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# Socioeconomic Disparities in Brain Metastasis Survival and Treatment: A Population-Based Study

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## Abstract

**OBJECTIVE:** In the present study, we used a validated socioeconomic status (SES) index and population-based registry to identify and quantify the impact of SES on access to treatment and overall survival for patients diagnosed with synchronous brain metastases.

**METHODS:** The Surveillance, Epidemiology, and End Results database was used to extract all patients between 2010 and 2016 with brain metastases at initial presentation. SES was stratified into tertiles and quintiles using the validated Yost index. Multivariable logistic regressions were used to evaluate the impact of demographic, tumor, and socioeconomic covariates on receipt of radiotherapy and chemotherapy. Kaplan-Meier curves were used to estimate survival.

**RESULTS:** Between 2010 and 2016, 35,595 patients presented with brain metastases at the time of primary cancer diagnosis. Most patients received radiation and/or chemotherapy as part of the initial course of their treatment; 71.6% ($n$ = 25,484) were irradiated while 54.4% ($n$ = 19,371) received chemotherapy and 44.9% ($n$ = 15,984) received chemoradiation. Patients in the highest Yost tertile and quintile experienced longer overall survival ($P < 0.001$). Additionally, multivariable logistic regression revealed that the lowest Yost quintile was significantly less likely to receive either radiation (adjusted OR: 0.82; 95% confidence interval: 0.75–0.89; $P < 0.001$) or chemotherapy (adjusted OR: 0.62; 95% confidence interval: 0.58–0.67; $P < 0.001$).

**CONCLUSIONS:** In a large, population-based analysis of brain metastasis patients, we found significant differences in treatment access and mild survival differences along socioeconomic strata. More specifically, patients in lower SES tiers suffered worse outcomes and received radiation and chemotherapy less frequently than patients in higher tiers, even after accounting for other tumor- and demographic-related information.

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CRediT AUTHORSHIP CONTRIBUTION STATEMENT

**Adrian Rodrigues:** Methodology, Formal analysis, Manuscript writing and submission. **Guan Li:** Formal analysis, Writing – original draft, Writing – review & editing. **Hriday Bhambhvani:** Data access, Formal analysis. **Melanie Hayden-Gephart:** Writing – review & editing, Supervision.

**Keywords**

Brain metastasis; Brain metastases; Chemotherapy; Radiation; Socioeconomic status; Survival

## INTRODUCTION

Brain metastases (BMs) are the most commonly diagnosed central nervous system tumor in the United States,[1] and approximately 20%–40% of patients with any cancer will develop metastatic brain tumors.[2] The incidence of BM is increasing as new therapeutics, advanced imaging, and improved screening have led to longer patient survival and better metastasis detection.[1,3] The most common primary cancers that metastasize to the brain include lung (~50%), breast (15%–20%), melanoma (5%–10%), kidney (7%), and colon (4%–6%).[4] Depending on the primary tumor, the median survival of patients with BM ranges from 2 to 27 months.[5] Current treatment options for BM include surgery, whole-brain radiotherapy, stereotactic radiosurgery, chemotherapy, immunotherapy, and targeted therapy.[6] While the preferred treatment strategy depends on patient-specific factors, such as disease severity, tumor histology, mutation status, medical comorbidities, and patient preference, radiation and chemotherapy remain an important therapy for many BM patients.[7–9]

The majority of patients are diagnosed with BMs during the course of treatment for the primary cancer, which are referred to as metachronous metastases.[10,11] Patients diagnosed with brain metastases simultaneously with the diagnosis of the primary cancer or before the diagnosis of the primary cancer are called *synchronous* and *precocious metastases*, respectively.[10,11] The timing of brain metastases diagnosis reflects clinical features, patient outcomes, and treatment strategies.[10,11] Several studies have previously revealed disparities in access to treatment options and clinical outcomes on the basis of race, insurance status, and gender differences among BM patients.[12–17] However, the current literature lacks data on the role of socioeconomic status (SES) in treatment access and overall survival (OS) for patients with synchronous BM. In this study, we analyzed a large cohort of BM patients along validated SES strata to better characterize the relationship between socioeconomic factors and receipt of radiation or chemotherapy and patient prognosis. It is hoped that identifying and quantifying the association between SES on OS and treatment access will lead to solutions addressing the disparities faced by BM patients.

## METHODS

### Data

Data were collected from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) database between 2010 and 2016. SEER (http://seer.cancer.gov) covers almost 35% of the U.S. population and captures nearly 97% of incident cases. The SEER registry intentionally overrepresents ethnic minorities to ensure it obtains proper national-level estimates, and it is considered to be an accurate representation of the national cancer population.[18] All patient information is deidentified and therefore exempt from institutional review board approval.

First, all patients diagnosed with brain metastases at first presentation were isolated from the SEER database (SEER combined mets at DX-brain = "yes"). The SEER database records the presence of brain metastases at the time of primary cancer diagnosis, and this variable was used to extract synchronous brain metastasis patients. Then, only patients with a primary tumor in the lung (C34.0–C34.9), breast (C50.0–C50.9), gastrointestinal (GI) space (C15.3–C15.9; C16.0–C16.9; C17.0–C17.9; C18.0–C18.9; C19.9; C20.9; C21.0; C22.0–C22.1; C23.9; C24.0–C24.9; C25.0–C25.9; C26.8–C26.9), kidney (C64.9), or skin (C44.3–C44.9) were included. For primary skin tumors, any nonmelanoma cancers were excluded. Tumors without histologic confirmation were also excluded. SES status was measured through the validated Yost Index,[19] which stratifies patients into tertiles and quintiles through a principal component analysis of U.S. Census block group level variables including income, education, and occupation. In this stratification schema, group 1 indicates the lowest socioeconomic status, while groups 3 and 5 indicate the highest socioeconomic status for tertiles and quintiles, respectively.

### Statistical Analyses

Multivariable Cox proportional hazards regressions were used to evaluate the impact of demographic, tumor, SES, and treatment-related covariates on OS. Models were adjusted for Yost quintile, patient age, sex, race, insurance status, marital status, primary tumor size, primary tumor grade, and receipt of radiation or chemotherapy. Student's *t*-tests, Wilcoxon rank sum, and chi-squared tests were used to compare variables across groups, as appropriate. Survival was recorded in months. Patients with a survival time of 0 months were averaged to 15 days so that they could be included in survival analyses. Kaplan-Meier curves were used to estimate survival. The log rank test was used to assess the equality of the survivor function across groups. Landmark analysis at 1 months was used to correct for immortal time bias in the OS curves. Multivariable logistic regression models were employed to evaluate the association between SES and treatment-related variables on receipt of radiation or chemotherapy. Each model was adjusted for Yost quintile, patient age, sex, race, insurance status, marital status, primary tumor size, primary tumor grade, and primary tumor location (lung, breast, melanoma, GI, or kidney). A value of $P \leq 0.05$ was considered to be statistically significant. Statistical tests were based on a 2-sided significance level. Statistical analysis was conducted in R Studio version 1.0.153 and Stata/SE 16.1 (StataCorp, College Station, Texas, USA).

## RESULTS

The number of patients meeting inclusion criteria was 35,595. The median patient age was 65 years (IQR: 57–72) (Table 1), and the majority of patients were diagnosed with lung-to-brain metastases ($n$ = 29,502; 82.9%). The use of radiation (71.6%) and/or chemotherapy (54.4%) as part of a patient's initial treatment was common.

After adjusting for demographic, tumor, and treatment-related variables, patients in lower Yost quintiles were less likely to receive radiation (Figure 1A). Patients in the first quintile had 18% lower odds to receive radiation (adjusted odds ratio [aOR]: 0.82; 95% confidence interval [CI]: 0.75–0.89; $P < 0.001$) than were patients in the highest quintile. Uninsured

patients had 30% lower odds to receive radiation (aOR: 0.70; 95% CI: 0.62–0.79; P < 0.001), and Medicaid patients had 19% lower odds (aOR: 0.81; 95% CI: 0.76–0.87; P < 0.001). Race and marital status were also associated with reduced odds of radiation. In particular, Hispanic and Asian patients received radiation less frequently than white patients, as did nonmarried patients.

SES differences in the receipt of chemotherapy were also noted (see Figure 1B). Patients in lower Yost quintiles were less likely to be treated with chemotherapy, and the magnitude of the association increased sequentially by Yost quintile. Patients in the lowest quintile had 38% lower odds to receive chemotherapy (aOR: 0.62; 95% CI: 0.58–0.67; P < 0.001) than did patients in the highest quintile; patients in the second, third, and fourth quintiles had 33%, 25%, and 15% lower odds to receive chemotherapy, respectively. As with radiation, uninsured (aOR: 0.54; 95% CI: 0.49–0.61; P < 0.001) and Medicaid patients (aOR: 0.73; 95% CI: 0.68–0.78; P < 0.001) were less likely to receive chemotherapy. Nonmarried patients and Black and Native American patients were treated with chemotherapy less often than their married and non-Black peers.

Patients in the lowest Yost tertile experienced abbreviated OS (median OS: 5 months; 95% CI: 5–5 months) compared with patients in the highest Yost tertile (median OS: 7 months; 95% CI: 6–7 months) (P < 0.001) (see Figure 2A). The difference in OS was recapitulated when stratifying patients into quintiles (see Figure 2B); those in the lowest quintile had a median survival of 5 months (95% CI: 5–5 months), while those in the highest quintile had a median survival of 7 months (95% CI: 7–7 months).

When patients were separated by primary tumor location, those with lung-to-brain metastases in lower Yost quintiles experienced inferior survival compared with lung-to-brain patients in the highest quintile (Table 2). The magnitude of the association was inversely associated with Yost quintile; those patients in the first quintile experienced worse survival (aHR [adjusted hazard ratio]: 1.22; 95% CI: 1.17–1.27) than those in the second (aHR: 1.18; 95% CI: 1.14–1.23) and third quintiles (aHR: 1.17; 95% CI: 1.12–1.22). Uninsured and Medicaid lung-to-brain patients also had shorter survival than insured patients.

The lowest Yost quintile of breast-to-brain patients experienced worse survival (aHR: 1.31; 95% CI: 1.06–1.63), as did the third and second quintile kidney-to-brain patients. However, survival differences along SES strata were not noted for patients with GI or melanoma BMs.

## DISCUSSION

While differences in treatment patterns and survival by patient SES have been documented in patients with different types of cancer including meningioma,[20] malignant glioma,[21] prostate,[22] and lung,[23] analyses on BM patients have not been conducted. In a large, population-based analysis, we showed how SES variables were associated with differences in treatment and OS among BM patients. To the best of our knowledge, this is the first study to examine how the SES of BM patients correlates with OS and treatment. After adjusting for a range of patient-specific and tumor-related variables, we found that patients in the lowest SES quintile had 17% lower odds to receive radiation and 35% lower odds

to receive chemotherapy. Patients in the lowest SES quintile also experienced a median survival 2 months shorter, on average, than those in the highest SES quintile. Although this represented a 40% difference (5 months vs. 7 months), the absolute difference was not large. Moreover, we found that other sociodemographic information including race, marital status, and insurance status were associated with OS and treatment. Specifically, Hispanic and Asian patients were less likely to receive radiation than were White patients, while Black patients were less likely to receive chemotherapy than non-Black patients. Patients who were uninsured or on Medicaid had shorter OS and were less likely to be treated with either chemotherapy or radiation. Additionally, nonmarried patients were less likely to be treated with chemotherapy and radiation than were married patients. Taken together, these findings offer substantial evidence that SES, race, and insurance status are associated with access to radiation and chemotherapy, and while these factors were associated with OS for BM patients, the absolute impact on survival did not appear to be large.

Unfortunately, our results are consistent with past studies that examined treatment disparities in the BM patient population. In 2012, Nuño et al[12] used Nationwide Inpatient Sample data from 1998 to 2007 (N = 78,170) to show that Black BM patients spent 2.7 days longer in the hospital, had higher rates of nonroutine discharge (44.8 vs. 35.8 %, $P < 0.0001$), and suffered higher rates of postoperative complications (26.6 vs. 23.7 %, $P < 0.0001$) compared with their White peers. Additionally, the authors reported that Black BM women were almost twice as likely to die as white BM women and had a higher mortality rate than Black BM men. In 2020, Lamba et al,[24] using the SEER database (N = 17,957), identified significant racial disparities in the use of supportive medication for newly diagnosed BM patients. Black, Hispanic, and Asian patients were less likely to receive opioids, antiepileptics, steroids, antidepressants, and other supportive medications compared with White patients.[24] Although these findings are consistent with our results showing racial disparities in minority BM patients, the authors did not evaluate the effect of socioeconomic status, nor did they assess the odds of chemotherapy and radiation. Examining these additional factors will provide a more comprehensive picture of the disparities that exist for BM patients.

In addition, several papers have examined disparities that exist in access to stereotactic radiosurgery (SRS), a key treatment option for many BM patients. In 2017, Kann et al[13] found that patients from less wealthy and less educated areas or with Medicaid or without insurance were less likely to receive SRS. Similar results were reported in 2019 by Jiang et al,[16] who found that several SES factors including residence in higher-educated regions and household income were associated with increased SRS use. Another paper showed that insured patients, patients with higher median income, or those treated in an academic facility or metropolitan setting were more likely to receive SRS over whole-brain radiotherapy.[17] These findings of inequity are consistent with our own.

A limitation of our study is the inability to determine causation of these disparities, but recent studies have offered several plausible hypotheses. Patients from lower SES strata may present with more advanced disease, thus limiting the number of effective treatment options available to them. In an analysis of >400,000 patients with the 10 deadliest cancers (including breast, lung, and colorectal cancers), Walker et al[25] found those with less

insurance coverage were more likely to present with advanced disease and receive less radiation therapy. Patients with private insurance are more likely to receive proper cancer screening, more prompt appointments, and necessary prescription medications,[26] which may identify the cancer earlier and at more treatable stage. In addition, patients from lower SES backgrounds may only have access to safety-net hospitals, which may have fewer resources and less access to different treatment options. In a retrospective study, the authors found that BM patients treated at safety-net hospitals had fewer follow-up visits and were at a higher risk for neurologic symptoms and hospitalization compared with patients treated at private hospitals.[15] The authors also suggest that limited access to systemic therapies, fewer hospital resources, and a lower quality of medical care at safety-net hospitals may contribute to these results.

The significance of our findings must be considered in the context of the study limitations. First, the study is retrospective and no causality can be determined. Second, the SES variables used rely on Census tract-level attributes and thus are not patient specific. This is an obvious limitation as there exists heterogeneity within a Census tract. Still, Census tracts are areas of 1500–8000 people that are specifically designed to be homogenous with respect to SES and are much smaller than counties, which are more often used to describe patient SES.[27,28] In this way, the Yost index remains a validated metric to measure SES in a large, nationally representative population cancer registry,[29] with robust validity and internal consistency compared with competing measures of SES.[30] Third, as a SEER database study, we are subjected to the limitations common to all administrative datasets including missing data and a reliance on the accurate coding of diagnoses, procedures, and disease characteristics. Given our large sample size, however, the effects of individual, isolated errors on our overall results are unlikely to be large. Fourth, the SEER database does not have granular information on radiation or chemotherapeutic treatment including the dosage, site, fractionation, timing, or radiation delivery method (e.g., LINAC, proton beam, intensity-modulated radiotherapy). Therefore we were unable to assess whether the radiation or chemotherapy received by the patient was intended to treat the systemic disease or whether it was targeted against the central nervous system disease. Notably, SEER does not include data after the first treatment of the cancer and BM, and thus we could not assess the association between SES and receipt of second- or third-line therapies, nor could we determine whether specific patients received care at National Cancer Institute–designated cancer centers, county hospitals, or facilities with radiosurgical equipment. Lastly, we were unable to directly assess disease severity through tumor-specific markers or mutation profiles and, in this way, could not disentangle how this information may have affected individual-level treatment decisions. In the realm of oncologic treatment, we were also unable to determine how individual insurance providers decided to approve or deny coverage for antineoplastic agents. However, we did limit our analyses to patients with known brain metastases at presentation and controlled multivariate analyses for other important covariates including tumor size, location, and grade, and patient insurance status.

Although we were unable to include more granular data on the characteristics of a patient’s radiation or chemotherapeutic treatment, the data did allow us to broadly identify associations with receipt of any radiation or chemotherapy as part of the patient’s first-line therapy. Further studies are needed to assess how SES differences affect treatment selection,

sequence, cost, or dose. In addition, multiinstitution studies with sufficient statistical power and population diversity to assess SES differences across patient groups while concurrently gathering patient-specific information (mutation status, tumor marker levels, insurance providers, etc.) will further elucidate the role that SES occupies in treatment decisions and overall prognosis.

## CONCLUSION

In a large, population-based analysis of brain metastasis patients, we found differences in OS and treatment along socioeconomic strata. More specifically, patients in lower SES tiers suffered worse outcomes and received radiation and chemotherapy less frequently than patients in higher tiers, even after accounting for other tumor- and demographic-related information. While these results are consistent with those of previous studies that identified associations between SES and treatment access for patients with primary brain tumors, this is the first population-based effort to quantify such patterns for patients with BMs. Although awareness is a crucial first step, a concerted effort is required to identify and reverse the causes of this inequity.

## Conflict of interest statement:

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## Abbreviations and Acronyms

| | |
|---|---|
| **aHR** | adjusted hazard ratio |
| **AOR** | Adjusted odds ratio |
| **BM** | Brain metastasis |
| **CI** | Confidence interval |
| **GI** | Gastrointestinal |
| **OS** | Overall survival |
| **SEER** | Surveillance, Epidemiology, and End Results |
| **SES** | Socioeconomic status |
| **SRS** | Stereotactic radiosurgery |

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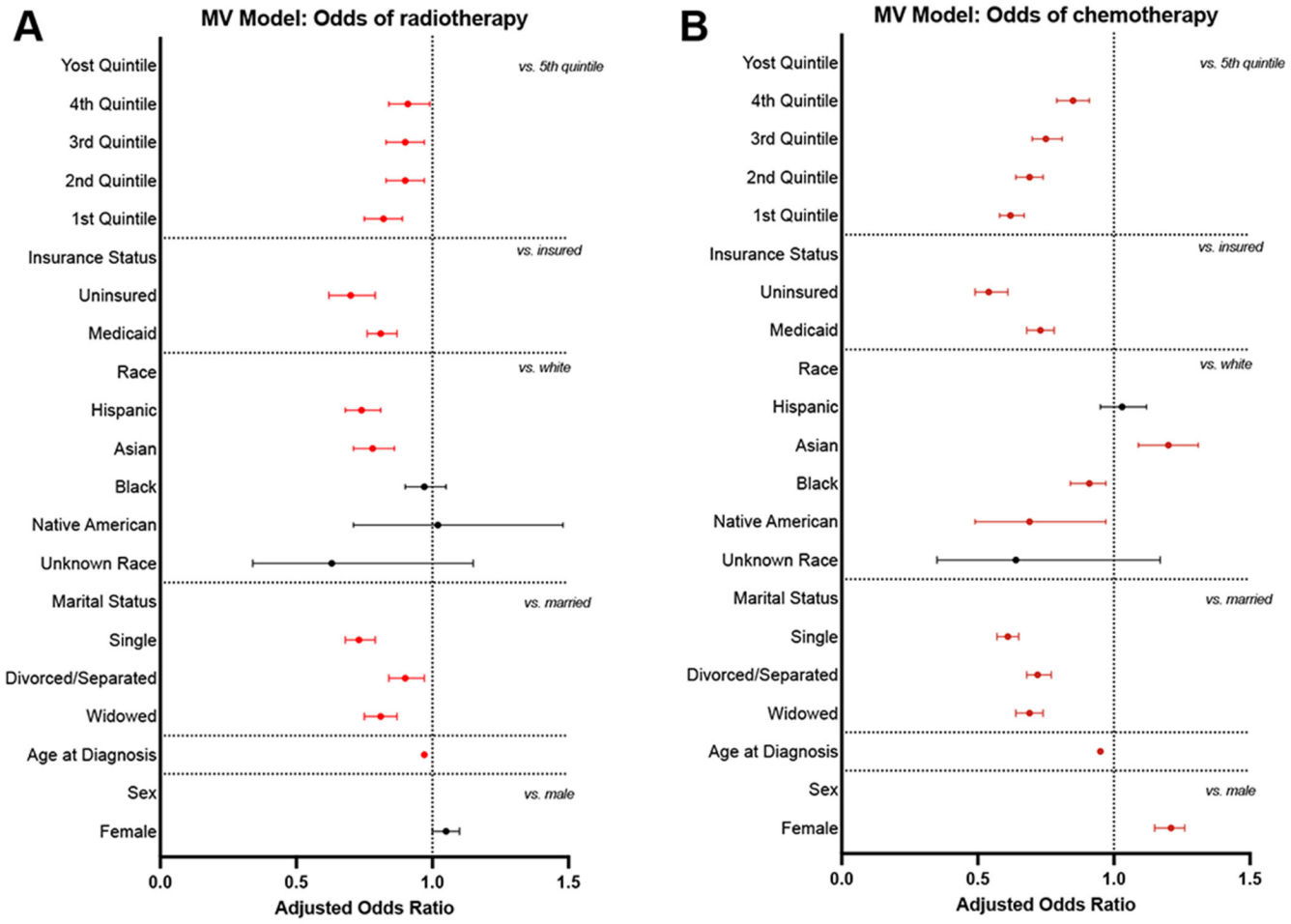


**Figure 1.**

Multivariable logistic regression models. Vertical dotted line is placed at an adjusted odds ratio (OR) of 1.0. For a given variable, the dot indicates the OR and the range indicates the 95% confidence interval. Significant ORs are demarcated in red. In addition to the displayed covariates, each model was also adjusted for primary tumor size, primary tumor grade, and primary tumor location (lung, breast, melanoma, gastrointestinal, or kidney). Receipt of radiation (**A**) or chemotherapy (**B**) as the outcome variable.

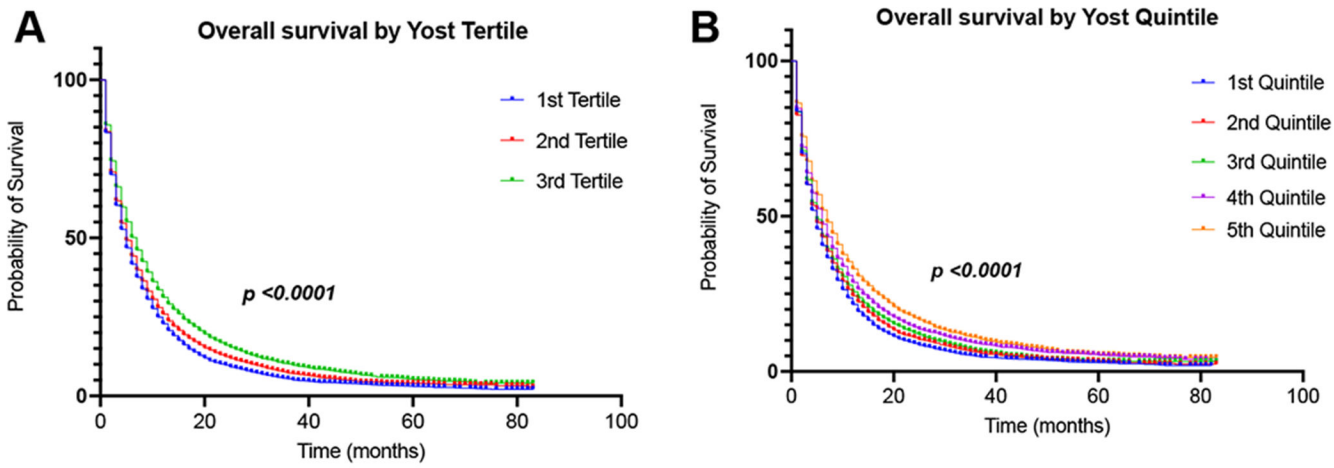


**Figure 2.**

Kaplan-Meier curves stratified by Yost fertile (**A**) or quintile (**B**). All patients were landmarked at 1 month to account for immortal time bias. The log-rank test was used to calculate *P* values.

**Table 1.**

Brain Metastasis Cohort Description

| Variable | Total (n = 35,595) (%) |
|---|---|
| Year of diagnosis | |
| 2010 | 4727 (13.28) |
| 2011 | 4827 (13.56) |
| 2012 | 5017 (14.09) |
| 2013 | 5219 (14.66) |
| 2014 | 5331 (14.98) |
| 2015 | 5318 (14.94) |
| 2016 | 5,156 (14.49) |
| Age at diagnosis (median: IQR) | 65 (57–72) |
| Marital status | |
| Married | 18,444 (51.82) |
| Single | 6358 (17.86) |
| Divorced/separated | 5092 (14.31) |
| Widowed | 4315 (12.12) |
| Unknown | 1386 (3.89) |
| Female | 17,042 (47.88) |
| Primary tumor location | |
| Gastrointestinal tract | 1793 (5.04) |
| Breast | 1490 (4.19) |
| Kidney | 1144 (3.21) |
| Lung | 29,502 (82.88) |
| Melanoma | 1666 (4.68) |
| Race | |
| White | 25,878 (72.70) |
| Hispanic | 2711 (7.62) |
| Asian | 2618 (7.35) |
| Black | 4193 (11.78) |
| Native American | 148 (0.42) |
| Unknown | 47 (0.13) |
| Insurance | |
| Insured | 27,601 (77.54) |
| Uninsured | 1522 (4.28) |
| Medicaid | 5870 (16.49) |
| Unknown insurance status | 602 (1.69) |
| Yost tertile | |
| First | 12,391 (34.81) |
| Second | 12,353 (34.70) |

| Variable | Total (n = 35,595) (%) |
|---|---|
| Third | 10,851 (30.48) |
| Yost quintile | |
| First | 7251 (20.37) |
| Second | 7727 (21.71) |
| Third | 7471 (20.99) |
| Fourth | 7075 (19.88) |
| Fifth | 6071 (17.06) |
| Primary tumor size | |
| 0.1 mm–2 cm | 3153 (8.86) |
| >2–4 cm | 8229 (23.12) |
| >4–6 cm | 6916 (19.43) |
| >6 cm | 8274 (23.24) |
| Unknown | 9023 (25.35) |
| Radiation | |
| No | 10,112 (28.41) |
| Yes | 25,484 (71.59) |
| Chemotherapy | |
| No | 16,225 (45.58) |
| Yes | 19,371 (54.42) |

**Table 2.**

Association Between Socioeconomic Status, Insurance Status, Patient Demographics and Brain Metastasis Survival, Stratified by Primary Site

| | Lung Brain Metastasis (n = 29,502) | | | Breast Brain Metastasis (n = 1490) | | |
|---|---|---|---|---|---|---|
| **Characteristic** | **aHR*** | **95% CI** | ***P* Value** | **aHR*** | **95% CI** | ***P* Value** |
| Yost quintile | | | | | | |
| Fifth | 1.00 | – | – | 1.00 | – | – |
| Fourth | 1.07 | 1.03–1.12 | **0.001** | 1.07 | 0.87–1.31 | 0.537 |
| Third | 1.17 | 1.12–1.22 | **<0.001** | 1.09 | 0.89–1.34 | 0.415 |
| Second | 1.18 | 1.14–1.23 | **<0.001** | 1.17 | 0.96–1.43 | 0.128 |
| First | 1.22 | 1.17–1.27 | **<0.001** | 1.31 | 1.06–1.63 | **0.014** |
| Age at diagnosis | 1.01 | 1.01–1.02 | **<0.001** | 1.01 | 1.00–1.02 | **<0.001** |
| Sex | | | | | | |
| Male | 1.00 | – | – | 1.00 | – | – |
| Female | 0.87 | 0.84–0.89 | **<0.001** | 0.86 | 0.49–1.50 | 0.594 |
| Race | | | | | | |
| White | 1.00 | – | – | 1.00 | – | – |
| Hispanic | 0.86 | 0.82–0.91 | **<0.001** | 0.96 | 0.79–1.17 | 0.698 |
| Asian | 0.71 | 0.67–0.74 | **<0.001** | 1.06 | 0.83–1.36 | 0.623 |
| Black | 0.89 | 0.86–0.93 | **<0.001** | 1.14 | 0.97–1.35 | 0.111 |
| Native American | 1.03 | 0.85–1.25 | 0.741 | 0.63 | 0.23–1.69 | 0.358 |
| Unknown | 0.51 | 0.34–0.77 | **0.001** | – | – | – |
| Insurance status | | | | | | |

| | Lung Brain Metastasis (n = 29,502) | | | Breast Brain Metastasis (n = 1490) | | |
|---|---|---|---|---|---|---|
| **Characteristic** | **aHR*** | **95% CI** | ***P* Value** | **aHR*** | **95% CI** | ***P* Value** |
| Insured | 1.00 | – | – | 1.00 | – | – |
| Uninsured | 1.11 | 1.04–1.18 | **0.002** | 1.22 | 0.95–1.56 | 0.123 |
| Medicaid | 1.07 | 1.03–1.11 | **<0.001** | 0.99 | 0.84–1.15 | 0.851 |
| Unknown insurance status | 0.96 | 0.87–1.06 | 0.454 | 0.60 | 0.35–1.02 | 0.058 |
| | **GI Brain Metastasis (n = 1793)** | | | **Melanoma Brain Metastasis (n = 1666)** | | |
| **Characteristic** | **aHR*** | **95% CI** | ***P* Value** | **aHR*** | **95% CI** | ***P* Value** |
| Yost quintile | | | | | | |
| Fifth | 1.00 | – | – | 1.00 | – | – |
| Fourth | 1.00 | 0.84–1.18 | 0.975 | 1.04 | 0.89–1.22 | 0.611 |
| Third | 1.10 | 0.93–1.30 | 0.261 | 1.08 | 0.92–1.27 | 0.326 |
| Second | 1.16 | 0.99–1.36 | 0.073 | 1.09 | 0.92–1.30 | 0.311 |
| First | 1.07 | 0.90–1.27 | 0.443 | 0.96 | 0.79–1.17 | 0.688 |
| Age at diagnosis | 1.01 | 1.00–1.01 | **0.007** | 1.01 | 1.01–1.02 | **<0.001** |
| Sex | | | | | | |
| Male | 1.00 | – | – | 1.00 | – | – |
| Female | 0.92 | 0.82–1.02 | 0.123 | 0.91 | 0.80–1.03 | 0.126 |
| Race | | | | | | |
| White | 1.00 | – | – | 1.00 | – | – |
| Hispanic | 0.88 | 0.75–1.04 | 0.135 | 0.81 | 0.63–1.06 | 0.123 |
| Asian | 1.07 | 0.86–1.33 | 0.562 | 1.01 | 0.63–1.60 | 0.982 |
| Black | 0.97 | 0.82–1.15 | 0.767 | 1.24 | 0.62–2.51 | 0.543 |

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| Characteristic | Lung Brain Metastasis (n = 29,502) | | | Breast Brain Metastasis (n = 1490) | | |
|---|---|---|---|---|---|---|
| | aHR* | 95% CI | *P* Value | aHR* | 95% CI | *P* Value |
| Native American | 1.44 | 0.77–2.70 | 0.254 | 0.30 | 0.07–1.20 | 0.089 |
| Unknown | 0.82 | 0.20–3.37 | 0.780 | – | – | 1.000 |
| Insurance status | | | | | | |
| Insured | 1.00 | – | – | 1.00 | – | – |
| Uninsured | 0.92 | 0.72–1.17 | 0.492 | 1.27 | 0.96–1.69 | 0.092 |
| Medicaid | 0.94 | 0.81–1.08 | 0.381 | 1.18 | 0.99–1.39 | 0.062 |
| Unknown insurance status | 0.93 | 0.64–1.36 | 0.710 | 1.06 | 0.74–1.52 | 0.742 |

| Characteristic | Kidney Brain Metastasis (n = 1144) | | |
|---|---|---|---|
| | aHR* | 95% CI | *P* Value |
| Yost quintile | | | |
| Fifth | 1.00 | – | – |
| Fourth | 1.17 | 0.94–1.46 | 0.165 |
| Third | 1.30 | 1.05–1.60 | **0.016** |
| Second | 1.31 | 1.06–1.62 | **0.012** |
| First | 1.20 | 0.95–1.50 | 0.127 |
| Age at diagnosis | 1.01 | 1.00–1.02 | **0.002** |
| Sex | | | |
| Male | 1.00 | – | – |
| Female | 1.08 | 0.93–1.24 | 0.313 |
| Race | | | |

| | Kidney Brain Metastasis (n = 1144) | | |
|---|---|---|---|
| **Characteristic** | **aHR*** | **95% CI** | ***P* Value** |
| White | 1.00 | – | – |
| Hispanic | 0.87 | 0.73–1.05 | 0.155 |
| Asian | 1.09 | 0.82–1.43 | 0.559 |
| Black | 1.17 | 0.90–1.54 | 0.243 |
| Native American | 0.45 | 0.11–1.83 | 0.262 |
| Unknown | 0.24 | 0.03–1.72 | 0.155 |
| Insurance status | | | |
| Insured | 1.00 | – | – |
| Uninsured | 0.98 | 0.71–1.37 | 0.928 |
| Medicaid | 1.01 | 0.84–1.23 | 0.895 |
| Unknown insurance status | 2.46 | 1.14–5.30 | **0.022** |

Bold values indicate statistical significance.

aHR, adjusted hazard ratio; CI, confidence interval.

*All models also adjusted for marital status, primary tumor size, primary tumor grade, and receipt of radiation and chemotherapy.