

Predictors of Survival After Prophylactic Femoral Fixation for Metastatic Bone Disease: Where You Live Matters

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Significance: Expected survival is a critical factor in the management of patients with metastatic bone disease (MBD), as it guides both the decision to pursue surgical intervention and the selection of operative technique. While tumor biology is a well-established determinant of survival, the role of social determinants of health has not been well characterized. The Area Deprivation Index (ADI) measures neighborhood-level socioeconomic deprivation and may represent an underappreciated contributor to survival differences in this population. This study aims to assess the association between ADI and two-year disease-specific survival (DSS) in patients undergoing prophylactic femoral fixation for MBD. We hypothesize that greater neighborhood deprivation would independently predict worse survival.

Innovation: This is the first study to evaluate survival in MBD using the emerging and widely adopted ADI metric. The findings may offer a novel framework for understanding disparities in surgical oncology outcomes and allow future research to elucidate the mechanisms underlying this association.

Approach: This was an institutional retrospective study of 336 patients who underwent prophylactic intramedullary nail fixation of the femur for MBD from January 2009 to December 2025. Restricting the cohort to this population was intended to reduce variability in a highly heterogeneous population and allow for more consistent comparisons of survival outcomes. ADI was derived from U.S. Census-based measures of income, education, employment, and housing quality, with higher values indicating greater deprivation. Scores were categorized into three groups (Group 1 = 0 to 33, Group 2 = 34 to 66, Group 3 = 67 to 100). The primary outcome was two-year DSS, measured from the date of surgery. Kaplan-Meier analysis with log-rank testing was used to compare survival by ADI as well as primary tumor type. Multivariable Cox proportional hazards models adjusted for age, race, ADI, and primary cancer type were used to identify independent predictors of survival.

Results: Two-year DSS was significantly worse for patients in ADI3 and ADI2 compared to ADI1 (34% vs. 38% vs. 64%, $p = 0.048$) (Figure 1A). When controlling for age, race, and primary cancer, ADI3 [HR 1.97 (1.03-3.8), $p = 0.042$] and ADI2 [HR 1.96 (1.0-3.9), $p = 0.049$] were associated with worse survival compared to ADI1 (Table 2). Median time to death was 10 months [IQR 6.7-35.4] for ADI1, 7 months [IQR 2.8-15.8] for ADI2, and 8 months [IQR 2.2-17.3] for ADI3 ($p = 0.34$) (Figure 1B). Primary tumor type was also significantly associated with survival in unadjusted and adjusted models (Figure 1C and Table 2).

Discussion and Impact: In unadjusted and adjusted models, ADI independently predicted survival following prophylactic fixation for MBD. These findings highlight that survival disparities are not only driven by tumor biology, but also social determinants of health. Incorporating ADI into clinical risk stratification may improve prognostication and inform patient counseling and resource allocation.

Variable	Level	ADI 1 (n = 29)	ADI 2 (n = 105)	ADI 3 (n = 202)
Age*		63.5 (56.3–68.4)	65.4 (58.3–72.5)	62.6 (55.4–72.7)
Sex	Female	16 (55.2%)	56 (53.3%)	113 (55.9%)
	Male	13 (44.8%)	49 (46.7%)	89 (44.1%)
Race	White/Other	29 (100.0%)	100 (95.2%)	161 (79.7%)
	Black	0 (0.0%)	5 (4.8%)	41 (20.3%)
Primary Cancer	Breast	5 (17.2%)	20 (19.0%)	45 (22.3%)
	Myeloma	5 (17.2%)	25 (23.8%)	42 (20.8%)
	Lung	3 (10.3%)	19 (18.1%)	46 (22.8%)
	Prostate	1 (3.4%)	9 (8.6%)	17 (8.4%)
	RCC	6 (20.7%)	16 (15.2%)	18 (8.9%)
	Other	9 (31.0%)	16 (15.2%)	34 (16.8%)

Table 1. Baseline Characteristics

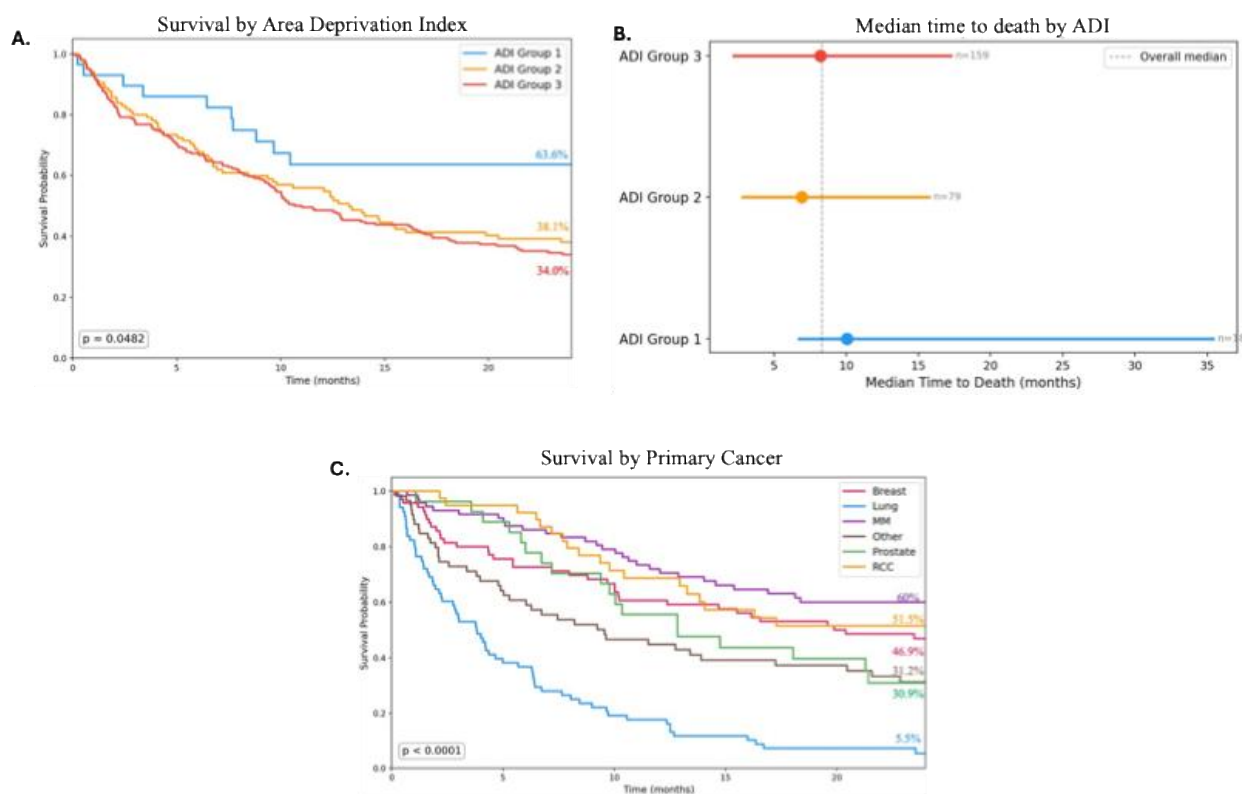


Figure 1. Kaplan-Meier Survival Plots and Forest Plots for Median Time to Death

Variable		2-Year Risk of Disease-Specific Death		
		HR	95% CI	P-value
Age		1.01	(0.999 – 1.023)	0.067
ADI	Group 1			
	Group 2	1.96	(1.001 – 3.853)	0.049
	Group 3	1.97	(1.026 – 3.799)	0.042
Race	White/Other			
	Black	1.48	(0.998 – 2.180)	0.051
Primary Cancer	Myeloma			
	Breast	1.62	(0.988 – 2.664)	0.056
	Lung	6.34	(4.012 – 10.002)	<0.0001
	Prostate	1.85	(1.019 – 3.352)	0.043
	RCC	1.32	(0.722 – 2.404)	0.37
	Other	2.90	(1.765 – 4.749)	<0.0001

Table 2. Cox Proportional Hazard Model for Risk of Disease-Specific Death