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Marital Status, Treatment Delay, and Survival in Renal Cell Carcinoma: A Population-Based SEER Cohort Study

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ABSTRACT

Background

Marital status influences cancer outcomes, but whether earlier surgical access explains the "marriage benefit" in renal cell carcinoma (RCC) remains unclear.

Methods

Using SEER data (2010–2017), we identified adults with primary RCC of the kidney. Marital status was classified as married, single, divorced, separated, widowed, or domestic partner. Time-to-treatment (TTT) was the primary process outcome; delay was defined as TTT >30 days. Overall survival (OS) was the primary clinical outcome. Multivariable logistic regression, Kaplan–Meier and Cox models, propensity score matching (PSM), and mediation analysis were employed.

Results

Among 19,579 patients (median age 66.0 years; 65.2% male), median TTT was 9.0 days for married patients versus 22.0 days for separated patients and 20.0 days for domestic partners. Black race (OR 1.35), separated status (OR 1.39), and divorced status (OR 1.17) independently predicted a delay of >30 days. Five-year OS ranged from 84.2% (domestic partners) to 65.5% (widowed). Married patients had lower mortality (HR 0.82) and retained a survival advantage after PSM (HR 0.50; 6,924 matched pairs). Mediation analysis showed that TTT accounted for <1% of the association between marriage and survival.

Conclusions

Marriage is strongly associated with treatment timeliness and survival in RCC, yet earlier surgery explains little of this benefit, implicating broader psychosocial and structural factors. Separated, divorced, domestic partner, older, and Black patients warrant prioritised support.

Keywords: Renal cell carcinoma · marital status · social determinants of health · time-to-treatment · treatment delay · overall survival · SEER · propensity score matching · mediation analysis

Introduction

Renal cell carcinoma (RCC) accounts for approximately 90% of kidney cancers, with over 430,000 new cases estimated globally in 2020 [1]. Surgery remains the mainstay of curative treatment, and timely definitive therapy is a key quality indicator [2]. Increasingly, outcomes are recognised to depend not only on tumour biology but also on social determinants of health,

including relationship status and social support [3–5].

Marital status is a strong indicator of social support in cancer. In a large SEER analysis spanning the leading causes of cancer death, Aizer et al. showed that unmarried individuals presented with more advanced disease, received less definitive treatment, and had higher mortality [6], and similar associations have been reported across other tumour types [7,8]. Meta-analytic evidence further links marriage or strong social support to a 10–25% relative mortality reduction, plausibly mediated through better adherence, psychological buffering, and healthier behaviours [9].

Several SEER-based studies have confirmed that married RCC patients experience better survival than unmarried patients [3,10,11]. However, most have focused on survival and stage, with limited attention to process measures such as time-to-treatment. Whether married patients live longer partly because they reach surgery more promptly remains uncertain [2].

Additionally, racial and ethnic disparities in RCC outcomes are well documented, with Black patients often faring worse [12]. Asian/Pacific Islander groups are typically analysed as a single category, potentially masking subgroup differences, and marital subcategories such as separated and domestic partner statuses are frequently collapsed [13].

Using SEER data (2010–2017), we examined the associations between marital status, treatment delay, and survival in a large RCC cohort. We analysed treatment latency across detailed marital and racial/ethnic subgroups, identified predictors of delay, and assessed survival using Cox and propensity score–matched analyses with mediation testing. We hypothesised that married patients would have shorter delays and better survival, but that surgical timeliness would only partly explain the “marriage benefit”.

Methods

Study Design and Data Source

We conducted a retrospective cohort analysis using anonymised Surveillance, Epidemiology, and End Results (SEER) Programme data on primary kidney RCC (excluding renal pelvis) diagnosed between 2010 and 2017. Analyses of de-identified, publicly available SEER data are exempt from institutional ethics review. The study is reported in accordance with the Strengthening the Reporting of Observational Studies in Epidemiology (STROBE) guideline.

Study Population

Analyses were restricted to adults (≥18 years) with complete data on age, sex, race/ethnicity, marital status, time to treatment, survival time, and vital status. Non-parsable entries were excluded through complete-case analysis. Histological and site restrictions were applied during SEER extraction.

Variables

Marital Status

Marital status at diagnosis was recorded from the "Marital status at diagnosis" category and classified into six groups:

- Married (including common-law)
- Single (never married)
- Divorced
- Separated
- Widowed
- Domestic partner

For certain analyses, a binary variable was also created to distinguish between Married and Unmarried (all other categories).

Demographic Variables

Age at diagnosis was treated continuously. Sex was recorded directly from SEER. Race/ethnicity was grouped as White, Black, or Other (including Asian/Pacific Islander, American Indian/Alaska Native, and other/unknown); Asian/Pacific Islander subgroups were examined separately in descriptive latency analyses.

Outcomes

- **Time-to-treatment (TTT):** days from diagnosis to first definitive therapy, analysed continuously and as a binary indicator of delay (TTT >30 days).
- **Overall survival (OS):** time in months from diagnosis to death from any cause or last follow-up, based on "Survival months" and "Vital status recode (study cutoff used)." Patients alive at last contact were censored.

Statistical Analysis

Descriptive and Correlation Analyses

Baseline characteristics were summarised using medians (IQR) or counts (percentages). TTT and OS were stratified by marital status and race/ethnicity. Pearson correlations quantified associations between age, TTT, and survival.

Predictors of Treatment Delay

Multivariable logistic regression modelled delay >30 days as the outcome, with marital status and race as main predictors, adjusting for age and sex. Results are reported as odds ratios (ORs) with 95% CIs.

Survival Analysis

Kaplan–Meier curves and log-rank tests estimated unadjusted OS differences. Cox proportional hazards models, adjusting for age, sex, and race, estimated hazard ratios (HRs) with 95% CIs. Proportional hazards assumptions were assessed with standard diagnostics.

Propensity Score Matching

Propensity score matching (PSM) compared married versus unmarried patients. Scores were estimated via logistic regression on age, sex, and race; 1:1 nearest-neighbour matching was applied. Balance was assessed using standardised mean differences. A Cox model estimated the matched HR for death.

Mediation Analysis

Mediation analysis examined whether TTT mediated the association between marriage and survival by comparing Cox models with and without adjustment for TTT. The proportion mediated was approximated from the change in the marriage coefficient.

Software and statistical significance

All analyses were performed in Python 3.12 using pandas, statsmodels, lifelines, and scikit-learn. Two-sided p-values <0.05 were considered significant.

Results

Patient population

A total of 19,579 patients with RCC diagnosed between 2010 and 2017 were included. The median age at diagnosis was 66.0 years (mean 61.2, SD 12.3). Most were male (65.2%, n=12,768) and White (80.2%, n=15,701), with Black (9.6%, n=1,874), Asian/Pacific Islander (6.6%, n=1,302), American Indian/Alaska Native (1.7%, n=327), and Other (1.9%, n=375) minorities. The largest marital group was Married (64.6%, n=12,649), followed by Single never married (16.9%, n=3,308), Divorced (9.9%, n=1,933), Widowed (7.2%, n=1,413), Separated (0.9%, n=179), and Domestic partner (0.5%, n=97) (**Table 1**).

Table 1. Baseline characteristics of the study cohort (n = 19,579)

Characteristic	Category	N	Percentage (%)
Total		19,579	100.0
Age (years)	Mean (SD)	61.2	12.3
	Median (IQR)	66.0	–
Sex	Male	12,768	65.2
	Female	6,811	34.8
Race	White	15,701	80.2
	Black	1,874	9.6
	Asian / Pacific Islander	1,302	6.6
	American Indian / Alaska Native	327	1.7
	Other	375	1.9
Marital status	Married	12,649	64.6
	Single (never married)	3,308	16.9
	Divorced	1,933	9.9
	Widowed	1,413	7.2
	Separated	179	0.9
	Domestic partner	97	0.5

Time-to-treatment

Overall, the median time-to-treatment (TTT) was 10.0 days (IQR 45.0). Marked differences were observed by marital status: Married patients had the shortest TTT (median 9.0 days), Single patients a median of 11.0 days, Divorced and Widowed patients 13.0 and 15.0 days, and Separated and Domestic partner patients the most extended delays at 22.0 and 20.0 days, respectively, consistent with a ‘partner penalty’ in disrupted or non-formalised unions (**Table 2, Figure 1**).

Table 2. Time-to-treatment by marital status

Marital status	N	Median TTT (days)	Mean TTT (days)	SD (days)
Married	12,644	9.0	28.74	46.95
Single (never married)	3,304	11.0	35.31	58.92
Divorced	1,931	13.0	34.16	51.25
Widowed	1,413	15.0	35.58	57.44
Separated	179	22.0	40.82	57.08
Domestic partner	97	20.0	44.35	63.40

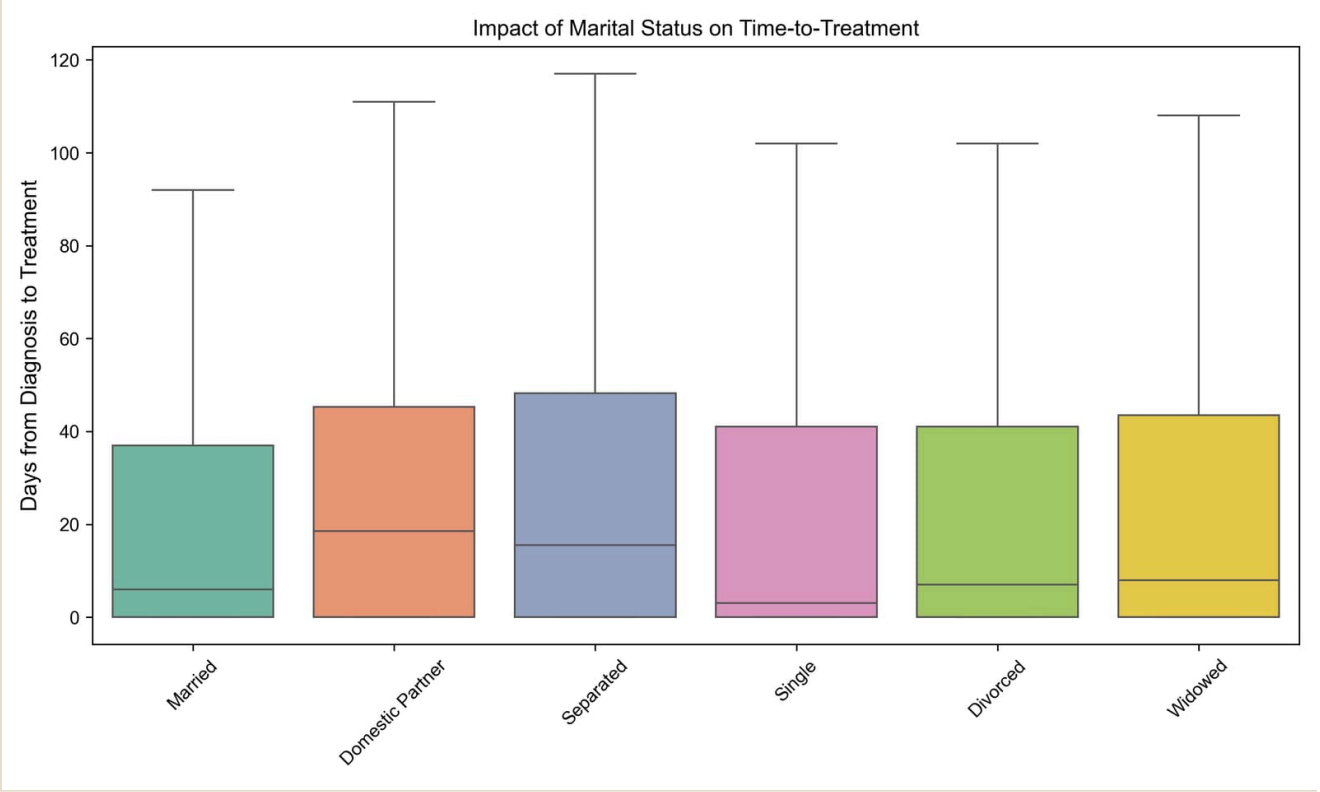


Figure 1. Impact of marital status on time-to-treatment

By race, median TTT was 10 days for White and 9 days for Black patients. Disaggregation of Asian/Pacific Islander subgroups revealed substantial heterogeneity: Kampuchean (Cambodian) patients had the most extended delay (64.0 days), followed by Thai and Korean (29.0 days each) and Tongan (27.0 days). In contrast, Asian Indian and Laotian patients had median TTTs of 0.0 days, and Samoan patients had a median TTT of 1.0 days (**Table 3**).

Table 3. Median time-to-treatment by detailed racial/ethnic subgroup

Race/ethnicity	Median TTT (days)
Kampuchean (Cambodian)	64.0
Thai	29.0
Korean	29.0
Tongan	27.0
Vietnamese	21.5
Micronesian, NOS	21.0
Filipino	17.0
American Indian / Alaska Native	16.0
Chinese	13.0
White	10.0
Black	9.0
Asian Indian	0.0
Laotian	0.0
Samoan	1.0

A correlation matrix showed a weak negative correlation between TTT and survival (r = –0.0528, p<0.05), a stronger negative correlation between age and survival (r = –0.1727), and almost no correlation between age and TTT (r = 0.0498), indicating that delay alone explains little of the survival variation.

Predictors of significant treatment delay

Clinically significant delay (TTT >30 days) occurred in approximately one-third of Married patients and more frequently in all other marital categories (**Figure 2**). In multivariable logistic regression (**Table 4**), compared with Married patients, Separated patients had 39% higher odds of delay (OR 1.39; 95% CI 1.03–1.87; p=0.033) and Divorced patients 17% higher odds (OR 1.17; 95% CI 1.06–1.29; p=0.002), while Widowed status was not significant (OR 1.08; 95% CI 0.96–1.22; p=0.185). Black race was strongly associated with delay (OR 1.35; 95% CI 1.22–1.49; p<0.001), and the “Other” race showed a borderline effect (OR 1.10; 95% CI 1.00–1.21; p=0.063). Each additional year of age increased the odds of delay by 1% (OR 1.01; p<0.001), whereas sex was not associated with delay (OR for male 1.02; 95% CI 0.96–1.08; p=0.575) (**Table 4**).

Table 4. Multivariable logistic regression for predictors of time-to-treatment > 30 days

Predictor	Odds ratio (OR)	95% CI	p-value
Marital status (ref: Married)			
Divorced	1.17	1.06–1.29	0.002
Separated	1.39	1.03–1.87	0.033
Widowed	1.08	0.96–1.22	0.185
Race (ref: White)			
Black	1.35	1.22–1.49	<0.001
Other	1.10	1.00–1.21	0.063
Covariates			
Age (per year)	1.01	1.01–1.02	<0.001
Sex (male)	1.02	0.96–1.08	0.575

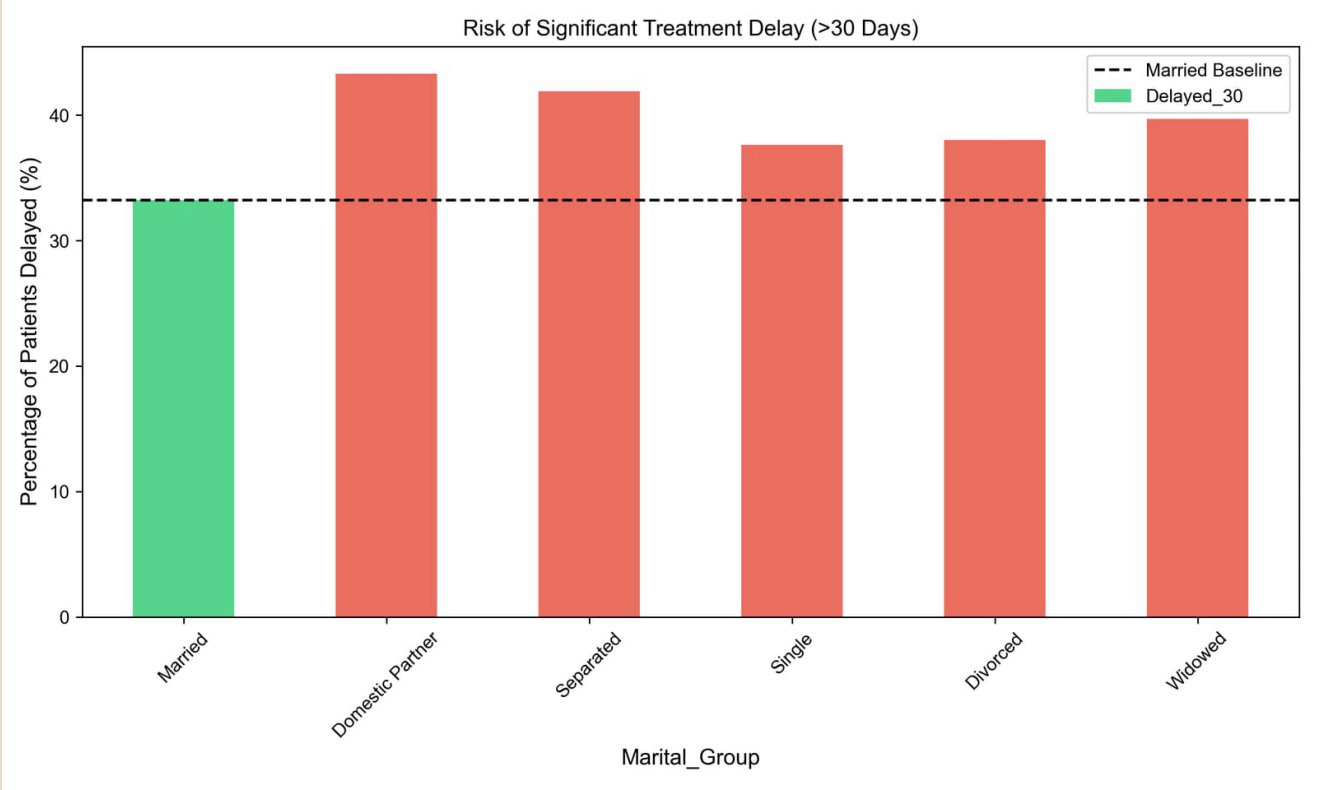


Figure 2. Risk of clinically significant treatment delay by marital status

Survival analysis

Unadjusted 5-year overall survival (OS) differed significantly by marital status (log-rank p<0.001; **Figure 3**). Domestic partners had the highest 5-year OS (84.2%), Married and Single patients had similar survival (both 79.8%), Divorced and Separated patients were intermediate (76.9% and 73.7%), and Widowed patients had the poorest survival (65.5%). Kaplan–Meier curves showed early and sustained separation for Widowed patients, with Married and Domestic partner curves consistently highest and Separated patients intermediate (**Figure 3**).

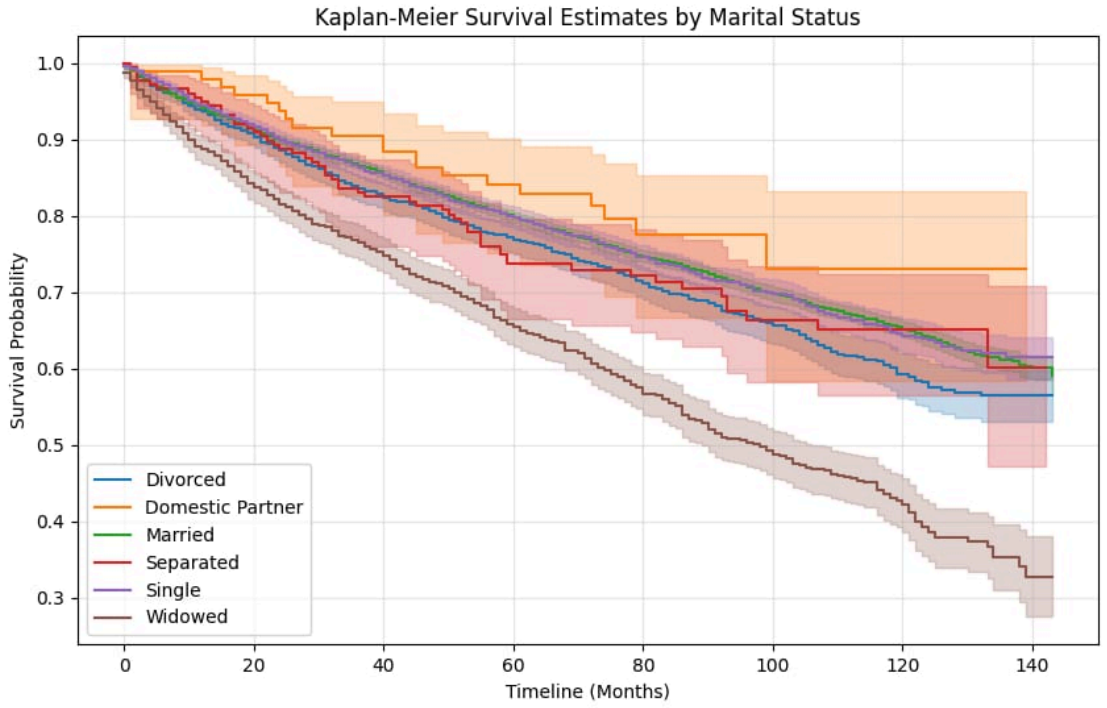


Figure 3. Kaplan–Meier overall survival by marital status

In the adjusted Cox model, Married patients had an 18% lower risk of death than Single patients (HR 0.82; 95% CI 0.75–0.89; p<0.001). Separated (HR 1.08; p=0.581) and Widowed (HR 1.08; p=0.198) patients did not differ significantly from Single patients after adjustment. Age was a strong predictor of mortality (HR 1.05 per year; 95% CI 1.04–1.05; p<0.001), and males had a higher risk than females (HR 1.31; 95% CI 1.24–1.39; p<0.001). Compared with Other/Unknown race, White patients had modestly better survival (HR 0.88; 95% CI 0.81–0.96; p=0.005), while the Other category did not differ (HR 0.94; 95% CI 0.83–1.05; p=0.271) (**Table 5**).

Table 5. Cox proportional hazards model for overall survival

Variable	Hazard ratio (HR)	95% CI	p-value
Marital status (ref: Single)			
Married	0.82	0.75–0.89	<0.001
Separated	1.08	0.82–1.42	0.581
Widowed	1.08	0.96–1.20	0.198
Demographics			
Age (per year)	1.05	1.04–1.05	<0.001
Sex (male)	1.31	1.24–1.39	<0.001
Race (ref: Other/Unknown)			
White	0.88	0.81–0.96	0.005
Other	0.94	0.83–1.05	0.271

Propensity score–matched analysis

Propensity score matching yielded 6,924 Married and 6,924 Unmarried patients with balanced age, sex, and race (all post-match standardised mean differences <0.1; **Figure 4**). The mean age difference fell from 1.23 to 0.09 years. In this matched cohort, Married patients still had

substantially shorter TTT (median 0.0 vs 13.0 days for Unmarried) and a marked survival advantage: the matched HR for death was 0.50 (p<0.001), indicating a 50% lower mortality risk for Married patients despite comparable baseline demographics.

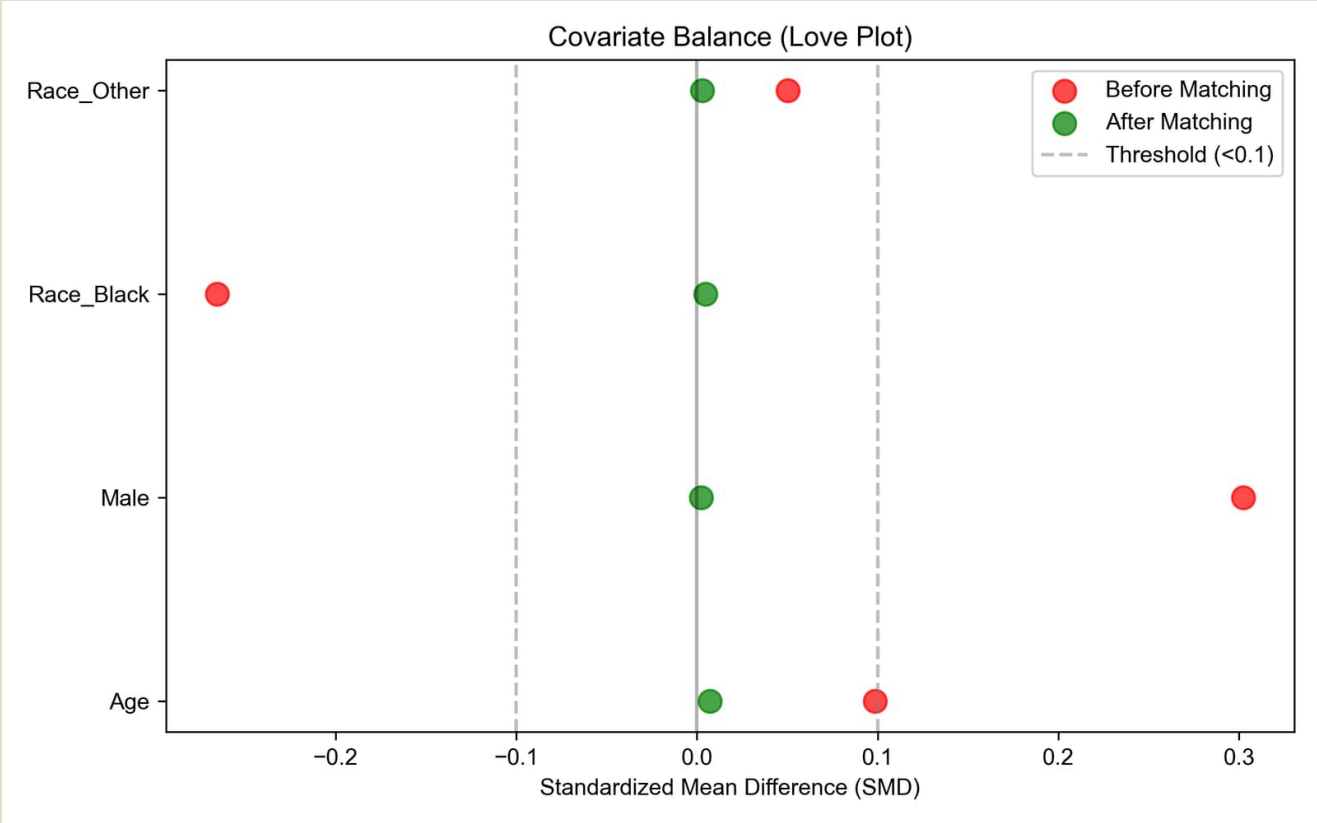


Figure 4. Covariate balance before and after propensity score matching (Love plot)

Mediation analysis of time-to-treatment

Mediation analysis examined the pathway "Marital status → TTT → Survival." Being married was associated with shorter TTT (path A coefficient = –6.4255; p < 0.001), but TTT was essentially unrelated to survival in the mediation model (path B coefficient = 0.0004). The total effect of marriage on survival (Cox coefficient –0.2851) changed minimally after including TTT (direct effect –0.2828), representing only a 0.80% attenuation (**Figure 5**). Corresponding hazard ratios (≈0.75 for both total and direct effects) were nearly identical, indicating that TTT does not materially mediate the survival benefit of marriage.

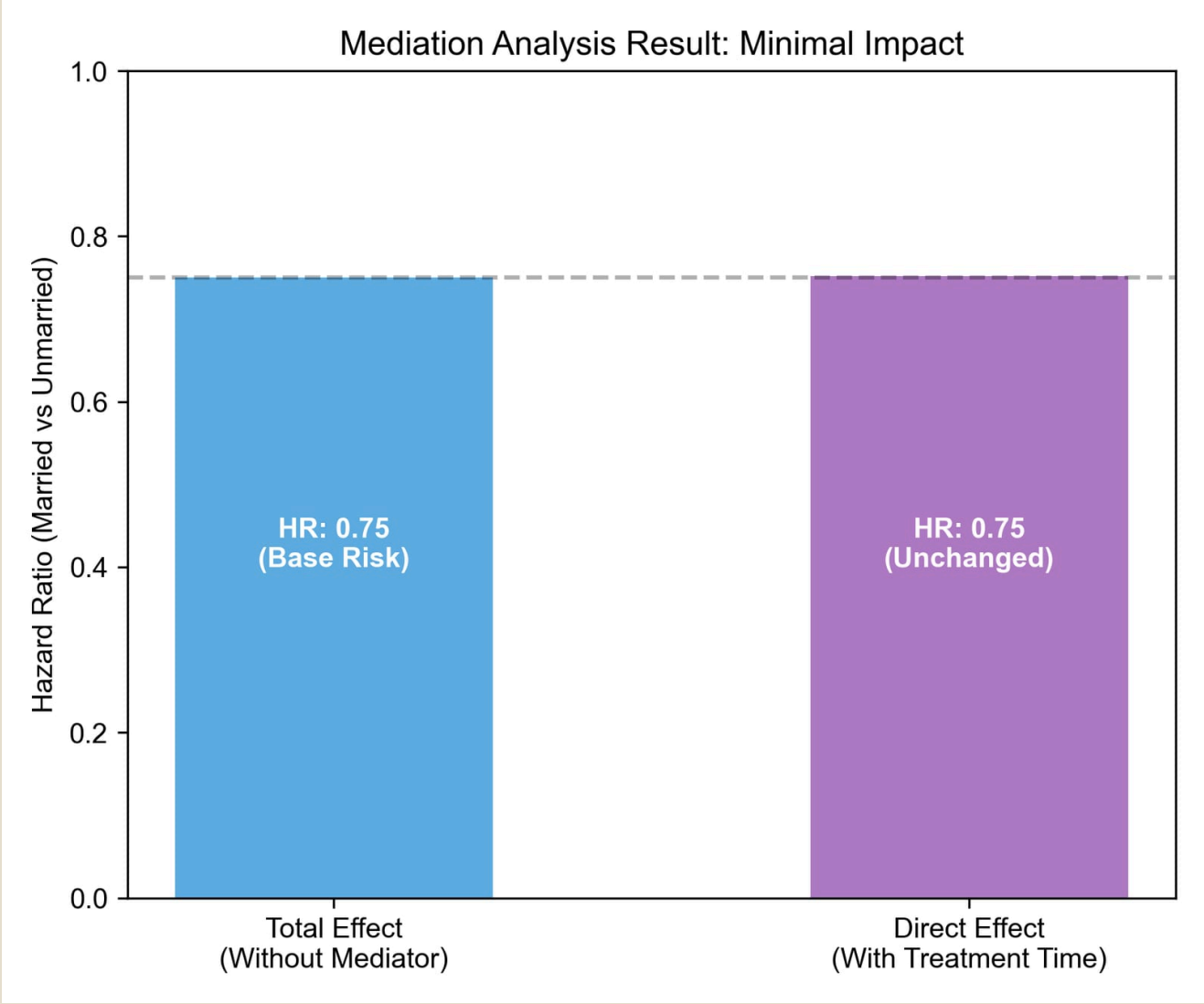


Figure 5. Mediation analysis of time-to-treatment in the marriage–survival association

Overall, these findings show that marriage is associated with faster treatment and substantially better survival, whereas the survival advantage appears largely driven by factors other than earlier surgery.

Discussion

In this population-based analysis of 19,579 RCC patients, marital status was strongly associated with treatment timeliness and overall survival. Married patients had the shortest TTT and best survival, whereas separated, divorced, and domestic partner groups experienced longer delays. Black race and older age independently predicted delay >30 days, and several Asian/Pacific Islander subgroups had strikingly prolonged TTT. However, mediation analysis showed that TTT accounted for <1% of the marriage–survival advantage, suggesting the mechanism is not primarily faster surgical access.

Comparison with previous literature

Our results align with prior work. Aizer et al. reported that married patients had earlier-stage disease, more definitive therapy, and better survival across major cancer types [6], and subsequent meta-analyses have reinforced a modest but clinically relevant marriage–survival benefit [14].

For RCC specifically, several SEER-based studies have identified marital status as an independent prognostic factor [3,10,11]. Li and colleagues, analysing almost 100,000 RCC cases, found that married patients had higher 5-year overall and cancer-specific survival than single, divorced/separated, or widowed patients, even

after adjustment for demographic and tumour characteristics [10]. Similarly, Wang et al., analysing more than 62,000 renal cancer patients, reported the highest 5-year cause-specific survival in the married group, with widowed and divorced/separated patients experiencing significantly worse outcomes on multivariable modelling [3]. Our findings corroborate this pattern: in unadjusted analyses, married patients had superior 5-year overall survival, and widowed patients had the poorest outcomes.

Our study adds nuance. In our Cox model, married status remained protective (HR 0.82) with single patients as the reference, whereas separated and widowed status were no longer significant after adjustment. The attenuation of the widowhood effect is consistent with these patients being substantially older, suggesting that age and comorbidities, rather than widowhood per se, drive their poorer survival [11,15].

Unlike most prior RCC studies, which examined survival alone [16–18], we explicitly evaluated TTT as a mediator. Although pan-cancer work suggests that the marriage–survival link may be partly mediated through earlier treatment [7], our mediation analysis showed negligible attenuation, suggesting that in RCC the association is driven more by downstream behavioural or comorbidity-related factors than by surgical timing.

We demonstrate a pronounced "partner penalty": separated and domestic partner patients had the longest delays, although both were small subgroups. Yet separated status did not confer higher adjusted mortality than single status, suggesting that social disruption at diagnosis affects care timeliness more than long-term survival.

We extend the literature on racial disparities in RCC [12]. Black patients had significantly higher odds of delay (OR 1.35) despite a comparable median TTT, suggesting that the excess risk is concentrated in a subset of patients with prolonged delay. We also found substantial heterogeneity within Asian/Pacific Islander subgroups: Kampuchean, Thai, and Korean patients had the longest delays, whereas Asian Indian and Laotian patients often received same-day treatment, patterns largely absent from prior reports.

Potential mechanisms

The social support literature suggests that spouses provide instrumental assistance, emotional support, financial stability, and healthcare advocacy, improving adherence and reducing physiological stress. Married patients may also have healthier behaviours and greater engagement with preventive care [19].

Delays among separated and domestic partner patients likely reflect logistical disruptions, financial instability, and the loss of a primary support person. Domestic partnerships may also lack legal recognition, which can limit access to coordinated care. The attenuation of the widowhood effect after age adjustment aligns with prior research, suggesting widowhood may serve as a proxy for advanced age and frailty rather than an independent cause of poor outcomes.

Strengths and limitations

Strengths include the large, contemporary SEER cohort, which provides substantial statistical power; complementary analytic approaches (multivariable regression, PSM, mediation analysis); and disaggregation of marital status into six categories, with detailed Asian/Pacific Islander subgroup analysis.

Limitations include residual confounding inherent to registry-based studies. SEER lacks data on comorbidities, performance status, income, education, and psychosocial measures. We were unable to adjust for tumour stage, grade, and treatment modality, which were not uniformly available and may lie on the causal pathway; thus, hazard ratios should be interpreted as partially adjusted associations.

Marital status was recorded only at diagnosis and may not reflect subsequent changes or supportive non-marital relationships. The domestic partner group was small, producing wide confidence intervals. TTT was registry-derived and may be subject to measurement error. We examined

overall rather than cause-specific survival, so non-cancer deaths may contribute to observed patterns.

Clinical implications and future directions

These findings argue for systematic identification of socially vulnerable RCC patients at diagnosis. Separated, divorced, domestic partner, and widowed patients—along with Black patients and older adults—warrant proactive referral to navigation and psycho-oncology services.

The negligible mediating role of TTT suggests that shortening wait times alone will not eliminate survival disparities. Interventions targeting adherence, comorbidity management, and social connectedness for unmarried patients may be more impactful [14].

The heterogeneity across racial/ethnic subgroups underscores the need for disaggregated data in equity-focused care, with targeted outreach for high-risk communities such as Kampuchean, Thai, and Korean patients.

Future research should incorporate comorbidity indices, detailed staging, insurance status, and validated social support measures. Prospective intervention trials examining navigation or psychosocial programmes for socially isolated patients could clarify whether the "marriage benefit" is modifiable.

Conclusion

This study confirms that marriage is associated with both faster treatment and substantially better survival in RCC, but demonstrates that earlier surgery explains very little of this survival advantage. The data point instead towards broader psychosocial and structural determinants of outcome, highlighting marital status and social support as key, and potentially modifiable, dimensions of contemporary RCC care.

DECLARATIONS

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Competing interests

The authors declare that they have no competing interests.

Ethical approval

This study utilised anonymised, publicly available data from the Surveillance, Epidemiology, and End Results (SEER) Programme. In accordance with institutional policies and national regulations, secondary analyses of de-identified SEER data are exempt from formal review by a research ethics committee or institutional review board, and no approval number was required. As no identifiable human subjects were involved, informed consent was not required.

Informed consent

NA

Data availability

The datasets analysed during the current study are available from the SEER Programme of the US National Cancer Institute (https://seer.cancer.gov) upon reasonable request and data-use agreement with SEER. The analytic code used in this study is available from the corresponding author on reasonable request.

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