analysis of the causal effect of squamous cell lung cancer on COVID-19 hospitalization.

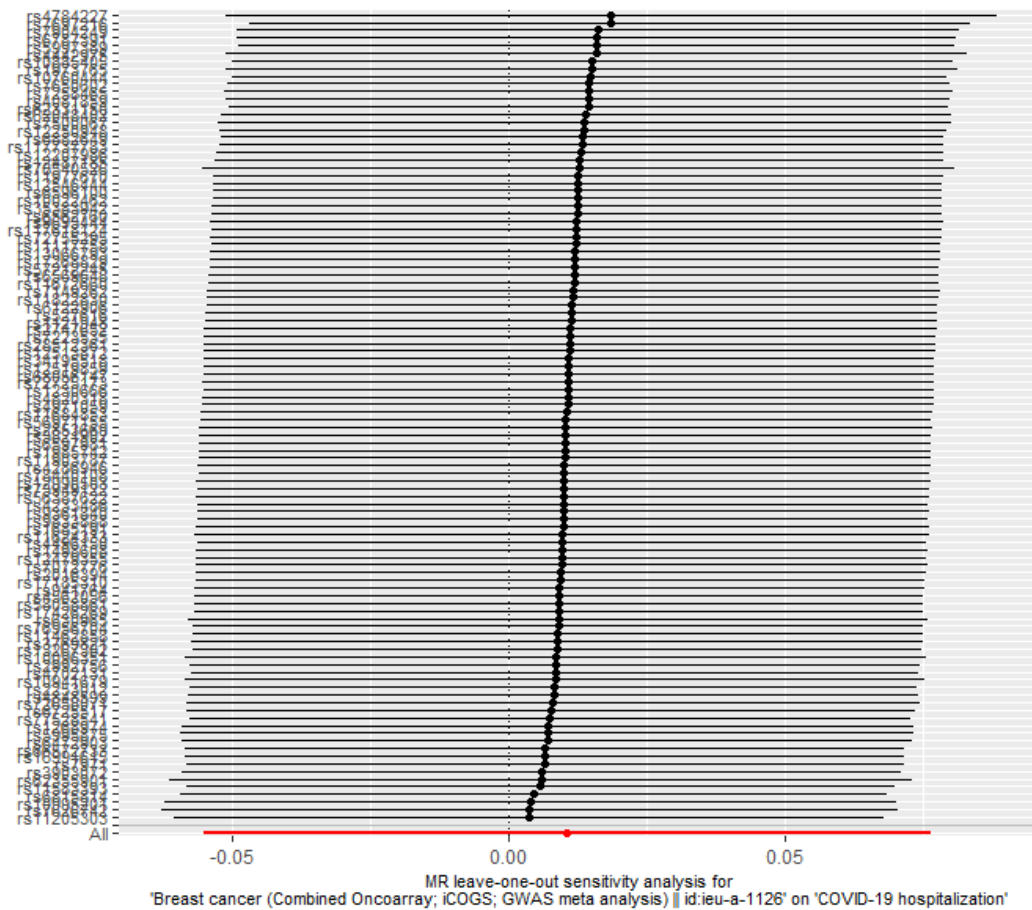


Figure S5D. The leave-one-out sensitivity analysis of the causal effect of breast cancer on COVID-19 hospitalization.

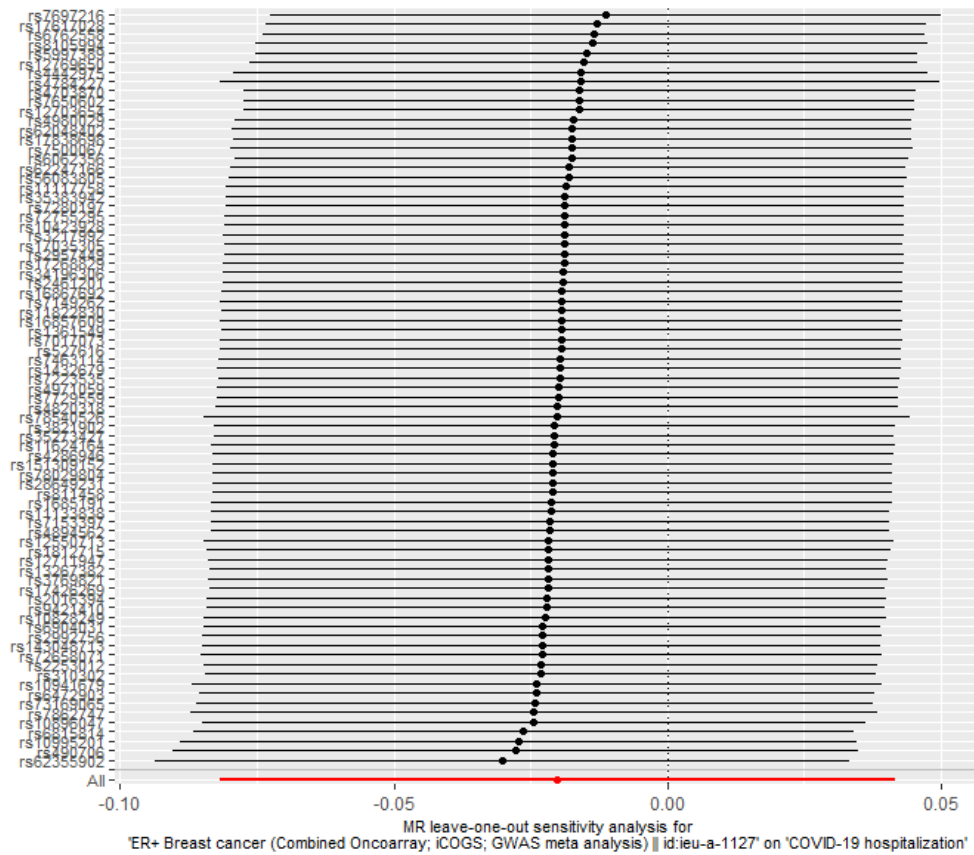


Figure S5E. The leave-one-out sensitivity analysis of the causal effect of ER+ breast cancer on COVID-19 hospitalization.

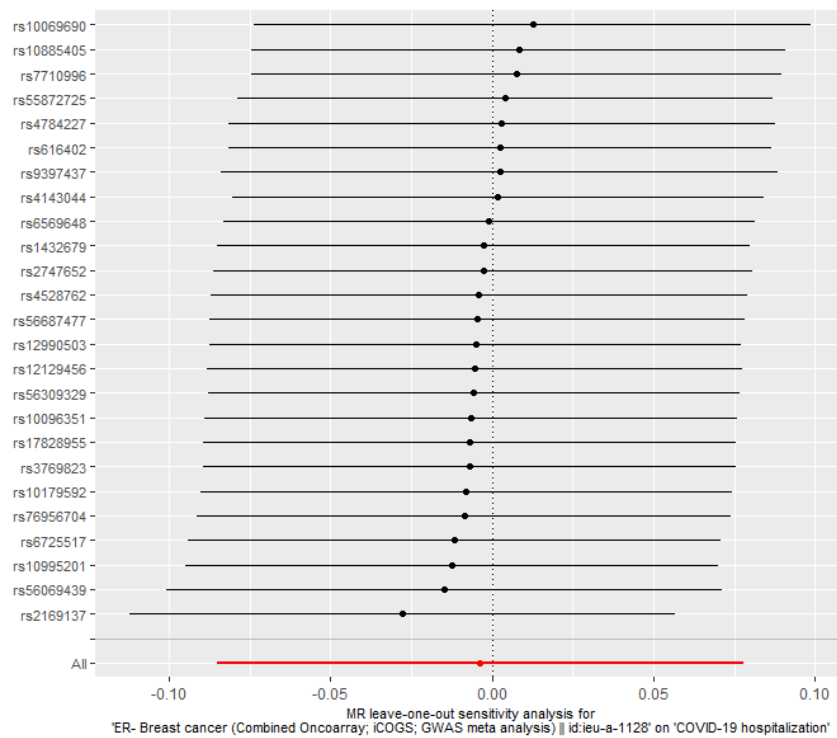


Figure S5F. The leave-one-out sensitivity analysis of the causal effect of ER- breast cancer on COVID-19 hospitalization.

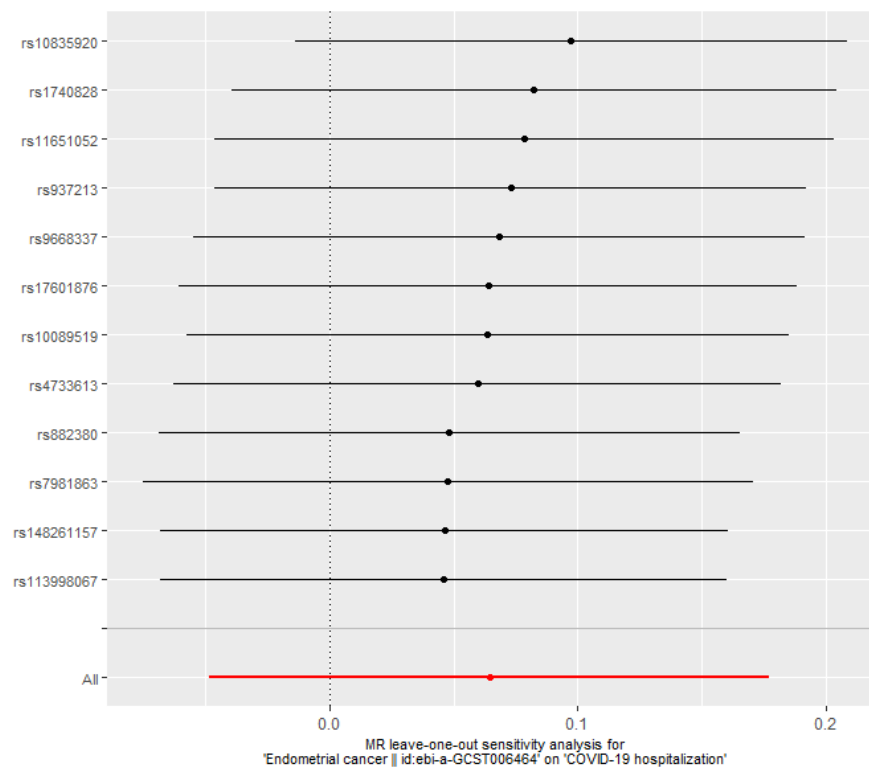


Figure S5G. The leave-one-out sensitivity analysis of the causal effect of endometrial cancer on COVID-19 hospitalization.

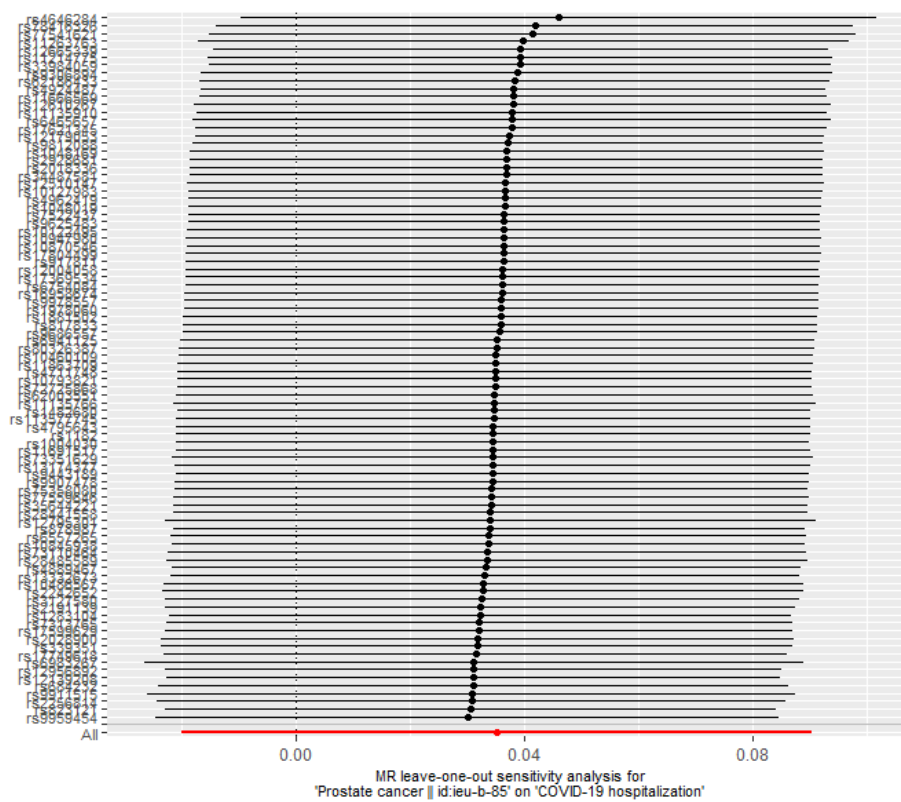


Figure S5H. The leave-one-out sensitivity analysis of the causal effect of prostate cancer on COVID-19 hospitalization.

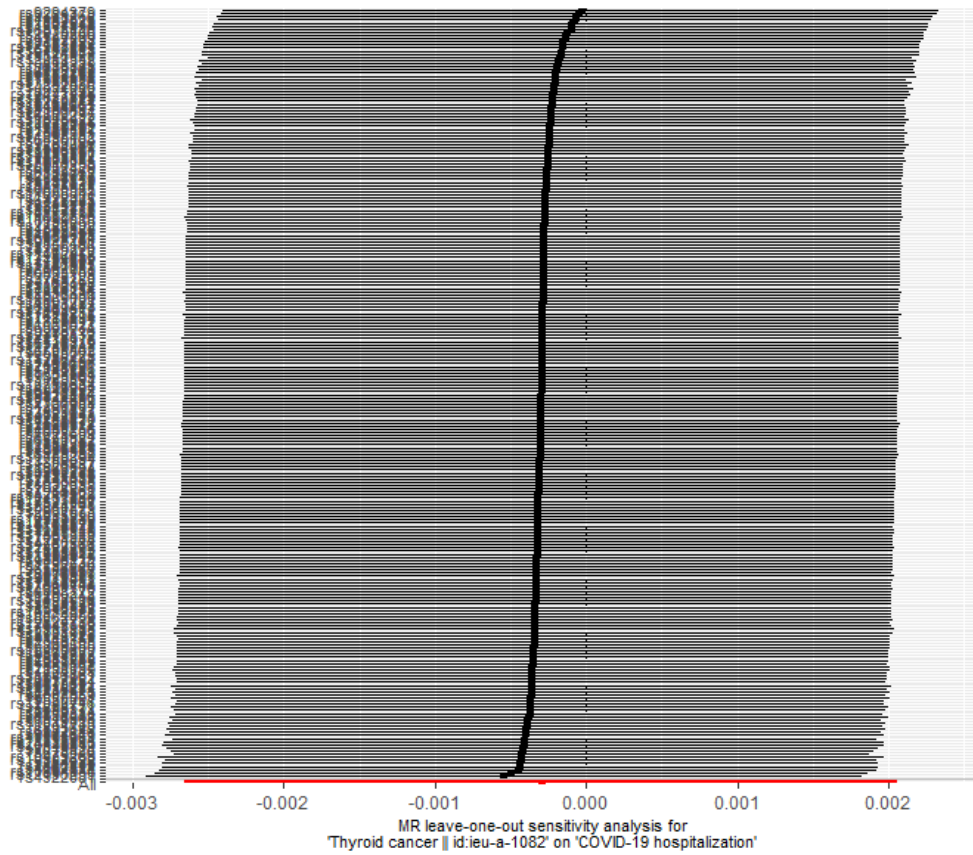


Figure S5I. The leave-one-out sensitivity analysis of the causal effect of thyroid cancer on COVID-19 hospitalization.

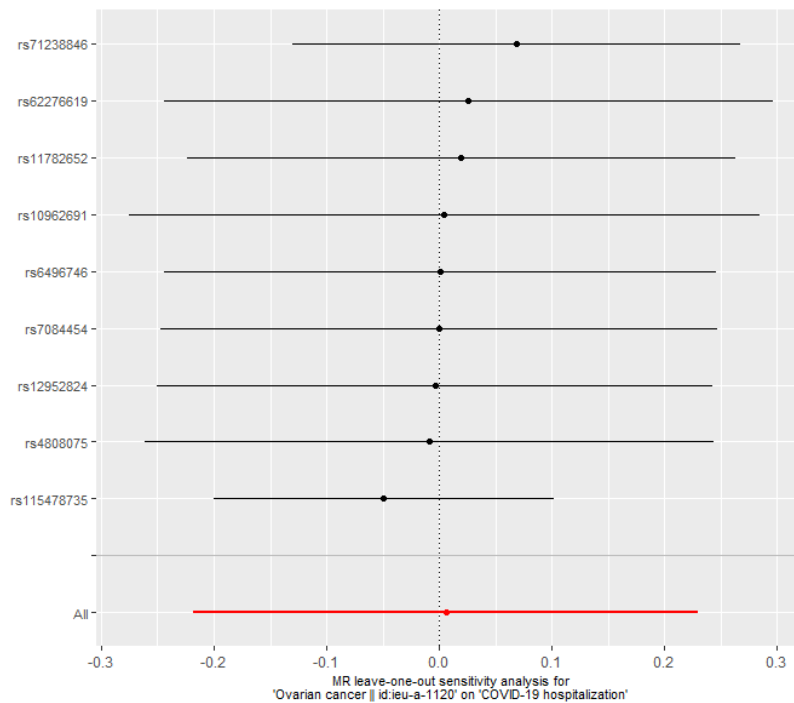


Figure S5J. The leave-one-out sensitivity analysis of the causal effect of ovarian cancer on COVID-19 hospitalization.

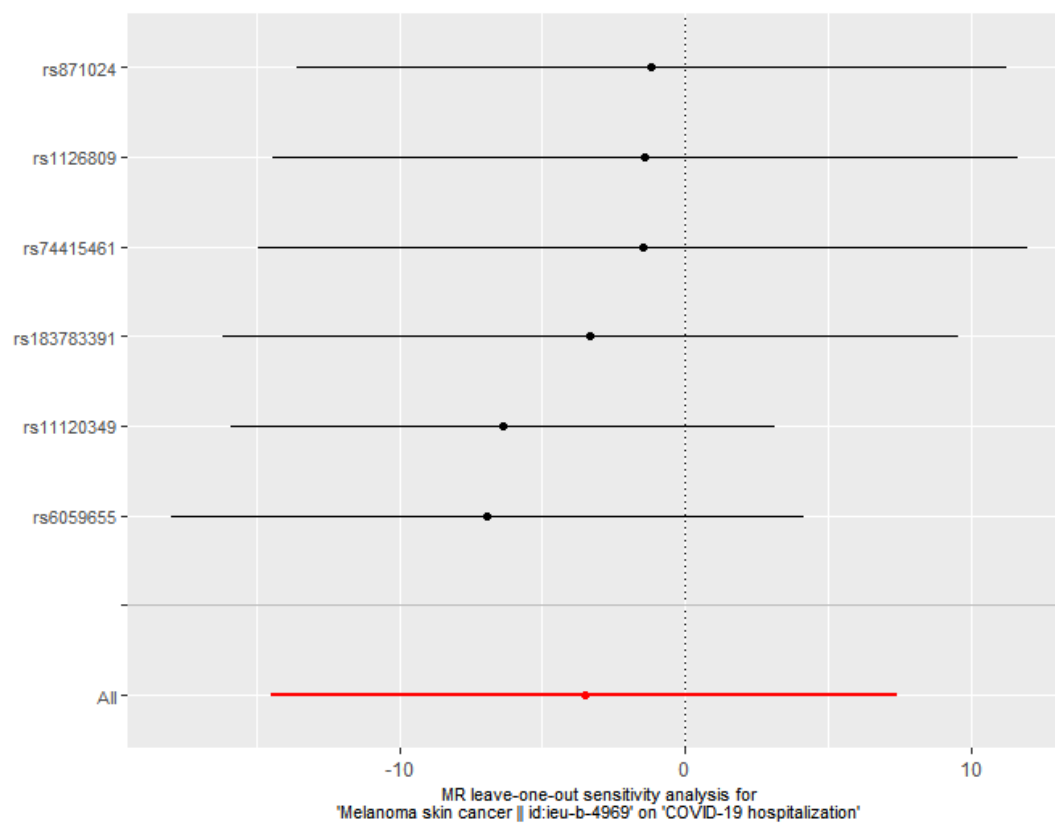


Figure S5K. The leave-one-out sensitivity analysis of the causal effect of melanoma on COVID-19 hospitalization.

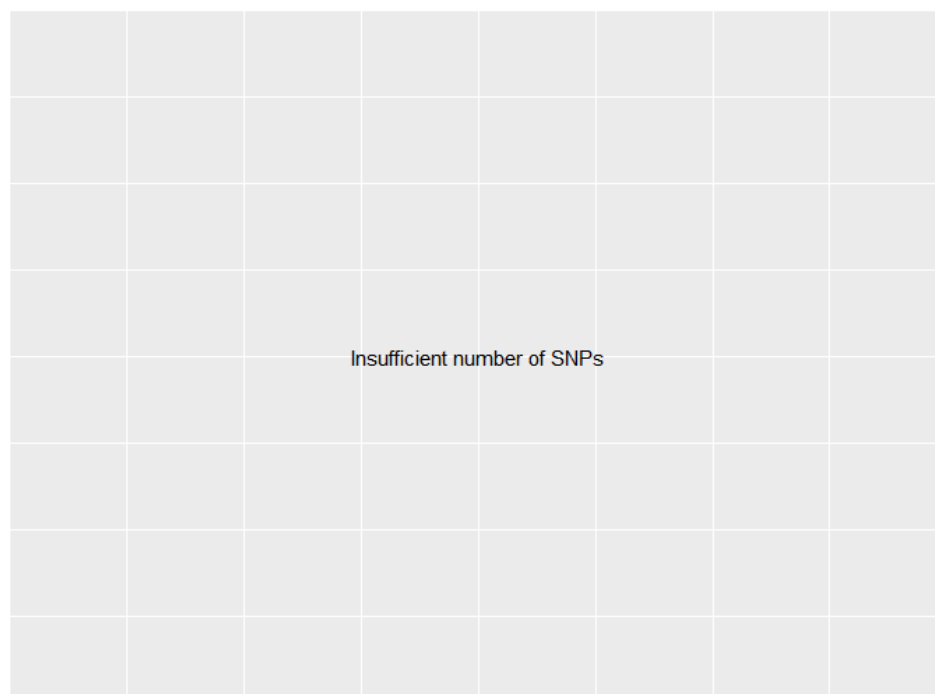


Figure S5L. The leave-one-out sensitivity analysis of the causal effect of small bowel cancer on COVID-19 hospitalization.

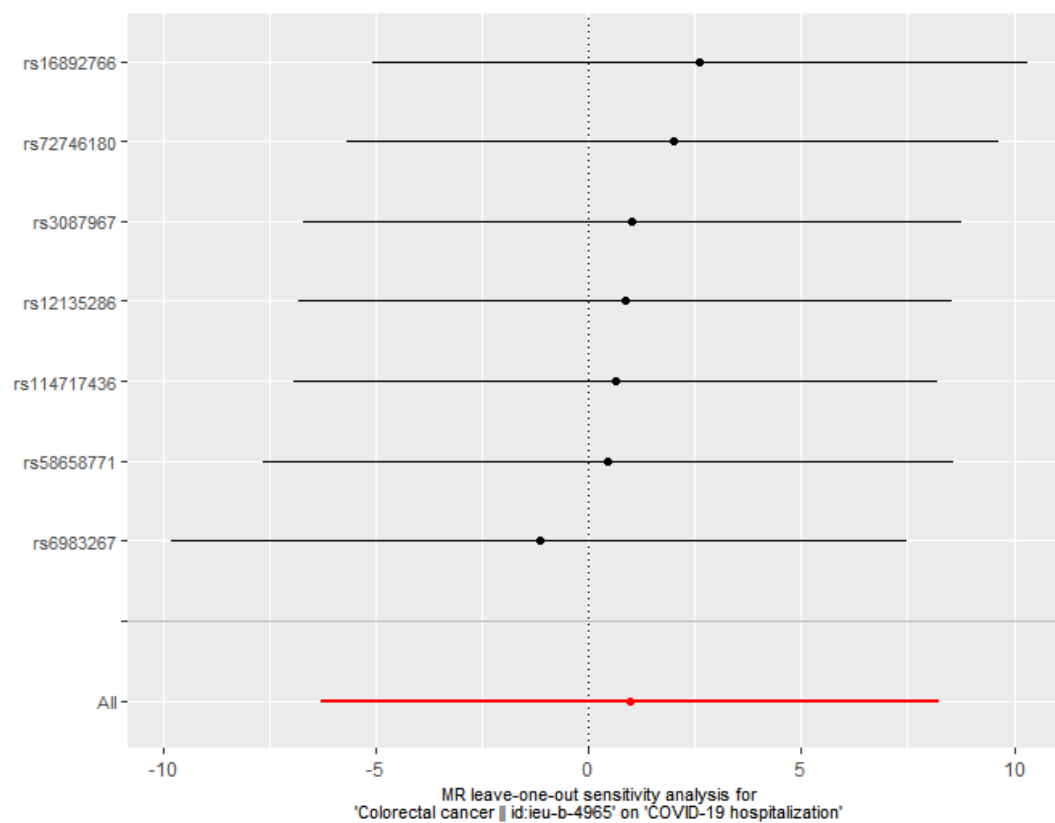


Figure S5L. The leave-one-out sensitivity analysis of the causal effect of colorectal cancer on COVID-19 hospitalization.

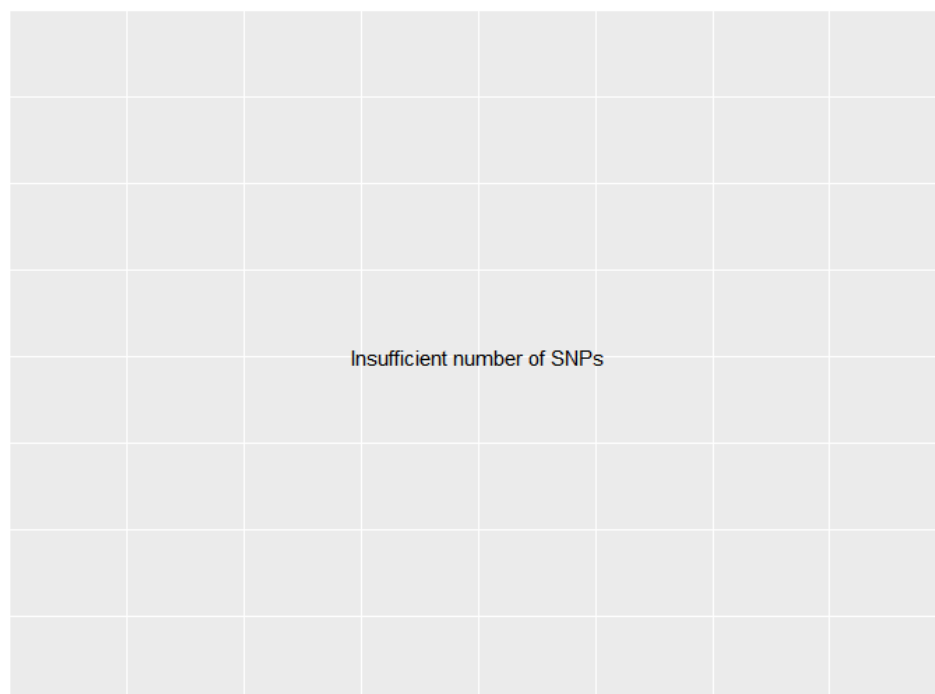


Figure S5N. The leave-one-out sensitivity analysis of the causal effect of oropharyngeal cancer on COVID-19 hospitalization.



Figure S5O. The leave-one-out sensitivity analysis of the causal effect of lymphoma on COVID-19 hospitalization.



Figure S5P. The leave-one-out sensitivity analysis of the causal effect of cervix cancer on COVID-19 hospitalization.

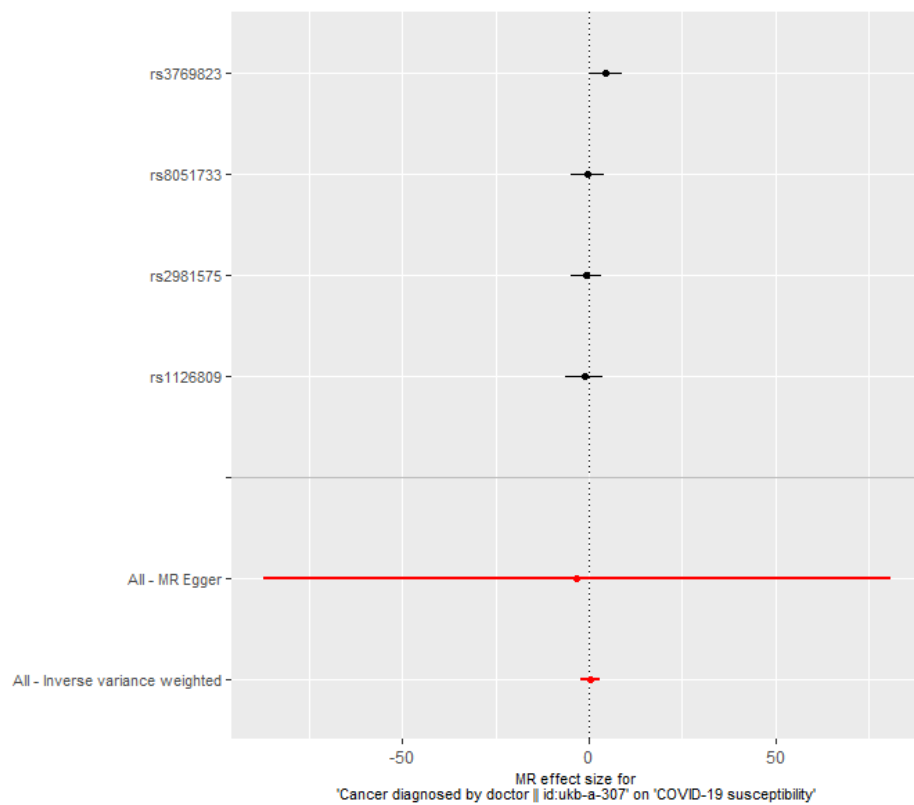


Figure S6A. The leave-one-out sensitivity analysis of the causal effect of overall cancer on COVID-19 susceptibility.

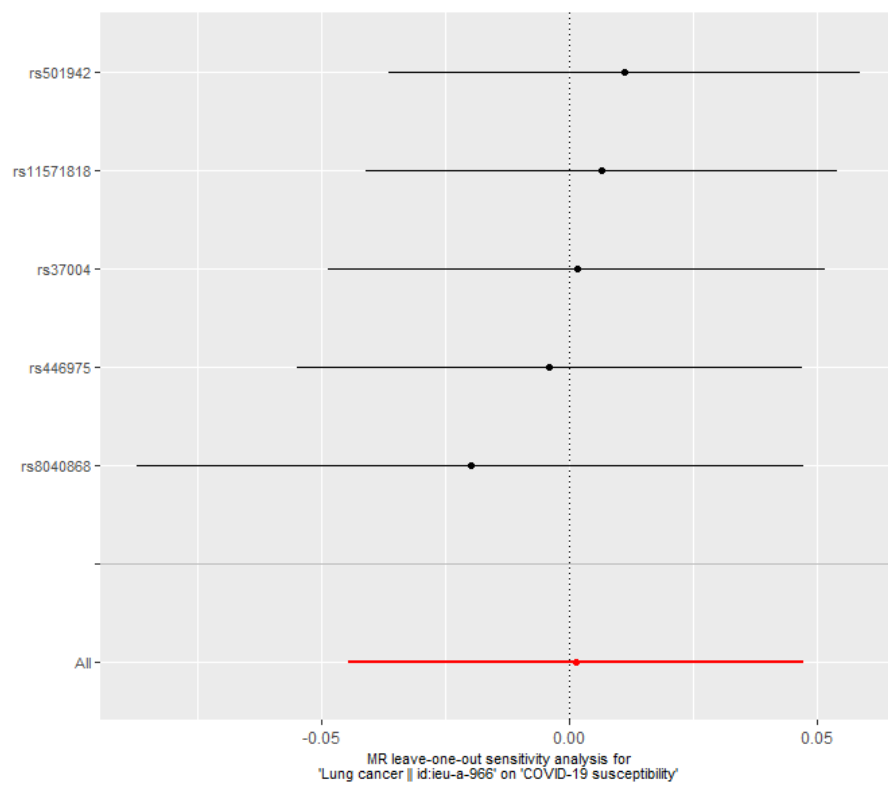


Figure S6B. The leave-one-out sensitivity analysis of the causal effect of lung cancer on COVID-19 susceptibility.

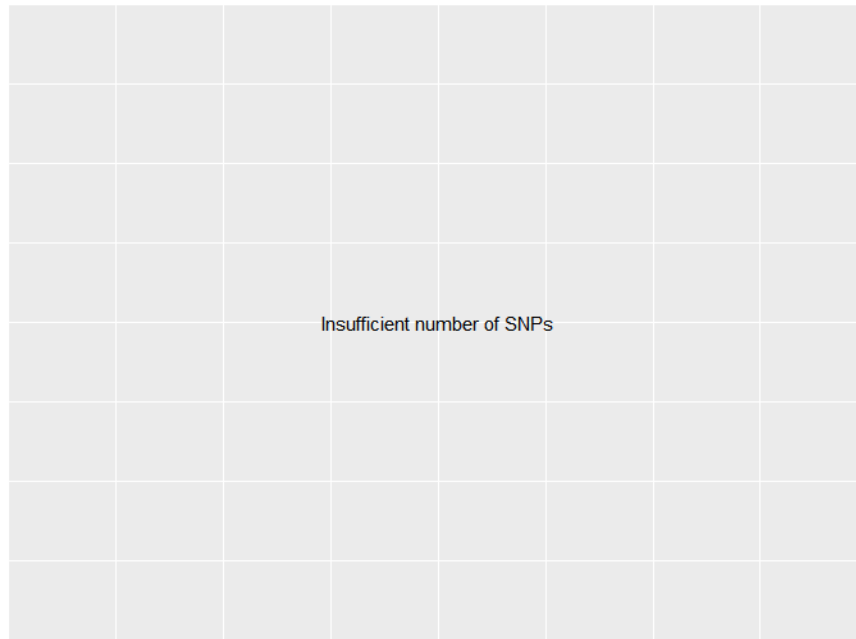


Figure S6C. The leave-one-out sensitivity analysis of the causal effect of squamous cell lung cancer on COVID-19 susceptibility.

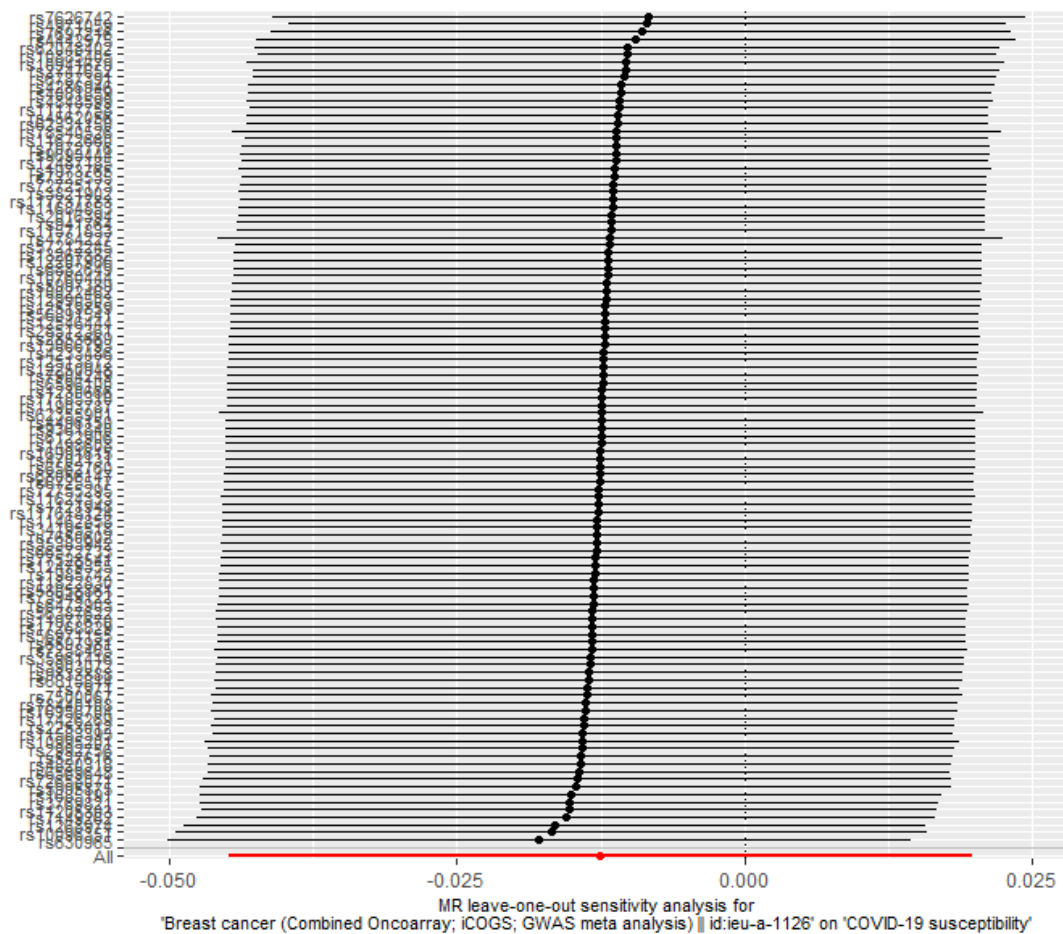


Figure S6D. The leave-one-out sensitivity analysis of the causal effect of breast cancer on COVID-19 susceptibility.

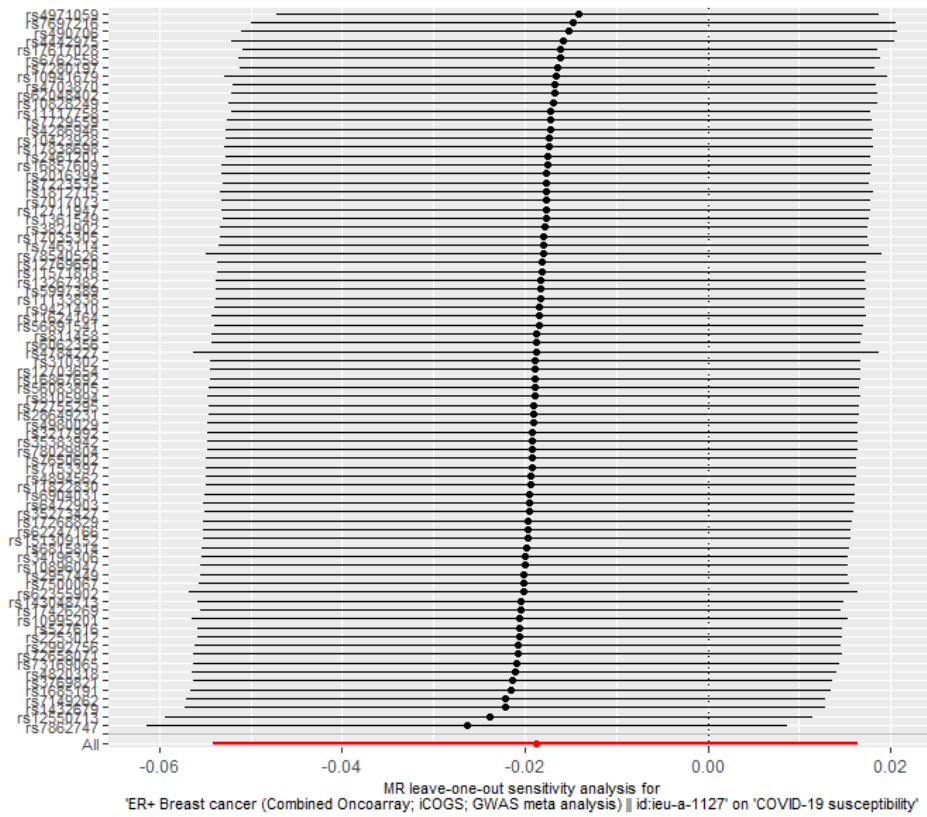


Figure S6E. The leave-one-out sensitivity analysis of the causal effect of ER+ breast cancer on COVID-19 susceptibility.

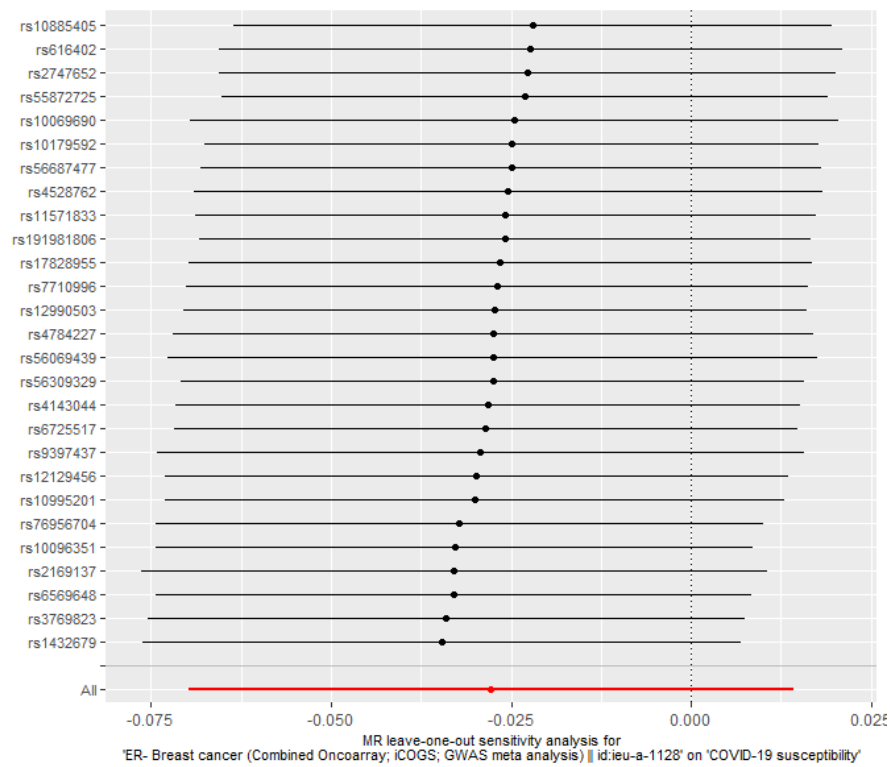


Figure S6F. The leave-one-out sensitivity analysis of the causal effect of ER- breast cancer on COVID-19 susceptibility.

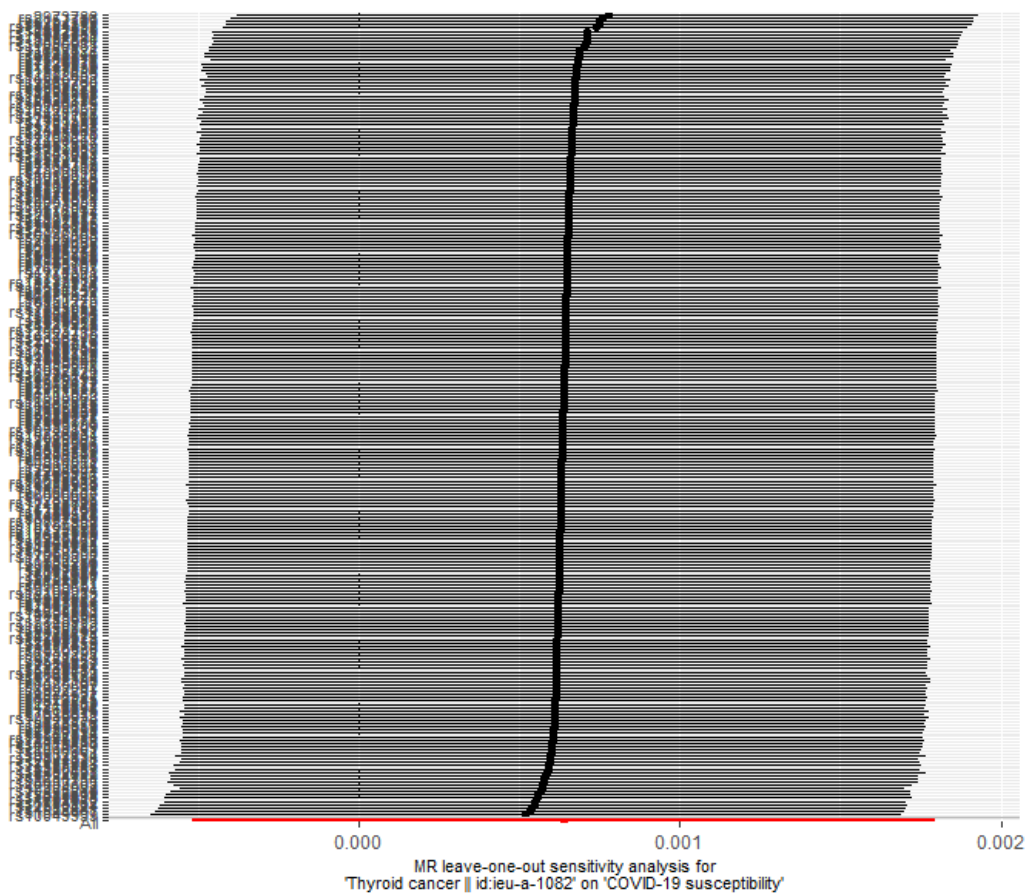


Figure S6I. The leave-one-out sensitivity analysis of the causal effect of thyroid cancer on COVID-19 susceptibility.

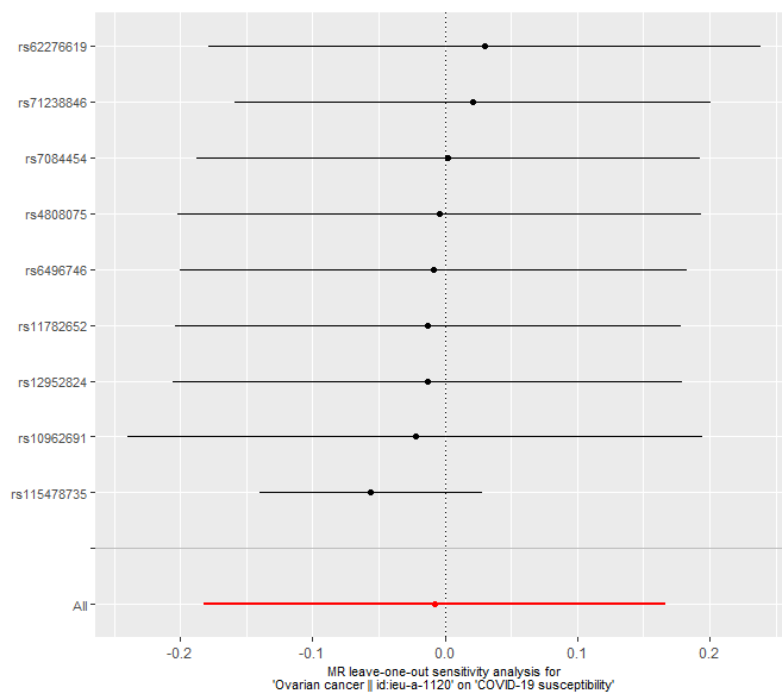


Figure S6J. The leave-one-out sensitivity analysis of the causal effect of ovarian cancer on COVID-19 susceptibility.

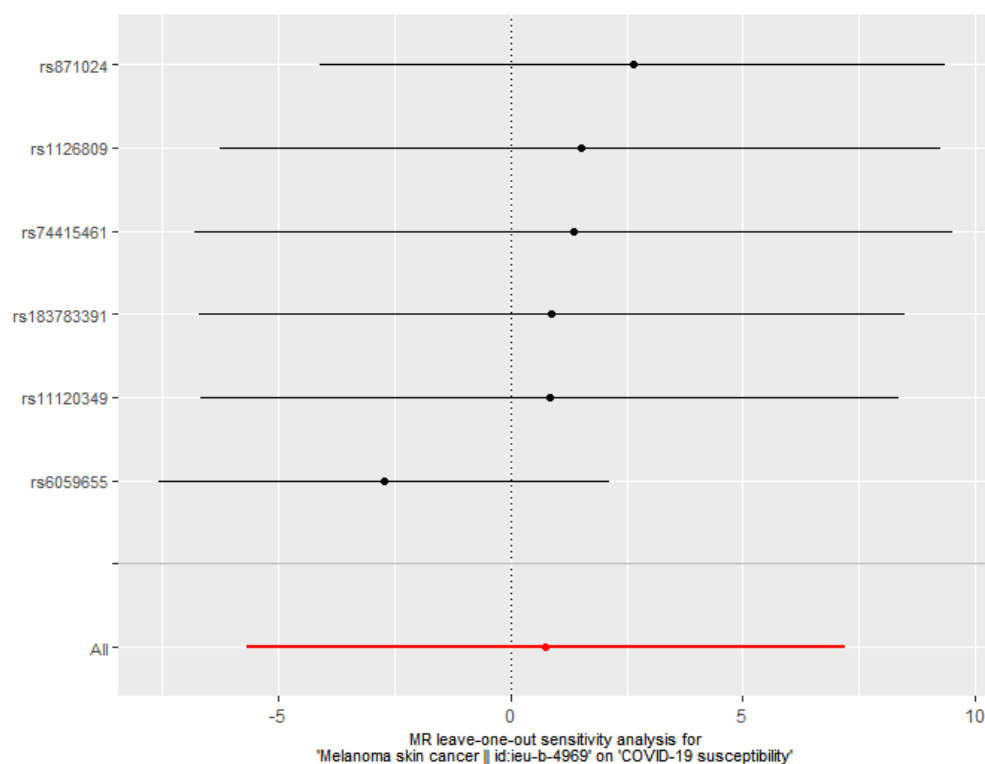


Figure S6K. The leave-one-out sensitivity analysis of the causal effect of melanoma on COVID-19 susceptibility.

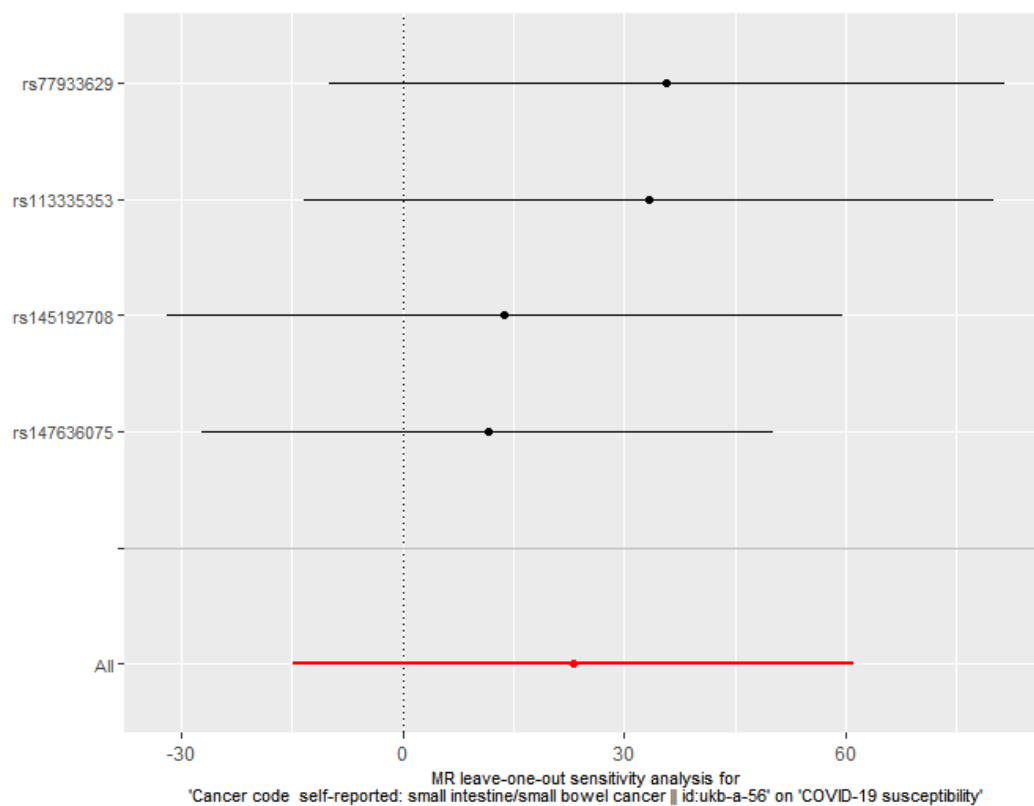


Figure S6L. The leave-one-out sensitivity analysis of the causal effect of small bowel cancer on COVID-19 susceptibility.

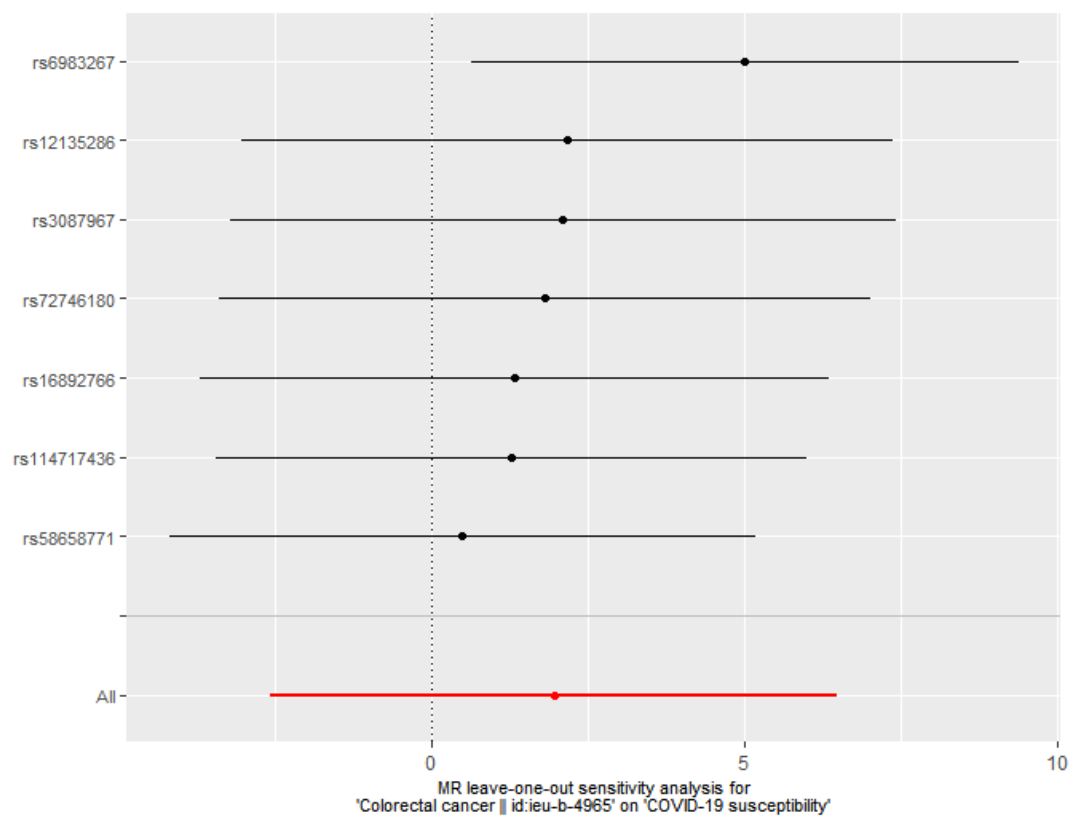


Figure S6M. The leave-one-out sensitivity analysis of the causal effect of colorectal cancer on COVID-19 susceptibility.

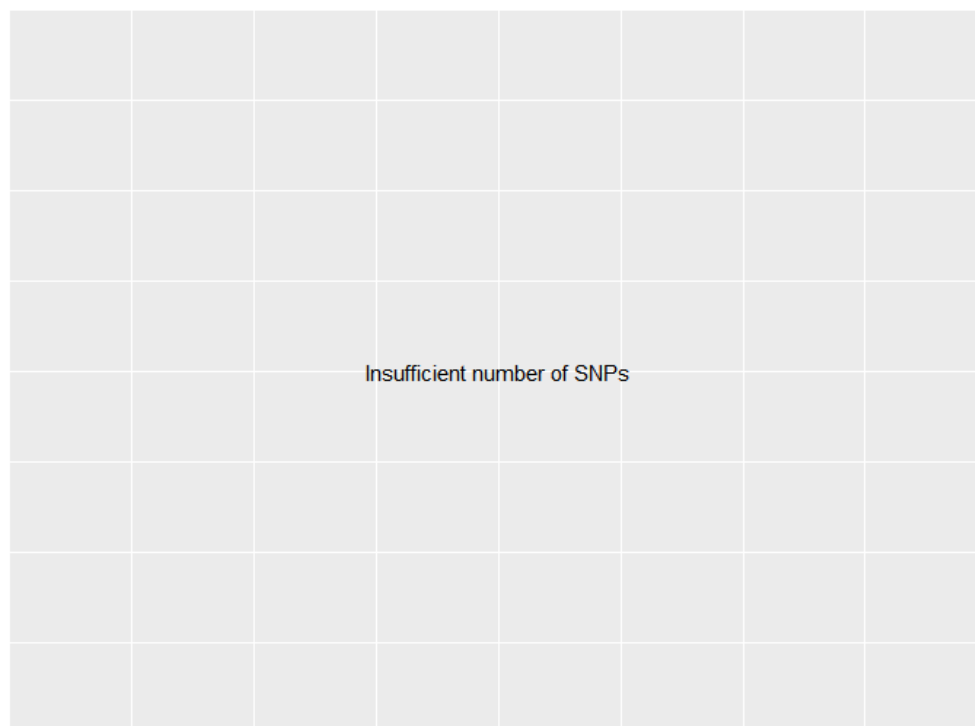


Figure S6N. The leave-one-out sensitivity analysis of the causal effect of oropharyngeal cancer on COVID-19 susceptibility.



Figure S6O. The leave-one-out sensitivity analysis of the causal effect of lymphoma on COVID-19 susceptibility.



Figure S6P. The leave-one-out sensitivity analysis of the causal effect of cervix cancer on COVID-19 susceptibility.

Table S3. Causal effects of cancers on COVID-19 severity estimated by multivariable Mendelian randomization.

Variable adjustment	BMI				Education attainment				Intelligence				Income				Smoking				Alcohol consumption					
Cancer	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>		
Overall cancer	-	-	-	-	2	2.13	2.59	0.41	4	-2.91	3.03	0.34	4	0.71	3.30	0.83	4	-2.76	3.69	0.45	-	-	-	-		
Lung cancer	2	0.03	0.07	0.70	4	0.08	0.06	0.18	5	0.03	0.07	0.61	5	0.04	0.06	0.51	5	-0.05	0.09	0.59	4	-0.03	0.11	0.77		
Squamous cell lung cancer	1	0.01	0.06	0.80	1	0.01	0.07	0.87	1	0.03	0.10	0.75	1	0.06	0.12	0.62	3.0	-0.05	0.11	0.62	2.0	0.04	0.12	0.72		
Breast cancer	37	0.11	0.07	0.12	73	0.02	0.06	0.67	87	0.05	0.05	0.38	100	0.04	0.05	0.43	97	0.05	0.05	0.38	96	0.05	0.05	0.34		
ER+ Breast cancer	28	0.08	0.08	0.27	51	0.003	0.05	0.96	60	-0.01	0.05	0.79	70	-0.02	0.05	0.75	71	-0.01	0.05	0.83	69	-0.003	0.05	0.96		
ER- Breast cancer	8	0.02	0.07	0.74	20	-0.03	0.07	0.69	23	0.02	0.07	0.82	24	0.01	0.06	0.85	24	0.03	0.06	0.67	25	0.05	0.07	0.41		
Endometrial cancer	2	0.14	0.09	0.11	5	-0.06	0.10	0.54	9	0.11	0.10	0.26	10	0.06	0.08	0.46	10	0.01	0.10	0.88	9.0	0.10	0.10	0.35		
Prostate cancer	30	0.03	0.06	0.58	64	0.001	0.04	0.98	70	0.001	0.05	0.98	82	-0.01	0.04	0.75	81	-0.01	0.05	0.82	82	-	0.05	1.00		
																					0.0001					
Thyroid cancer	127	-	0.001	0.002	196	-	0.0008	0.002	0.69	221	-	0.0004	0.002	-	0.0008	0.002	0.66	237	-	0.0005	0.002	234	-	0.0008	0.002	0.67
Ovarian cancer	4	0.12	0.09	0.15	6	-0.12	0.10	0.21	7	-0.008	0.09	0.93	9	0.10	0.10	0.29	9	0.07	0.12	0.57	7.0	0.06	0.10	0.57		
Melanoma	1	-1.45	6.61	0.83	5	-0.82	6.02	0.89	6	-0.34	7.46	0.96	6	1.41	8.29	0.87	6	-2.84	9.51	0.77	6	-3.14	9.16	0.73		
Small bowel cancer	-	-	-	-	1	-7.99	39.57	0.84	4	66.15	45.54	0.15	4	35.28	49.53	0.48	5	86.50	45.10	0.06	4	82.11	53.35	0.12		
Colorectal cancer	2	-2.47	5.08	0.63	6	-2.37	4.70	0.61	6	-5.71	5.51	0.30	7	-2.40	5.31	0.65	7	-0.25	4.91	0.96	6	-2.77	5.63	0.62		
Oropharyngeal cancer	-	-	-	-	1	-20.85	22.75	0.36	2	-25.41	28.14	0.37	1	39.70	59.00	0.50	2	-43.71	44.89	0.33	2	-53.00	44.49	0.23		
Lymphoma	-	-	-	-	-	-	-	-	1	4.78	16.51	0.77	1	18.00	20.95	0.39	1	-7.31	28.07	0.79	1	2.65	23.10	0.91		
Cervix cancer	-	-	-	-	-	-	-	-	2	-20.89	12.39	0.09	2	-19.47	14.43	0.18	2	-17.55	15.79	0.27	2	-24.41	15.57	0.12		

Table S4. Causal effects of cancers on COVID-19 hospitalization estimated by multivariable Mendelian randomization.

Variable adjustment	BMI				Education attainment				Intelligence				Income				Smoking				Alcohol consumption			
Cancer	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>
Overall cancer	-	-	-	-	2	4.01	1.63	0.01 [#]	4	-2.63	1.98	0.18	4	2.85	2.62	0.28	4	-1.93	2.32	0.41	4	1.19	2.12	0.58
Lung cancer	2	0.03	0.05	0.51	3	0.04	0.04	0.32	4	0.05	0.05	0.31	4	0.03	0.05	0.51	4	0.006	0.07	0.93	3	0.0005	0.07	0.99
Squamous cell lung cancer	1	0.02	0.04	0.67	1	-0.05	0.05	0.29	1	0.03	0.07	0.67	1	-0.05	0.09	0.55	3	-0.01	0.07	0.87	2	0.04	0.07	0.52
Breast cancer	37	0.02	0.05	0.61	72	-	0.04	1.00	86	0.01	0.04	0.76	99	0.01	0.04	0.74	97	0.001	0.04	0.78	96	0.01	0.03	0.71
ER+ Breast cancer	28	0.02	0.05	0.66	51	0.007	0.03	0.85	59	-0.03	0.04	0.33	69	-0.02	0.04	0.63	70	-0.02	0.03	0.46	68	-0.02	0.03	0.50
ER- Breast cancer	8	0.02	0.05	0.70	19	-0.05	0.04	0.30	22	-0.01	0.05	0.75	23	0.001	0.05	0.98	24	-0.01	0.04	0.81	25	0.005	0.04	0.91
Endometrial cancer	2	0.02	0.06	0.77	5	-0.007	0.06	0.91	9	0.09	0.06	0.18	10	0.07	0.06	0.20	10	0.04	0.06	0.54	9	0.07	0.06	0.24
Prostate cancer	30	0.07	0.04	0.07	64	0.05	0.03	0.046 [#]	70	0.05	0.03	0.10	82	0.05	0.03	0.06	81	0.04	0.03	0.15	82	0.05	0.03	0.11
Thyroid cancer	127	-	0.0009	0.53	195	-	0.0003	0.83	221	-	0.0001	0.91	237	-	0.0002	0.86	235	-	0.0002	0.89	232	-	0.0002	0.86
Ovarian cancer	4	0.07	0.06	0.24	6	-0.02	0.06	0.74	7	-0.06	0.06	0.34	9	0.03	0.07	0.69	9	0.01	0.09	0.90	7	-0.007	0.01	0.89
Melanoma	1	-0.22	4.55	0.96	5	-3.03	3.75	0.42	6	-3.01	4.52	0.51	6	-0.22	6.02	0.97	6	-2.77	5.26	0.60	6	-2.51	4.71	0.59
Small bowel cancer	-	-	-	-	-	-	-	-	1	45.31	37.55	0.23	2	56.63	52.13	0.28	2	89.14	44.82	0.047 [#]	1	35.74	45.77	0.43
Colorectal cancer	2	-2.11	3.50	0.55	6	0.21	3.15	0.95	6	1.06	3.66	0.77	7	1.51	4.64	0.74	7	1.27	3.52	0.72	6	-0.18	3.45	0.96
Oropharyngeal cancer	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Lymphoma	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	
Cervix cancer	-	-	-	-	-	-	-	-	2	-12.42	8.17	0.13	2	-10.65	12.96	0.41	2	-16.78	11.00	0.13	2	-14.75	10.41	0.16

[#] Potential association ($p < 0.05$).

Table S5. Causal effects of cancers on COVID-19 susceptibility estimated by multivariable Mendelian randomization.

Variable adjustment	BMI				Education attainment				Intelligence				Income				Smoking				Alcohol consumption			
Cancer	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>
Overall cancer	-	-	-	-	2	0.65	0.80	0.41	4	0.23	1.06	0.83	4	0.87	1.17	0.46	4	0.43	1.14	0.71	4	0.26	1.15	0.82
Lung cancer	2	-0.004	0.02	0.87	4	0.01	0.02	0.49	5	0.006	0.02	0.79	5	0.004	0.02	0.85	5	-0.003	0.03	0.92	4	-0.002	0.03	0.94
Squamous cell lung cancer	1	0.001	0.02	0.96	1	-0.007	0.02	0.75	1	0.03	0.10	0.75	1	-0.002	0.04	0.97	3	-0.03	0.04	0.41	2	-0.002	0.04	0.97
Breast cancer	37	0.001	0.02	0.96	73	-0.01	0.02	0.57	87	-0.01	0.02	0.51	100	-0.01	0.02	0.53	97	-0.01	0.02	0.48	96	-0.008	0.02	0.65
ER+ Breast cancer	28	-0.02	0.02	0.50	51	-0.02	0.02	0.25	60	-0.03	0.02	0.20	70	-0.02	0.02	0.23	71	-0.03	0.02	0.15	69	-0.02	0.02	0.29
ER- Breast cancer	8	0.003	0.02	0.91	20	-0.03	0.02	0.15	23	-0.04	0.03	0.15	24	-0.03	0.02	0.27	24	-0.02	0.02	0.31	25	-0.02	0.02	0.30
Endometrial cancer	2.0	0.008	0.03	0.78	5	-0.03	0.03	0.35	9.0	-0.01	0.03	0.76	10	0.01	0.03	0.61	10	0.001	0.02	0.97	9	-0.004	0.03	0.89
Prostate cancer	30	0.009	0.02	0.66	64	-0.008	0.01	0.56	70	-0.005	0.02	0.76	82	-0.004	0.01	0.76	81	-0.005	0.02	0.75	82	-0.002	0.02	0.88
Thyroid cancer	127	0.0002	0.0007	0.78	196	0.0008	0.0006	0.17	221	0.0007	0.0006	0.27	239	0.0007	0.0006	0.28	237	0.0006	0.0006	0.29	234	0.0006	0.0006	0.31
Ovarian cancer	4	0.03	0.03	0.31	6	-0.03	0.03	0.30	7	-0.06	0.03	0.07	9	0.002	0.05	0.97	9	-0.005	0.06	0.93	7	-0.03	0.03	0.32
Melanoma	1	-1.50	2.13	0.48	5	-0.60	1.83	0.74	6	-0.44	2.34	0.85	6	0.96	2.62	0.71	6	0.74	2.57	0.77	6	0.60	2.49	0.81
Small bowel cancer	-	-	-	-	-	-	-	-	3	28.72	17.06	0.09	3	10.12	20.33	0.62	4	19.39	17.35	0.26	3	19.35	18.90	0.31
Colorectal cancer	2	-1.89	1.65	0.25	6	0.48	1.62	0.77	6	-0.14	2.00	0.95	7	1.52	2.19	0.49	7	2.16	1.95	0.27	6	0.87	2.10	0.68
Oropharyngeal cancer	-	-	-	-	1	-5.96	7.23	0.41	2	2.19	9.46	0.82	1	-0.44	20.13	0.98	2	-16.91	11.45	0.14	2	-16.08	11.73	0.17
Lymphoma	-	-	-	-	-	-	-	-	1	-0.73	5.52	0.89	1	2.65	7.52	0.72	1	-1.74	7.66	0.82	1	-3.18	6.22	0.61
Cervix cancer	-	-	-	-	-	-	-	-	2	-7.01	4.47	0.12	2	-4.12	6.26	0.51	2	-5.18	6.35	0.41	2	-5.55	6.04	0.36

Table S6. Verification of the causal effects of cancers on COVID-19 outcomes.

Cancer	GWAS ID	Year	Cases	Controls	COVID-19 severity				COVID-19 hospitalization				COVID-19 susceptibility			
					SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>	SNP	β	SE	<i>p</i>
Lung cancer	ukb-a-54	2017	190	336,969	5	42.50	27.67	0.12	3	54.83	34.50	0.11	3	40.48	26.25	0.12
Breast cancer	ukb-b-16890	2018	10,303	452,630	15	1.09	3.64	0.76	15	0.21	1.72	0.90	15	-0.27	1.13	0.81
Ovarian cancer	ieu-b-4963	2021	1218	198,523	-	-	-	-	-	-	-	-	-	-	-	-
Endometrial cancer	ukb-b-13545	2018	1151	461,782	-	-	-	-	-			-	-	-	-	-
Prostate cancer	ieu-b-4809	2021	9132	173,493	27	-0.51	0.90	0.57	27	0.37	0.59	0.53	27	-0.20	0.31	0.52
Thyroid malignant neoplasm	finn-b-C3_THYROID_GLAND	2021	989	217,803	3	0.02	0.05	0.71	3	-0.03	0.03	0.34	3	0.01	0.02	0.45
Situ melanoma	finn-b-CD2_INSITU_MELANOMA	2021	393	218,399	-	-	-	-	-	-	-	-	-	-	-	-
Colorectal cancer	finn-b-C3_COLORECTAL	2021	3022	215,770	-	-	-	-	-			-	-	-	-	-
Oropharyngeal cancer	ieu-b-96	2016	1090	2928	-	-	-	-	-	-	-	-	-	-	-	-
non-Hodgkin lymphoma	finn-b-CD2_NONHODGKIN_NAS	2021	533	218,259	-	-	-	-	-	-	-	-	-	-	-	-
Cervix situ carcinoma	finn-b-CD2_INSITU_CERVIX_UTERI	2021	298	123,281	-	-	-	-	-			-	-	-	-	-