A

Study	HCC Total	HCC Mean	HCC SD	Non-HCC Total	Non-HCC Mean	Non-HCC SD	TMEM106C SMD	SMD	95%−CI	Weight
E_MTAB_8887	23	8.12	0.9524	17	7.08	0.6805		1.20	[0.51; 1.88]	2.4%
GPL11154	245	3.65	1.0928	168	3.05	0.9590		0.57	[0.37; 0.77]	3.1%
GPL13667	338	7.92	0.8406	342	6.98	0.4491		1.39	[1.23; 1.56]	3.2%
GPL14951	93	8.95	0.7701	18	8.85	1.0323		0.13	[−0.38; 0.63]	2.7%
GPL16043	25	1.66	1.2667	25	1.62	1.1228		0.03	[−0.52; 0.59]	2.7%
GPL16791	209	5.68	1.2939	114	4.39	0.7686		1.13	[0.89; 1.38]	3.1%
GPL17586	101	7.40	0.6534	89	6.59	0.2078		1.61	[1.29; 1.94]	3.0%
GPL18573	215	3.39	2.2599	13	1.19	1.6108		0.98	[0.42; 1.55]	2.6%
GPL20301	48	3.23	1.7649	30	2.40	1.6566		0.47	[0.01; 0.94]	2.8%
GPL20795	38	5.48	1.1152	38	4.09	0.7444		1.45	[0.94; 1.96]	2.7%
GPL21047	10	3.56	0.0976	10	3.32	0.0829		2.49	[1.26; 3.72]	1.6%
GPL24676	406	4.90	1.8585	135	2.98	1.3903		1.09	[0.89; 1.30]	3.1%
GPL4133	18	13.86	0.6066	18	12.03	0.6307		2.90	[1.93; 3.86]	2.0%
GPL5175	48	3.41	0.0937	48	3.19	0.0563		2.76	[2.20; 3.33]	2.6%
GPL570	844	4.54	0.3133	528	4.12	0.2017		1.53	[1.41; 1.66]	3.2%
GPL571	96	3.15	0.1169	131	3.08	0.0568		0.82	[0.55; 1.10]	3.1%
GPL6244	66	4.15	0.1585	75	3.99	0.0844		1.28	[0.91; 1.64]	2.9%
GPL6480	83	3.76	0.0886	82	3.69	0.0580		0.83	[0.51; 1.15]	3.0%
GPL6947	104	3.46	0.1069	97	3.32	0.0568		1.69	[1.36; 2.01]	3.0%
GPL9052	60	5.39	0.7798	60	4.00	0.4475		2.17	[1.72; 2.63]	2.8%
GPL5474	80	12.12	1.0016	307	10.91	0.8116		1.41	[1.14; 1.67]	3.1%
GPL15491	10	7.36	1.6412	26	8.13	1.5646		−0.47	[−1.21; 0.27]	2.3%
GPL20115	12	−0.04	0.8414	12	−1.37	0.2506		2.07	[1.05; 3.10]	1.9%
GPL3921	225	3.15	0.1311	220	2.95	0.0629		1.99	[1.76; 2.21]	3.1%
GPL23126	3	6.81	0.7401	3	7.47	0.8365		−0.67	[−2.40; 1.05]	1.1%
GPL18461	35	8.88	0.5013	34	8.34	0.3062		1.27	[0.75; 1.79]	2.7%
GPL6793	100	11.30	0.6775	97	10.05	0.3630		2.30	[1.93; 2.66]	2.9%
GPL10687	268	3.25	0.3726	289	2.70	0.1268		2.00	[1.80; 2.20]	3.1%
GPL10999	3	4.55	0.9077	3	1.85	0.1740		3.31	[−0.26; 6.88]	0.3%
GPL13369	88	8.90	0.8537	48	8.55	1.0492		0.38	[0.02; 0.73]	3.0%
GPL14550	67	3.75	0.0767	10	3.62	0.0385		1.85	[1.12; 2.58]	2.4%
GPL16955	26	10.98	0.8426	30	9.40	0.5740		2.19	[1.52; 2.86]	2.4%
GPL9115	4	4.67	1.1955	4	3.24	0.2027		1.46	[−0.25; 3.17]	1.1%
GPL15433	21	3.44	0.1225	21	3.21	0.0611		2.36	[1.56; 3.17]	2.2%
GPL16699	5	0.36	0.3915	5	0.03	0.0702		1.06	[−0.32; 2.43]	1.4%
GPL18451	8	12.47	0.8985	8	11.56	0.3505		1.26	[0.16; 2.36]	1.8%
GPL96	18	10.03	0.9362	18	8.23	0.9811		1.84	[1.05; 2.64]	2.2%
GPL17077	3	1.79	0.2633	6	1.47	0.1640		1.46	[−0.19; 3.11]	1.1%
ICGC_LIRI_JP	240	3.71	2.5814	197	2.57	2.2911		0.46	[0.27; 0.65]	3.1%
TCGA_GTEx_HCC	371	4.76	0.9041	276	4.39	1.0990		0.37	[0.22; 0.53]	3.2%
Random effects model	**4657**			**3652**				**1.31**	[1.09; 1.52]	100.0%

Heterogeneity: $I^2 = 93\%$, $\tau^2 = 0.3779$, $p < 0.01$

B

AUC = 0.8835
Senitivity = 77.76 %
Specificity = 87.15 %
Positive LR = 6.3719
Negative LR = 0.2563
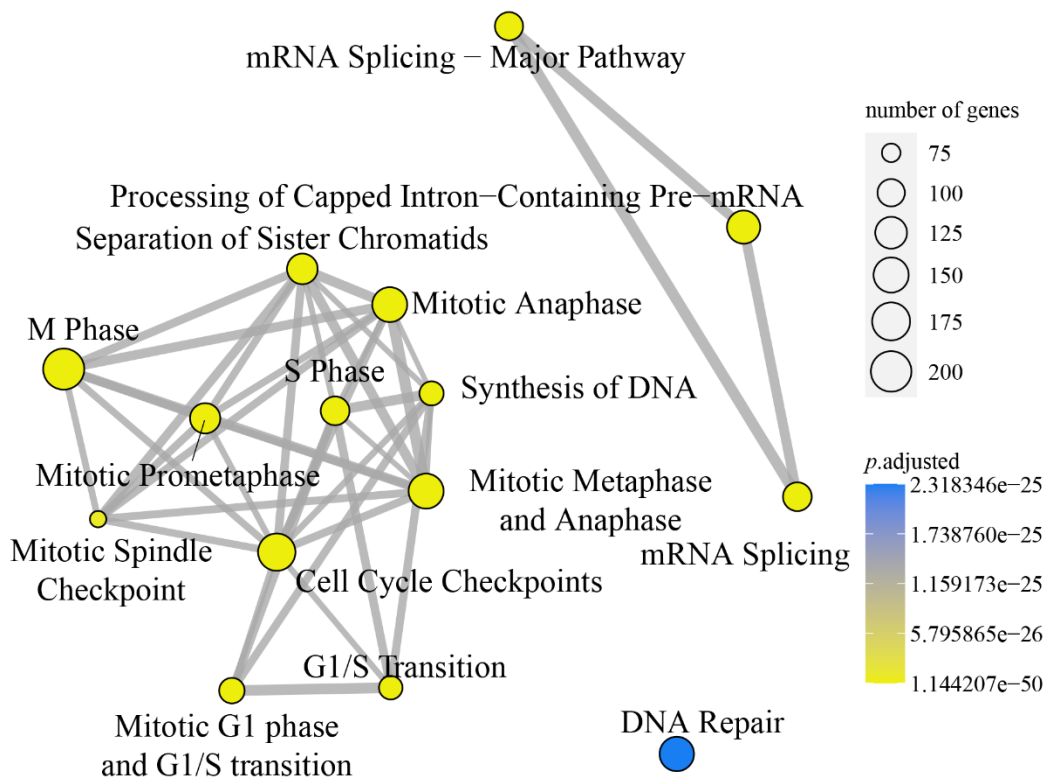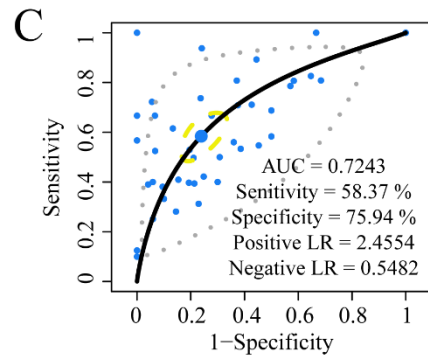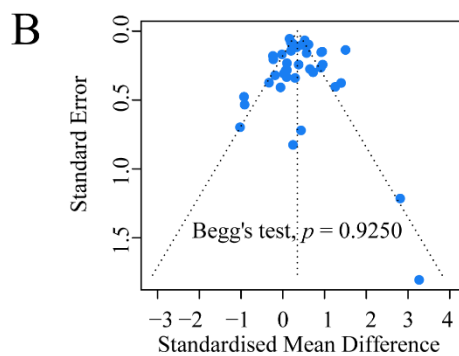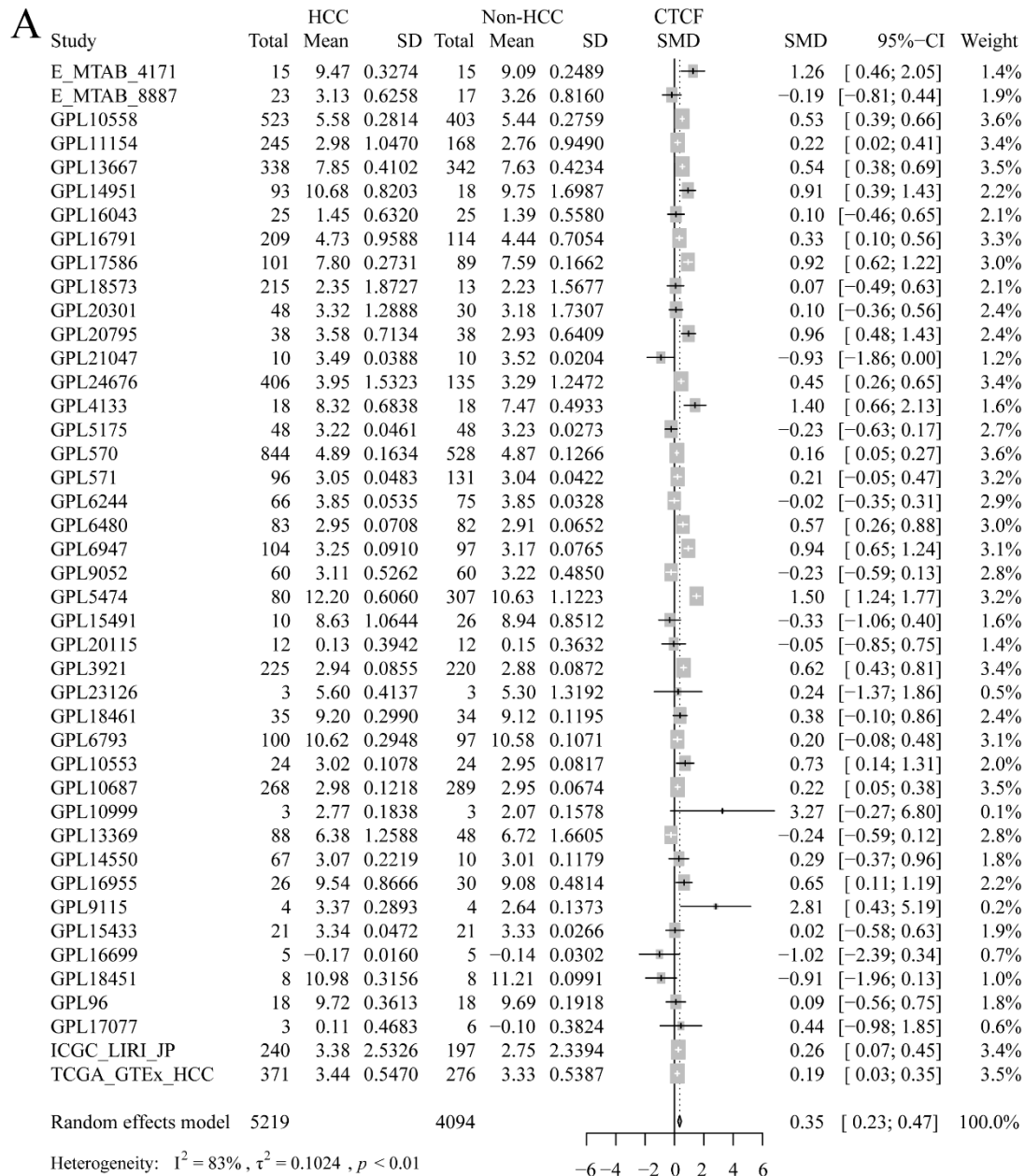
C

Begg's test, $p = 0.7798$

Supplementary Figure 1 Comprehensive expression levels of transmembrane protein 106C in global liver hepatocellular carcinoma datasets. A: Transmembrane protein 106C (TMEM106C) exhibited significantly elevated expression, as indicated by a higher standardized mean difference value, in liver hepatocellular carcinoma (LIHC) tissue compared to non-LIHC

control tissue samples; B: Begg's funnel plot showed no evidence of publication bias; C: Overexpression of TMEM106C possesses moderate discriminatory ability in distinguishing between HCC tissue and non-LIHC control tissue. AUC: area under the curve; CI: confidence interval; GPL: gene expression omnibus platform; GTEx: genotype-tissue expression project; HCC: hepatocellular carcinoma; ICGC: international cancer genome consortium; LR: likelihood ratio; SD: standard deviation; SMD: standardized mean difference; TCGA: the cancer genome atlas; TMEM106C: transmembrane protein 106C.

Supplementary Figure 2 Reactome enrichment of transmembrane protein 106C in hepatocellular carcinoma tissue.

A

Study	HCC Total	HCC Mean	SD	Non-HCC Total	Non-HCC Mean	SD	CTCF SMD	SMD	95%−CI	Weight
E_MTAB_4171	15	9.47	0.3274	15	9.09	0.2489		1.26	[0.46; 2.05]	1.4%
E_MTAB_8887	23	3.13	0.6258	17	3.26	0.8160		−0.19	[−0.81; 0.44]	1.9%
GPL10558	523	5.58	0.2814	403	5.44	0.2759		0.53	[0.39; 0.66]	3.6%
GPL11154	245	2.98	1.0470	168	2.76	0.9490		0.22	[0.02; 0.41]	3.4%
GPL13667	338	7.85	0.4102	342	7.63	0.4234		0.54	[0.38; 0.69]	3.5%
GPL14951	93	10.68	0.8203	18	9.75	1.6987		0.91	[0.39; 1.43]	2.2%
GPL16043	25	1.45	0.6320	25	1.39	0.5580		0.10	[−0.46; 0.65]	2.1%
GPL16791	209	4.73	0.9588	114	4.44	0.7054		0.33	[0.10; 0.56]	3.3%
GPL17586	101	7.80	0.2731	89	7.59	0.1662		0.92	[0.62; 1.22]	3.0%
GPL18573	215	2.35	1.8727	13	2.23	1.5677		0.07	[−0.49; 0.63]	2.1%
GPL20301	48	3.32	1.2888	30	3.18	1.7307		0.10	[−0.36; 0.56]	2.4%
GPL20795	38	3.58	0.7134	38	2.93	0.6409		0.96	[0.48; 1.43]	2.4%
GPL21047	10	3.49	0.0388	10	3.52	0.0204		−0.93	[−1.86; 0.00]	1.2%
GPL24676	406	3.95	1.5323	135	3.29	1.2472		0.45	[0.26; 0.65]	3.4%
GPL4133	18	8.32	0.6838	18	7.47	0.4933		1.40	[0.66; 2.13]	1.6%
GPL5175	48	3.22	0.0461	48	3.23	0.0273		−0.23	[−0.63; 0.17]	2.7%
GPL570	844	4.89	0.1634	528	4.87	0.1266		0.16	[0.05; 0.27]	3.6%
GPL571	96	3.05	0.0483	131	3.04	0.0422		0.21	[−0.05; 0.47]	3.2%
GPL6244	66	3.85	0.0535	75	3.85	0.0328		−0.02	[−0.35; 0.31]	2.9%
GPL6480	83	2.95	0.0708	82	2.91	0.0652		0.57	[0.26; 0.88]	3.0%
GPL6947	104	3.25	0.0910	97	3.17	0.0765		0.94	[0.65; 1.24]	3.1%
GPL9052	60	3.11	0.5262	60	3.22	0.4850		−0.23	[−0.59; 0.13]	2.8%
GPL5474	80	12.20	0.6060	307	10.63	1.1223		1.50	[1.24; 1.77]	3.2%
GPL15491	10	8.63	1.0644	26	8.94	0.8512		−0.33	[−1.06; 0.40]	1.6%
GPL20115	12	0.13	0.3942	12	0.15	0.3632		−0.05	[−0.85; 0.75]	1.4%
GPL3921	225	2.94	0.0855	220	2.88	0.0872		0.62	[0.43; 0.81]	3.4%
GPL23126	3	5.60	0.4137	3	5.30	1.3192		0.24	[−1.37; 1.86]	0.5%
GPL18461	35	9.20	0.2990	34	9.12	0.1195		0.38	[−0.10; 0.86]	2.4%
GPL6793	100	10.62	0.2948	97	10.58	0.1071		0.20	[−0.08; 0.48]	3.1%
GPL10553	24	3.02	0.1078	24	2.95	0.0817		0.73	[0.14; 1.31]	2.0%
GPL10687	268	2.98	0.1218	289	2.95	0.0674		0.22	[0.05; 0.38]	3.5%
GPL10999	3	2.77	0.1838	3	2.07	0.1578		3.27	[−0.27; 6.80]	0.1%
GPL13369	88	6.38	1.2588	48	6.72	1.6605		−0.24	[−0.59; 0.12]	2.8%
GPL14550	67	3.07	0.2219	10	3.01	0.1179		0.29	[−0.37; 0.96]	1.8%
GPL16955	26	9.54	0.8666	30	9.08	0.4814		0.65	[0.11; 1.19]	2.2%
GPL9115	4	3.37	0.2893	4	2.64	0.1373		2.81	[0.43; 5.19]	0.2%
GPL15433	21	3.34	0.0472	21	3.33	0.0266		0.02	[−0.58; 0.63]	1.9%
GPL16699	5	−0.17	0.0160	5	−0.14	0.0302		−1.02	[−2.39; 0.34]	0.7%
GPL18451	8	10.98	0.3156	8	11.21	0.0991		−0.91	[−1.96; 0.13]	1.0%
GPL96	18	9.72	0.3613	18	9.69	0.1918		0.09	[−0.56; 0.75]	1.8%
GPL17077	3	0.11	0.4683	6	−0.10	0.3824		0.44	[−0.98; 1.85]	0.6%
ICGC_LIRI_JP	240	3.38	2.5326	197	2.75	2.3394		0.26	[0.07; 0.45]	3.4%
TCGA_GTEx_HCC	371	3.44	0.5470	276	3.33	0.5387		0.19	[0.03; 0.35]	3.5%
Random effects model	5219			4094				0.35	[0.23; 0.47]	100.0%

Heterogeneity: $I^2 = 83\%$, $\tau^2 = 0.1024$, $p < 0.01$

−6 −4 −2 0 2 4 6

B — Begg's test, $p = 0.9250$

C — AUC = 0.7243; Senitivity = 58.37 %; Specificity = 75.94 %; Positive LR = 2.4554; Negative LR = 0.5482

Supplementary Figure 3 Comprehensive expression levels of CCCTC-binding factor in global liver hepatocellular carcinoma datasets. A: CCCTC-binding factor (CTCF) exhibited significantly elevated expression in liver

hepatocellular carcinoma (LIHC) tissue compared to non-LIHC control tissue samples; B: Begg's funnel plot showed no evidence of publication bias; C: Overexpression of CTCF possesses moderate discriminatory ability in distinguishing between HCC tissue and non-LIHC control tissue. AUC: area under the curve; CI: confidence interval; CTCF: CCCTC-binding factor; GPL: gene expression omnibus platform; GTEx: genotype-tissue expression project; HCC: hepatocellular carcinoma; ICGC: international cancer genome consortium; LR: likelihood ratio; SD: standard deviation; SMD: standardized mean difference; TCGA: the cancer genome atlas.

Supplementary Figure 4 Feature plot of markers for liver hepatocellular carcinoma single cells.

Supplementary Table 1 Included datasets for transmembrane protein 106C expression analysis

Accession number	Platform	LIHC	Non-LIHC	Total
GSE233422_GPL11154	GPL11154	8	8	16
GSE113617	GPL11154	68	10	78
GSE192862	GPL11154	0	4	4
GSE87410	GPL11154	6	6	12
GSE114564	GPL11154	63	45	108
GSE148355	GPL11154	0	45	45
GSE63863	GPL11154	12	12	24
GSE65485	GPL11154	50	5	55
GSE73708	GPL11154	8	4	12
GSE81550	GPL11154	3	3	6
GSE87592	GPL11154	27	26	53
GSE174570	GPL13667	57	57	114
GSE164760	GPL13667	53	117	170
GSE63898	GPL13667	228	168	396
GSE57727	GPL14951	57	5	62
GSE98617	GPL14951	36	13	49
GSE113996	GPL16043	20	20	40
GSE74656	GPL16043	5	5	10
GSE169289	GPL16791	17	17	34
GSE135631	GPL16791	15	15	30
GSE185700	GPL16791	20	4	24
GSE179443	GPL16791	78	0	78
GSE104310	GPL16791	12	8	20
GSE63018	GPL16791	8	9	17
GSE77509	GPL16791	20	20	40
GSE94660	GPL16791	21	21	42
GSE97214	GPL16791	9	9	18
GSE140845	GPL16791	5	5	10

GSE112221	GPL16791	4	6	10
GSE136247	GPL17586	39	30	69
GSE76311_GPL17586	GPL17586	62	59	121
GSE141202	GPL18573	206	0	206
GSE193567	GPL18573	9	9	18
GSE179746_GPL18573	GPL18573	0	4	4
GSE164359	GPL20301	19	1	20
GSE176271	GPL20301	16	16	32
GSE164441	GPL20301	10	10	20
GSE125469	GPL20301	3	3	6
GSE146719	GPL20795	3	3	6
GSE124535	GPL20795	35	35	70
GSE101728	GPL21047	7	7	14
GSE98269_GPL21047	GPL21047	3	3	6
GSE222334	GPL24676	70	0	70
GSE227335	GPL24676	40	0	40
GSE195952	GPL24676	60	0	60
GSE164121	GPL24676	81	0	81
GSE216613	GPL24676	3	3	6
GSE214846	GPL24676	65	65	130
GSE207435	GPL24676	27	27	54
GSE184733	GPL24676	17	17	34
GSE185799	GPL24676	3	3	6
GSE183406	GPL24676	29	0	29
GSE179746_GPL24676	GPL24676	11	20	31
GSE147888	GPL4133	12	12	24
GSE46408	GPL4133	6	6	12
GSE12941	GPL5175	10	10	20
GSE84005	GPL5175	38	38	76
GSE101685	GPL570	24	8	32
GSE102079	GPL570	152	105	257

GSE107170	GPL570	118	189	307
GSE112790	GPL570	183	15	198
GSE121248	GPL570	70	37	107
GSE17548	GPL570	17	20	37
GSE19665	GPL570	10	10	20
GSE29721	GPL570	10	10	20
GSE33006	GPL570	3	3	6
GSE41804	GPL570	20	20	40
GSE45436	GPL570	93	41	134
GSE6222	GPL570	10	2	12
GSE62232	GPL570	81	10	91
GSE6764	GPL570	35	40	75
GSE99807	GPL570	4	4	8
GSE84402	GPL570	14	14	28
GSE14323_GPL571	GPL571	55	60	115
GSE14520_GPL571	GPL571	22	21	43
GSE17967	GPL571	16	47	63
GSE9839	GPL571	3	3	6
GSE45050	GPL6244	6	10	16
GSE64041	GPL6244	60	65	125
GSE117361	GPL6480	2	2	4
GSE54236	GPL6480	81	80	161
GSE87630	GPL6947	64	30	94
GSE89377	GPL6947	40	67	107
GSE25599	GPL9052	10	10	20
GSE77314	GPL9052	50	50	100
GSE25097	GPL10687	268	289	557
GSE33294	GPL10999	3	3	6
GSE46444	GPL13369	88	48	136
GSE50579	GPL14550	67	10	77
GSE56545	GPL15433	21	21	42

GSE114783	GPL15491	10	26	36
GSE57555_GPL16699	GPL16699	5	5	10
GSE54238	GPL16955	26	30	56
GSE67764	GPL17077	3	6	9
GSE59259	GPL18451	8	8	16
GSE20140_GPL18461	GPL18461	35	34	69
GSE115018	GPL20115	12	12	24
GSE166163	GPL23126	3	3	6
GSE14520_GPL3921	GPL3921	225	220	445
GSE10143	GPL5474	80	307	387
GSE22058	GPL6793	100	97	197
GSE55048	GPL9115	4	4	8
GSE60502	GPL96	18	18	36
ICGC_LIRI_JP	ICGC	240	197	437
E_MTAB_8887	/	23	17	40
GTEx	TCGA_GTEx_LIHC	0	226	226
TCGA	TCGA_GTEx_LIHC	371	50	421

GPL: Gene expression omnibus platform; GTEx: Genotype-tissue expression project; ICGC: International cancer genome consortium; LIHC: Liver hepatocellular carcinoma; TCGA: The cancer genome atlas; TMEM106C: Transmembrane protein 106C.