

Table 1a. Patient characteristics by astrocytoma grade in the SEER (2004-2019, biopsy only)*.

Factors	A2	A3	Glioblastoma	p-value
Total	1452	1514	10676	
Surgery recommendation				<0.001
Yes (EB)	649 (44.7)	645 (42.6)	5766 (54.0)	
No (DB)	803 (55.3)	869 (57.4)	4910 (46.0)	
Surgery				<0.001
No surgery	846 (58.3)	900 (59.4)	5107 (47.8)	
Local excision/biopsy	606 (41.7)	614 (40.6)	5569 (52.2)	
Age at dx, median (IQR)	54 (37, 66)	60 (46, 71)	65 (57, 74)	<0.001
Age group				<0.001
18-45	541 (37.3)	374 (24.7)	732 (6.9)	
46-60	385 (26.5)	418 (27.6)	3120 (29.2)	
61-75	374 (25.8)	476 (31.4)	4529 (42.4)	
76-	152 (10.5)	246 (16.2)	2295 (21.5)	
Race				0.004
NHW	1089 (75.0)	1161 (76.7)	8425 (78.9)	
NHB	98 (6.7)	88 (5.8)	574 (5.4)	
Hispanic	183 (12.6)	163 (10.8)	1135 (10.6)	
Asian/PI/AI/AN	82 (5.6)	102 (6.7)	542 (5.1)	
Sex				0.002
Male	831 (57.2)	801 (52.9)	6168 (57.8)	
Female	621 (42.8)	713 (47.1)	4508 (42.2)	
Income, \$				<0.001
<50000	214 (14.7)	196 (12.9)	1429 (13.4)	
50000-74999	851 (58.6)	803 (53.0)	5803 (54.4)	
>=75000	387 (26.7)	515 (34.0)	3444 (32.3)	
Residential location				0.017
Metropolitan area	1238 (85.3)	1339 (88.4)	9360 (87.7)	
Non-metropolitan area	214 (14.7)	175 (11.6)	1316 (12.3)	
Tumor location				0.066
Supratentorial	1038 (71.5)	1136 (75.0)	7902 (74.0)	
Infratentorial/NOS	414 (28.5)	378 (25.0)	2774 (26.0)	
Tumor size				<0.001
<=3cm	547 (37.7)	592 (39.1)	2823 (26.4)	
3-5cm	523 (36.0)	569 (37.6)	4632 (43.4)	
>5cm	382 (26.3)	353 (23.3)	3221 (30.2)	
IDH mutation status				<0.001
Wildtype	46 (3.2)	80 (5.3)	1024 (9.6)	
Mutation	50 (3.4)	51 (3.4)	0 (0.0)	
Unknown	1356 (93.4)	1383 (91.3)	9652 (90.4)	

* Pearson's chi-square test.

Table 1b. Patient characteristics by astrocytoma grade in the NCDB (2010-2017, biopsy only)*.

Factor	A2	A3	Glioblastoma	p-value
Total	1278	1329	9942	
Surgery recommendation				<0.001
Yes (EB)	493 (38.6)	481 (36.2)	4986 (50.2)	
No (DB)	785 (61.4)	848 (63.8)	4956 (49.8)	
Age at diagnosis, median (IQR)	55 (39, 66)	59 (46, 70)	65 (56, 73)	<0.001
Age group				<0.001
18-45	453 (35.4)	328 (24.7)	727 (7.3)	
46-60	333 (26.1)	383 (28.8)	2997 (30.1)	
61-75	360 (28.2)	436 (32.8)	4308 (43.3)	
76-	132 (10.3)	182 (13.7)	1910 (19.2)	
Race				<0.001
NHW	1034 (80.9)	1088 (81.9)	8486 (85.4)	
NHB	86 (6.7)	102 (7.7)	605 (6.1)	
Asian/PI	35 (2.7)	37 (2.8)	234 (2.4)	
Hispanic	103 (8.1)	79 (5.9)	515 (5.2)	
Others	20 (1.6)	23 (1.7)	102 (1.0)	
Sex				0.050
Male	714 (55.9)	711 (53.5)	5665 (57.0)	
Female	564 (44.1)	618 (46.5)	4277 (43.0)	
Education, %				0.084
≥29	206 (16.1)	187 (14.1)	1469 (14.8)	
20-28.9	300 (23.5)	297 (22.3)	2292 (23.1)	
14-19.9	298 (23.3)	286 (21.5)	2394 (24.1)	
<14	474 (37.1)	559 (42.1)	3787 (38.1)	
Income, \$				0.38
<30,000	144 (11.3)	137 (10.3)	1090 (11.0)	
30,000-35,999	232 (18.2)	209 (15.7)	1749 (17.6)	
36,000-45,999	380 (29.7)	390 (29.3)	2830 (28.5)	
≥46,000	522 (40.8)	593 (44.6)	4273 (43.0)	
Insurance				<0.001
No-insured	76 (5.9)	46 (3.5)	399 (4.0)	
Government	556 (43.5)	619 (46.6)	5423 (54.5)	
Private	646 (50.5)	664 (50.0)	4120 (41.4)	
Residential location				0.16
Metropolitan	1047 (81.9)	1122 (84.4)	8197 (82.4)	
Urban/rurual	231 (18.1)	207 (15.6)	1745 (17.6)	
Facility type				<0.001
Non-AC	413 (32.3)	456 (34.3)	3714 (37.4)	
AC	369 (28.9)	440 (33.1)	3983 (40.1)	
INCP	158 (12.4)	203 (15.3)	1864 (18.7)	
Unknown	338 (26.4)	230 (17.3)	381 (3.8)	
Travel distance, miles				0.48
[0,5]	309 (24.2)	296 (22.3)	2271 (22.8)	
(5-10]	273 (21.4)	260 (19.6)	2017 (20.3)	
(10,20]	240 (18.8)	257 (19.3)	2058 (20.7)	
(20,50]	276 (21.6)	311 (23.4)	2171 (21.8)	
>50	180 (14.1)	205 (15.4)	1425 (14.3)	
Tumor location				0.20
Supratentorial	881 (68.9)	924 (69.5)	7058 (71.0)	
Infratentorial/NOS	397 (31.1)	405 (30.5)	2884 (29.0)	

Tumor size				<0.001
≤3cm	467 (36.5)	499 (37.5)	2647 (26.6)	
3-5cm	481 (37.6)	529 (39.8)	4307 (43.3)	
>5cm	330 (25.8)	301 (22.6)	2988 (30.1)	
Charlson/Deyo Score				<0.001
0	960 (75.1)	976 (73.4)	6783 (68.2)	
1	204 (16.0)	203 (15.3)	1849 (18.6)	
≥2	114 (8.9)	150 (11.3)	1310 (13.2)	
Radiation				<0.001
None	446 (34.9)	293 (22.0)	2876 (28.9)	
Yes	832 (65.1)	1036 (78.0)	7066 (71.1)	
Chemotherapy				<0.001
None	641 (50.2)	391 (29.4)	3384 (34.0)	
Yes	637 (49.8)	938 (70.6)	6558 (66.0)	

* Pearson's chi-square test.

Table 2a. Logistic regression to recommendation against surgery (DB vs. EB) in the SEER*.

	Total cohort (A2, A3, glioblastoma)		
	OR	95%CI	p-value
Tumor histology			
A2	1.77	1.57 - 2.00	<0.001
A3	1.78	1.59 - 2.00	<0.001
Glioblastoma	1.00	-	-
Age group			
18-45	1.00	-	-
46-60	1.42	1.26 - 1.61	<0.001
61-75	1.70	1.51 - 1.92	<0.001
76-	2.77	2.42 - 3.17	<0.001
Race/ethnicity			
NHW	1.00	-	-
NHB	0.95	0.81 - 1.10	0.470
Hispanic	1.15	1.03 - 1.29	0.013
Asian/PI/AI/AN	1.35	1.15 - 1.57	<0.001
Gender			
Male	1.00	-	-
Female	1.00	0.94 - 1.08	0.938
Income, dollars			
<50000	1.00	-	-
50000-74999	1.19	1.05 - 1.34	0.005
≥75000	1.14	1.00 - 1.30	0.048
Residential location			
Metropolitan	1.00	-	-
Urban/Rural	1.03	0.91 - 1.17	0.595
Tumor site			
Supratentorial	1.00	-	-
Infratentorial/NOS	1.64	1.51 - 1.77	<0.001
Tumor size			
≤3cm	1.00	-	-
3-5cm	0.96	0.89 - 1.05	0.368
>5cm	0.83	0.76 - 0.91	<0.001

* Multivariable logistic regression.

Table 2b. Logistic regression to recommendation against surgery (DB vs. EB) in the NCDB*.

	Total cohort (A2, A3, glioblastoma)		
	OR	95%CI	p-value
Tumor histology			
A2	1.88	1.65 - 2.14	<0.001
A3	1.97	1.74 - 2.23	<0.001
Glioblastoma	1.00	-	-
Age group			
18-45	1.00	-	-
46-60	1.07	0.89 - 1.29	0.472
61-75	1.20	1.00 - 1.44	0.055
76-	1.72	1.40 - 2.10	<0.001
Race/ethnicity			
NHW	1.00	-	-
NHB	1.17	1.00 - 1.37	0.044
Hispanic	1.28	1.01 - 1.62	0.043
API	0.98	0.83 - 1.16	0.836
Others	0.57	0.41 - 0.81	0.002
Gender			
Male	1.00	-	-
Female	1.00	0.93 - 1.08	0.981
Education, %			
≥29	1.00	-	-
20-28.9	0.97	0.85 - 1.10	0.597
14-19.9	1.03	0.90 - 1.19	0.649
<14	1.04	0.90 - 1.21	0.614
Income, dollars			
<30,000	1.00	-	-
30,000-35,999	0.98	0.85 - 1.14	0.801
36,000-45,999	1.00	0.86 - 1.16	0.984
≥46,000	0.95	0.80 - 1.12	0.523
Insurance status			
No-insured	1.16	0.96 - 1.40	0.120
Government	1.15	1.05 - 1.25	0.002
Private	1.00	-	-
Residential location			
Metropolitan	1.00	-	-
Urban/Rural	1.08	0.96 - 1.22	0.198
Facility type			
Non-AC	1.47	1.35 - 1.60	<0.001
AC	1.00	-	-
INCP	1.36	1.23 - 1.51	<0.001
Unknown	0.87	0.70 - 1.08	0.207
Residence-hospital distance, miles			
[0,5]	1.00	-	-
(5-10]	0.95	0.85 - 1.06	0.332
(10,20]	0.88	0.79 - 0.98	0.024
(20,50]	0.92	0.82 - 1.03	0.144
>50	0.88	0.77 - 1.02	0.083
Tumor site			
Supratentorial	1.00	-	-
Infratentorial/NOS	1.73	1.59 - 1.87	<0.001

Tumor size			
<=3cm	1.00	-	-
3-5cm	0.93	0.86 - 1.02	0.131
>5cm	0.82	0.74 - 0.90	<0.001
Charlson/Deyo Score			
0	1.00	-	-
1	0.96	0.88 - 1.06	0.462
≥ 2	0.98	0.88 - 1.10	0.745

* Multivariable logistic regression.

Table 3a. Logistic regression to recommendation against surgery (DB vs. EB) in the SEER (2018-2019, with *IDH*-mutation status)*.

	Sub-cohort (A2, A3, glioblastoma)		
	OR	95%CI	p-value
Tumor histology			
A2	1.61	1.05 - 2.48	0.029
A3	2.13	1.43 - 3.17	<0.001
Glioblastoma	1.00	-	-
Age group			
18-45	1.00	-	-
46-60	0.91	0.60 - 1.38	0.664
61-75	1.07	0.72 - 1.59	0.741
76-	1.54	1.00 - 2.38	0.053
Race/ethnicity			
NHW	1.00	-	-
NHB	0.57	0.37 - 0.89	0.012
Hispanic	1.40	1.01 - 1.94	0.046
Asian/PI/AI/AN	1.01	0.66 - 1.57	0.954
Gender			
Male	1.00	-	-
Female	1.07	0.87 - 1.31	0.535
Income, dollars			
<50000	1.00	-	-
50000-74999	1.00	0.68 - 1.49	0.982
≥75000	0.98	0.64 - 1.49	0.925
Residential location			
Metropolitan	1.00	-	-
Urban/Rural	0.80	0.54 - 1.18	0.266
Tumor site			
Supratentorial	1.00	-	-
Infratentorial/NOS	1.74	1.38 - 2.19	<0.001
Tumor size			
≤3cm	1.00	-	-
3-5cm	1.11	0.87 - 1.42	0.412
>5cm	0.88	0.68 - 1.15	0.365
<i>IDH</i> mutation status			
Wildtype	1.00	-	-
Mutation	0.60	0.35 - 1.01	0.056
Unknown	1.31	1.01 - 1.72	0.045

*Covariates have been adjusted in logistic regression models.

Table 3b. Logistic regression to recommendation against surgery (DB vs. EB) in the NCDB
(2018-2020, with *IDH*-mutation status).

	Sub-cohort (A2, A3, glioblastoma)		
	OR	95%CI	p-value
Tumor histology			
A2	2.06	1.72 - 2.47	<0.001
A3	2.05	1.72 - 2.44	<0.001
Glioblastoma	1.00	-	-
Age group			
18-45	1.00	-	-
46-60	1.03	0.79 - 1.33	0.838
61-75	1.11	0.86 - 1.45	0.420
76-	1.20	0.90 - 1.59	0.210
Race/ethnicity			
NHW	1.00	-	-
NHB	0.96	0.80 - 1.17	0.710
Hispanic	1.02	0.77 - 1.35	0.906
API	1.04	0.85 - 1.26	0.730
Others	0.78	0.50 - 1.20	0.258
Gender			
Male	1.00	-	-
Female	1.03	0.93 - 1.13	0.570
Education, %			
≥29	1.00	0.82 - 1.22	0.973
20-28.9	0.92	0.79 - 1.08	0.299
14-19.9	0.91	0.79 - 1.04	0.177
<14	1.00	-	-
Income, dollars			
<30,000	0.91	0.72 - 1.13	0.390
30,000-35,999	1.12	0.94 - 1.34	0.201
36,000-45,999	1.08	0.95 - 1.24	0.250
≥46,000	1.00	-	-
Insurance status			
No-insured	0.79	0.60 - 1.04	0.091
Government	1.00	-	-
Private	0.91	0.80 - 1.02	0.102
Residential location			
Metropolitan	1.00	-	-
Urban/Rural	1.17	1.00 - 1.37	0.050
Facility type			
Non-AC	1.21	1.07 - 1.35	0.001
AC	1.00	-	-
INCP	1.21	1.05 - 1.40	0.008
Unknown	0.79	0.58 - 1.07	0.129
Residence-hospital distance, miles			
[0,5]	1.00	-	-
(5-10]	0.97	0.84 - 1.13	0.740
(10,20]	1.05	0.91 - 1.22	0.516
(20,50]	1.03	0.89 - 1.20	0.665
>50	1.04	0.86 - 1.24	0.707

Tumor site			
Supratentorial	1.00	-	-
Infratentorial/NOS	1.54	1.39 - 1.71	<0.001
Tumor size			
≤3cm	1.00	-	-
3-5cm	0.87	0.57 - 1.33	0.535
>5cm	0.64	0.41 - 1.01	0.054
Unknown	1.44	1.03 - 1.99	0.031
IDH mutation status			
Wildtype	1.00	-	-
Mutation	0.47	0.37 - 0.59	<0.001
Unknown	0.96	0.85 - 1.07	0.446
Charlson/Deyo Score			
0	1.00	-	-
1	1.07	0.94 - 1.23	0.311
≥ 2	1.04	0.90 - 1.20	0.614

* Multivariable logistic regression.

Table 4. Cox regression models in relation to recommendation against surgery (EB vs. DB) in the NCDB and SEER (total cohort and sub-cohort)*.

Cox model	A2 biopsy			A3 biopsy			Glioblastoma biopsy		
	aHR	95%CI	P_value	aHR	95%CI	P_value	aHR	95%CI	P_value
SEER, total cohort									
Surgery recommendation									
Yes (EB)	1.00	-	-	1.00	-	-	1.00	-	-
No (DB)	1.15	1.01 - 1.31	0.039	1.53	1.36 - 1.72	<0.001	1.55	1.49 - 1.62	<0.001
NCDB, total cohort									
Surgery recommendation									
Yes (EB)	1.00	-	-	1.00	-	-	1.00	-	-
No (DB)	1.23	1.06 - 1.43	0.006	1.44	1.26 - 1.65	<0.001	1.51	1.44 - 1.57	<0.001
SEER, Sub-cohort (2018-2019, after adjusting <i>IDH</i> -mutation status)									
Surgery recommendation									
Yes (EB)	1.00	-	-	1.00	-	-	1.00	-	-
No (DB)	1.28	0.51 - 3.19	0.602	2.27	1.20 - 4.28	0.012	1.53	1.32 - 1.77	<0.001
NCDB, Sub-cohort (2018-2020, after adjusting <i>IDH</i> -mutation status)									
Surgery recommendation									
Yes (EB)	1.00	-	-	1.00	-	-	1.00	-	-
No (DB)	1.29	1.17 - 1.41	<0.001	1.53	1.41 - 1.67	<0.001	1.51	1.46 - 1.56	<0.001

*: Covariates have been adjusted in Cox proportional hazard models.