

Benefits of marriage on relative and conditional relative cancer survival differ between males and females in the USA

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Abstract

Purpose The purpose of the paper is to assess the influence of marital status on conditional relative survival of cancer according to sex.

Methods Analyses involved 779,978 males and 1,032,868 females diagnosed with 1 of 13 cancer types between 2000 and 2008, and followed through 2013. Data are from the Surveillance, Epidemiology, and End Results (SEER) Program. Regression models were adjusted for age, sex, race, and tumor stage.

Results Five-year relative survival conditional on years already survived is higher among married patients with less lethal cancers (oral cavity and pharynx, colon and rectum, breast, urinary bladder, kidney and renal pelvis, melanoma of the skin, thyroid, lymphoma). For more lethal cancers, married patients have similar (liver, lung and bronchus, pancreas, leukemia) or poorer (brain and other nervous system) cancer survival. Separated/divorced or widowed patients have the lowest conditional relative survival rates. For most cancers, 5-year cancer relative survival rates conditional on time already survived through 5 years approach 70 to 90% of that for the general population. The beneficial effect of marriage on survival decreases with years already survived. Superior conditional relative survival rates in females decrease with time already survived and are less pronounced in married patients.

Conclusion Five-year relative survival rates improve with time already survived. The benefits of marriage on conditional

relative survival are greater for less lethal cancers. Greater 5-year conditional relative survival rates in females narrow with time already survived and are less pronounced in married patients.

Implications for Cancer Survivors Conditional relative survival rates of cancer can lead to more informed decisions and understanding regarding treatment and prognosis.

Keywords Cancer · Conditional survival · Relative survival · Population-based · Prognosis · SEER

Introduction

In the USA, population-based 5-year relative survival for all cancers combined increased over the past 3 decades (e.g., 20% for Whites and 24% for Blacks) [1]. From 2003 through 2012, cancer death rates decreased by 1.8% per year for males and 1.4% per year for females [2]. For cancer survivors, the prospect of recovery from the usual course of the disease changes with time already survived. Conditioning the survival rate on time already survived is a more informative prognostic indicator as the patient advances through the course of the disease. For example, 5-year relative survival for melanoma skin cancer is 18% for distant staged cases, 30% for those who already survived 1 year, 50% for those who already survived 2 years, and above 80% for those who already survived 5 years [3]. Conditional relative survival rates for cancer patients may be further tailored by variables such as age, sex, and marital status. This more specific information is of greater importance to patients, their families, and physicians in terms of shared decision-making and determining the likely time to “cure.”

Several studies have identified improved relative cancer survival among married patients, even among those diagnosed in later stages or who go untreated [4–11]. Married cancer

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patients generally experience higher rates of early detection, surgical treatment, and long-term survival [8, 12–15]. The effect of marital status on conditional relative survival rates of cancer is not well understood.

Although females generally have better cancer survival than males [16, 17], the beneficial effect of marriage on cancer survival is greater in males than that in females [8–10, 18]. Reasons why males benefit more from marriage than females in terms of cancer survival remain somewhat speculative. However, research has linked depression in cancer patients with lower adherence to treatment and poorer survival [19], and research has also found that married men have lower levels of depressive symptoms than married women, whereas there is no difference in depressive symptoms between men and women who are not married [17]. The effect of marital status on conditional relative cancer survival rates of cancer according to sex is also not well understood.

The purpose of the current paper is to identify the influence of marital status on conditional relative cancer survival in patients diagnosed with selected types of cancer. The modifying effect of sex on the association between marital status and conditional cancer survival will be explored. Possible reasons for differences in conditional cancer survival between males and females will be discussed.

Methods

Analyses are based on 779,978 males and 1,032,868 females diagnosed with 1 of 13 selected cancer sites (oral cavity and pharynx, colon and rectum, liver, breast, lung and bronchus, pancreas, urinary bladder, kidney and renal pelvis, melanoma of the skin [Whites only], brain and other nervous system, thyroid, lymphoma, and leukemia), diagnosed between 2000 and 2008, and followed through 2013 using data from the National Cancer Institute's Surveillance, Epidemiology, and End Results (SEER) Program. SEER defines cancer sites using ICD-O-3 based on the WHO Classification of Tumours of Haematopoietic and Lymphoid Tissue (2008) [20]. The 18 cancer registries represented in this study include San Francisco, Connecticut, Detroit (Metropolitan), Hawaii, Iowa, New Mexico, Seattle (Puget Sound), Utah, Atlanta (Metropolitan), San Jose-Monterey, Los Angeles, Alaska Natives, Rural Georgia, California (excluding San Francisco, San Jose-Monterey, and Los Angeles), Kentucky, Louisiana, New Jersey, and Greater Georgia. These population cancer registries cover 28% of the United States population [21].

The SEER Program selected these geographic areas because of their ability to collect and carry out a high-quality population-based cancer registry system. In addition, the populations covered by SEER are similar to the general US population with respect to measures of education and poverty, but they tend to have a higher proportion of foreign-born

individuals [22]. The law requires that new cases of cancer be reported to state cancer registries, such as those in the SEER Program, by providers who diagnose/treat cancer, doctors' offices, laboratories, radiology departments, surgical centers, and hospitals. Reporting is conducted electronically or in paper format following standard reporting protocols. Cancer registrars also improve the completeness of case information by visiting these facilities [23]. Cancer cases from the registry catchment areas were selected for inclusion in the study if they were actively followed and had malignant behavior and known age. Cases were excluded if they were alive with no survival time or if they were identified only by death certificate or autopsy. Site-specific cancers represented first primaries only. Marital status is commonly available from medical records, being complete is 95% or more of all patients [24]. This study was deemed exempt for review by the Institutional Review Board at Brigham Young University.

We use relative cancer survival rates in this study [25], as opposed to observed survival. Relative survival is a measure of net survival, which is cancer survival in the absence of other causes of death. Relative cancer survival removes the effect of other independent causes of death. The relative survival rate compares those with the disease to those without the disease over a given period of time. It is calculated by dividing the proportion of disease cases who are alive at the end of a given time period by the proportion of people in the general population who have a similar age, sex, and race who are alive at the end of the same period of time [26]. This cancer measure indicates the probability that the specific disease shortens life.

Conditional relative survival is the probability of surviving the specific disease, given the patient has already survived a certain length of time [27]. Conditional relative cancer survival probabilities were estimated using the SEER Survival System (SEER*Stat). The association between conditional relative survival of cancer and marital status was estimated using linear regression models. These models were adjusted by age, race, ethnicity, and tumor stage at diagnosis. Statistical significance was based on the 0.05 level. Regression models were calculated using SAS 9.4 (SAS Institute, Cary, NC, USA, 2012).

Results

Five-year relative survival by marital status and sex is presented for the 13 leading cancer sites (Table 1). Male patients are more likely than female patients to be married, whereas female patients are more likely than male patients to be widowed. Five-year relative survival is lowest for cancers of the brain and other nervous system, liver, lung and bronchus, and pancreas. It is highest for cancers of the thyroid, melanin-forming cells, and breast. Females have higher 5-year relative survival than males for every cancer site except urinary

Table 1 Patients with selected types of cancer diagnosed during 2000–2008 and followed through 2013 for 5-year survival according to marital status at the time of diagnosis (least to most lethal)

Cancer site	Male		5-year relative survival %	Female		5-year relative survival %	Relative survival (female:male) Ratio
	No.	%		No.	%		
Thyroid							
Single	2620	19.0	93.1	9776	21.1	98.2	1.05
Married	10,017	72.8	96.2	29,538	63.7	99.1	1.03
Separated/divorced	800	5.8	88.1	3930	8.5	97.6	1.11
Widowed	327	2.4	76.0	3111	6.7	87.9	1.16
Unknown	603		93.2	2083		97.3	1.04
Melanoma of the skin (Whites)							
Single	7214	15.2	81.2	6567	17.9	92.0	1.13
Married	35,213	74.0	89.3	22,383	61.0	94.7	1.06
Separated/divorced	3000	6.3	76.4	3133	8.5	89.1	1.17
Widowed	2186	4.6	72.9	4621	12.6	80.7	1.11
Unknown	12,380		98.2	10,663		99.2	1.01
Breast							
Single	353	13.4	73.0	52,163	13.3	83.8	1.15
Married	1824	69.3	89.8	225,193	57.5	92.5	1.03
Separated/divorced	228	8.7	68.0	45,320	11.6	86.2	1.27
Widowed	226	8.6	72.1	68,637	17.5	85.0	1.18
Unknown	148		82.0	16,691		84.8	1.03
Urinary bladder							
Single	7903	10.2	72.5	2970	11.5	70.5	0.97
Married	55,996	72.1	83.1	10,926	42.5	81.3	0.98
Separated/divorced	5933	7.6	69.4	2657	10.3	69.5	1.00
Widowed	7794	10.0	64.1	9166	35.6	62.9	0.98
Unknown	4757		86.8	1790		82.9	0.96
Kidney and renal pelvis							
Single	6886	14.9	67.5	4115	14.3	74.4	1.10
Married	32,508	70.6	72.6	14,322	49.8	76.3	1.05
Separated/divorced	4023	8.7	61.3	3337	11.6	69.1	1.13
Widowed	2649	5.8	51.2	7004	24.3	57.6	1.13
Unknown	1771		73.0	1271		71.2	0.98
Lymphoma							
Single	16,106	23.9	69.0	10,595	18.3	77.1	1.12
Married	42,724	63.4	70.6	28,000	48.4	78.1	1.11
Separated/divorced	4883	7.2	61.1	5609	9.7	70.2	1.15
Widowed	3677	5.5	44.6	13,614	23.5	53.5	1.20
Unknown	4267		78.5	3961		78.4	1.00
Leukemia							
Single	10,467	26.0	65.4	7501	24.9	66.4	1.02
Married	24,274	60.3	54.1	12,138	40.4	56.6	1.05
Separated/divorced	2674	6.6	45.9	2606	8.7	48.4	1.05
Widowed	2842	7.1	34.2	7834	26.0	37.0	1.08
Unknown	3488		72.4	2720		72.4	1.00
Colon and rectum							
Single	18,245	13.5	54.0	15,722	12.1	59.8	1.11
Married	93,746	69.2	69.5	57,777	44.3	71.0	1.02
Separated/divorced	11,743	8.7	54.4	13,461	10.3	61.5	1.13

Table 1 (continued)

Cancer site	Male		5-year relative survival %	Female		5-year relative survival %	Relative survival (female:male) Ratio
	No.	%		No.	%		
Widowed	11,652	8.6	51.3	43,348	33.3	57.1	1.11
Unknown	6788		69.5	6897		69.5	1.00
Oral cavity and pharynx							
Single	8052	19.7	50.1	2960	16.8	62.8	1.25
Married	24,673	60.5	68.1	8156	46.4	72.9	1.07
Separated/divorced	5742	14.1	47.1	2129	12.1	55.7	1.18
Widowed	2312	5.7	40.1	4326	24.6	47.6	1.19
Unknown	2620		66.6	1367		67.4	1.01
Brain and other nervous system							
Single	6931	31.1	55.7	5329	29.9	60.9	1.09
Married	13,043	58.6	22.4	8054	45.2	30.3	1.35
Separated/divorced	1503	6.7	22.4	1603	9.0	26.2	1.17
Widowed	797	3.6	6.4	2829	15.9	7.8	1.22
Unknown	658		30.4	571		33.8	1.11
Liver							
Single	5512	20.9	14.4	1577	16.6	21.7	1.51
Married	15,716	59.7	17.7	3912	41.1	20.9	1.18
Separated/divorced	3539	13.4	11.2	1154	12.1	18.1	1.62
Widowed	1572	6.0	7.2	2881	30.2	7.8	1.08
Unknown	1009		12.0	384		17.9	1.49
Lung and bronchus							
Single	24,601	13.5	11.2	16,342	10.7	17.7	1.58
Married	115,488	63.5	15.7	62,154	40.8	23.1	1.47
Separated/divorced	21,924	12.1	10.9	22,027	14.4	17.8	1.63
Widowed	19,760	10.9	8.8	51,982	34.1	13.7	1.56
Unknown	7257		12.7	6384		18.2	1.43
Pancreas							
Single	4043	13.0	6.0	3532	10.9	8.1	1.35
Married	21,455	68.7	6.3	13,459	41.6	8.0	1.27
Separated/divorced	3020	9.7	3.8	3593	11.1	5.9	1.55
Widowed	2702	8.7	2.5	11,738	36.3	3.4	1.36
Unknown	1104		7.1	1275		7.8	1.10

“Single” refers to never married. “Married” includes common law

Source: Surveillance, Epidemiology, and End Results Program, 18 registries

bladder, where it is the same or slightly better for males. The greatest 5-year relative survival advantage among females is in the more lethal cancers (i.e., brain and other nervous system, liver, lung and bronchus, and pancreas). The survival advantage among females tends to be less pronounced among those who are married, with an exception in those with cancer of the brain and other nervous system.

Cancer relative survival through 10 years and 5-year conditional cancer relative survival rates for time periods already survived after diagnosis appear in Fig. 1. Cancer sites are

presented from the least to most lethal. Marital status is associated with cancer relative survival through 10 years from diagnosis. Married patients have better relative survival through 10 years for the less lethal cancers (i.e., thyroid, melanoma of the skin, breast, urinary bladder, kidney and renal pelvis), as well as the moderately lethal cancers colon and rectum and oral cavity and pharynx. Relative survival through 10 years is similar between married and single (never married) patients for leukemia and the more lethal cancers (i.e., liver, lung and bronchus, and pancreas). Relative survival through



Fig. 1 Relative survival through 10 years (*left side of each panel*) and 5-year relative survival conditioned on having survived 0–5 years (*right side of each panel*). Married (*red*), single, never married (*blue*),

separated/divorced (*green*), and widowed (*purple*). The cancers are presented from the least to most lethal

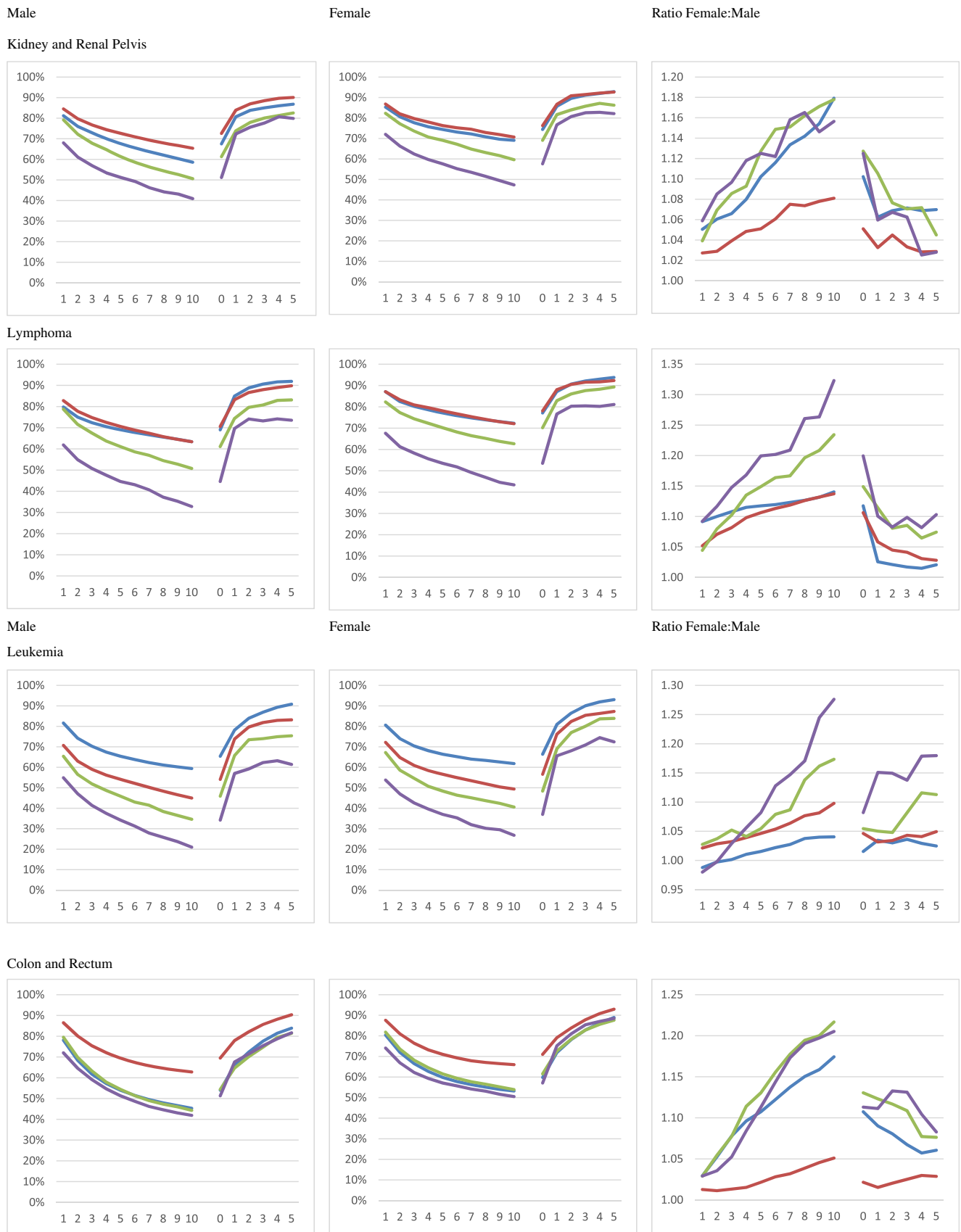


Fig. 1 (continued)

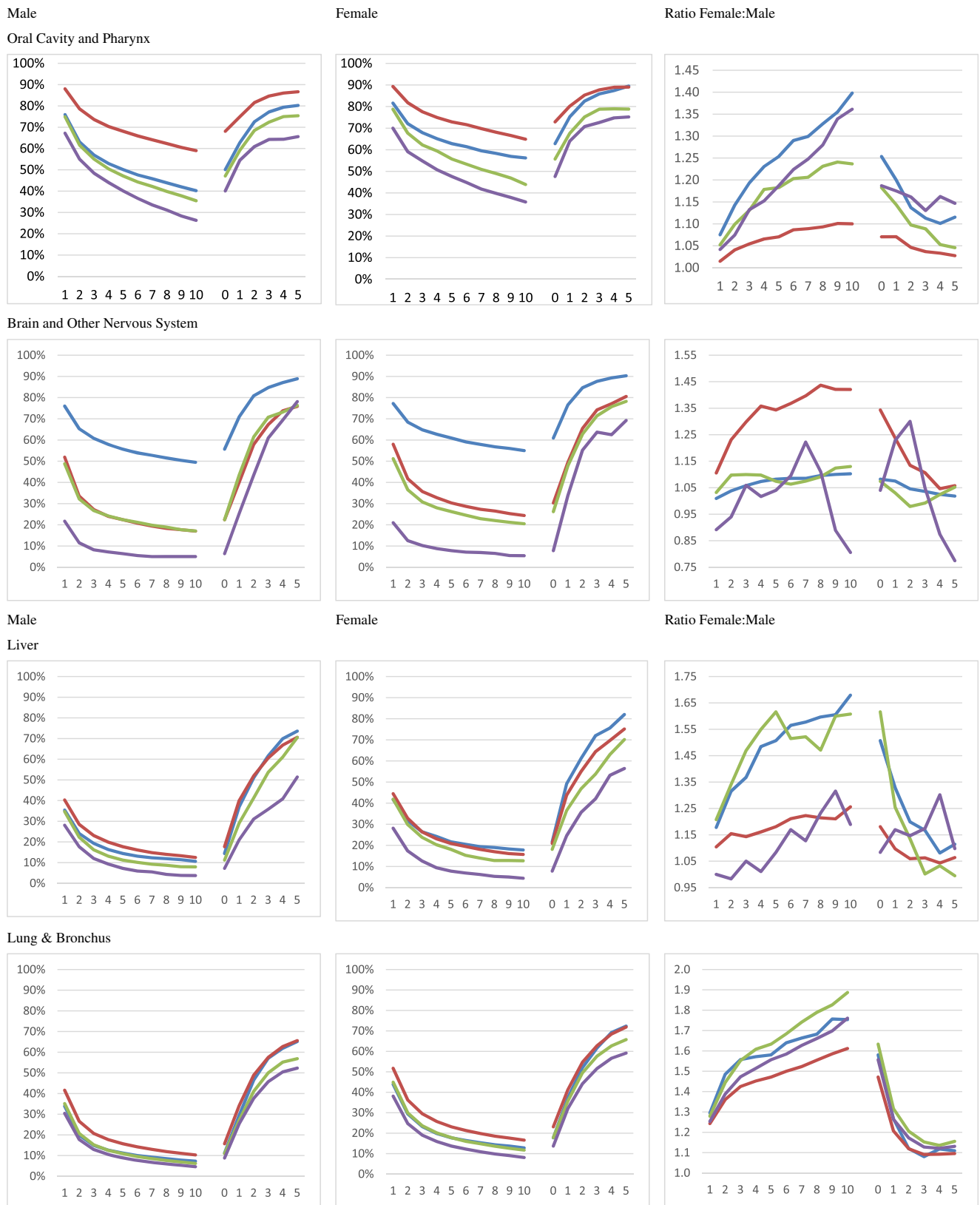


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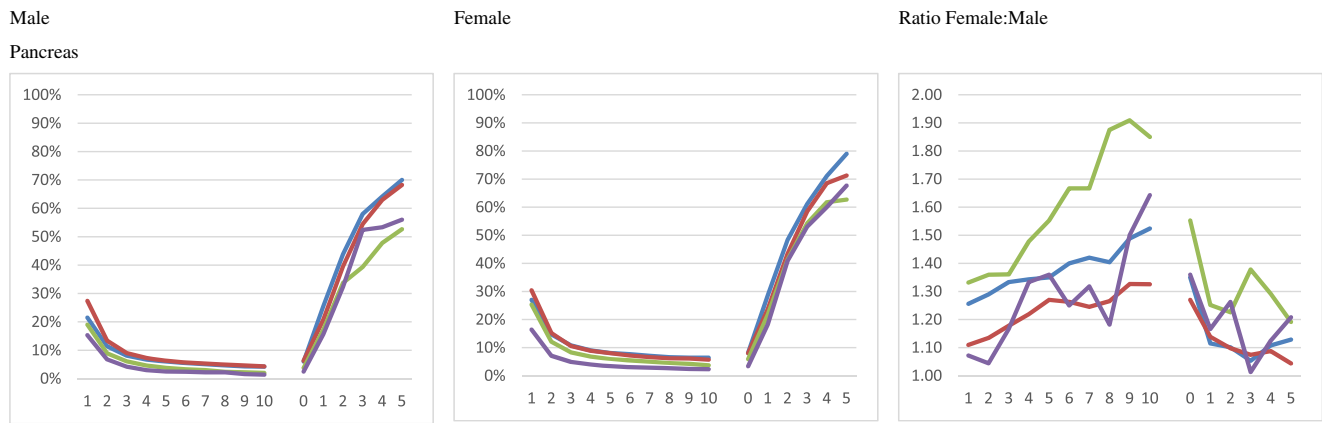


Fig. 1 (continued)

10 years for married patients is lower than that for single (never married) for two cancer sites, leukemia and brain and other nervous system. Separated/divorced and widowed patients have the lowest cancer relative survival through 10 years, especially in non-married patients. Higher cancer relative survival rates among females compared with males become more pronounced through 10 years, especially in non-married patients.

As the time after diagnosis (in years) increases, the 5-year cancer relative survival rate improves, with an exception for male breast cancer (Fig. 1). For most cancers considered, the 5-year cancer relative survival rate conditioned on time already survived up through 5 years approaches 70 to 90% of that for the general population, depending on marital status. The effect of marital status on 5-year conditional cancer relative survival is similar to that observed for cancer relative survival. Higher 5-year conditional relative survival rates in females compared with males tend to increase in more lethal cancers. For most of the cancer sites considered, the survival advantage among females diminishes when conditioned on years already survived. Exceptions include breast cancer, urinary bladder cancer, and leukemia. The higher conditional cancer relative survival among females tends to be smaller among those who are married at the time of diagnosis. An exception involves cancer of the brain and other nervous system.

Multiple regression models were estimated to assess the effect of marital status on cancer relative survival according to sex. We regressed cancer relative survival rates on time (0–10), marital status, age, sex, race, and tumor stage. An interaction effect between marital status and sex was tested and found to be significant for the cancer sites considered ($p < 0.05$), except for breast, pancreas, and brain and other nervous system. Similar regression models were also estimated, but with 5-year cancer relative survival rates regressed on time (0–5) survived, marital status, age, sex, race, and tumor stage. An interaction effect between marital status and sex was significant for each cancer site ($p < 0.05$), except for breast,

pancreas, brain and other nervous system, and leukemia. Because of the significant interaction effects involving sex, the estimated model results are stratified by this variable (Table 2).

In the multiple regression models, each adjusted for age, race, and tumor stage, mean relative survival and 5-year conditional relative survival was significantly greater among married patients for cancers of the thyroid, melanoma of the skin, breast, urinary bladder, kidney and renal pelvis (but for males only), lymphoma, leukemia (conditional relative survival in males only), colon and rectum, oral cavity and pharynx, lung and bronchus (relative survival in males only), and pancreas (relative survival in males only). Mean relative and 5-year conditional relative survival rates were greater in single (never married) cancer patients with brain and other nervous system and leukemia (relative survival in females only). Patients who were separated/divorced or widowed tended to have the poorest mean relative survival and 5-year conditional relative survival rates.

Discussion

Cancer relative survival and 5-year conditional cancer relative survival rates were presented for the 13 leading cancer sites. Identifying the effect of marital status on conditional cancer relative survival and the potential modifying effect of sex was the focus of this study. As consistent with previous research [4–11], marriage was often associated with longer cancer survival. A supportive spouse may encourage earlier cancer screening and cancer-directed treatment [12–15]. Support through an existing social network in general has been shown to yield survival benefits among cancer patients [28–32]. It may be that married individuals, as a whole, have greater economic resources, better health-promoting behaviors (more exercise and better diet), and a stronger social support system [33], each of which may extend cancer survival. Some forms of cancer treatment are complex, invasive, and onerous,

Table 2 Relative survival (0–10 years) and 5-year relative survival conditioned on (0–5) years already survived (least to most lethal)

	Male						Female					
	Relative survival ^a	95% LCL	95% UCL	Conditional relative survival ^a	95% LCL	95% UCL	Relative survival ^a	95% LCL	95% UCL	Conditional relative survival ^a	95% LCL	95% UCL
Thyroid												
Single	0.0			0.0			0.0			0.0		
Married	8.5	6.9	10.1	5.5	4.0	7.0	3.3	1.8	4.9	2.6	1.3	3.9
Separated/divorced	-3.2	-5.3	-1.1	-2.4	-4.3	-0.4	-2.7	-4.6	-0.8	-1.8	-3.4	-0.2
Widowed	-2.5	-6.0	1.0	0.8	-2.6	4.1	-3.6	-5.4	-1.8	-1.8	-3.3	-0.2
Unknown	2.2	-0.2	4.6	1.4	-0.9	3.6	-5.8	-7.8	-3.9	-3.7	-5.3	-2.0
Melanoma of the skin (Whites)												
Single	0.0			0.0			0.0			0.0		
Married	6.6	5.7	7.4	4.3	3.0	5.7	2.6	1.7	3.5	1.8	0.8	2.9
Separated/divorced	-3.9	-5.3	-2.5	-2.3	-4.6	0.0	-2.1	-3.5	-0.7	-1.8	-3.4	-0.2
Widowed	-6.7	-8.3	-5.1	-4.7	-7.4	-2.0	-6.5	-7.8	-5.1	-5.0	-6.6	-3.5
Unknown	8.4	7.5	9.3	5.6	4.0	7.1	3.6	2.7	4.6	2.3	1.2	3.5
Breast												
Single	0.0			0.0			0.0			0.0		
Married	12.9	10.3	15.4	9.5	7.0	12.0	5.2	4.5	5.8	3.8	3.2	4.4
Separated/divorced	-6.3	-10.1	-2.6	-4.3	-8.0	-0.6	0.4	-0.5	1.3	0.2	-0.6	1.0
Widowed	3.2	-0.9	7.2	2.4	-1.6	6.4	-0.3	-1.1	0.6	-0.1	-0.9	0.7
Unknown	6.2	1.7	10.6	5.9	1.5	10.3	0.5	-0.7	1.8	0.5	-0.6	1.7
Urinary bladder												
Single	0.0			0.0			0.0			0.0		
Married	10.9	10.0	11.8	7.8	6.2	9.5	6.2	5.1	7.4	3.3	1.2	5.4
Separated/divorced	-2.9	-4.2	-1.6	-2.9	-5.3	-0.6	-2.9	-4.4	-1.4	-3.0	-5.7	-0.2
Widowed	-2.8	-4.1	-1.6	-1.1	-3.4	1.2	-1.7	-3.0	-0.5	-1.2	-3.5	1.1
Unknown	11.6	10.2	13.0	8.5	5.9	11.0	5.9	4.2	7.6	3.6	0.6	6.7
Kidney and renal pelvis												
Single	0.0			0.0			0.0			0.0		
Married	5.5	4.6	6.4	1.8	0.2	3.3	0.4	-0.8	1.5	-1.5	-3.3	0.2
Separated/divorced	-5.1	-6.4	-3.8	-6.3	-8.6	-4.0	-7.0	-8.5	-5.5	-7.9	-10.2	-5.5
Widowed	-5.6	-7.2	-4.0	-4.1	-6.9	-1.3	-6.9	-8.2	-5.5	-6.3	-8.4	-4.1
Unknown	5.0	3.2	6.7	2.0	-1.1	5.1	-3.0	-5.1	-0.9	-3.2	-6.5	0.1
Lymphoma												
Single	0.0			0.0			0.0			0.0		
Married	6.0	3.9	8.1	4.9	2.3	7.4	4.4	2.6	6.2	2.8	0.4	5.2
Separated/divorced	-4.6	-6.6	-2.6	-5.1	-7.5	-2.6	1.6	-0.1	3.2	1.9	-0.4	4.1
Widowed	-9.8	-12.2	-7.4	-6.5	-9.4	-3.6	-4.8	-6.6	-3.0	-3.1	-5.5	-0.7
Unknown	15.5	13.7	17.3	7.4	5.2	9.5	11.6	10.1	13.1	6.2	4.1	8.2
Leukemia												
Single	0.0			0.0			0.0			0.0		
Married	-0.5	-2.8	1.9	5.0	1.8	8.1	-3.1	-5.6	-0.7	0.9	-2.1	3.9
Separated/divorced	-7.7	-9.8	-5.5	-2.4	-5.3	0.6	-4.5	-6.6	-2.4	-2.4	-4.9	0.2
Widowed	-6.4	-9.0	-3.8	-6.5	-10.0	-3.0	-5.0	-7.3	-2.7	-4.2	-6.9	-1.4
Unknown	19.6	17.6	21.7	12.2	9.4	15.0	22.5	20.4	24.6	14.3	11.7	16.8
Colon and rectum												
Single	0.0			0.0			0.0			0.0		
Married	9.9	8.8	11.0	6.3	4.5	8.0	7.4	6.3	8.5	4.9	3.2	6.5
Separated/divorced	-1.4	-2.6	-0.2	-3.4	-5.3	-1.6	0.6	-0.5	1.6	-0.7	-2.3	0.9

Table 2 (continued)

	Male						Female					
	Relative survival ^a	95% LCL	95% UCL	Conditional relative survival ^a	95% LCL	95% UCL	Relative survival ^a	95% LCL	95% UCL	Conditional relative survival ^a	95% LCL	95% UCL
Widowed	1.3	0.0	2.6	-2.0	-4.1	0.1	0.2	-0.9	1.3	-0.9	-2.5	0.8
Unknown	8.8	7.5	10.1	4.9	2.9	6.9	5.7	4.6	6.9	3.4	1.6	5.1
Oral cavity and pharynx												
Single	0.0			0.0			0.0			0.0		
Married	17.3	16.5	18.2	10.7	9.5	11.9	7.4	6.3	8.5	3.8	2.2	5.3
Separated/divorced	-2.0	-3.2	-0.9	-2.3	-3.9	-0.7	-5.9	-7.4	-4.4	-5.4	-7.4	-3.4
Widowed	-1.9	-3.6	-0.2	-6.1	-8.4	-3.8	-5.0	-6.4	-3.6	-5.8	-7.7	-4.0
Unknown	11.5	9.9	13.0	7.2	5.1	9.4	3.6	1.8	5.4	2.7	0.2	5.1
Brain and other nervous system												
Single	0.0			0.0			0.0			0.0		
Married	-14.8	-16.5	-13.2	-15.4	-19.6	-11.2	-13.0	-15.0	-11.0	-11.5	-15.5	-7.4
Separated/divorced	-10.3	-12.2	-8.3	-5.8	-11.0	-0.7	-11.1	-13.1	-9.1	-5.0	-9.0	-0.9
Widowed	-9.9	-12.1	-7.6	-17.0	-22.9	-11.1	-11.1	-13.2	-9.1	-11.0	-15.0	-6.9
Unknown	-2.5	-4.8	-0.1	2.6	-3.6	8.8	-1.0	-3.6	1.6	4.7	-0.5	9.9
Liver												
Single	0.0			0.0			0.0			0.0		
Married	0.5	-0.4	1.4	-6.9	-9.3	-4.5	-1.1	-2.8	0.5	-6.6	-10.0	-3.2
Separated/divorced	-3.6	-4.8	-2.4	-6.1	-9.1	-3.1	-5.5	-7.6	-3.4	-9.5	-13.9	-5.1
Widowed	-2.7	-4.6	-0.8	-4.2	-9.2	0.8	-5.7	-7.7	-3.7	-11.7	-15.9	-7.6
Unknown	-1.2	-3.2	0.8	-6.3	-11.5	-1.1	-0.4	-4.1	3.2	1.7	-5.9	9.3
Lung and bronchus												
Single	0.0			0.0			0.0			0.0		
Married	4.6	3.5	5.7	1.2	-1.2	3.6	0.6	-0.6	1.7	-3.2	-5.2	-1.2
Separated/divorced	-1.8	-2.8	-0.8	-5.3	-7.6	-3.1	-1.5	-2.6	-0.3	-4.2	-6.3	-2.1
Widowed	-1.2	-2.3	-0.1	-4.8	-7.3	-2.2	-4.1	-5.2	-2.9	-6.4	-8.4	-4.4
Unknown	-0.7	-1.8	0.4	-1.1	-3.5	1.4	-1.9	-3.1	-0.7	-0.1	-2.2	2.1
Pancreas												
Single	0.0			0.0			0.0			0.0		
Married	0.9	0.1	1.8	-5.9	-8.9	-2.8	-0.1	-1.5	1.2	-4.9	-8.0	-1.9
Separated/divorced	-3.0	-4.3	-1.7	-16.2	-20.9	-11.6	-2.0	-3.6	-0.3	-8.5	-12.2	-4.7
Widowed	-1.0	-2.5	0.5	1.9	-3.6	7.4	-0.8	-2.3	0.7	-4.5	-7.9	-1.1
Unknown	1.4	-0.3	3.1	4.3	-2.0	10.5	2.1	-0.6	4.8	5.2	-1.0	11.3

“Single” refers to never married, and “Married” includes common law

Source: Surveillance, Epidemiology, and End Results Program, 18 registries, 2000–2008 and followed through 2013

LCL lower confidence limit, UCL upper confidence limit

wherein a social network may contribute to an ability to better accept and cope with the demands of the therapy.

The superior cancer relative survival in married patients persisted for most cancers when conditioned on years already survived. Females generally showed better cancer survival than males, as consistent with other studies [16, 17], but the difference decreased when conditioned on years already survived. The female to male ratio in conditional cancer relative survival was generally closer to unity for married patients, particularly for less lethal cancers. The benefit of marriage

on cancer survival was smaller or did not exist for the more lethal cancers: pancreatic, lung and bronchus, liver, and brain and central nervous system. Currently, early detection methods are still being developed for pancreatic cancer and are possibly less effective for these other cancers, and so the support from a friend, spouse, or other family member is less effective [34]. In addition, the effect of family or friends on the ability to accept and cope with treatment is less relevant for more advanced tumors or lethal cancers where treatment is less effective. The relatively small benefit of cancer survival

among married patients with brain and other central nervous system cancer may also be related to one of the side effects of the disease, cognitive impairment [35]. If a patient is delirious or has other mental health issues like depression, then it is possible that the social support found in a spouse or others would have little effect [19].

Interaction terms between marriage and sex were tested in order to identify whether males or females had a greater advantage to being married, after adjusting for time already survived, age, race, and tumor stage at diagnosis. Although males benefitted more from being married than females in terms of relative cancer survival, this benefit was less pronounced when conditioned on years already survived. This may indicate that the support from a spouse or other individuals is most critical in the early stages of the cancer, when their influence on treatment and coping is potentially greatest.

Among cancer patients who are single, females do much better than males. Perhaps single women tend to have a better social support system than single men. Research has shown that the quality of life (lower anxiety, depression, fatigue, pain) among cancer patients can improve through the help of social networks (a spouse or intimate partner, religious or social ties, close friends, and relatives) as well as social support in the form of tangible support, emotional/informational support, affection, and positive social interaction [19, 36, 37]. Social networks and support have been shown to help the patient improve their ability to cope with stress, to feel in control, and to improve their self-image and mood [19, 38–42]. If social networks and support are primarily beneficial among patients with less severe cancers [43], this may indicate that the social networks and support are related to more aggressive screening and treatment.

Beyond treatment, having a social network through marriage, family, friends, or religion has been shown to be associated with fewer physical limitations and less decline in being able to perform daily activities [44]. Research has further shown that women with chronic physical illnesses are 10% more likely to pursue support for mental health issues than men with similar illnesses [45]. Women were also more likely to use medical services for mental health treatment 6 months earlier than men. Differential mental health treatment between men and women may be ameliorated through marriage and other social networks.

This study was limited in that the registry data did not include information on certain variables that would have added to our understanding of the impact of marriage on cancer survival (e.g., health behaviors, body mass, diet, education, social support). In addition, the results reflect what is seen on average. We also did not consider various forms of treatment strategies and their effect on the survival rates. The reason why being single was associated with greater relative and conditional relative survival for cancers of the liver, pancreas, and brain and other nervous system remains unclear and requires further investigation.

Conclusions

Conditional cancer relative survival is more meaningful to patients who desire to have an updated assessment of their prognosis as they live one or more years beyond their initial diagnosis. The benefit of marriage on cancer relative survival is greater for less lethal cancers and persists, for most cancer types, when conditioned on time already survived. Although females have better cancer relative survival than males, for each year already survived, the subsequent survival benefit decreases, except for breast cancer, urinary bladder, and leukemia. The superior survival benefit among females is less pronounced in married patients. For more lethal cancers like liver, pancreas, and brain and other nervous system, marriage does not result in a survival benefit, but survival is similar or better (for brain and other nervous system cancer and single (never married) patients). Divorced/separated or widowed patients have the poorest cancer survival.

Compliance and ethical standards

Conflict of interest The authors declare they have no competing interests.

Ethics approval This study was deemed exempt for review by the Institutional Review Board at Brigham Young University.

Informed consent Not applicable.

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References

1. American Cancer Society Cancer facts & figures 2017 Atlanta American Cancer Society, 2017.
2. Ryerson AB, Ehemann CR, Altekruse SF, et al. Annual report to the nation on the status of cancer 1975–2012 featuring the increasing incidence of liver cancer. *Cancer*. 2016;122(9):1312–37.
3. Merrill RM, Bateman S. Conditional melanoma cancer survival in the United States. *Cancers*. 2016;8(2):20.
4. Aizer AA, Chen MH, McCarthy EP, et al. Marital status and survival in patients with cancer. *J Clin Oncol*. 2013;31:3869–76.
5. Gomez SL, Hurley S, Canchola AJ, et al. Effects of marital status and economic resources on survival after cancer: a population-based study. *Cancer*. 2016;122:1618–25.
6. Sammon JD, Morgan M, Djahangirian O, et al. Marital status: a gender-independent risk factor for poorer survival after radical cystectomy. *BJU Int*. 2012;110(9):1201–29.
7. Zhang J, Gan L, Wu Z, et al. The influence of marital status on the stage at diagnosis, treatment, and survival of adult patients with gastric cancer: a population-based study. *Oncotarget* (2016); Epub ahead of print.
8. Wang L, Wilson SE, Stewart DB, et al. Marital status and colon cancer outcomes in US Surveillance, Epidemiology and End Results registries: does marriage affect cancer survival by gender and stage? *Cancer Epidemiol*. 2011;35(5):417–22.

9. Martínez ME, Anderson K, Murphy JD, et al. Differences in marital status and mortality by race/ethnicity and nativity among California cancer patients. *Cancer*. 2016;15:122(10):1570–8.
10. He XK, Lin ZH, Qian Y, et al. Marital status and survival in patients with primary liver cancer. *Oncotarget*. 2016 Aug 5. doi: [10.18632/oncotarget.11066](https://doi.org/10.18632/oncotarget.11066). [Epub ahead of print].
11. Shi RL, Qu N, Lu ZW, et al. The impact of marital status at diagnosis on cancer survival in patients with differentiated thyroid cancer. HYPERSLINK "<https://www.ncbi.nlm.nih.gov/pubmed/27264532>" *Cancer Med*. 2016;5(8):2145–54.
12. Jin JJ, Wang W, Dai FX, et al. Marital status and survival in patients with gastric cancer. *Cancer Med*. 2016;5(8):1821–9.
13. Inverso G, Mahal BA, Aizer AA, et al. Marital status and head and neck cancer outcomes. *Cancer*. 2015;121(8):1273–8.
14. Enewold L, Harlan LC, Tucker T, et al. Pancreatic cancer in the USA: persistence of undertreatment and poor outcome. *J Gastrointest Cancer*. 2015;46(1):9–20.
15. Baine M, Sahak F, Lin C, et al. Marital status and survival in pancreatic cancer patients: a SEER based analysis. *PLoS One*. 2011;6(6):e21052.
16. Ellison LF. Differences in cancer survival in Canada by sex. *Health Rep*. 2016;27(4):19–27.
17. St John PD, Montgomery PR. Marital status, partner satisfaction, and depressive symptoms in older men and women. *Can J Psychiatr*. 2009;54(7):487–92.
18. Rendall MS, Weden MM, Favreault MM, et al. The protective effect of marriage for survival: a review and update. *Demography*. 2011;48(2):481–506.
19. Bortolato B, Hyphantis TN, Valpione S, et al. Depression in cancer: the many biobehavioral pathways driving tumor progression. *Cancer Treat Rev*. 2017;52:58–70.
20. The International Agency for Research on Cancer. WHO classification of tumours of haematopoietic and lymphoid tissue (IARC WHO classification of tumours) 4th Edition. World Health Organization, 2008.
21. National Cancer Institute. Data flow in NCI's SEER Registries. https://seer.cancer.gov/about/factsheets/SEER_Data_Flow_.pdf. Accessed 26 Nov 2016.
22. National Cancer Institute. Characteristics of the SEER population compared with the total United States population. <https://seer.cancer.gov/registries/characteristics.html>. Accessed 26 Nov 2016.
23. National Cancer Institute. Process of cancer data collection. <https://training.seer.cancer.gov/registration/data/collection.html>. Accessed 7 Jun 2017.
24. Adamo M, Dickie L, Ruhl J. SEER program coding and staging manual 2015. National Cancer Institute, Bethesda, MD 20850-9765, 2015.
25. National Cancer Institute. Relative survival rate. <http://www.cancer.gov/publications/dictionaries/cancer-terms?cdrid=44296>. Accessed 8 Sep 2016.
26. Ederer F, Axtell LM, Culter SJ. The relative survival rate: a statistical methodology. *J Natl Cancer Inst Monogr*. 1961;6:101–21.
27. Hieke S, Kleber M, König C, et al. Conditional survival: a useful concept to provide information on how prognosis evolves over time. *Clin Cancer Res*. 2015;21(7):1530–6.
28. Reynolds P, Hurley S, Torres M, et al. Use of coping strategies and breast cancer survival: results from the Black/White Cancer Survival Study. *Am J Epidemiol*. 2000;152:940–9.
29. Kroenke CH, Kubzansky LD, Schernhammer ES, et al. Social networks, social support, and survival after breast cancer diagnosis. *J Clin Oncol*. 2006;24(7):1105–11.
30. Epplein M, Zheng Y, Zheng W, et al. Quality of life after breast cancer diagnosis and survival. *J Clin Oncol*. 2011;29(4):406–12.
31. Kroenke CH, Quesenberry C, Kwan ML, et al. Social networks, social support, and burden in relationships, and mortality after breast cancer diagnosis in the Life After Breast Cancer Epidemiology (LACE) Study. *Breast Cancer Res Treat*. 2013;137(1):261–71.
32. Jafri NS, Gould M, El-Serag HB, et al. Incidence and survival of colorectal cancer among Hispanics in the United States: a population-based study. *Dig Dis Sci*. 2013;58:2052–60.
33. Sjødahl R, Rosell J, Starkhammar H. Causes of death after surgery for colon cancer—impact of other diseases, urgent admittance, and gender. *Scand J Gastroenterol*. 2013;48:1160–5.
34. Kotake K, Asano M, Ozawa H, et al. Gender differences in colorectal cancer survival in Japan. *International J Clin Oncol*. 2016;21:194–203.
35. Lee W, Nelson R, Mailey B, et al. Socioeconomic factors impact colon cancer outcomes in diverse patient populations. *J Gastrointest Surg*. 2016;16:692–704.
36. Institute of Medicine. Meeting psychosocial needs of women with breast cancer. Washington, D.C., National Academies Press, 2004.
37. Kwan ML, Ergas IJ, Somkin CP, et al. Quality of life among women recently diagnosed with invasive breast cancer: the Pathways Study. *Breast Cancer Res Treat*. 2010;123(2):507–24.
38. Classen C, Butler LD, Koopman C, et al. Supportive-expressive group therapy and distress in patients with metastatic breast cancer: a randomized clinical intervention trial. *Arch Gen Psychiatry*. 2001;58:494–501.
39. Goodwin PJ, Leszcz M, Ennis M, et al. The effect of group psychosocial support on survival in metastatic breast cancer. *N Engl J Med*. 2001;345:1719–26.
40. Rowland JH, Massie MJ. Chapter 95: Psychosocial adaptation during and after breast cancer, in J.R. Harris, M.E. Lippman, M. Morrow, C.K. Osborne. *Diseases of the Breast*, 4th edition. Lippincott Williams and Wilkins, 2010.
41. Hoyer H, Johansson B, Nordin K, et al. Health-related quality of life among women with breast cancer—a population-based study. *Acta Oncol*. 2011;50(7):1015–26.
42. Bjömecklett HG, Lindemalm C, Rosenblad A, et al. A randomised controlled trial of support group intervention after breast cancer treatment: results on anxiety and depression. *Acta Oncol*. 2012;51(2):198–207.
43. Nausheen B, Gidron Y, Peveler R, et al. Social support and cancer progression: a systematic review. *J Psychosom Res*. 2009; 2009;67(5):403–15.
44. Michael YL, Berkman LF, Colditz GA, et al. Social networks and health-related quality of life in breast cancer survivors: a prospective study. *J Psychosom Res*. 2002;52:285–93.
45. Matheson FI, Smith KL, Fazli GS, et al. Physical health and gender as risk factors for usage of services for mental illness. *J Epidemiol Community Health*. 2014;68(10):971–8.