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Quality of Life among Cancer Survivors: Comparison of Multiple Cancers Using iCaRe2

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Abstract:

Background: The number of cancer survivors continues to increase due to dramatic improvements in cancer treatment, accounting for approximately 5% of the entire population. As cancer survivors continue to live longer, it is important to understand their quality of life (QoL) in order to maximize supportive care efforts.

Objectives: In this study, the quality of life (QoL) among patients with different types of cancer was examined. The objectives were to: 1) compare patient-reported outcome measures of QoL using the Short-Form (SF-36) Health Survey scores among patients of different cancer types and 2) identify demographic, oncologic, and clinical factors that are associated with SF-36 QOL scores.

Methods: We performed a retrospective review of prospectively collected data from a multi-center cancer registry data collected between January 2007 and February 2020. Multiple linear regression analysis was conducted to identify demographic and clinical factors that are associated with SF-36 Physical Component Score (PCS) and Mental Component Score (MCS).

Findings: Both mental and physical aspects of QoL were affected in all cancer patients, regardless of the type, prognosis, and time since diagnosis and treatment. Individual, socioeconomic, disease, and treatment-related variables were associated with QoL among different cancer populations and should be addressed as part of shared treatment decision-making.

Keywords: Cancer, quality of life, rural, survivors

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Introduction

In 2021, the estimated cancer burden in the United States was approximately 1.9 million newly diagnosed cases and more than 600,000 deaths (ACS, 2021). The number of cancer survivors has now reached over 16.9 million survivors in the U.S., comprising approximately 5% of the entire population (NCI, 2020). This number is anticipated to increase by 31% over the next 10 years (NCI, 2020). The magnitude of this number emphasizes the need for an understanding of quality of life (QoL) such that patient care can be optimized.

QoL is a multidimensional concept defined as a "state of complete physical, mental, and social well-being, and not merely the absence of disease and infirmity" (Spitzer, 1987). QoL is frequently an area of focus as an outcome to improve health care provider-patient communication, tailor individualized treatment plans, and predict survival (McDowell et al., 2020), thus, QoL is an essential part of cancer care planning and management (Economou & Sun, 2018; McDowell et al., 2020). It is known that cancer survivors frequently experience poorer health and well-being compared to people without a cancer diagnosis, even if they have a good prognosis from their underlying malignancy (Firkins et al., 2020; Joshy et al., 2020; Zhang et al., 2020). Therefore, addressing QoL as a multidimensional concept and utilizing comprehensive measures are critical to informing personalized multidisciplinary approaches to the care of individuals with cancer.

There are many different instruments to assess QoL. The Short-Form (SF-36) Health Survey has been used across many adult patients and nonpatient populations for a variety of purposes, such as screening individual patients, monitoring the results of care, comparing the relative burden of diseases, and comparing the benefits of different treatments(Banihashem et

al., 2020; Zhang et al., 2022). The SF-36 is composed of 36 questions which yield a profile of physical and mental health component summary measures and eight health domain scales. The SF-36 is one of the most frequently used measures of QoL of cancer patients and is commonly used to comp6are the health status of cancer patients to the general population or other disease groups as well as among diverse ethnic and language groups (Courneya et al., 2023; Pequeno et al., 2020).

QoL can differ considerably depending on individual, disease, or treatment-related factors. Individual factors such as age, gender, marital status, education and lifestyle habits (e.g., exercise, diet) have been shown to influence QoL for cancer survivors (Han et al., 2021; Manne et al., 2023; Tabaczynski et al., 2023). Disease-related factors such as type of cancer, body mass index (BMI), and presence of co-morbidities and treatment-related factors such as type, duration, and toxicity can contribute to QoL for cancer survivors (Han et al., 2021; Klevebro et al., 2020; Manne et al., 2023). It is common for cancer survivors to develop physical and/or psychological side effects and symptoms related to the cancer and its treatment that can emerge immediately to months or years later (Niedzwiedz et al., 2019; Pitman et al., 2018; Ramasubbu et al., 2021). Understanding the individual, disease, and/or treatment-related factors that impact QoL are essential to providing tailored education, risk assessment, and early intervention, contributing to enhanced patient-centered care.

QoL is strongly associated with prognosis and survival outcomes in patients with different cancer types (Ediebah et al., 2018; Hui et al., 2022; Westhofen et al., 2022). However, comparison of QoL by cancer type is often difficult because the data come from different population groups and settings and from differences in data collection timing and methods.

Data registries are well poised to address these limitations. Thus, in this study, data from University of Nebraska Medical Center (UNMC) Fred and Pamela Buffett Cancer Center Integrated Cancer Repository for Cancer Research (iCaRe2), was used to compare QoL across 6 types of cancers.

The purpose of this study was to examine the QoL scores among the common cancer types: breast, thyroid, uterine/endometrial, lung, ovarian, and kidney cancers. The objectives of this study were to: 1) compare patient-reported QoL among patients of different cancer types using the Short-Form (SF-36) Health Survey scores and 2) identify individual, disease, and treatment-related factors associated with SF-36 QOL scores.

Methods

Study design

We conducted a cross-sectional, exploratory study that compared QoL among patients with different cancers and explored potential factors impacting QoL in cancer patients using iCaRe2 data. The iCaRe2 is a bioinformatics and biospecimen registry created and maintained by the UNMC Fred & Pamela Buffett Cancer Center to collect and manage standardized, multi-dimensional, longitudinal data and biospecimens on consented adult cancer patients (19 years and older), high-risk individuals, and normal controls. iCaRe2 includes the following registries: breast cancer, central nervous system tumors, head & neck cancer, gastrointestinal & abdominal cancer, genitourinary cancer, gynecologic cancer, pancreatic cancer, leukemia, melanoma, neuroendocrine tumor, non-melanoma skin cancer, sarcoma, plasma cell dyscrasia, thoracic oncology, and thyroid cancer. Patients with active cancer, as well as cancer survivors are invited to enroll in the registry at any time after diagnosis of cancer. At the time of

enrollment, participants are asked to complete a questionnaire that includes demographic, lifestyle and clinical information as well as the SF-36 QoL questionnaire. A distinct advantage of the iCaRe2 registry is its statewide geographical coverage, with a significant percentage of small and rural hospitals and cancer centers in Nebraska.

Ethics Approval

iCaRe2 registry is an IRB approved protocol and all participants have provided informed consent to be included.

Setting and study participants

All participants included in this study were diagnosed with one of the following cancers: breast, kidney, lung, ovarian, thyroid, and uterine/endometrium and completed the registry questionnaires on their demographics, lifestyles, and quality of life. We focused on these cancer types because the registries for these cancer types have a large sample size. Normal controls, high-risk disease non-cancer patients (e.g., family history of pancreatic cancer), and thyroid nodules were excluded from the data analysis. Data were collected between January 2007 and February 2020.

Measures

The main outcome of this study was QoL, measured by Physical Component Summary (PCS) and Mental Component Summary (MCS), calculated from SF-36 scores (Treanor & Donnelly, 2014). The SF-36 contains 8 subscales with a sum of 36 items: Physical functioning (10 items), Role-physical (4 items), Bodily Pain (2 items), General Health (5 items), Vitality (4 items), Social functioning (2 items), Role-emotional (3 items), and Mental Health (5 items). PCS and MCS are computed and adjusted based on scores of the 8 subscales, with a mean of

50 and a standard deviation of 10.

The potential predictive factors included age upon enrollment into the iCaRe2 registry, sex, race/ethnicity, education level, whether the participant lived in a rural or urban area (defined by the Rural-Urban Community Area [RUCA] codes), body mass index (BMI), the survivorship time (the number of years between the time of cancer diagnosis and the survey completion), and number of comorbidities (see below). For univariate and multiple linear regression analysis, the approach of categorizing age groups was based on the rationales of age grouping in clinical practices for each cancer because the most affected age groups vary from cancer to cancer. Rural/urban category was determined using the Rural-Urban Commuting Area (RUCA) codes (US Department of Agriculture, n.d.). RUCA codes of 1.0, 1.1, 2.0, 2.1, 3.0, 4.1, 5.1, 7.1, 8.1, and 10.1 were used to classify urban communities and the remaining RUCA codes were used to classify rural communities. We categorized participants into 3 groups based on the number of comorbidities they had – "None", "1-2 comorbidities", and "3+ comorbidities".

Statistical analysis

Statistical analyses were performed using SAS 9.4 software (Cary, North Carolina). Means, standard deviations, frequencies and percentages were calculated to describe demographic and clinical information. Analysis of variance (ANOVA) was used to compare SF-36 PCS and MCS scores between patients with different cancers. Pairwise comparisons were completed with Tukey method. We conducted a univariate analysis to generate a profile of potential risk factors. Multiple linear regression with backward elimination was further conducted to predict how different risk factors would impact patients' quality of life among different cancers.

Significance level was set as 0.05.

Results

We included a total of 1,907 patients with six types of cancers (1,339 breast, 29 kidney, 58 lung, 378 thyroid, 63 uterine/endometrial, 40 ovarian) from the iCaRe2 Registry. Table 1 reports the sociodemographic differences by cancer type. Age at diagnosis distributions significantly differed by cancer type. Thyroid cancer patients were relatively young, with a mean age of 47.2, while lung, kidney, and uterine cancer patients had the oldest average ages of 67.9, 66.9, and 64.6, respectively. The majority of kidney cancer patients (69.0%, N=20) were male while the majority of thyroid cancer patients were female (79.6%, N=301). Race/ethnicity distributions were similar among cancer types. Over 90% (N=1699) of patients reported non-Hispanic white. Educational attainment levels differed considerably across different cancer types; the percent of patients with "at college or above" was only 15.5% (N=9) of lung cancer patients but 52.9% (N=197) of thyroid cancer patients. In this sample, 17.2-30.2% were from rural areas across different types of cancers. The number of underlying comorbidities in patients also varied significantly among different cancers. A high proportion of kidney (79.3%, N=23), uterine/endometrial (66.7%, N=42) and ovarian (62.5%, N=25) cancer patients had 3 or more comorbidities. Patients with uterine/endometrial cancer had a significantly greater BMI than patients with kidney, breast, and lung cancer. The mean time from cancer diagnosis to survey completion ranged from 1.5 years for lung cancer to 4.8 years for kidney cancer.

Although the confidence intervals overlapped, as shown in Figure 1, significant variations in both PCS and MCS were observed by different cancer types. Overall, thyroid cancer patients

(PCS 48.5±7.0, MCS 48.7±8.9) and breast cancer patients (PCS 47.1±7.7, MCS 48.7±9.1) had relatively better quality of life from both physical and mental perspectives. In terms of PCS, thyroid cancer patients had significantly higher scores than those with other cancer types. For MCS, lung cancer patients reported the lowest scores compared to those with other cancer types. (Figure 1).

In univariate analysis (Supplemental Table 1), we explored whether selected demographic or clinical factors would affect QoL in patients with different cancers. In breast cancer patients, younger age, normal BMI, non-Hispanic white race/ethnicity (compared to Other), higher education levels, higher income levels, and a lower number of comorbidities were significantly associated with higher PCS and MCS scores. In ovarian cancer patients, non-Hispanic white race/ethnicity was significantly associated with higher PCS scores. In thyroid cancer patients, normal BMI, higher education levels, higher income levels, a lower number of comorbidities, and a longer time period between cancer diagnosis and survey completion were significantly associated with higher PCS and MCS scores. Also, in thyroid cancer older age at diagnosis was significantly associated with higher MCS scores. For kidney, lung, and uterine cancers, none of the variables examined for this study were significantly associated with the PCS or MCS scores.

Multivariable regression analysis results for breast cancer patients are shown in Table 2. The PCS score was significantly lower among overweight (47.4) and obese (44.5) individuals compared to individuals with normal weight (49.5) ($p<0.01$ and $p<0.0001$, respectfully). Individuals who self-identified as non-Hispanic whites (47.5) had a significantly higher PCS scores compared to individuals who self-identified as Hispanics or non-Hispanics of races other

than white (44.4) ($p<0.05$). The mean PCS score was also significantly associated with annual income levels – the higher the income, the higher the PCS score (e.g., 49.0 for individuals with income of at least $100,000 compared to 38.6 for individuals with income of less than $10,000). Individuals residing in states other than Iowa or Nebraska (43.8) had significantly lower mean PCS score compared to individuals living in Iowa (47.4) or Nebraska (47.0) ($p<0.01$ and $p<0.05$, respectfully). The higher the number of comorbidities, the lower the PCS score (e.g., 49.1 for individuals with no comorbidities compared to 43.1 for individuals with 3 or more comorbidities, $p<0.001$). Similar patterns were observed for the MCS score except race/ethnicity and state residency were not significantly associated with the MCS score.

Table 3 shows multivariable regression analysis results for thyroid cancer patients. The PCS score was significantly inversely associated with BMI – compared to individuals with normal weight (49.85), obese individuals (46.6) had significantly lower PCS scores ($p<0.01$). The PCS score was also significantly associated with the educational level--individuals with lower educational level tended to have lower PCS scores ($p<0.001$). The PCS score was also significantly associated with the number of comorbidities ($p<0.01$). Similar patterns were observed for the MCS score except the older age at time of diagnosis was associated with higher MCS scores ($p<0.01$) but BMI was not significantly associated with the MCS score. For kidney, lung, ovarian, and uterine cancers, none of the variables examined for this study were significantly associated with the PCS or MCS scores. Therefore, we did not conduct multivariable analysis for these cancers.

Discussion

This study provides an overview of physical and mental QoL by cancer type from a

hospital-based cancer registry. To our knowledge this is one of few published studies since 2008 which used the SF-36 data from one data source to compare QoL across different cancer types. In our study, in both domains, patients with thyroid cancer (PCS: 42.8; MCS: 48.7) had the highest scores and lung cancer (PCS: 41.1; MCS: 43.0) patients had the lowest scores. (Clauser et al., 2008), analyzed SF-36 data from Surveillance Epidemiology, and End Results Medicare Health Outcome Survey (Clauser et al., 2008). Their study was similar to ours regarding inclusion of participants with varied diagnoses and survival times. For age group 65-74 years they reported lower mean PCS score for patients with lung cancer (35.3) compared to prostate (43.8), breast (42.3), and colorectal cancer (41.9). For the same age group they reported similar results with MCS scores – patients with lung cancer had lower scores (47.2) compared to prostate (52.2), breast (50.9) and colorectal cancer (50.8).

Our study examined SF-36 data from cancer patients on average 1.5 to 3.4 years after the diagnosis; therefore, the discussion will focus on studies that had similar survival times. In the (Maly et al., 2015)study, low-income women were enrolled in the Breast and Cervical Cancer Treatment Program funded by California and Medicaid (Maly et al., 2015). Their PCS score decreased from 43.4 at 18 months post diagnosis to 31.8 60 months post diagnosis, while the MCS score remained relatively stable from 18 (46.4) to 60 months post diagnosis (47.5). These scores are lower than our results, at time frames similar to our follow up times, but we analyzed cross sectional data rather than longitudinal data. Previous research suggested that QoL is lower among individuals from low socioeconomic status (Manne et al., 2023). As for ovarian cancer, a study conducted by (Zhou et al., 2016) used data from the American Cancer Society Study of Cancer Survivors-I and reported PCS and MCS scores of 45.6 and 49.8, respectfully, at 2-

year post diagnosis, which are somewhat higher than the PCS (42.8) and MCS (44.8) scores from our study. The demographic characteristics of these study samples are similar.

(Möller & Sartipy, 2011)studied lung cancer patients seen at a hospital in Sweden. Their results for PCS (41.4) and MCS (46.9) score 2 years post-surgery were similar to our results (PCS: 41.1, MCS: 43.0). Previous studies on thyroid cancer patients reported a wide range of SF-36 results (PCS: 49.8-7.1; MCS: 49.8-73.8) (Li et al., 2020; Maki et al., 2022). When we examined factors associated with PCS and MCS scores using multivariate regression for breast and thyroid cancer, we found that those in better general health (based on BMI and comorbidities) had better scores. Those with the highest levels of income or education also had higher scores than those in the lowest comparison categories, with scores improving across the categorical gradients. These results were expected and consistent with gradient effects of social determinants of health across a variety of health outcomes (Ahmed et al., 2018; Manne et al., 2023; Tabaczynski et al., 2023). Regarding age at diagnosis, interestingly, those in the oldest age group at time of diagnosis had the highest MCS scores, while results were not significantly different for PCS. One potential explanation for this inverse relationship is that younger patients may be at higher risk for impact of cancer diagnosis and treatment on family and occupational responsibilities, as well as financial toxicity. Younger patients may also have less peer support given the lower overall prevalence of oncologic diagnoses in their peer group. Together, the impact on MCS scores may reflect concern or anxiety surrounding all of these issues. State of residence was significant for breast cancer PCS scores. One explanation for this observation is that local (Nebraska and Iowa) patients may seek treatment at our institution across a range of diagnostic stages and treatment complexity, while those traveling from more

distant areas may reflect more severe cases seeking specialized care.

Due to the timing of the survey, differences by cancer type likely reflect underlying differences in the age distribution of incident cancer types and stage of diagnosis rather than only treatment options and potential side-effects. However, treatment decisions can have both short- and long-term impacts on physical and mental health, so shared patient-provider decision making should address the potential pros and cons with different time points in mind (Josfeld et al., 2021). Because QoL is time-varying, it is important to include a time reference when reporting population estimates. The time reference should reflect the purpose of the measurement, such as time since diagnosis, treatment initiation, or treatment completion. Most publications reporting cancer QoL use it as an outcome measure for treatment intervention comparisons and include timepoints such as pre- and post-operation(Chiu et al., 2018; Luddy et al., 2021), or as a measure for long-term survivorship (Kunitake et al., 2017). Specifying time since diagnosis, last treatment, etc. can be helpful to determine factors affecting QOL long term.

Study Limitations

Strengths of this study include the use of a standardized measurement of QoL (SF-36) with separate domains or physical and mental health, making our results comparable to other published studies across multiple cancer sites. In the future we plan to include prostate, colorectal, and liver cancers. These were not included in this analysis because there was low enrollment in these registries for completed SF-36 baseline measures due to the registries being started more recently, limiting our ability to find meaningful results in multivariate regression analyses. Our results are heterogeneous, as they represent baseline enrollment in our registry,

which can occur at any point in the survivorship continuum. However, this is also useful to understand QoL as it is affected both short and long term after a diagnosis of cancer and not just at the time of diagnosis and treatment. Another limitation of this study is the lack of racial/ethnic diversity. The patient population in this study represents the population seen at our institution, but our findings may not be generalizable to all races/ethnicities. Overall, this study adds to the literature by providing useful information about the roles of sociodemographic variables/factors in QoL across a variety of cancer types, rather than only focusing on a single cancer site.

Clinical Implications

QoL collected near the time of cancer diagnosis can serve as an important institutional baseline measure for future comparisons of QoL at more distant time points or as a means of quality improvement programming by identifying cancer patients who may need additional supportive care. Understanding QoL and the individual, disease, and treatment-related factors contributing to QoL, can be used to guide tailored education, risk assessment, and early intervention development to optimize survivorship planning. QoL assessment can also serve as a starting place for discussions with the care team for treatment, survivorship, and hospice, especially for patients for whom quality of life may be more valued than extending the quantity of life.

Conclusion

Both mental and physical aspects of quality of life are commonly affected in all cancer patients, regardless of the type, prognosis, and time since diagnosis and treatment. We identified several individual, disease, and treatment-related variables that are associated with

QoL among different cancer populations. Further results from this study support the importance of monitoring QoL not only at the time of diagnosis and treatment, but also longitudinally into survivorship.

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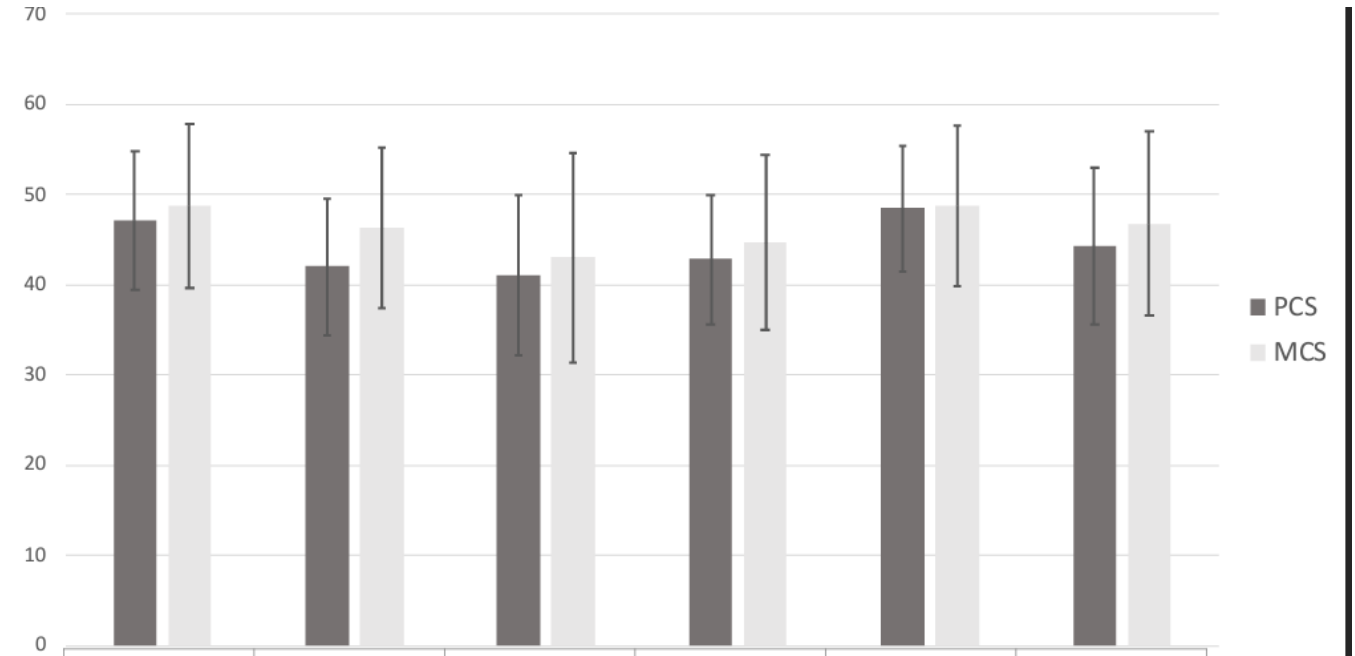

	Breast Cancer (N=1173)	Kidney Cancer (N=26)	Lung Cancer (N=23)	Ovarian Cancer (N=36)	Thyroid Cancer (N=338)	Uterine/Endometrium Cancer (N=43)
PCS	47.1±7.7	42.0±7.6	41.1±8.9	42.8±7.1	48.5±7.0	44.3±8.7
MCS	48.7±9.1	46.4±8.9	43.0±11.6	44.8±9.7	48.7±8.9	46.8±10.2

Figure 1. SF-36 scores among different cancer types

Table 1. Demographic and socioeconomic characteristics

Variable	Breast Cancer (n=1,339)		Kidney Cancer (n= 29)		Lung Cancer (n= 58)		Thyroid Cancer (n= 378)		Uterine/Endometrial Cancer (n= 63)		Ovarian Cancer (n= 40)		P-value
	No. (mean)	% (SD)	No. (mean)	% (SD)	No. (mean)	% (SD)	No. (mean)	% (SD)	No. (mean)	% (SD)	No. (mean)	% (SD)	-
Sex													***<0.0001***
Female	1328	99.2	9	31.0	33	56.9	301	79.6	63	100	40	100	
Male	11	0.8	20	69.0	25	43.1	77	20.4	-	-	-	-	
Age	59.1 ± 11.9		66.9 ± 10.4		67.9 ± 8.9		47.2 ± 15.0		64.6 ± 9.0		61.3 ± 11.8		***<0.0001***
Age category (years)													***<0.0001***
19-29	8	0.6	0	0	0	0	55	14.6	0	0	0	0	
30-39	69	5.2	0	0	0	0	72	19.1	2	3.2	1	2.5	
40-49	220	16.4	1	3.5	2	3.5	93	24.6	2	3.2	6	15.0	
50-59	401	30.0	7	24.1	11	19.0	84	22.2	10	15.9	12	30.0	
60+	641	47.90	21	72.40	45	77.60	74	19.60	49	77.80	21	52.50	
BMI	28.5 ± 6.2		30.4 ± 6.2		27.7 ± 5.2		29.4 ± 7.0		32.8 ± 6.1		28.9 ± 7.3		***0.0009***
BMI													***0.0024***
<18.5, underweight	19	1.4	0	0	0	0	7	1.9	0	0	0	0	
18.5-25, normal	385	28.8	4	13.8	19	32.8	105	27.8	6	9.5	11	27.5	
25-30, overweight	386	28.8	12	41.4	17	29.3	107	28.3	12	19.1	12	30.0	
≥30, obese	464	34.7	11	37.9	13	22.4	147	38.9	39	61.9	10	25.0	
Missing	85	6.4	2	6.9	9	15.5	12	3.2	6	9.5	7	17.5	
Race/Ethnicity													0.2139
Non-Hispanic White	1179	88.0	27	93.1	56	96.6	342	90.5	58	92.1	37	92.5	
Others	160	12.0	2	6.9	2	3.4	36	9.5	5	7.9	3	7.5	
Rurality													***0.0154***
Rural	272	20.3	8	27.6	10	17.2	105	27.8	19	30.2	11	27.5	
Urban	1067	79.70	21	72.40	48	82.80	273	72.20	43	68.31	29	72.50	
Education													***0.0004***
Less than high school	105	7.8	4	13.8	12	20.7	36	9.5	10	15.9	5	12.5	
High school	534	39.9	15	51.7	33	56.9	145	38.4	33	52.4	17	42.5	
College	335	25.0	6	20.7	4	6.9	116	30.7	10	15.9	8	20.0	
Graduate and above	223	16.7	4	13.8	5	8.6	81	21.4	9	14.3	9	22.5	
Missing	142	10.6	0	0	4	6.9	0	0	1	1.6	1	2.5	

Annual Income													***0.0019***
$10,000 - 44,999	295	22.0	9	31.0	17	29.3	6	1.6	26	41.3	6	2.5	
$45,000 - 74,999	254	19.0	8	27.6	4	6.9	13	3.4	15	23.8	6	15.0	
$75,000 - 100,000	198	14.8	2	6.9	12	20.7	4	1.1	7	11.1	5	15.0	
$100,000 and above	309	23.1	5	17.2	7	12.1	9	2.4	6	9.5	12	12.5	
Less than $10,000	37	2.8	2	6.9	4	6.9	1	0.3	0	0	1	30.0	
Missing	246	18.4	3	10.3	14	24.1	345	91.2	9	14.3	10	25.0	
Comorbidity													***<0.0001***
0	481	35.9	1	3.5	10	17.2	103	27.3	5	7.9	2	5.0	
1-2	556	41.5	5	17.2	14	24.1	186	49.2	16	25.4	13	32.5	
3+	302	22.6	23	79.3	34	58.6	89	23.5	42	66.7	25	62.5	
Time between cancer diagnosis and survey completion (years)	2.4 ± 4.3		4.8 ± 4.5		1.5 ± 2.1		3.5 ± 5.5		3.1 ± 3.8		3.4 ± 5.6		***<0.0001***

Table 2. Multivariable regression analysis: breast cancer patients

Breast cancer (N observed=1339, N used in model=921)										
Variables		PCS					MCS			
		N	Mean ± SD	Beta ± SE	p-value		Mean ± SD	Beta ± SE	p-value	
Age	40-59	434	NS				48.2 ± 9.3	1.86 ± 1.20	0.1199	***<0.001***
	60-69	268					48.7 ± 9.7	4.50 ± 1.25	***<0.001***	
	70 and above	161					50.2 ± 8.4	7.23 ± 1.35	***<0.001***	
	Less than 40	58					46.8 ± 7.6	Reference	-	
BMI	25-30, overweight	290	47.4 ± 7.4	-1.58 ± 0.60	***<0.01***	***<.0001***	48.7 ± 8.9	-2.36 ± 0.72	***<0.001***	***<0.001***
	30+, obese	335	44.5 ± 8.2	-3.73 ± 0.59	***<0.001***		46.4 ± 9.5	-3.65 ± 0.71	***<0.001***	
	<18.5, underweight	14	47.1 ± 9.1	-2.04 ± 1.96	0.2977		48.2 ± 9.0	-1.62 ± 2.32	0.4862	
	18.5-25, normal	282	49.5 ± 7.0	Reference	-		51.1 ± 8.4	Reference	-	
Race/Ethnicity	Others	135	44.4±8.5	-1.51±0.74	***<0.05***	***<0.05***	NS			
	Non-Hispanic White	1038	47.5±7.6	Reference	-					
Annual Income	< $10,000	29	38.6 ± 8.7	Reference	-	***<.0001***	38.2 ± 12.6	Reference	-	***<0.001***
	$10,000 - 44,999	232	43.9 ± 8.2	3.48 ± 1.43	***<0.05***		46.5 ± 8.9	6.95 ± 1.68	***<0.001***	

	$45,000 - 74,999	223	48.0 ± 7.4	6.79 ± 1.44	***<.0001***		49.3 ± 8.7	9.77 ± 1.70	***<0.001***	
	$75,000 - 100,000	172	48.2 ± 7.3	7.10 ± 1.48	***<.0001***		49.8 ± 8.6	10.91 ± 1.73	***<0.001***	
	> $100,000	265	49.0 ± 6.9	7.31 ± 1.45	***<.0001***		50.0 ± 8.8	10.66 ± 1.71	***<0.001***	
State	Iowa	126	47.4 ± 8.1	4.46 ± 1.73	***<0.01***	***<0.05***	NS			
	Nebraska	775	47.0 ± 7.8	3.67 ± 1.62	***<0.05***					
	Others	20	43.8 ± 7.6	Reference	-					
Number of Comorbidities	≥3	205	43.1 ± 8.4	-3.93 ± 0.68	***<0.001***	***<.0001***	45.6 ± 9.9	-5.19 ± 0.84	***<0.001***	***<0.001***
	1-2	418	47.4 ± 7.5	-1.10 ± 0.55	***<0.05***		48.3 ± 9.1	-2.77 ± 0.66	***<0.001***	
	0	298	49.1 ± 7.1	Reference	-		51.0 ± 8.1	Reference	-	

Table 3. Multivariable linear regression analysis: thyroid cancer patients

Thyroid cancer (N observed=378, N used in model=328)										
Variables		PCS					MCS			
		N	mean ± SD	Beta ± SE	p-value		mean ± SD	Beta ± SE	p-value	
Age	45-54	85	NS				49.7 ± 8.2	2.69 ± 1.17	***<0.05***	***<0.01***
	55 and above	97					49.9 ± 8.5	4.11 ± 1.16	***<0.001***	
	Less than 45	156					47.3 ± 9.4	Reference	-	
BMI	25-30, overweight	97	49.6 ± 6.9	0.12 ± 0.96	0.9042	***<0.05***	NS			
	30+, obese	128	46.6 ± 7.2	-2.40 ± 0.90	***<0.01***					
	<18.5 underweight	6	49.6 ± 10.8	-0.82 ± 2.78	0.7692					
	18.5-25, normal	97	49.8 ± 6.2	Reference	-					
Education level	Graduate and above	73	50.3 ± 6.2	2.15 ± 1.48	0.1474	***<0.001***	50.6 ± 7.5	3.95 ± 1.92	***<0.05***	***<0.001***
	College	99	50.1 ± 6.0	2.07 ± 1.42	0.1452		50.0 ± 8.3	3.43 ± 1.85	0.0644	
	High school	128	46.4 ± 7.6	-1.27 ± 1.38	0.3582		46.8 ± 9.7	-0.36 ± 1.80	0.8437	
	Less than high school	28	47.4 ± 7.1	Reference	-		47.1 ± 9.5	Reference	-	
Number of Comorbidities	1-2	161	49.1 ± 6.5	-0.82 ± 0.88	0.3485	***<0.01***	48.4 ± 8.8	-2.37 ± 1.14	***<0.05***	***<0.05***
	≥3	78	45.5 ± 7.6	-3.56 ± 1.04	***<0.001***		47.2 ± 9.2	-3.66 ± 1.35	***<0.01***	
	0	89	50.1 ± 6.7	Reference	-		50.5 ± 8.7	Reference	-	