

Mental and Physical Health–Related Quality of Life among U.S. Cancer Survivors: Population Estimates from the 2010 National Health Interview Survey

Kathryn E. Weaver¹, Laura P. Forsythe^{2,3}, Bryce B. Reeve⁴, Catherine M. Alfano², Juan L. Rodriguez⁵, Susan A. Sabatino⁵, Nikki A. Hawkins⁵, and Julia H. Rowland²

Abstract

Background: Despite extensive data on health-related quality of life (HRQOL) among cancer survivors, we do not yet have an estimate of the percentage of survivors with poor mental and physical HRQOL compared with population norms. HRQOL population means for adult-onset cancer survivors of all ages and across the survivorship trajectory also have not been published.

Methods: Survivors ($N = 1,822$) and adults with no cancer history ($N = 24,804$) were identified from the 2010 National Health Interview Survey. The PROMIS[®] Global Health Scale was used to assess HRQOL. Poor HRQOL was defined as 1 SD or more below the PROMIS[®] population norm.

Results: Poor physical and mental HRQOL were reported by 24.5% and 10.1% of survivors, respectively, compared with 10.2% and 5.9% of adults without cancer (both $P < 0.0001$). This represents a population of approximately 3.3 million and 1.4 million U.S. survivors with poor physical and mental HRQOL. Adjusted mean mental and physical HRQOL scores were similar for breast, prostate, and melanoma survivors compared with adults without cancer. Survivors of cervical, colorectal, hematologic, short-survival, and other cancers had worse physical HRQOL; cervical and short-survival cancer survivors reported worse mental HRQOL.

Conclusion: These data elucidate the burden of cancer diagnosis and treatment among U.S. survivors and can be used to monitor the impact of national efforts to improve survivorship care and outcomes.

Impact: We present novel data on the number of U.S. survivors with poor HRQOL. Interventions for high-risk groups that can be easily implemented are needed to improve survivor health at a population level. *Cancer Epidemiol Biomarkers Prev*; 21(11); 2108–17. ©2012 AACR.

Introduction

The remarkable progress made in the past few decades in early detection and effective treatment of cancer is leading to a steady increase in the number of long-term cancer survivors. Cancer incidence declined by approximately 1% per year during the period between 2003 and 2007, whereas cancer mortality has been slowly declining

since the 1990s (1). The result is that there are now an estimated 12.6 million cancer survivors in the United States alone, and these figures are expected to continue increasing largely due to the aging of the population (2). While many survivors report good health-related quality of life (HRQOL) after cancer, there appears to be a vulnerable subgroup of the survivor population that continues to experience poor HRQOL. It is critical to quantify the variation of cancer's impact on survivors' HRQOL if we are to understand the true burden of cancer on the population and, importantly, measure the effect of cancer control efforts on optimizing the health and well-being of cancer survivors (3). Understanding the risk factors associated with below population-average or poor HRQOL will help identify these individuals and aid in planning interventions for this group.

Previous research suggests that cancer survivors, relative to those without a cancer history, have poorer HRQOL on average. In particular, survivors report more functional impairment (4, 5), poorer health (5–7), greater psychologic distress (8), and more mental health needs (9). While older age and greater likelihood of co-morbid conditions exhibited by survivors contribute to these

Authors' Affiliations: ¹Department of Social Sciences and Health Policy, Wake Forest School of Medicine, Winston-Salem, North Carolina; ²Office of Cancer Survivorship, ³Cancer Prevention Fellow, Center for Cancer Training, National Cancer Institute, NIH/DHHS, Bethesda, Maryland; ⁴Department of Health Policy and Management, Gillings School of Global Public Health, University of North Carolina at Chapel Hill, Chapel Hill, North Carolina; and ⁵Division of Cancer Prevention and Control, Centers for Disease Control and Prevention, Atlanta, Georgia

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Corresponding Author: Kathryn E. Weaver, Department of Social Sciences & Health Policy, Wake Forest School of Medicine, Medical Center Boulevard, Winston-Salem, NC 27157. Phone: 336-713-5062; Fax: 336-716-7554; E-mail: keweaver@wakehealth.edu

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differences, studies that match individuals with and without cancer history on these factors also find decreased HRQOL among patients with cancer (10). Importantly, many of the prior population-based HRQOL studies conducted among survivors used sources such as the Medicare Health Outcomes Survey that were restricted to Medicare beneficiaries 65 years of age and older (e.g., 10, 11), whereas others have lacked a comprehensive HRQOL measure (e.g., 7, 9).

Identifying who in the survivor population is at risk for poor HRQOL and the associated risk factors for this status are important first steps in efforts to develop and appropriately target interventions with the potential to reduce the individual and social burden of cancer. The current study used a U.S. population-based sample to (i) compare the physical and mental HRQOL of cancer survivors to those without a cancer history by examining means and estimating the proportion who experience poor or below population-average physical and mental HRQOL and (ii) identify the general and cancer-specific characteristics that may put survivors at risk for experiencing poor physical and mental functioning.

Materials and Methods

Participants

Data came from the 2010 National Health Interview Survey (NHIS; ref. 12), an annual, in-person, nationwide survey that tracks trends in illness and disability in the United States. The NHIS uses a complex sampling framework involving clustering, stratification, and multistage sampling to derive a representative sample of the civilian, noninstitutionalized population. Blacks, Hispanics, and Asians are oversampled. Data are collected by trained census interviewers during household interviews using computer-assisted personal interviewing (CAPI). One adult per family was randomly chosen to complete the Sample Adult questionnaire, which contained the Cancer Control Supplement. The Cancer Control Supplement, developed and co-funded by the National Cancer Institute and the Centers for Disease Control and Prevention, is fielded approximately every 5 years and includes questions on cancer risk factors, health behaviors, cancer screening, and cancer survivorship.

The 2010 NHIS sample included 27,157 persons 18 years and older for the Sample Adult survey; the conditional response rate was 77.3% and the overall response rate was 60.8%. Data for the current analysis were drawn from the Person, Sample Adult, and Cancer Control Supplement files (12).

Measures

Demographic and disease variables. Sociodemographic variables included self-reported age, education [classified as <high school, high school or general educational development (GED), some college or 2-year degree, or ≥ 4 -year degree], race/ethnicity (non-Hispanic white, non-Hispanic black, Hispanic, Asian, or other), marital status (married or living with a partner vs. others), sex,

poverty status [defined relative to the poverty index using the NHIS imputed files (ref. 13)—<100%, 100%–199%, 200%–399%, and $\geq 400\%$], and employment status (full-time, part-time, retired, or not currently employed). In multivariate analyses, we chose to use education rather than poverty status because of significant collinearity between these predictors ($P \leq 0.0001$; χ^2). The Sample Adult file contained information on self-reported cancer history (including site and age at diagnosis), as well as other co-morbid health conditions. We grouped hematologic malignancies (leukemias, lymphomas, and other blood cancers), as well as cancers with a short survival time (esophagus, liver, lung, pancreas, and stomach) to create categories for most recent cancer type. As in prior studies, short-survival cancers were defined as those with a 5-year relative survival of less than 25% (5). For analyses including only cancer survivors, we used breast cancer as the reference group, as the quality of life of these survivors has been well characterized in the research literature. Time since cancer diagnosis was calculated by subtracting age at first cancer diagnosis from the participant's age at interview. A small number of individuals ($n = 54$) possibly misunderstood the age at cancer diagnosis question and reported cancer types and corresponding ages that were extremely unlikely (e.g., prostate cancer at the age of 3). Following the methodology of Yabroff and colleagues (5), we considered the time since diagnosis and cancer site to be missing for these cases. Adults who reported a history of cancer were also asked about current treatment status [in active treatment, received treatment in the last 12 months (recent), no current or recent treatment], types of treatments received for the most recent cancer (surgery, radiation, chemotherapy, hormonal, and bone marrow/stem cell transplant treatments), and cancer recurrence. We examined the prevalence of ever being diagnosed with non-cancer co-morbid health conditions (hypertension, heart disease, stroke, diabetes, lung disease), using definitions from previous NHIS research (5, 14). We defined heart disease as reporting coronary heart disease, angina, myocardial infarction, or any other heart condition. Lung disease included chronic bronchitis, emphysema, and current asthma. We added arthritis to the co-morbidities because of its important impact on health-related quality of life. We summed the co-morbidities for use in multivariate modeling.

HRQOL. The 10-item Patient-Reported Outcomes Measurement Information System (PROMIS[®]) Global Health Scale (PROMIS[®] Global 10) was used to assess key HRQOL domains including pain, fatigue, mental health, physical health, social health, and overall health. Prior psychometric work suggests the presence of two 4-item factors: global physical health (overall physical health, physical functioning, pain, and fatigue) and global mental health (quality of life, mental health, satisfaction with social activities, and emotional problems; ref. 15). The general health and satisfaction with social roles items were examined as single items, as were the pain and fatigue items because these are important symptoms among long-term cancer survivors. The physical and

mental health summary scores were scored according to PROMIS® instructions (16) and transformed to *T*-score distributions with a mean of 50 and SD of 10. The PROMIS® *T*-score metric was set on the basis of a sample that is representative of the U.S. adult population (17). Higher PROMIS® scores represent better HRQOL.

Analytic plan

We conducted weighted analyses using SUDAAN (Version 9) to account for the unequal probability of selection resulting from the complex survey design of the NHIS. The incorporation of sampling weights is necessary to avoid biased estimates of model parameters and variances. First, we examined mean HRQOL outcomes for adults without cancer and cancer survivors (stratified by most recent cancer type), in both unadjusted and adjusted ordinary least-squares regression models including socio-demographic and health characteristics (age, sex, race/ethnicity, education, marital status, and non-cancer co-morbidities). We also examined time since most recent cancer diagnosis as a predictor of HRQOL, combining across cancer types. Survivors (<2, 2–5, 6–10, and 11+ years) were compared with adults without cancer in both unadjusted and adjusted models to assess HRQOL impact across the cancer trajectory.

Next, we calculated population estimates for the proportion of survivors and adults without cancer who report PROMIS® mental and physical health HRQOL scores more than 1 SD below the population mean of 50 (PROMIS® *T*-score <40). Standardized values for clinically important differences have not yet been identified for the PROMIS® summary scales, so we chose to use the conservative 1-SD criterion, which is commonly used as a definition for impairment in functioning. This standard would be expected to identify the 15% of individuals in the population with the worst HRQOL. Population estimates for the number of U.S. cancer survivors with poor HRQOL were calculated by multiplying the proportion of the population by the sum of the population weights.

Finally, we also examined multivariable logistic regression models stratified by cancer history with poor HRQOL (defined as a PROMIS® score <40) as the outcome. Age, race/ethnicity, sex, marital status, education, and number of non-cancer co-morbidities were included as covariates for both groups; most recent cancer site, time since diagnosis, recurrence, treatment recency, and number of cancers were included as covariates only for cancer survivors.

Results

Sample

In the 2010 NHIS, a total of 2,333 adults reported a history of cancer. We excluded persons who reported a history of exclusively non-melanoma skin or "unknown" skin cancers ($n = 494$) and those who did not answer questions about cancer type ($n = 17$), resulting in an analytic sample of 1,822 cancer survivors. The comparison population included 24,804 adults without a history of

cancer. HRQOL data was missing for 8.6% of the cases. Older persons and those with less education were more likely to be missing mental and physical HRQOL data. Black and Asian adults were more likely to be missing mental HRQOL data than non-Hispanic whites.

As found in previous analyses, adult cancer survivors were older, less likely to be racial and ethnic minorities, more likely to be female, reported higher incomes, and had more non-cancer co-morbidities than adults without a history of cancer (see Table 1). Cancer-specific characteristics of survivors are shown in Table 2. Almost 12% of the survivors reported that they had a recurrence of their cancer.

HRQOL in survivors and individuals without a history of cancer

In unadjusted models (shown in Supplementary Table S1), the overall effect of both cancer site and time since last cancer diagnosis was statistically significant for all HRQOL outcomes. In multivariate-adjusted models, most recent cancer type was a significant predictor of HRQOL outcomes (see Table 3); time since most recent cancer diagnosis was significantly associated with only physical, general health, fatigue, and pain HRQOL. Breast, prostate, and melanoma cancer survivors had HRQOL-estimated marginal means that were not statistically different from or exceeded those of adults without a history of cancer. In contrast, survivors of colorectal, cervical, hematologic, short-survival, and "other" cancers had significantly poorer physical HRQOL and fatigue compared with adults without cancer (all $P < 0.05$). Survivors of cervical and short-survival cancers also reported significantly poorer mental HRQOL and general health. Worse pain was reported by survivors of cervical, hematologic, and "other" malignancies.

In multivariate-adjusted models, the overall effect of time since diagnosis (with adults without cancer as a comparison group) was significant for physical HRQOL, fatigue, pain, and general health but not mental HRQOL or satisfaction with social functioning (see Table 3). Survivors who were less than 2 years from their most recent cancer diagnosis reported lower physical HRQOL, fatigue, and pain scores but were not significantly different from adults without cancer on mental HRQOL, general health, and satisfaction with social roles. Survivors 2 to 5 years since their most recent cancer diagnosis reported significantly lower physical and mental HRQOL, general health, and fatigue scores than adults without cancer. The groups that were 6–10 and 11+ years from their last cancer diagnosis reported significantly lower physical HRQOL and fatigue (scores only for the 6–10 year survivors) than adults without cancer.

Population estimates for poor HRQOL among cancer survivors

Approximately 24.5% of cancer survivors reported physical HRQOL more than 1 SD below the population mean (i.e., a *T*-score <40), whereas 10.1% reported poor mental HRQOL (see Table 4). This represents an estimated

Table 1. Demographic characteristics of cancer survivors and adults without a history of cancer from the 2010 NHIS

Characteristic	Grouping	Cancer survivors	No cancer diagnosis
		(N = 1,822)	(N = 24,804)
		Raw N (weighted %)	Raw N (weighted %)
Current age group, y	<50	353 (20.8)	14,586 (61.5)
	50–64	555 (31.9)	5,951 (24.4)
	65–79	599 (32.5)	3,121 (10.6)
	80+	315 (14.7)	1,146 (3.5)
Race/ethnicity	White	1,340 (83.2)	13,734 (66.9)
	Black	245 (8.2)	4,250 (12.4)
	Hispanic	169 (5.9)	4,977 (14.8)
	Asian	54 (1.8)	1,668 (5.0)
	Other	14 (0.9)	175 (0.8)
Sex	Male	682 (42.0)	11,063 (48.8)
	Female	1,140 (58.0)	13,741 (51.2)
Marital status	Married/living with partner	881 (63.0)	12,448 (60.9)
	Not married	940 (37.0)	12,310 (39.1)
Education	<High school	308 (14.0)	4,292 (14.5)
	High school or GED	495 (28.6)	6,540 (26.9)
	Some college or 2-y degree	544 (30.5)	7,338 (30.5)
	≥4-y degree	465 (26.9)	6,522 (28.0)
Poverty status, % of federal poverty level ^a	<100%	244.6 (9.1)	4,572.0 (13.8)
	100%–199%	425.8 (20.7)	5,291.8 (19.2)
	200%–399%	573.2 (33.1)	7,226.2 (30.1)
	400%+	578.4 (37.1)	7,714.0 (36.9)
Non-cancer co-morbid conditions, % yes	Hypertension	909 (47.0)	6,436 (24.0)
	Heart disease	480 (25.9)	2,697 (10.5)
	Stroke	128 (6.9)	687 (2.4)
	Diabetes	343 (18.1)	2,352 (8.4)
	Lung disease	329 (17.3)	2,765 (11.2)
	Arthritis	872 (46.4)	5,323 (20.5)
Number of non-cancer co-morbid conditions	0	415 (24.9)	13,479 (55.9)
	1	488 (27.1)	5,691 (23.4)
	2+	903 (48.0)	5,485 (20.6)
Employment	Full-time	448 (27.5)	11,963 (50.5)
	Part-time	161 (9.4)	2,659 (11.8)
	Retired	768 (41.0)	3,741 (12.9)
	Not employed	433 (22.1)	6,229 (24.8)

NOTE: All descriptive characteristics with the exception of marital status and education were significantly different between survivors and adults without a history of cancer ($P < 0.0001$; χ^2). Weighting incorporates design, ratio, nonresponse, and poststratification adjustments.

^a2010 Federal Poverty Level was \$22,050 for a family of 4. Raw Ns include decimal places for this variable due to multiple imputation procedures applied by the National Center for Health Statistics.

population of approximately 3.3 and 1.4 million U.S. cancer survivors with poor physical and mental HRQOL, respectively. Prevalence of poor HRQOL in adults without a history of cancer was significantly lower than in the survivor sample, 10.2% for physical HRQOL and 5.9% for mental HRQOL ($\chi^2 = 142.5$ and 23.4 , respectively; $P < 0.0001$). Seven percent of survivors, representing a population of almost 973,000 U.S. adults, reported both physical and mental HRQOL <40.

Predictors of poor HRQOL in survivors and adults without cancer

Physical health. We stratified multivariate models by cancer history and adjusted for age, sex, race/ethnicity, marital status, education, and number of co-morbidities (Table 5), as well as time since diagnosis, treatment recency, number of cancers, recurrence, and most recent cancer site for the survivors. There was no linear trend for age category with increasing risk for poor physical HRQOL in

Table 2. Cancer-related characteristics of survivors in the 2010 NHIS (N = 1,822)

	Raw N (weighted %)
Site of most recent cancer	
Female breast	398 (19.8)
Prostate	261 (15.5)
Melanoma	153 (10.5)
Cervix	143 (7.8)
Colorectal	143 (7.6)
Hematologic malignancies	106 (6.6)
Short-survival cancers	102 (5.6)
Other	427 (24.5)
Unknown ^a	35 (2.1)
Missing ^b	54
Time since last diagnosis, y	
<2	256 (15.7)
2–5	440 (28.5)
6–10	347 (20.3)
11+	611 (35.5)
Ever had a recurrence	
Yes	185 (11.8)
No	1,463 (88.2)
Treatment status	
Current	109 (6.3)
Within the past 12 mo	154 (9.5)
Not in the past 12 mo	1,389 (84.2)
Number of cancers	
1	1,633 (89.6)
≥2	189 (10.4)
Treatments received, % yes	
Surgery	1,145 (69.8)
Radiation	449 (26.8)
Chemotherapy	422 (25.6)
Hormonal therapy	113 (7.0)
Bone marrow/stem cell transplant	8 (0.5)
None	98 (5.9)

NOTE: Numbers may not sum to 1,822 due to missing data for some variables.

^aLast cancer site "unknown" was either due to multiple cancers diagnosed in the same calendar year or missing data on year of diagnosis for one or more reported cancers.

^bFifty-four cases were defined as missing on cancer site and time since diagnosis due to improbable combinations of cancer site and age at diagnosis.

either survivors or adults without cancer. Adults without cancer who were ages 50 to 64 were the only group with significantly increased risk compared with the youngest age groups. Less education and having more than one non-cancer co-morbidity were also independently associated with poor physical HRQOL among both groups. Females without cancer were at increased risk for poor physical HRQOL, but this was not true among survivors.

There were no significant race/ethnicity differences in physical HRQOL among cancer survivors; among adults without cancer. Asian adults were significantly less likely than non-Hispanic whites to report poor physical HRQOL.

Compared with survivors with breast cancer, survivors with cervical, hematologic, short-survival, and less common "other" cancers were more likely to report poor physical HRQOL. Survivors of prostate cancer were significantly less likely to report poor physical HRQOL. Neither cancer recurrence nor time since most recent cancer diagnosis was a significant predictor of poor physical HRQOL. Survivors currently receiving cancer treatment (excluding maintenance hormonal therapies) were significantly more likely to report poor physical HRQOL than survivors who did not receive treatment in the past 12 months. Survivors with more than one cancer diagnosis were not more likely to report poor physical HRQOL.

Mental health. Younger, unmarried, less educated, and persons with more non-cancer co-morbidities were at greater risk for poor mental HRQOL in both the cancer survivor and general adult populations. Hispanic and Asian adults without cancer were less likely than non-Hispanic whites to report poor mental HRQOL; there were no race/ethnicity differences among cancer survivors.

There were few site differences among cancer survivors. Compared with survivors with breast cancer, only survivors with short-survival cancers were significantly more likely to have poor mental HRQOL. Survivors with a recurrence were also more likely to report poor mental HRQOL. Neither time since diagnosis nor treatment recency was associated with likelihood of poor HRQOL. Surprisingly, survivors with multiple cancers were significantly less likely to report poor mental HRQOL.

Discussion

Overall, these data suggest resilience among many long-term survivors. In general, we found that after adjustment for sociodemographic differences, long-term survivors of many of the most common cancers in the survivor population (breast, prostate, and melanoma) were doing as well or better than adults without a history of cancer. However, not all survivors report they are thriving. This study adds to the literature on HRQOL after cancer by specifying that 25% and 10% of cancer survivors report poor physical and mental HRQOL, respectively, compared with only 10% and 6% of the adults without cancer. We estimate that more than 3.6 million cancer survivors report mental and/or physical HRQOL more than 1 SD below the population mean.

The higher rates of poor HRQOL among cancer survivors observed in this study are consistent with findings suggesting higher prevalence of poor physical and mental health outcomes among survivors relative to adults without cancer (8, 4, 18). Predictors of poor mental and physical HRQOL identified in this study, such as lower socioeconomic status and a greater number of

Table 3. Adjusted marginal means for HRQOL as measured by the PROMIS Global 10 by cancer site and time since most recent cancer diagnosis from the 2010 NHIS

	Physical HRQOL T-score mean (SE)	Mental HRQOL T-score mean (SE)	General health mean (SE)	Satisfaction with social roles mean (SE)	Fatigue mean (SE)	Pain mean (SE)
Adults without cancer (<i>N</i> = 22,370) ^a	53.2 (0.07)	53.9 (0.07)	3.9 (0.01)	3.8 (0.01)	4.1 (0.01)	4.1 (0.01)
Cancer type (most recent diagnosis); overall effect [Wald <i>F</i> (8 df)]	13.3, <i>P</i> < 0.0001	4.42, <i>P</i> < 0.0001	4.98, <i>P</i> < 0.0001	3.14, <i>P</i> = 0.002	8.61, <i>P</i> < 0.0001	7.00, <i>P</i> < 0.0001
Breast (<i>n</i> = 356)	52.7 (0.51)	54.5 (0.52)	4.0 (0.06)	3.9 (0.07)	4.1 (0.05)	4.1 (0.06)
Prostate (<i>n</i> = 229)	54.8 (0.62)	54.8 (0.72)	4.0 (0.08)	3.9 (0.07)	4.21 (0.06)	4.4 (0.07)
Melanoma (<i>n</i> = 139)	52.5 (0.74)	53.8 (0.65)	4.0 (0.08)	3.7 (0.08)	4.0 (0.08)	4.1 (0.08)
Cervix (<i>n</i> = 135)	49.3 (0.77)	50.2 (0.83)	3.6 (0.09)	3.5 (0.11)	3.8 (0.10)	3.7 (0.10)
Colorectal (<i>n</i> = 122)	50.7 (0.88)	53.3 (0.88)	3.8 (0.10)	3.7 (0.12)	3.9 (0.09)	4.1 (0.10)
Hematologic (<i>n</i> = 93)	48.5 (1.07)	51.7 (1.17)	3.7 (0.14)	3.5 (0.13)	3.7 (0.11)	3.9 (0.10)
Short-survival (<i>n</i> = 90)	47.5 (1.44)	50.9 (1.30)	3.5 (0.14)	3.5 (0.17)	3.6 (0.13)	3.9 (0.15)
All other tumor sites (<i>n</i> = 386)	50.4 (0.59)	52.9 (0.58)	3.7 (0.07)	3.7 (0.07)	3.9 (0.06)	3.9 (0.06)
Time since most recent cancer diagnosis; overall effect [Wald <i>F</i> (3 df)]	12.0, <i>P</i> < 0.0001	2.2, <i>P</i> = 0.07	3.0, <i>P</i> = 0.02	1.4, <i>P</i> = 0.25	9.2, <i>P</i> < 0.0001	2.8, <i>P</i> = 0.03
<2 y (<i>n</i> = 226)	49.0 (0.87)	52.4 (0.83)	3.7 (0.10)	3.7 (0.09)	3.7 (0.09)	3.9 (0.09)
2–5 y (<i>n</i> = 396)	51.1 (0.54)	52.7 (0.49)	3.7 (0.06)	3.7 (0.06)	3.9 (0.05)	4.0 (0.06)
6–10 y (<i>n</i> = 312)	52.0 (0.56)	53.5 (0.63)	3.9 (0.07)	3.8 (0.08)	4.0 (0.06)	4.0 (0.07)
11+ y (<i>n</i> = 553)	52.0 (0.41)	53.7 (0.43)	3.9 (0.05)	3.8 (0.05)	4.1 (0.04)	4.0 (0.05)

NOTE: All scales were coded so that higher scores indicate better HRQOL. Adjusted marginal means incorporate design, ratio, nonresponse, and poststratification adjustments and are adjusted for age, sex, race/ethnicity, education (<high school, high school or GED, ≥some college), marital status (married or living with partner vs. not married), education, and non-cancer co-morbidities (0, 1, or ≥2). Bold means are statistically significant (*P* < 0.05) for the comparison between the cancer site or time since diagnosis category group and adults without cancer.

^aCancer site subgroup ns shown are for the physical health summary score model. The subgroup "ns" vary slightly for the other models because of differences in missing data.

non-cancer co-morbidities, have also been identified in prior population and clinic-based samples (11, 19). Younger current age was also a correlate of poor mental health, consistent with prior research (18, 20).

Interventions to promote well-being among vulnerable populations of survivors are needed to improve HRQOL at a population level. For example, both cognitive behavioral therapy and physical activity interventions have been shown to improve physical and mental health quality of life in cancer survivors (21–23). The increasing availability of these kinds of interventions via telephone (24, 25) or Internet (26, 27) platforms will increase the scalability and reach of effective interventions. Given the very high prevalence of non-cancer co-morbidities in this population, as well as the importance of co-morbidities on HRQOL, it is essential to address both prevalent co-morbid disease, as well as risk factors for poor health as a part of comprehensive cancer-related follow-up care.

In contrast to other population-based studies of cancer survivors (28, 29), we did not observe any race/ethnicity

differences in mental or physical HRQOL among the cancer survivor sample. There is considerable heterogeneity in the research literature about racial and ethnic difference in HRQOL after cancer (for review, see ref. 30). Differences in the HRQOL measures used, as well as the sample characteristics (e.g., single cancer site vs. multiple cancers, population-based vs. clinic samples), may account for the different findings. It is possible that disease-specific measures of HRQOL may be more sensitive to racial/ethnic differences in the experience of cancer.

In addition, our finding about the lower risk for poor mental health among survivors with multiple cancers contrasts with recent population studies reporting worse physical and mental health outcomes for survivors of multiple cancers, compared with survivors with a single primary cancer (31, 32). This difference may be due to the specific outcomes examined (HRQOL vs. mental distress, co-morbidities, and disability) or the analytic strategy used for describing the effect. Burris and Andrykowski (31, 32) treated multiple cancers as a distinct group,

Table 4. Population estimates for poor HRQOL among cancer survivors from the 2010 NHIS as measured by the PROMIS Global 10

	Weighted prevalence adults without cancer	Weighted prevalence cancer survivors	Population estimate for cancer survivors (SE)
Physical health score < 1 SD below U.S. population mean	10.2%	24.5%	3,278,000 (184,000)
Mental health score < 1 SD below U.S. population mean	5.9%	10.1%	1,356,000 (122,000)
Physical and mental HRQOL < 1 SD below U.S. population mean	3.5%	7.2%	973,000 (99,000)

NOTE: 1 SD score below population mean = 40 on the PROMIS T-score metric. The comparison between survivors and adults without cancer is statistically significant for all comparisons ($P < 0.0001$).

comparing them with both single primary survivors and no-cancer controls. In contrast, we used single/multiple cancers as a covariate in multiple regression models that also controlled for site of most recent cancer diagnosis.

Interestingly, the PROMIS® Global Health Scale scores in our sample were somewhat higher than those observed in the PROMIS® validation sample (33). We observed an unadjusted mean of 53.3 and 53.9 for physical and mental health, respectively, in our adults without cancer compared with 49.8 and 49.0 in the overall validation sample. In addition, the unadjusted means for our cancer survivors were higher than those reported for the cancer subgroup of the PROMIS® validation sample (47.3 for mental and 43.6 for physical). We also observed that a smaller proportion of our participants had scores that were 1 SD below the population mean than would be expected on the basis of the comparison to the normal curve. It is difficult to explain the observed differences because both the PROMIS® validation and NHIS samples were weighted to reflect 2000 U.S. Census data. There were differences in both the sampling strategy and mode of PROMIS® data collection. The PROMIS® validation sample used a commercial Internet polling panel (17), whereas NHIS data are collected in-person by trained census workers using a geographic sampling strategy. Prior studies have suggested that telephone administration tends to yield more positive HRQOL scores than mail completion (34) and in-person administration as used in NHIS may have a similar effect. Ongoing studies of PROMIS® are collecting population-based data on cancer survivors with the goal to estimate population norms for cancer survivors.

Limitations of this study include the lack of recommended cutoff points for clinically significant impairments or minimally important differences in HRQOL. Further work will be needed to confirm the clinical significance of various cutoff points for the PROMIS® Global 10 items. Furthermore, because of the large number of cancer sites included in this study and the heterogeneity in treatments received by cancer site, we

were unable to examine treatment influences on HRQOL. Site-specific studies are more appropriate to answer the important question of how treatment influences long-term HRQOL, particularly if they include cancer-specific measures of HRQOL. As a generic HRQOL measure, the PROMIS® Global 10 is suitable to compare survivors with other adults but may not fully capture all domains of HRQOL relevant to cancer, such as sexual functioning. In addition, all data, including cancer history, were based on self-report. Although prior studies have suggested that there is good concordance between self-reported cancer and registry or medical record confirmed cases, misreporting may be a particular concern for male survivors (35) and women with endometrial and cervical cancers (35, 36). Our cancer survivor sample was 58% female compared with 54% female reported in the NCI SEER complete prevalence estimate (1) which may be evidence of under-reporting by males. Participants may also have had a hard time distinguishing between recurrence (either local or distal) and second cancers and between invasive cancer and precancerous conditions such as cervical dysplasia. Finally, the NHIS did not include cancer survivors living in institutions such as nursing homes or those too ill to participate who may have had worse HRQOL.

In conclusion, we present unique data on the HRQOL of long-term cancer survivors in the United States and the proportion and number with self-reported levels of HRQOL that may be of clinical concern. This study builds on prior research by examining the prevalence of poor HRQOL, rather than just average HRQOL scores, in a population-based sample of U.S. cancer survivors that includes both younger and older survivors. Cancer survivors were significantly more likely than adults without cancer to report poor HRQOL, with 24.5% reporting poor physical HRQOL and 10.1% reported poor mental HRQOL. Most concerning, 7.2% of survivors reported both poor mental and physical HRQOL. These data are useful for comparing the

Table 5. Multivariate predictors of poor HRQOL in cancer survivors and adults without a history of cancer from the 2010 NHIS using the PROMIS Global 10

Characteristic	Grouping	Physical HRQOL T-score <40		Mental HRQOL T-score <40	
		Cancer survivors [OR (95% CI)]	No cancer [OR (95% CI)]	Cancer survivors [OR (95% CI)]	No cancer [OR (95% CI)]
Current age, y	<50	Ref.	Ref.	Ref.	Ref.
	50–64	1.40 (0.85–2.31)	1.51 (1.32–1.73)	0.99 (0.58–1.67)	0.95 (0.81–1.12)
	65–79	0.76 (0.46–1.28)	0.95 (0.80–1.13)	0.30 (0.15–0.60)	0.39 (0.31–0.49)
	80+	1.01 (0.49–2.08)	1.23 (0.98–1.54)	0.37 (0.10–1.29)	0.42 (0.31–0.58)
	Linear trend	<i>P</i> = 0.61	<i>P</i> = 0.67	<i>P</i> = 0.03	<i>P</i> < 0.0001
Race/ethnicity	White	Ref.	Ref.	Ref.	Ref.
	Black	1.56 (0.95–2.55)	1.26 (1.08–1.46)	0.71 (0.38–1.31)	0.96 (0.80–1.15)
	Hispanic	1.08 (0.59–1.97)	1.19 (1.00–1.43)	1.19 (0.62–2.30)	0.78 (0.64–0.93)
	Asian	1.88 (0.69–5.09)	0.69 (0.50–0.94)	1.45 (0.41–5.12)	0.65 (0.44–0.98)
	Other	0.98 (0.25–3.85)	0.89 (0.52–1.54)	1.35 (0.26–6.92)	1.08 (0.61–1.90)
Sex	Male	Ref.	Ref.	Ref.	Ref.
	Female	0.95 (0.62–1.45)	1.42 (1.25–1.61)	0.90 (0.50–1.61)	1.10 (0.97–1.26)
Marital status	Married	Ref.	Ref.	Ref.	Ref.
	Not married	1.12 (0.81–1.56)	1.27 (1.12–1.43)	1.66 (1.09–2.51)	2.25 (1.95–2.61)
Education	<High school	4.36 (2.42–7.83)	4.73 (3.77–5.94)	3.59 (1.80–7.15)	4.33 (3.37–5.56)
	High school	2.01 (1.24–3.27)	2.78 (2.25–3.45)	2.85 (1.49–5.45)	2.36 (1.86–2.99)
	Some college	2.43 (1.47–4.00)	2.10 (1.72–2.56)	1.70 (0.82–3.49)	1.87 (1.49–2.35)
	≥4-y degree	Ref.	Ref.	Ref.	Ref.
Non-cancer, co-morbid conditions	0	Ref.	Ref.	Ref.	Ref.
	1	3.28 (1.84–5.85)	3.11 (2.60–3.72)	2.37 (1.17–4.80)	2.17 (1.79–2.62)
	2+	11.22 (6.65–18.93)	11.60 (9.84–13.68)	4.48 (2.26–8.90)	5.41 (4.52–6.48)
Site of last cancer	Female breast	Ref.		Ref.	
	Prostate	0.44 (0.19–0.99)		0.78 (0.23–2.60)	
	Melanoma	1.35 (0.67–2.74)		0.49 (0.15–1.61)	
	Cervix	2.16 (1.12–4.16)		1.67 (0.73–3.84)	
	Colorectal	1.49 (0.76–2.93)		1.89 (0.76–4.67)	
	Hematologic	2.51 (1.28–4.95)		1.87 (0.77–4.51)	
	Short survival	3.43 (1.62–7.25)		4.63 (1.83–11.70)	
	Other	1.97 (1.20–3.23)		1.56 (0.83–2.91)	
Time since last diagnosis, y	<2	Ref.		Ref.	
	2–5	1.27 (0.71–2.28)		0.75 (0.37–1.49)	
	6–10	0.67 (0.35–1.29)		0.51 (0.24–1.09)	
	>10	0.91 (0.47–1.77)		0.63 (0.30–1.32)	
Ever had a recurrence	No	Ref.		Ref.	
	Yes	1.45 (0.89–2.37)		2.44 (1.32–4.53)	
Treatment status	No recent	Ref.		Ref.	
	Recent ^a	1.01 (0.53–1.91)		0.78 (0.36–1.68)	
	Current	4.02 (1.96–8.26)		1.14 (0.48–2.71)	
Number of cancers	1 (ref)	Ref.		Ref.	
	≥2	1.09 (0.62–1.91)		0.25 (0.09–0.65)	

NOTE: Estimates shown in bold are statistically significant, *P* < 0.05. Non-cancer co-morbid conditions included hypertension, heart disease, stroke, diabetes, lung disease, and arthritis.

^aRecent treatment was defined as report of treatment in the last 12 months but not currently receiving treatment.

representativeness of other clinic- and state-based samples, identifying potentially vulnerable populations of survivors for clinic and public health interventions,

guiding the implementation of plans for survivorship care with the potential to improve HRQOL, and determining progress toward national goals of enhancing

life after cancer for the growing population of cancer survivors.

Disclosure of Potential Conflicts of Interest

Findings and conclusions in this report are those of the authors and do not necessarily represent the official position of the National Cancer Institute or the Centers for Disease Control and Prevention. No potential conflicts of interest were disclosed.

Authors' Contributions

Conception and design: K.E. Weaver, B.B. Reeve, C.M. Alfano, J.L. Rodriguez, N.A. Hawkins, J.H. Rowland

Development of methodology: K.E. Weaver, B.B. Reeve, J.L. Rodriguez, J. H. Rowland

Analysis and interpretation of data (e.g., statistical analysis, biostatistics, computational analysis): K.E. Weaver, L.P. Forsythe, B.B. Reeve, C.M. Alfano, J.L. Rodriguez, S.A. Sabatino, N.A. Hawkins, J.H. Rowland

Writing, review, and/or revision of the manuscript: K.E. Weaver, L.P. Forsythe, B.B. Reeve, C.M. Alfano, J.L. Rodriguez, S.A. Sabatino, N.A. Hawkins, J.H. Rowland

Administrative, technical, or material support (i.e., reporting or organizing data, constructing databases): J.L. Rodriguez

Study supervision: K.E. Weaver, J.H. Rowland

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References

- Howlader N, Noone AM, Krapcho M, Neyman N, Aminou R, Altekruse SF, et al. SEER cancer statistics review, 1975–2009 (Vintage 2009 Populations). Bethesda, MD: National Cancer Institute; 2012 Apr 30.
- Parry C, Kent EE, Mariotto AB, Alfano CM, Rowland JH. Cancer survivors: a booming population. *Cancer Epidemiol Biomarkers Prev* 2011;20:1996–2005.
- Institute of Medicine. From cancer patient to cancer survivor: lost in transition. The National Academies Press; Washington, DC 2006.
- Hewitt M, Rowland JH, Yancik R. Cancer survivors in the United States: age, health, and disability. *J Gerontol A Biol Sci Med Sci* 2003;58:82–91.
- Yabroff KR, Lawrence WF, Clauser S, Davis WW, Brown ML. Burden of illness in cancer survivors: findings from a population-based national sample. *J Natl Cancer Inst* 2004;96:1322–30.
- Dowling E, Yabroff KR, Mariotto A, McNeel T, Zeruto C, Buckman D. Burden of illness in adult survivors of childhood cancers. *Cancer* 2010;116:3712–21.
- Keating NL, Norredam M, Landrum MB, Huskamp HA, Meara E. Physical and mental health status of older long-term cancer survivors. *J Am Geriatr Soc* 2005;53:2145–52.
- Hoffman KE, McCarthy EP, Recklitis CJ, Ng AK. Psychological distress in long-term survivors of adult-onset cancer: results from a national survey. *Arch Intern Med* 2009;169:1274–81.
- Hewitt M, Rowland JH. Mental health service use among adult cancer survivors: analyses of the national health interview survey. *J Clin Oncol* 2002;20:4581–90.
- Reeve BB, Potosky AL, Smith AW, Han PK, Hays RD, Davis WW, et al. Impact of cancer on health-related quality of life of older Americans. *J Natl Cancer Inst* 2009;101:860–8.
- Smith AW, Reeve BB, Bellizzi KM, Harlan LC, Klabunde CN, Amsellem M, et al. Cancer, comorbidities, and health-related quality of life of older adults. *Health Care Financ Rev* 2008;29:41.
- National Center for Health Statistics. National Health Interview Survey, 2010 (machine readable data file and documentation). Hyattsville, MD: National Center for Health Statistics, Centers for Disease Control and Prevention; 2011.
- National Center for Health Statistics. NHIS - 2010 Imputed Income File. [accessed March 7th, 2012]. Available from: <http://www.cdc.gov/nchs/nhis/2010imputedincome.htm>.
- Pratt LA. Serious psychological distress, as measured by the K6, and mortality. *Ann Epidemiol* 2009;19:202–9.
- Hays RD, Bjorner JB, Revicki DA, Spritzer KL, Cella D. Development of physical and mental health summary scores from the patient-reported outcomes measurement information system (PROMIS®) global items. *Qual Life Res* 2009;18:873–80.
- PROMIS Network. Scoring PROMIS Global Short Form. PROMIS Scoring Manuals [cited 2010 Dec 16]; Available from: <http://www.assessmentcenter.net/documents/Scoring%20PROMIS%20Global%20short%20form.pdf>.
- Liu H, Cella D, Gershon R, Shen J, Morales LS, Riley W, et al. Representativeness of the patient-reported outcomes Measurement Information System Internet panel. *J Clin Epidemiol* 2010;63:1169–78.
- Costanzo ES, Ryff CD, Singer BH. Psychosocial adjustment among cancer survivors: findings from a national survey of health and well-being. *Health Psychol* 2009;28:147–56.
- Kroenke CH, Rosner B, Chen WY, Kawachi I, Colditz GA, Holmes MD. Functional impact of breast cancer by age at diagnosis. *J Clin Oncol* 2004;22:1849–56.
- Howard-Anderson J, Ganz PA, Bower JE, Stanton AL. Quality of life, fertility concerns, and behavioral health outcomes in younger breast cancer survivors: a systematic review. *J Natl Cancer Inst* 2012; 104:386–405.
- Jacobsen PB, Donovan KA, Vadapampili ST, Small BJ. Systematic review and meta-analysis of psychological and activity-based interventions for cancer-related fatigue. *Health Psychol* 2007;26:660–7.
- Rajotte E, Yi J, Baker K, Gregerson L, Leiserowitz Aa, Syrjala K. Community-based exercise program effectiveness and safety for cancer survivors. *J Cancer Surviv* 2012;6:219–28.
- Hart SL, Hoyt MA, Diefenbach M, Anderson DR, Kilbourn KM, Craft LL, et al. Meta-analysis of efficacy of interventions for elevated depressive symptoms in adults diagnosed with cancer. *J Natl Cancer Inst* 2012;104:990–1004.
- Ligibel JA, Meyerhardt J, Pierce JP, Najita J, Shockro L, Campbell N, et al. Impact of a telephone-based physical activity intervention upon exercise behaviors and fitness in cancer survivors enrolled in a cooperative group setting. *Breast Cancer Res Treat* 2012;132:205–13.
- Basen-Engquist K, Carmack CL, Perkins H, Hughes D, Serice S, Scruggs S, et al. Design of the steps to health study of physical activity in survivors of endometrial cancer: testing a social cognitive theory model. *Psychol Sport Exerc* 2011;12:27–35.
- Ritterband LM, Bailey ET, Thorndike FP, Lord HR, Farrell-Carnahan L, Baum LD. Initial evaluation of an Internet intervention to improve the sleep of cancer survivors with insomnia. *Psychooncology* 2012; 21:695–705.
- Leykin Y, Thekdi SM, Shumay DM, Munoz RF, Riba M, Dunn LB. Internet interventions for improving psychological well-being in psycho-oncology: review and recommendations. *Psychooncology* 2012; 21:1016–25.
- Clauser SB, Arora NK, Bellizzi KM, Haffer SC, Topor M, Hays RD. Disparities in HRQOL of cancer survivors and non-cancer managed care enrollees. *Health Care Financ Rev* 2008;29:23–40.
- Bowen D, Alfano C, McGregor B, Kuniyuki A, Bernstein L, Meeske K, et al. Possible socioeconomic and ethnic disparities in quality of life in a cohort of breast cancer survivors. *Breast Cancer Res Treat* 2007; 106:85–95.
- Aziz N, Rowland J. Cancer survivorship research among ethnic minority and medically underserved groups. *Oncol Nurs Forum* 2002;29: 789–801.

31. Andrykowski MA. Physical and mental health status of survivors of multiple cancer diagnoses. *Cancer* 2011;118:3645–53.
32. Burris J, Andrykowski M. Physical and mental health status and health behaviors of survivors of multiple cancers: a national, population-based study. *Ann Behav Med* 2011;42:304–12.
33. PROMIS Health Organization and PROMIS Cooperative Group. PROMIS instrument-level statistics including gender, educational level, age bracket, clinical, and levels of self-rated general health sub-groups. [cited 2011 Feb 16]; Available from: http://www.nihpromis.org/Documents/PROMIS_Age_Gender_Comorbidty.pdf.
34. Hays RD, Kim S, Spritzer KL, Kaplan RM, Tally S, Feeny D, et al. Effects of mode and order of administration on generic health-related quality of life scores. *Value Health* 2009;12:1035–9.
35. Hewitt M, Breen N, Devesa S. Cancer prevalence and survivorship issues: analyses of the 1992 national health interview survey. *J Natl Cancer Inst* 1999;91:1480–6.
36. Parikh-Patel A, Allen M, Wright WE. The California Teachers Study Steering Committee. Validation of self-reported cancers in the California Teachers Study. *Am J Epidemiol* 2003;157:539–45.