

Neighborhood Material Deprivation and Days at Home After Glioblastoma Diagnosis

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Case Report

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Abstract

Purpose

To examine the association between neighborhood material deprivation and days at home (DAH) after glioblastoma diagnosis.

Methods

This population-based retrospective cohort study used linked administrative data from Ontario, Canada, for adults diagnosed with glioblastoma during 2003–2023. Material deprivation was assigned using Ontario Marginalization Index quintiles (Q1, least deprived; Q5, most deprived). The primary outcome was DAH within 365 days, defined as days alive outside acute hospitals, inpatient rehabilitation, and continuing or complex care. The primary analysis included diagnoses through 2022. Median quantile regression adjusted for age, sex, comorbidity, frailty, rurality, and diagnosis year. Secondary outcomes included other DAH horizons and overall survival.

Results

Among 9172 adults, 4491 (49.0%) were younger than 65 years and 5435 (59.3%) were male. Median DAH-365 was 249 days (interquartile range, 67–350) in Q1 and 138 (27–332) in Q5. In 8234 complete cases, adjusted median differences versus Q1 were – 8.8 days for Q2 (95% confidence interval [CI], – 19.6 to 2.0), – 14.8 for Q3 (– 27.0 to – 2.6), – 18.3 for Q4 (– 29.4 to – 7.2), and – 36.2 for Q5 (– 51.5 to – 20.9). Median survival was 324 days (95% CI, 306–343) in Q1 and 225 (211–244) in Q5.

Conclusion

Greater neighborhood material deprivation was associated with substantially fewer DAH after glioblastoma diagnosis. The adjusted gap exceeding 5 weeks supports investigation of treatment access and supportive care pathways to inform efforts to improve equity.

Introduction

Glioblastoma (GBM) limits both survival and the time patients can spend outside health care institutions. The 2021 World Health Organization classification defines GBM as an IDH–wildtype diffuse astrocytic glioma with specified histologic or molecular features [1]. Maximal safe resection followed by radiotherapy and temozolomide remains central to treatment [2–4]. Randomized trials have established survival benefits from chemoradiotherapy, including selected older patients, and tumor-treating fields in eligible patients [5–7]. Nevertheless, population-based outcomes remain poor, and trial estimates do not represent all patients diagnosed with GBM [8, 9].

Days at home (DAH) integrates survival and institutional health care use within a defined period. It has been evaluated in perioperative care, cancer, hip fracture, traumatic brain injury, and spinal metastases [10–14]. Reviews support its potential as a pragmatic patient-centered measure while identifying substantial variation in definitions and analysis [15, 16]. Unlike survival alone, DAH describes time alive outside captured institutions, although it does not measure every dimension of well-being. For equity analysis, similar survival could coexist with different amounts of institutional care, whereas a survival disadvantage could be compounded by fewer days outside institutions. Examining DAH alongside survival therefore broadens the description of disparity without assuming that time outside hospital is equivalent to symptom control, independence, or a preferred place of care.

Socioeconomic differences in GBM treatment and survival have been reported in Ontario and the United States [17–20]. Similar disparities occur in other cancers [21, 22]. Whether neighborhood material deprivation is associated with DAH after GBM diagnosis remains unclear. We examined this association in Ontario's publicly funded health system, hypothesizing fewer DAH within 365 days among patients from more deprived neighborhoods. Secondary outcomes included DAH at other horizons and overall survival.

Methods

Study Design and Setting

This retrospective cohort study used linked administrative health data at ICES (formerly known as the Institute for Clinical Evaluative Sciences) in Ontario, Canada [23]. Ontario publicly funds medically necessary physician and hospital services through the Ontario Health Insurance Plan (OHIP). Records were linked using unique encoded identifiers and analyzed at ICES. The Unity Health Toronto research ethics board approved the study (approval no. 21–145); individual consent was waived for use of deidentified administrative data. Data use was authorized under section 45 of Ontario's Personal Health Information Protection Act. Reporting followed the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) statement and the Reporting of Studies Conducted Using Observational Routinely Collected Health Data (RECORD) statement [24, 25].

Participants and Data Sources

Adults with newly diagnosed GBM recorded in the Ontario Cancer Registry (OCR) between January 1, 2003, and December 31, 2023, were identified using International Classification of Diseases for Oncology, Third Edition histologic morphology codes 9440/3 and 9441/3 and brain topography codes C71.0-C71.9 [26]. Cohort entry was the diagnosis date. Study size reflected all eligible registry patients. The selection process excluded records with missing age or sex, age younger than 18 or older than 105 years, death on or before diagnosis, and absence of OHIP eligibility at diagnosis; additional eligible OCR

records for the same patient were removed. Further exclusions were applied under ICES privacy requirements (Fig. 1).

The OCR supplied cancer diagnoses; the Registered Persons Database supplied demographics, eligibility, and vital status. The Canadian Institute for Health Information Discharge Abstract Database identified acute hospitalizations and procedures. The National Rehabilitation Reporting System and Continuing Care Reporting System identified post-acute institutional stays. OHIP claims and Activity Level Reporting (ALR) identified treatment activity. Postal codes linked patients to neighborhood and geographic measures. Diagnostic codes, data sources, and treatment algorithms appear in Tables S1–S3 in Online Resource 1. Surgery was ascertained from 30 days before through 60 days after diagnosis using OHIP and Canadian Classification of Health Interventions codes. Chemotherapy and radiation therapy receipt were ascertained within 90 days after diagnosis using OHIP claims and ALR records, respectively.

Exposure and Covariates

Neighborhood material deprivation was measured using the Ontario Marginalization Index (ON-Marg) [27, 28]. Postal codes at diagnosis were linked to dissemination areas and deprivation quintiles (Q1–Q5), with Q1 representing the least deprived neighborhoods (reference) and Q5 the most deprived. This measure characterizes neighborhoods rather than individual socioeconomic status. The 2021 ON-Marg version, which labels this dimension “material resources,” was applied across all diagnosis years.

Covariates were selected a priori using subject-matter knowledge and a directed acyclic graph (Fig. S1 in Online Resource 1) [29–32]. Adjustment included age (< 65, 65–74, 75–84, or ≥ 85 years), sex, comorbidity, frailty, rurality, and diagnosis year. Elixhauser conditions were identified from hospital diagnoses during a 5-year lookback using administrative coding algorithms [33, 34]. Categories were no prior hospitalization, prior hospitalization without an identified condition, and prior hospitalization with at least 1 condition. These categories did not represent a weighted Elixhauser score [35].

Frailty was identified using the Johns Hopkins Adjusted Clinical Groups indicator over the same lookback [36]. Rurality Index for Ontario scores of 40 or greater defined rural residence; lower scores defined urban residence [37]. Diagnosis year was continuous. Treatment and access variables were considered potential mediators and excluded from primary adjustment. Distance to the nearest cancer center was described.

Outcomes

The primary outcome, DAH within 365 days (DAH-365), was calculated by subtracting days in acute hospitals, inpatient rehabilitation, and continuing or complex care, together with days after death, from 365 days [15]. Values ranged from 0 to 365; higher values indicated more time alive outside captured institutions. Secondary horizons were 90 (DAH-90), 180 (DAH-180), and 730 (DAH-730) days (Fig. S2 in Online Resource 1). Each assessment window began on the diagnosis date. Overlapping institutional

stays and same-day transfers were consolidated so that each calendar day was counted only once. The date of death contributed a home day if no institutional stay was recorded that day; subsequent days contributed zero home days. Follow-up was available through December 31, 2023. Eligibility for each DAH outcome required the full assessment window to fall within available administrative follow-up. DAH-365 and DAH-730 analyses included diagnoses through December 31, 2022, and December 31, 2021, respectively; corresponding restrictions applied to DAH-90 and DAH-180.

Overall survival was measured from diagnosis to death from any cause. Patients without recorded deaths were censored on December 31, 2023. Survival probabilities were estimated at 365 and 730 days.

Statistical Analysis

Categorical variables were summarized as numbers and percentages and continuous variables as medians and interquartile ranges (IQRs). DAH distributions were compared using Kruskal-Wallis tests. Unadjusted and adjusted median quantile regression ($\tau = 0.50$) estimated differences in DAH by quintile. This approach modeled the conditional median without assuming a normally distributed outcome [38, 39]. Standard errors used 1000 bootstrap resamples; 95% confidence intervals (CIs) were calculated as coefficients plus or minus 1.96 bootstrap standard errors. Covariates were identical across horizons.

Kaplan-Meier estimates and log-rank tests compared survival. Cox regression used the same adjustment set. Scaled Schoenfeld residuals indicated nonproportional hazards for deprivation and globally [40]. Piecewise Cox regression therefore estimated associations during the first 365 days and thereafter. The cutoff aligned with the primary DAH horizon. Estimates after 365 days applied to patients still alive and observed at that time.

Regression used complete cases without imputation; patients missing deprivation were retained in overall descriptions. Model-specific denominators were reported. Tests were 2-sided with $P < .05$ considered statistically significant. Multiple comparisons were not adjusted; secondary analyses were exploratory. Analyses used R version 4.5.3 (R Foundation for Statistical Computing). Data were analyzed from June to August 2026.

Results

Cohort Characteristics

Of 9363 patients meeting GBM diagnostic criteria after initial registry selection, 191 were excluded under ICES privacy requirements, leaving 9172 (Fig. 1). Of these, 4491 (49.0%) were younger than 65 years and 5435 (59.3%) were male. Median diagnosis year was 2014 (IQR, 2009–2019). Deprivation was missing for 79 patients (0.9%), frailty for 864 (9.4%), and rurality for 13 (0.1%). There were 2102 patients in Q1 and 1489 in Q5 (Table 1).

Table 1
Cohort characteristics by neighborhood material deprivation

Characteristic	Overall (N = 9172)	Q1 (n = 2102)	Q2 (n = 1964)	Q3 (n = 1810)	Q4 (n = 1728)	Q5 (n = 1489)
Age group						
< 65 years	4,491 (49.0%)	1,109 (52.8%)	975 (49.6%)	862 (47.6%)	818 (47.3%)	693 (46.5%)
65–74 years	2,763 (30.1%)	569 (27.1%)	597 (30.4%)	561 (31.0%)	555 (32.1%)	453 (30.4%)
75–84 years	1,634 (17.8%)	354 (16.8%)	339 (17.3%)	329 (18.2%)	297 (17.2%)	300 (20.1%)
≥ 85 years	284 (3.1%)	70 (3.3%)	53 (2.7%)	58 (3.2%)	58 (3.4%)	43 (2.9%)
Sex						
Male	5,435 (59.3%)	1,283 (61.0%)	1,172 (59.7%)	1,062 (58.7%)	1,038 (60.1%)	826 (55.5%)
Female	3,737 (40.7%)	819 (39.0%)	792 (40.3%)	748 (41.3%)	690 (39.9%)	663 (44.5%)
Rurality						
Urban	7,892 (86.0%)	1,923 (91.5%)	1,688 (85.9%)	1,480 (81.8%)	1,435 (83.0%)	1,329 (89.3%)
Rural	1,267 (13.8%)	179 (8.5%)	276 (14.1%)	330 (18.2%)	293 (17.0%)	160 (10.7%)
Missing	13 (0.1%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)	0 (0.0%)
Elixhauser comorbidity category						
No prior hospitalization	4,099 (44.7%)	964 (45.9%)	848 (43.2%)	784 (43.3%)	777 (45.0%)	692 (46.5%)
Prior hospitalization, no identified comorbidities	3,990 (43.5%)	918 (43.7%)	873 (44.5%)	808 (44.6%)	741 (42.9%)	613 (41.2%)
Prior hospitalization, ≥ 1 identified comorbidity	1,083 (11.8%)	220 (10.5%)	243 (12.4%)	218 (12.0%)	210 (12.2%)	184 (12.4%)

Values are No. (%) unless indicated as median (interquartile range). Q1 is least deprived and Q5 most deprived. Seventy-nine patients missing deprivation are included only in the overall column. Treatment variables are descriptive. Q indicates quintile. Surgery was ascertained from 30 days before through 60 days after diagnosis; chemotherapy and radiotherapy were ascertained within 90 days after diagnosis.

Characteristic	Overall (N = 9172)	Q1 (n = 2102)	Q2 (n = 1964)	Q3 (n = 1810)	Q4 (n = 1728)	Q5 (n = 1489)
Age group						
Frailty						
No	7,416 (80.9%)	1,742 (82.9%)	1,610 (82.0%)	1,441 (79.6%)	1,382 (80.0%)	1,175 (78.9%)
Yes	892 (9.7%)	177 (8.4%)	176 (9.0%)	182 (10.1%)	177 (10.2%)	172 (11.6%)
Missing	864 (9.4%)	183 (8.7%)	178 (9.1%)	187 (10.3%)	169 (9.8%)	142 (9.5%)
Surgery						
No surgery identified	2,308 (25.2%)	523 (24.9%)	526 (26.8%)	463 (25.6%)	429 (24.8%)	359 (24.1%)
Biopsy	921 (10.0%)	207 (9.8%)	194 (9.9%)	180 (9.9%)	156 (9.0%)	165 (11.1%)
Resection	5,943 (64.8%)	1,372 (65.3%)	1,244 (63.3%)	1,167 (64.5%)	1,143 (66.1%)	965 (64.8%)
Radiation therapy						
No	4,432 (48.3%)	972 (46.2%)	950 (48.4%)	880 (48.6%)	843 (48.8%)	737 (49.5%)
Yes	4,740 (51.7%)	1,130 (53.8%)	1,014 (51.6%)	930 (51.4%)	885 (51.2%)	752 (50.5%)
Chemotherapy						
No	6,370 (69.5%)	1,362 (64.8%)	1,361 (69.3%)	1,284 (70.9%)	1,198 (69.3%)	1,100 (73.9%)
Yes	2,802 (30.5%)	740 (35.2%)	603 (30.7%)	526 (29.1%)	530 (30.7%)	389 (26.1%)
Continuous variables, median (IQR)						
Distance to nearest cancer center, km	14.5 (6.5–41.0)	13.4 (6.8–25.5)	15.6 (7.4–36.9)	17.3 (7.1–50.0)	15.2 (6.5–50.5)	11.3 (4.9–49.9)
Values are No. (%) unless indicated as median (interquartile range). Q1 is least deprived and Q5 most deprived. Seventy-nine patients missing deprivation are included only in the overall column. Treatment variables are descriptive. Q indicates quintile. Surgery was ascertained from 30 days before through 60 days after diagnosis; chemotherapy and radiotherapy were ascertained within 90 days after diagnosis.						

Characteristic	Overall (N = 9172)	Q1 (n = 2102)	Q2 (n = 1964)	Q3 (n = 1810)	Q4 (n = 1728)	Q5 (n = 1489)
Age group						
Year of diagnosis	2014 (2009–2019)	2014 (2009–2019)	2014 (2009–2019)	2014 (2009–2019)	2014 (2009–2019)	2014 (2009–2019)
Values are No. (%) unless indicated as median (interquartile range). Q1 is least deprived and Q5 most deprived. Seventy-nine patients missing deprivation are included only in the overall column. Treatment variables are descriptive. Q indicates quintile. Surgery was ascertained from 30 days before through 60 days after diagnosis; chemotherapy and radiotherapy were ascertained within 90 days after diagnosis.						

Resection was identified in 5943 patients (64.8%), biopsy in 921 (10.0%), radiotherapy in 4740 (51.7%), and chemotherapy in 2802 (30.5%). Resection frequencies were similar in Q5 and Q1 (965/1489 [64.8%] vs 1372/2102 [65.3%]); recorded chemotherapy was less frequent in Q5 (389/1489 [26.1%] vs 740/2102 [35.2%]). These were descriptive comparisons.

DAH

Median DAH-365 was 200 days (IQR, 49–346), ranging from 249 (IQR, 67–350) in Q1 to 138 (IQR, 27–332) in Q5 (Table 2; Fig. S3 in Online Resource 1). The unadjusted difference was 111 fewer days, corresponding to 44.6% fewer median DAH-365 in Q5. This percentage compares group medians; it is neither an adjusted effect nor an individual's proportion of remaining life at home.

Table 2
Days at home within 365 days by material deprivation

Quintile	Observed DAH-365, median (IQR), d	Unadjusted median difference (95% CI), d	Adjusted median difference (95% CI), d	Adjusted <i>P</i> value
Q1, least deprived	249 (67–350)	Reference	Reference	—
Q2	229 (56.75–347)	–20.0 (– 49.1 to 9.1)	–8.8 (– 19.6 to 2.0)	.103
Q3	194.5 (52–344)	–54.0 (– 78.7 to – 29.3)	–14.8 (– 27.0 to – 2.6)	.017
Q4	180.5 (43–340)	–68.0 (– 93.9 to – 42.1)	–18.3 (– 29.4 to – 7.2)	.001
Q5, most deprived	138 (27–332)	–111.0 (– 133.7 to – 88.3)	–36.2 (– 51.5 to – 20.9)	< .001
DAH indicates days at home; CI, confidence interval; IQR, interquartile range; Q, quintile. Overall median DAH-365 was 200 days (IQR, 49–346). Adjusted estimates used median quantile regression in 8234 complete cases, controlling for age, sex, comorbidity category, frailty, rurality, and diagnosis year. CIs used bootstrap standard errors from 1000 resamples. Negative estimates indicate fewer DAH than Q1. The Kruskal-Wallis comparison of observed distributions had <i>P</i> < .001.				

The complete-case primary model included 8234 patients. Relative to Q1, adjusted median differences were – 8.8 days for Q2 (95% CI, – 19.6 to 2.0; *P* = .10), – 14.8 for Q3 (95% CI, – 27.0 to – 2.6; *P* = .02), – 18.3 for Q4 (95% CI, – 29.4 to – 7.2; *P* = .001), and – 36.2 for Q5 (95% CI, – 51.5 to – 20.9; *P* < .001). Thus, adjustment attenuated the Q5 association, but a difference exceeding 5 weeks remained (Table 2).

Older age, comorbidity, and frailty were associated with fewer DAH-365; later diagnosis year was associated with more DAH (Table S4 in Online Resource 1). Adjusted Q5 differences at 90, 180, and 730 days were – 5.5 (95% CI, – 7.8 to – 3.1), – 13.4 (95% CI, – 19.0 to – 7.9), and – 54.2 (95% CI, – 73.4 to – 35.1) days, respectively (Fig. 2; Tables S5 and S6 in Online Resource 1).

Overall Survival

Quintile-stratified survival analysis included 9059 patients and 8077 deaths. Median survival was 324 days (95% CI, 306–343) in Q1 and 225 (95% CI, 211–244) in Q5, an unadjusted difference of 99 days, or 30.6% shorter median survival. One-year survival was 45.6% (95% CI, 43.5%–47.9%) and 34.4% (95% CI, 32.1%–37.0%), respectively, an 11.2-percentage-point difference (Table 3; Fig. S4 in Online Resource 1).

Table 3
Overall survival and adjusted mortality by material deprivation
a Kaplan–Meier survival estimates

Material deprivation quintile	N	Deaths, n	Median overall survival, days (95% CI)	1-year survival, % (95% CI)	2-year survival, % (95% CI)
Q1 (least deprived)	2,095	1,850	324 (306–343)	45.6 (43.5–47.9)	18.4 (16.8–20.3)
Q2	1,958	1,724	298 (279–317)	42.2 (40.0–44.4)	18.1 (16.4–20.0)
Q3	1,805	1,613	264 (241–282)	38.6 (36.4–41.0)	16.2 (14.5–18.1)
Q4	1,720	1,542	257 (237–278)	37.5 (35.3–39.9)	15.0 (13.3–16.9)
Q5 (most deprived)	1,481	1,348	225 (211–244)	34.4 (32.1–37.0)	14.8 (13.0–16.8)

b Piecewise Cox regression

Material deprivation quintile	Adjusted HR, 0–365 days (95% CI)	P value	Adjusted HR, >365 days (95% CI)	P value
Q1 (least deprived)	Reference	—	Reference	—
Q2	1.090 (0.998–1.189)	.054	0.938 (0.836–1.051)	.270
Q3	1.190 (1.089–1.300)	<.001	0.930 (0.813–1.063)	.285
Q4	1.226 (1.123–1.338)	<.001	1.013 (0.892–1.151)	.843
Q5 (most deprived)	1.308 (1.194–1.433)	<.001	0.914 (0.798–1.047)	.193

Q1 is least deprived and Q5 most deprived. HR indicates hazard ratio; CI, confidence interval; Q, quintile. Panel a includes 9059 patients and 8077 deaths; survival at 1 and 2 years corresponds to 365 and 730 days. Log-rank $P < .001$. Panel b adjusted for age, sex, comorbidity category, frailty, rurality, and diagnosis year; Q1 is the reference. Follow-up was divided at 365 days after evidence of nonproportional hazards. Estimates beyond 365 days are conditional on survival and observation to that time.

The conventional adjusted Cox model included 8202 patients and 7307 deaths (Table S7 and Fig. S5 in Online Resource 1). Proportional hazards tests were significant for deprivation ($P = .004$) and globally ($P < .001$; Table S8 in Online Resource 1). In piecewise models, Q5 was associated with higher mortality during the first 365 days (adjusted hazard ratio, 1.31; 95% CI, 1.19–1.43; $P < .001$), but the estimate after 365 days was not statistically significant (0.91; 95% CI, 0.80–1.05; $P = .19$). Q3 and Q4 also had higher first-year mortality; Q2 did not meet the significance threshold (Table 3).

Discussion

The deprivation gap in this population-based GBM cohort was substantial: patients in the most deprived neighborhoods had approximately 45% fewer median first-year DAH than those in the least deprived neighborhoods, together with approximately one-third shorter median survival. The absolute unadjusted gaps were 111 DAH and 99 days of survival. These differences matter in a disease with limited life expectancy. After adjustment, Q5 remained associated with 36.2 fewer median DAH-365. The persistence of this association within a publicly funded system warrants attention to barriers beyond coverage of physician and hospital services.

These findings extend Ontario evidence linking deprivation with GBM treatment and survival [17]. Omar et al reported median survival of 228 versus 294 days in the most versus least deprived neighborhoods among surgically treated patients. Our cohort included patients without recorded surgery and examined time alive outside institutions. Studies from the United States have also linked insurance and neighborhood socioeconomic circumstances to GBM care and survival [18–20]. Differences in eligibility, calendar periods, and treatment ascertainment limit direct comparisons across cohorts. This study characterizes the deprivation gradient using an outcome that combines survival with institutional care across the disease course.

DAH makes the scale of the disparity interpretable in days. Taslimi et al documented substantial hospitalization during the remaining lives of Ontario patients with GBM, particularly at older ages [9]. Studies in other serious illnesses support the feasibility of home-time outcomes [10, 12–14], and cancer studies connect these outcomes with end-of-life care and area deprivation [11, 41]. Our results extend this work to a rapidly progressive brain malignancy across multiple follow-up horizons. These are group differences, not individual predictions.

However, DAH integrates mortality and institutional use, and our analyses did not separate these components. We cannot determine how much of the deprivation gap reflects earlier death versus greater institutional use while alive. Nor does the adjusted median difference represent days that an intervention would necessarily restore. Socioeconomic associations should not be interpreted as causal effects without stronger assumptions and additional analyses [29, 32]. The crude and adjusted estimates answer different questions: the former describes the observed gap between neighborhood groups, whereas the latter compares conditional medians at the same modeled covariate values. Their difference cannot be used to calculate the proportion of disparity explained by those covariates or mediated through treatment. Likewise, subtracting the survival gap from the DAH gap would not isolate institutional care, because differences between group medians are not additive components of an individual outcome.

Public funding may leave transportation costs, employment disruption, caregiving needs, and navigation barriers unresolved. The time required for treatment can itself impose an unequal burden [42, 43]. Caregiver burden is particularly relevant in GBM [44]. The lower frequency of recorded chemotherapy in Q5 suggests a pathway for investigation but does not establish undertreatment or mediation.

Performance status, molecular characteristics, preferences, and treatment eligibility influence selection; MGMT promoter methylation also influences prognosis and temozolomide benefit [45]. Billing-based ascertainment may incompletely capture oral therapy. Similar recorded resection frequencies across quintiles do not establish equivalent surgical care, because administrative procedure categories do not resolve operative candidacy, residual tumor volume, or postoperative function. The treatment windows also describe early recorded care, rather than all treatment received over the remaining lifetime. Patients who die early have less opportunity to receive treatment, making these frequencies jointly dependent on access, clinical selection, and survival. Consequently, the descriptive chemotherapy gradient should motivate more detailed evaluation rather than serve as a direct estimate of inequitable treatment delivery.

The first year may offer opportunities to evaluate navigation, transportation assistance, and coordinated home support. Early palliative care improved quality of life and mood in a trial of metastatic non-small cell lung cancer [46], but its effect on deprivation-related DAH differences in GBM remains untested. Future work should separate DAH components, validate treatment capture, and examine treatment receipt and timing, geographic access, and community support as potential pathways. Null findings beyond 365 days do not establish equivalence across quintiles [47], and selection of survivors can complicate interpretation [48]. Interventions should be evaluated against the barriers they are intended to address. Transportation assistance could reduce the burden of attending treatment, while coordinated discharge planning and home support could address avoidable institutional time. Neither mechanism was tested here. An intervention could also increase survival while temporarily increasing hospital use, underscoring the need to report DAH together with its components and patient-reported outcomes. Equity-focused evaluation should assess whether benefits reach patients with the greatest needs, rather than infer success from an improvement in the population average alone.

Strengths and Limitations

Strengths include population-based ascertainment, linkage across acute and post-acute settings, and adjustment using prespecified covariates. Associations at multiple horizons were consistent, although these correlated outcomes are not independent replications. Requiring an observable administrative window for each DAH horizon avoids assigning unobserved future days as home time. However, horizon-specific diagnosis restrictions mean that the 90-, 180-, 365-, and 730-day estimates may represent different eligible populations. Differences in their magnitudes should therefore not be interpreted as a longitudinal trajectory for an identical set of patients.

First, neighborhood deprivation does not establish individual socioeconomic circumstances; interpreting it as an individual exposure risks ecological fallacy [49]. Second, administrative data lacked performance status, neurologic deficits, tumor burden, molecular markers, extent of resection, and caregiver resources, leaving residual confounding. Third, historical registry diagnoses cannot reproduce the contemporary molecular definition of GBM [1, 3]. A continuous diagnosis-year term may not fully capture nonlinear changes in classification, treatment, or coding. Applying a single census version across two

decades may misclassify neighborhood circumstances at diagnosis, particularly where areas experienced socioeconomic change. Linking the postal code at diagnosis identifies the relevant residence but does not eliminate this temporal mismatch. The direction of any resulting bias in quintile comparisons is uncertain.

Fourth, complete-case analysis may introduce selection bias; missing frailty was the largest recorded source of covariate missingness. Comparisons of included and excluded patients and sensitivity analyses using appropriate missing-data methods would help assess this concern [50]. Fifth, nonproportionality affected several covariates, and splitting follow-up for deprivation does not by itself establish adequate model fit within intervals. Missing frailty information may relate to prior health care use, and complete cases may differ from patients omitted from regression. In addition, administrative censoring without earlier censoring for loss of provincial eligibility could miss subsequent deaths or institutional care among patients who moved away. The extent and socioeconomic distribution of losses were unknown.

Finally, DAH does not directly measure function, symptoms, preferences, or caregiver burden. Outpatient visits, emergency visits without admission, imaging, and travel may count as home days despite consuming patient time [16, 42, 43]. More home time does not invariably indicate better care, and a minimally important DAH difference in GBM has not been established. Applicability outside Ontario depends on institutional care patterns, data capture, and health system context. DAH should therefore complement clinical and patient-reported measures rather than become a stand-alone target for minimizing admissions. Clinically necessary hospitalization can provide symptom relief and support patients whose needs cannot safely be met at home. The relevant goal is equitable access to care that supports patients' preferences, not simply fewer institutional days. Because multiple comparisons were not adjusted, secondary findings should also be interpreted cautiously, particularly estimates near conventional significance thresholds.

Conclusions

Greater neighborhood material deprivation was associated with substantially fewer DAH after GBM diagnosis and higher first-year mortality. An adjusted difference exceeding 5 weeks of DAH between the most and least deprived neighborhoods highlights a disparity warranting focused investigation of treatment access and supportive care. Identifying modifiable pathways may help direct efforts to improve equity in the time patients spend alive outside institutions.

Statements and Declarations

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Role of the funder

The funders had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; or decision to submit the manuscript for publication.

Competing interests

The authors reported no relevant financial or nonfinancial interests.

Author contributions

J.S. conceived and designed the study, performed the analyses, interpreted the data, and drafted the manuscript. C.L., V.K., H.S., and A.M. contributed to study methodology and interpretation. Y.H. provided data and administrative support. Jenna Sykes provided statistical and methodological guidance. M.J.L.F. provided neuro-oncology expertise. J.B. contributed methodological expertise. J.W. and S.A. supervised the study.

Data access and responsibility

J.S. had full access to all the data in the study and takes responsibility for the integrity of the data and the accuracy of the data analysis.

Data availability

The datasets used in this study are held securely in coded form at ICES. Data-sharing agreements between ICES and data providers prohibit the authors from making the underlying individual-level datasets publicly available. Access may be granted to researchers who meet prespecified criteria for

confidential access through ICES Data & Analytic Services (<https://www.ices.on.ca/use-ices-data/das@ices.on.ca>), subject to ICES review, applicable approvals, and data-provider agreements.

Ethics approval

The Unity Health Toronto Research Ethics Board approved the study (approval no. 21-145). The study was conducted in accordance with the Tri-Council Policy Statement: Ethical Conduct for Research Involving Humans (TCPS 2). Data use was authorized under section 45 of Ontario's Personal Health Information Protection Act.

Consent to participate

Individual consent was waived for use of deidentified administrative data.

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Figures

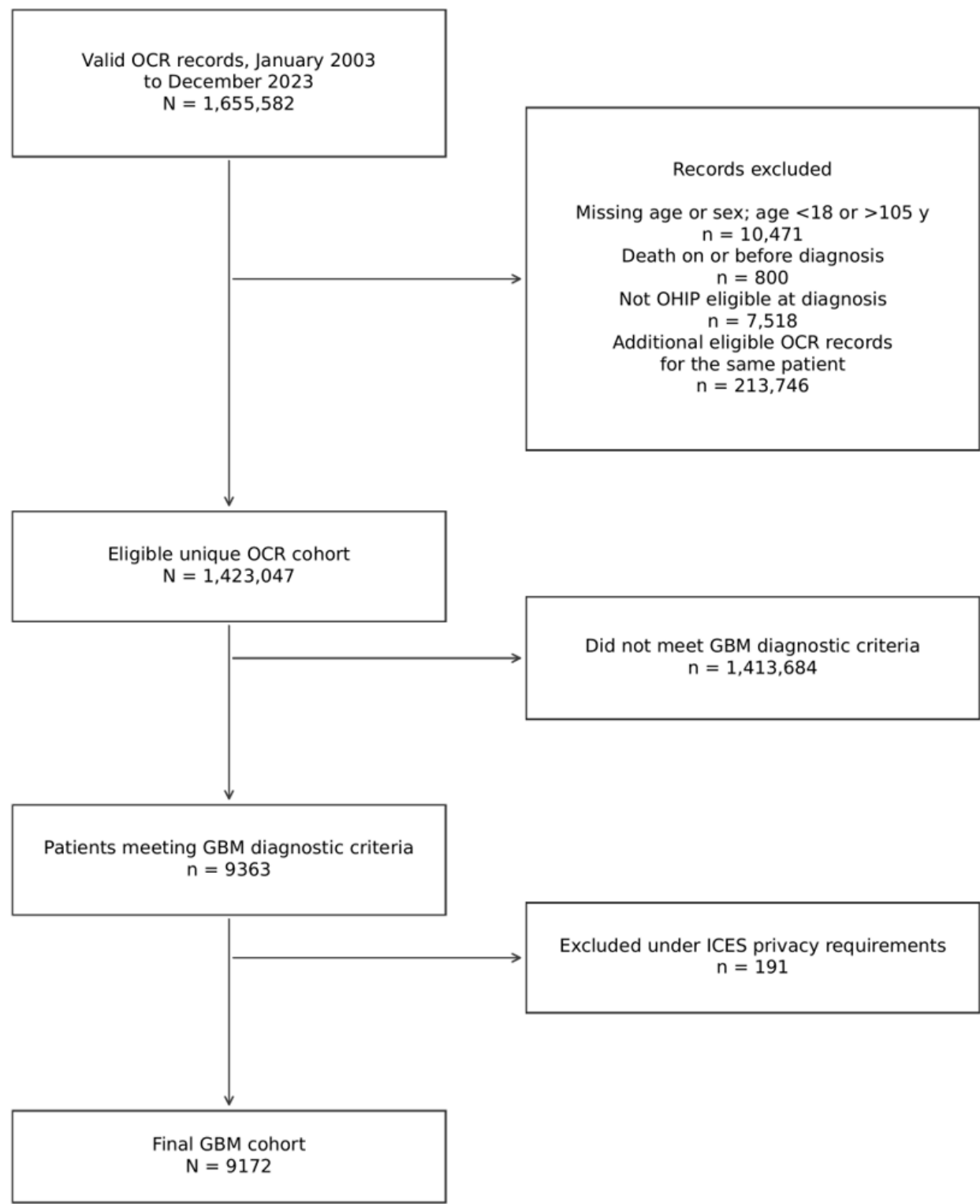


Figure 1

Cohort Identification and Selection. Registry records were filtered to identify unique patients meeting glioblastoma (GBM) diagnostic criteria from 2003 through 2023. After 191 exclusions under ICES privacy

requirements, the cohort included 9172 adults. OCR indicates Ontario Cancer Registry; OHIP, Ontario Health Insurance Plan

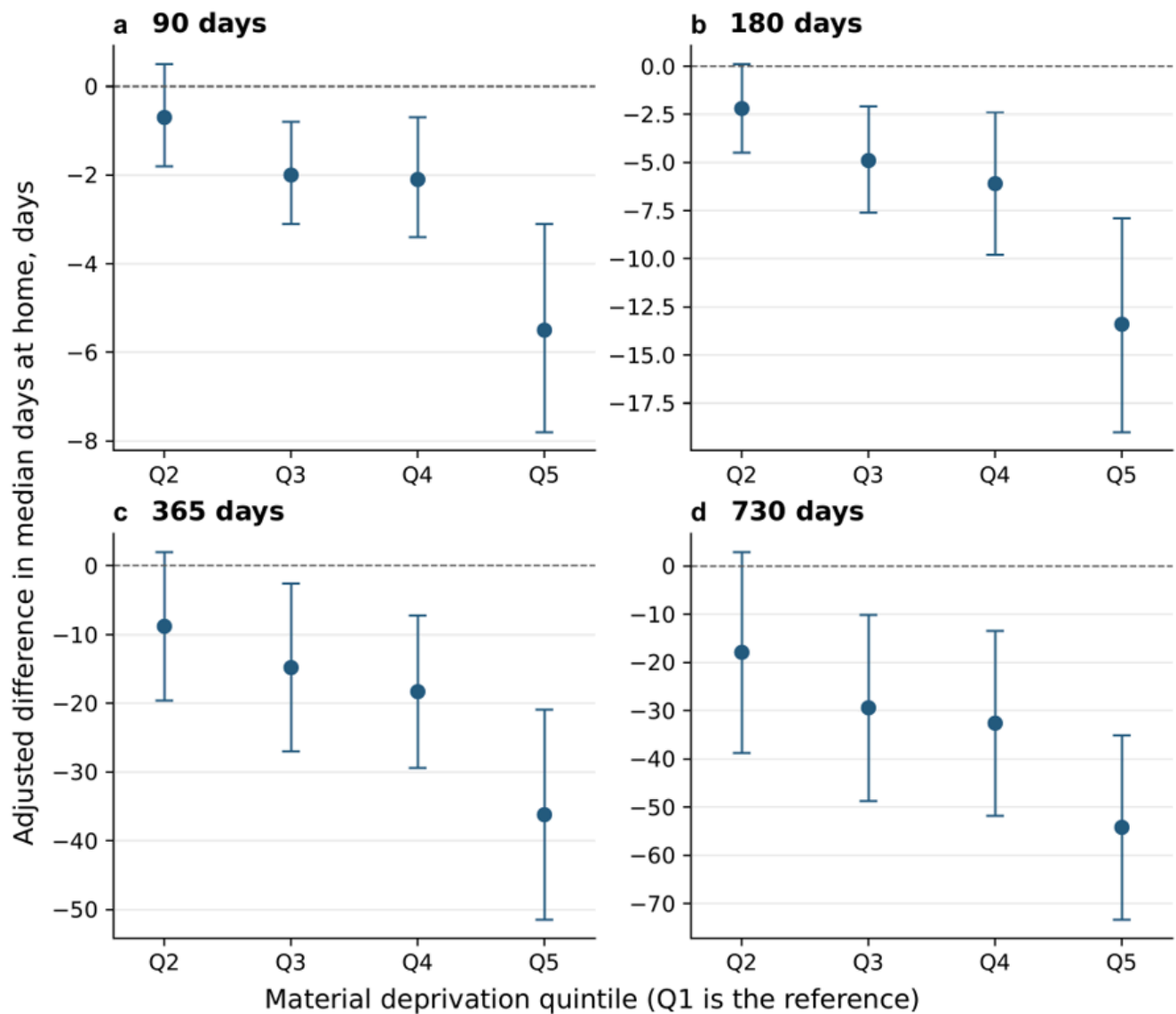


Figure 2

Adjusted Differences in Days at Home by Material Deprivation. Points show adjusted differences in median days at home (DAH) for Q2-Q5 versus Q1 (least deprived); bars show 95% CIs. Panels show horizons of 90 (a), 180 (b), 365 (c), and 730 (d) days. Models adjusted for age, sex, Elixhauser comorbidity category, frailty, rurality, and diagnosis year. Standard errors used 1000 bootstrap resamples. The dashed line denotes no difference. Axis ranges differ between panels. CI indicates confidence interval; Q, quintile

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