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Measuring health-related quality of life in adolescent and young adult cancer survivors with the National Institutes of Health Patient-Reported Outcomes Measurement Information System®: Comparing adolescent, emerging adult, and young adult survivor perspectives

Elizabeth J. Siembida[1] | Bryce B. Reeve[2] | Brad J. Zebrack[3] | Mallory A. Snyder[4] | John M. Salsman[5]

[1]Division of Cancer Control and Population Sciences, National Cancer Institute, Rockville, Maryland, USA

[2]Department of Population Health Sciences, Duke University School of Medicine, Durham, North Carolina, USA

[3]School of Social Work, University of Michigan, Ann Arbor, Missouri, USA

[4]Office of Research and National Laboratories, The University of Chicago, Illinois, Chicago, USA

[5]Department of Social Sciences and Health Policy, Wake Forest School of Medicine & the Wake Forest Baptist Comprehensive Cancer Center, North Carolina, Winston-Salem, USA

Correspondence
Elizabeth J. Siembida, Center for Health Innovation and Outcomes Research, Feinstein Institute for Medical Research, Northwell Health, 600 Community Dr, Suite 403, Manhasset, NY 11030, USA.
Email: esiembida@northwell.edu

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Abstract

Objective: Our knowledge of symptom burden and functioning among adolescent and young adult (AYA; diagnosed ages 15–39) cancer survivors has been hindered by variability in health-related quality of life (HRQOL) measurement associated with developmental and disease heterogeneity among AYAs. We aimed to examine the variability in domain-specific aspects of HRQOL as a function of cancer type and developmental stage to clarify commonalities and differences using the NIH Patient-Reported Outcome Measurement Information System®.

Methods: Five hundred seventy-two AYAs were recruited by an online research panel using stratified sampling (treatment status: on vs. off; developmental stage: adolescents, emerging adults, young adults). Participants completed questionnaires that included sociodemographic characteristics, clinical history, and the adult version of the Patient-Reported Outcomes Measurement Information System®-29 (PROMIS-29). Generalized linear models were run for each HRQOL domain and included treatment status, developmental stage, and cancer type (hematologic vs. solid tumor) and their interactions as independent variables.

Results: There were no significant differences in any HRQOL domain by cancer type, and few significant differences were observed in PROMIS domains between developmental groups among on-treatment AYA survivors. In contrast, off-treatment emerging adults and young adults reported significantly higher symptoms and worse functioning compared to adolescents (all $ps \leq 0.003$).

Conclusions: AYAs diagnosed in different developmental stages, particularly among off-treatment survivors, experienced diverse constellations of symptoms and functioning, and developmental stage was a more critical predictor of HRQOL than cancer type. These results suggest that supportive care interventions developed for

Present address: Elizabeth J. Siembida has since moved institutions since the completion of this work. Her current affiliation is the Center for Health Innovation and Outcomes Research at Northwell Health.

AYA cancer survivors must be tailored and flexible by developmental stage and treatment status.

KEYWORDS
adolescent and young adult, cancer, functioning, health-related quality of life, oncology, psycho-oncology, survivorship, symptoms

1 | BACKGROUND

Six times as many individuals are diagnosed with cancer in adolescence and young adulthood (diagnosed ages 15–39) compared to childhood (diagnosed < 15 years).[1] Adolescent and young adult (AYA) cancer survivors, inclusive of all individuals diagnosed with cancer regardless of treatment status, continue to experience significant impairment in health-related quality of life (HRQOL).[2,3] AYA cancer survivors report significantly lower HRQOL compared to their healthy peers in some studies,[4–6] but not all.[7] Discussions of HRQOL across the AYA survivor population have primarily focused on cancer type,[8,9] but there may be meaningful differences in HRQOL among AYA survivors diagnosed at different life stages.[4,10,11]

Adolescence and young adulthood are characterized by the development of autonomy, emotion regulation, and executive functioning.[12–15] For example, risk-taking increases in early adolescence and then decreases in emerging adulthood (18–25 years) while emotion regulation improves across late adolescence and young adulthood.[15,16] These changes occur in parallel to shifting parent–child relationships, beginning career paths, and childrearing.[13,17] Developmental changes may differentially impact AYA survivors' HRQOL, highlighting the need to examine HRQOL within the AYA developmental period.

The cancer types most commonly diagnosed among AYA patients also vary. Hematologic cancers are most common in adolescents (15–17 years) and emerging adults, and solid tumors are most common in young adults (26–39 years).[18] Disease heterogeneity leads to variations in treatment exposure, which may be associated with differences in HRQOL outcomes.[19,20] Within AYA cancer survivors, it is likely that both treatment exposure and developmental changes are influencing their HRQOL, but potentially influencing different domains.

The overall objective of this study is to improve our understanding of HRQOL within the diverse (by both age and cancer type) AYA cancer survivor population. Guided by lifespan developmental frameworks, we categorized AYA cancer survivors into three developmental stages: adolescence (15–17 years), emerging adulthood (18–25 years) and young adulthood (26–39 years).[17,21,22] First, we describe the symptom burden and functional impact of cancer in AYA survivors across seven domains of HRQOL overall and by treatment status. We hypothesized that the psychosocial HRQOL domains scores will reach the threshold for clinical relevance. Second, we examine the variability in domain-specific aspects of HRQOL as a function of cancer type, developmental stage, and treatment status. We hypothesize that the physical aspects of HRQOL will be more strongly associated with cancer type, and the psychosocial aspects of HRQOL will be more strongly associated with developmental stage.

2 | METHODS

2.1 | Data collection and study participants

We utilized a 2 × 3 stratified sampling design (on- vs. off-treatment; adolescents, emerging adults, young adults) to conduct an online, cross-sectional survey. AYAs were eligible to be included in the study if they: (1) were diagnosed with stage 0-IV cancer between the ages of 15 and 39, (2) were either currently receiving treatment or less than 5 years posttreatment, (3) were between the ages of 15 and 39 at time of survey, (4) could speak and read English, (5) had Internet access, and (6) could provide electronic consent to the study prior to participation. Individuals were not eligible if they were diagnosed with basal cell carcinoma.

We partnered with the online research panel Op4G to recruit and consent AYA cancer survivors. Op4G partners with national health-related nonprofit organizations to recruit their donors, volunteers, and the communities they support. This approach aids in recruiting panel members from high-, middle-, and low-socioeconomic strata. AYA survivors selected a nonprofit organization for an Op4G donation as incentive for completing the survey. Participants were provided the opportunity to opt out of the survey at any time. To ensure data quality, we eliminated surveys indicative of invalid responding (e.g., survey completion time < one-third median completion time, etc.), and excluded surveys missing >10% of the items. The study procedures were approved by the Northwestern University Institutional Review Board (Protocol #: IRB00035377). The data that support the findings of this study are available from the corresponding author upon reasonable request.

2.2 | Measures

2.2.1 | Health-related quality of life

HRQOL was assessed using the English-language, adult version of the Patient-Reported Outcomes Measurement Information System®-29 (PROMIS®-29) health status profile v2.0.[23] The PROMIS-29 was completed unassisted by self-report, and assessed seven HRQOL

domains (physical function, ability to participate in social roles and activities [social participation], fatigue, pain interference, sleep disturbance, anxiety, and depression) using four items for each domain. Internal consistency in the current sample (Cronbach's alpha [α]) was high (physical function $\alpha = 0.93$; fatigue $\alpha = 0.94$; pain interference $\alpha = 0.94$; sleep disturbance $\alpha = 0.85$; anxiety $\alpha = 0.93$; depression $\alpha = 0.93$; social participation $\alpha = 0.94$).

The raw sum score of each PROMIS measure was converted to a T-score with a mean of 50 and SD of 10 using the PROMIS-29 profile v2.0 scoring table.[24] A score of 50 is considered the general US population mean. For all symptom and functioning domains, summary scores were not calculated when ≥25% of items were missing. Higher scores represent greater symptom burden for pain interference, fatigue, sleep disturbance, anxiety, and depression; and for physical functioning and social participation, lower scores represent worse functioning.

Research in cancer survivors has identified ranges of PROMIS T-scores to indicate minimally important differences (MIDs) between groups for most of the HRQOL domains: fatigue (2.5–5.0 points), pain interference (4.0–6.0 points), physical function (4.0–6.0 points), anxiety (3.0–4.5 points), and depression (3.0–4.5 points).[25] MID cut-offs for social participation and sleep disturbance have not been established in cancer samples. Instead, we considered a one half SD (5 points) difference in scores to be clinically relevant for these two outcomes. This approach has been used in previous studies with PROMIS measures.[26]

2.2.2 | Sociodemographic and clinical characteristics

Sociodemographic and clinical characteristics were captured through self-report. The sociodemographic characteristics included: AYA developmental stage (adolescence; emerging adulthood; young adulthood), race/ethnicity (non-Hispanic white; other race/ethnicity), sex (male; female), health insurance coverage (yes; no), and history of other comorbid conditions (e.g. diabetes, migraines, etc.), which were grouped into four categories (no conditions; 1 condition; 2–3 conditions; 4+ conditions).

Clinical characteristics included: cancer type (hematologic cancer; solid tumor), treatment status (on-treatment; off-treatment), history of chemotherapy (yes; no), history of surgery (yes; no), and history of radiation (yes; no). In order to examine differences in HRQOL between cancer types, we created a dichotomous cancer type variable grouping hematologic cancers (Hodgkin lymphoma, leukemia, myeloma, non-Hodgkin lymphoma) and solid tumors (bladder cancer, bone tumors + sarcomas, brain cancer, breast cancer, central nervous system tumor, cervical cancer, colorectal cancer, esophageal cancer, head and neck cancer, hepatobiliary cancer, kidney cancer, lung cancer, melanoma, ovarian cancer, stomach cancer, testicular cancer, thyroid cancer) into separate categories. This was done in order to maintain sufficient power for subgroup analysis.

2.3 | Statistical analysis

We tested our first hypothesis by calculating the means and SDs for each HRQOL domain among the full sample and by treatment status. If the pain, fatigue, anxiety, sleep disturbance, and/or depression scores were above 50 and exceeded the lower bound of the MID range (or half a SD), we considered this HRQOL domain to be clinically impacted by cancer. Similarly, if the physical function and/or the social participation scores were below 50 and exceeded the lower bound for a MID (or half a SD), this domain was considered clinically impacted by cancer.

To test our second hypothesis, we ran a generalized linear model (GLM) for each HRQOL domain. Each GLM included developmental stage, cancer type, and treatment status as the primary independent variables. We also tested the interaction terms between all three variables (developmental stage*cancer type, developmental stage*-treatment status, cancer type*treatment status). If any of the interaction terms were found to be significant at $p \leq 0.003$ (Bonferroni-correction; 0.05/16), it was retained in the final model. Interaction terms that did not meet this threshold were removed. Each GLM also controlled for sociodemographic and clinical variables. All tests were two-sided, and analyses were conducted using SAS 9.4 (Cary, NC).

3 | RESULTS

3.1 | Sample characteristics

A total of 572 AYAs completed the survey with balanced representation by on-treatment ($N = 294$, 51.4%) and off-treatment ($N = 278$, 48.6%) survivors, and across the three developmental groups (adolescents: 189, 33.0%; emerging adults: 193, 33.7%; young adults: 190, 33.2%). Descriptive statistics stratified by cancer type and developmental stage are summarized in Table 1.

3.2 | Overall HRQOL in AYA cancer survivors

The overall means and SDs for each HRQOL domain in the full sample and stratified by treatment status can be found in Table 2. Five of the seven domains (anxiety, depression, fatigue, pain interference, and physical function) reached the clinically relevant threshold in the overall sample. Additionally, this finding held true and was extended in the on-treatment survivors with all seven domains reaching the minimum threshold for clinical relevance. Among off-treatment survivors, only the psychosocial outcomes (anxiety, depression) met the clinically relevant threshold.

3.3 | Differences in HRQOL by cancer type and developmental stage

For all HRQOL domains, we only saw a significant interaction effect between treatment status and developmental stage. There was no

TABLE 1 Sociodemographic and clinical characteristics among adolescent and young adult cancer survivors, stratified by age at diagnosis

	Adolescents, $N = 189$	Emerging adults, $N = 193$	Young adults, $N = 190$	Hematologic cancers, $N = 135$	Solid tumors, $N = 437$	Overall sample, $N = 572$
Developmental stage (*N*, %)						
Adolescents	-	-	-	73 (54.1)	116 (26.5)	189 (33.0)
Emerging adults	-	-	-	42 (31.1)	151 (34.6)	193 (33.7)
Young adults	-	-	-	20 (14.8)	170 (38.9)	190 (33.2)
Cancer diagnosis (*N*, %)						
Hematologic cancers	73 (38.6)	42 (21.8)	20 (10.5)	-	-	135 (23.6)
Solid tumors	116 (61.4)	151 (78.2)	170 (89.5)	-	-	437 (76.4)
Sex (*N*, %)						
Male	108 (57.1)	105 (54.4)	110 (57.9)	69 (51.1)	254 (58.1)	323 (56.5)
Female	81 (42.9)	88 (45.6)	80 (42.1)	66 (48.9)	183 (41.9)	249 (43.5)
Current living situation (*N*, %)						
Live alone	4 (2.1)	45 (23.3)	74 (39.0)	13 (9.6)	110 (25.2)	123 (21.5)
Live with others	185 (97.9)	148 (76.7)	116 (61.1)	122 (90.4)	327 (74.8)	449 (78.5)
Health insurance coverage (*N*, %)						
No	22 (11.6)	42 (21.8)	40 (21.1)	18 (13.3)	86 (19.7)	104 (18.2)
Yes	167 (88.4)	151 (78.2)	150 (79.0)	117 (86.7)	351 (80.3)	468 (81.8)
Race/ethnicity (*N*, %)						
Non-Hispanic white	118 (63.4)	130 (68.4)	142 (75.1)	304 (70.5)	86 (64.2)	390 (69.0)
Other race/ethnicity	68 (36.6)	60 (31.6)	47 (24.9)	127 (29.5)	48 (35.8)	175 (31.0)
Treatment location (*N*, %)						
Academic medical center	101 (53.4)	82 (42.5)	72 (37.9)	66 (48.9)	189 (43.3)	255 (44.6)
Community- or office-based practice	88 (46.6)	111 (57.5)	118 (62.1)	69 (51.1)	248 (56.8)	317 (55.4)
Comorbidity (*N*, %)						
0 comorbid conditions	6 (3.2)	22 (11.4)	28 (14.7)	8 (5.9)	48 (11.0)	56 (9.8)
1 comorbid condition	66 (34.9)	100 (51.8)	66 (34.7)	43 (31.9)	189 (43.3)	232 (40.6)
2–3 comorbid conditions	63 (33.3)	48 (24.9)	62 (32.6)	51 (37.8)	122 (27.9)	173 (30.2)
4+ comorbid conditions	54 (28.6)	23 (11.9)	34 (17.9)	33 (24.4)	78 (17.9	111 (19.4)
Chemotherapy (*N*, %)						
No	116 (61.4)	67 (34.7)	41 (21.6)	70 (51.9)	154 (35.2)	224 (39.2)
Yes	73 (38.6)	126 (65.3)	149 (78.4)	65 (48.2)	283 (64.8)	348 (60.8)
Radiation (*N*, %)						
No	49 (25.9)	84 (43.5)	83 (43.7)	38 (28.2)	178 (40.7)	216 (37.8)
Yes	140 (74.1)	109 (56.5)	107 (56.3)	97 (71.9)	259 (59.3)	356 (62.2)
Surgery (*N*, %)						
No	99 (52.4)	85 (44.0)	57 (30.0)	110 (81.5)	131 (30.0)	241 (42.1)
Yes	90 (47.6)	108 (56.0)	133 (70.0)	25 (18.5)	306 (70.0)	331 (57.9)

difference between AYAs with hematologic cancers compared to AYAs with solid tumors across any physical domains (all p's > 0.003; see Table 3). However, we saw statistically significant differences in some physical outcomes between treatment exposures (see Table 3). Although these differences were statistically significant, none of them exceeded the MID threshold.

TABLE 2 Overall means and SDs of PROMIS®-29 T-scores, stratified by treatment status

	Overall sample, $N = 572$	On-treatment, $N = 294$	Off-treatment, $N = 278$
Symptoms			
Anxiety	61.1 (11.3)	66.5 (8.0)	55.3 (11.5)
Depression	58.6 (10.7)	63.2 (8.0)	53.7 (10.9)
Fatigue	55.8 (10.2)	60.2 (7.3)	51.2 (10.8)
Pain interference	57.8 (9.1)	62.2 (6.5)	53.2 (9.2)
Sleep disturbance	54.0 (8.1)	57.0 (6.5)	50.8 (8.5)
Function			
Physical function	41.8 (9.2)	37.0 (6.8)	47.0 (8.6)
Social participation	46.0 (9.6)	41.2 (6.5)	51.0 (9.8)

Note: Higher scores = greater symptom burden for pain interference, fatigue, sleep disturbance, anxiety, depression; Lower scores = worse functioning for social participation, physical function.

Abbreviation: PROMIS, Patient-Reported Outcomes Measurement Information System.

TABLE 3 Generalized linear model examining differences in physical quality of life outcomes by developmental stage, treatment status, and cancer type

	Physical outcomes											
	Pain			Fatigue			Sleep disturbance			Physical function		
	B	SE	*p*-value	*β*	SE	*p*-value	*β*	SE	*p*-value	*β*	SE	*p*-value
Developmental stage*treatment status												
On-treatment												
Emerging adults versus young adults	−0.45	1.03	0.659	−0.74	1.19	0.530	−0.004	0.98	1.00	0.44	0.95	0.642
Emerging adults versus adolescents	−2.93	1.15	0.011	−1.06	1.32	0.420	−0.51	1.09	0.640	**5.80**	**1.06**	**<0.001**
Young adults versus adolescents	−2.47	1.13	0.029	−0.32	1.30	0.804	−0.51	1.07	0.637	**5.36**	**1.04**	**<0.001**
Off-treatment												
Emerging adults versus young adults	−1.99	1.05	0.058	−1.70	1.22	0.164	**−1.74**	**1.00**	0.082	**2.43**	**0.97**	0.013
Emerging adults versus adolescents	**6.25**	**1.05**	**<0.001**	**9.11**	**1.22**	**<0.001**	**6.13**	**1.00**	**<0.001**	**−5.97**	**0.98**	**<0.001**
Young adults versus adolescents	**8.24**	**1.10**	**<0.001**	**10.81**	**1.26**	**<0.001**	**7.87**	**1.04**	**<0.001**	**−8.40**	**1.02**	**<0.001**
Cancer type (ref = solid tumors)												
Hematologic cancers	−1.02	0.81	0.208	0.81	0.94	0.388	−0.02	0.77	0.982	0.23	0.75	0.767
Chemotherapy (ref = no chemotherapy)												
Received chemotherapy	**2.23**	**0.68**	**0.001**	1.34	0.78	0.088	0.89	0.65	0.171	**−1.88**	**0.63**	**0.003**
Radiation (ref = no radiation)												
Received radiation	**2.44**	**0.64**	**<0.001**	0.36	0.74	0.632	−0.15	0.61	0.810	−1.49	0.59	0.012
Surgery (ref = no surgery)												
Had surgery	−0.29	0.70	0.683	−1.18	0.81	0.150	−0.85	0.67	0.204	0.54	0.65	0.408
Comorbidity (ref = no comorbid conditions)												
1 comorbid condition	0.91	1.08	0.399	0.05	1.25	0.971	−0.87	1.03	0.400	−1.07	1.00	0.287
2–3 comorbid conditions	**3.92**	**1.11**	**0.001**	**5.65**	**1.29**	**<0.001**	**3.80**	**1.06**	**<0.001**	**−4.26**	**1.04**	**<0.001**
4+ comorbid conditions	**6.60**	**1.22**	**<0.001**	**7.13**	**1.40**	**<0.001**	**6.97**	**1.16**	**<0.001**	**−6.93**	**1.13**	**<0.001**

Note: All models were also adjusted for: race/ethnicity, sex, insurance status. Higher scores = greater symptom burden for pain, fatigue, sleep disturbance; lower scores = worse physical function; Bolded values = statistically significant result of $p \leq .003$.

Abbreviation: ref, reference group.

TABLE 4 Generalized linear model examining differences in psychosocial quality of life outcomes by developmental stage, treatment status, and cancer type

	Psychosocial outcomes								
	Anxiety			Depression			Social participation		
	β	SE	*p*-value	β	SE	*p*-value	β	SE	*p*-value
Developmental stage*treatment status									
On-treatment									
Emerging adults versus young adults	−1.75	1.28	0.172	−0.31	1.26	0.800	1.16	1.06	0.273
Emerging adults versus adolescents	**−4.66**	**1.43**	**0.001**	−2.90	1.41	0.040	**3.98**	**1.18**	**0.001**
Young adults versus adolescents	−2.91	1.40	0.038	−2.58	1.38	0.062	2.82	1.16	0.015
Off-treatment									
Emerging adults versus young adults	**−4.56**	**1.31**	**0.001**	−3.56	1.30	0.006	1.89	1.08	0.079
Emerging adults versus adolescents	**5.92**	**1.32**	**<.001**	**6.06**	**1.30**	**<.001**	**−7.04**	**1.08**	**<.001**
Young adults versus adolescents	**10.48**	**1.38**	**<.001**	**9.62**	**1.34**	**<.001**	**−8.93**	**1.13**	**<.001**
Cancer type (ref = solid tumors)									
Hematologic cancers	−1.01	1.02	0.322	−1.86	1.01	0.066	0.61	0.84	0.468
Chemotherapy (ref = no chemotherapy)									
Received chemotherapy	0.85	0.85	0.317	2.19	0.83	0.009	−2.57	0.7	0.007
Radiation (ref = no radiation)									
Received radiation	0.88	0.80	0.273	1.02	0.79	0.196	−1.77	0.66	0.007
Surgery (ref = no surgery)									
Had surgery	−1.03	0.87	0.240	−1.80	0.87	0.039	0.60	0.72	0.402
Comorbidity (ref = no comorbid conditions)									
1 comorbid condition	0.06	1.35	0.965	0.003	1.34	0.998	−0.27	1.11	0.806
2–3 comorbid conditions	**5.28**	**1.39**	**<.001**	**4.34**	**1.38**	**0.002**	**−4.53**	**1.15**	**<.001**
4+ comorbid conditions	**7.44**	**1.51**	**<.001**	**6.68**	**1.49**	**<.001**	**−6.67**	**1.25**	**<.001**

Note: All models were also adjusted for: race/ethnicity, sex, insurance status; Higher scores = greater symptom burden for anxiety, depression; lower scores = worse social participation; Bolded values = statistically significant result of $p \leq .003$.

Abbreviation: ref = reference group.

Developmental stage emerged as a significant predictor of HRQOL across all HRQOL domains, particularly among off-treatment survivors (see Tables 3 and 4 and Figures S1 through S7). Off-treatment emerging adults reported significantly higher and clinically relevant anxiety ($\beta = 5.92$, $p < 0.001$), depression ($\beta = 6.06$, $p < 0.001$), pain interference ($\beta = 6.25$, $p < 0.001$), fatigue ($\beta = 9.11$, $p < 0.001$), and sleep disturbance ($\beta = 6.13$, $p < 0.001$) compared with adolescents. Emerging adults also reported significantly worse and clinically relevant social participation ($\beta = -7.04$, $p < 0.001$) and physical function ($\beta = -5.97$, $p < 0.001$) compared with adolescents. Young adults reported significantly higher and clinically relevant anxiety ($\beta = 10.48$, $p < 0.001$), depression ($\beta = 9.62$, $p < 0.001$), pain interference ($\beta = 8.24$, $p < 0.001$), fatigue ($\beta = 10.81$, $p < 0.001$), and sleep disturbance ($\beta = 7.87$, $p < 0.001$) compared with adolescents. Young adults also reported significantly worse and clinically relevant social participation ($\beta = -8.93$, $p < 0.001$) and physical function ($\beta = -8.40$, $p < 0.001$) compared with adolescents. Among on-treatment survivors, there were few differences in HRQOL across the three developmental stages.

4 | DISCUSSION

AYA cancer survivors experience a clinically relevant level of symptom burden. The adjusted T-scores for all AYA cancer survivors reached the threshold for a clinically relevant difference compared to the general US population for anxiety, depression, fatigue, pain, and physical function, and all seven HRQOL domains reached the threshold for a clinically relevant difference in on-treatment survivors. Among the off-treatment AYA survivors, only the psychosocial outcomes (anxiety, depression) met the threshold for a clinically relevant difference. Contrary to our hypothesis, we found no

significant differences between hematologic cancers and solid tumors in any HRQOL domain assessed, but developmental stage was a consistent predictor of HRQOL across all domains in off-treatment AYA survivors.

Our results suggest that direct assessment of treatment exposure, rather than cancer type, may be more important in AYA survivors. We found that certain treatment exposures were associated with higher physical symptom burden and worse physical function, but were not associated with differences in psychosocial outcomes. This finding is distinct from previous research in non-AYA survivor populations that have found differences in psychosocial outcomes and overall HRQOL by treatment exposure[20] but is supported by previous research in samples of primarily AYA survivors that found no differences in distress by cancer type or treatment.[27,28] Adolescence and young adulthood are stages of development characterized by numerous physiological and psychosocial changes, and these factors may be even more critical in survivors' overall HRQOL than among older cancer patients.

Both off-treatment emerging adult and young adult survivors reported significantly greater symptoms and worse functioning compared to off-treatment adolescent survivors. For both developmental groups, the two domains with the highest adjusted mean T-scores were anxiety and depression. These two domains may be particularly impaired in older AYA survivors because they are likely to be balancing some of this life stage's most stressful responsibilities including full-time work, parenting, and financial stressors (e.g., lack of health insurance, mortgage).[29,30] Future interventions need to focus on the HRQOL domains most salient to AYAs and be flexible enough to target different domains across the AYA developmental period.

4.1 | Study limitations

The results of this study must be interpreted considering its limitations. First, this study was an anonymous, cross-sectional survey. We cannot directly test causality or confirm the accuracy of the clinical/sociodemographic details. However, the current study was the largest observational study to utilize a stratified sampling approach to ensure adequate representation and statistical power across the AYA developmental period. Second, AYA survivors were recruited through an online research panel which may limit generalizability. However, data collected through online research panels is comparable to data obtained from population-based estimates.[31] Third, the PROMIS-29 was developed and validated for use with adult (≥18 years) cancer survivors and this could drive some of the variability we saw in the current analysis. However, previous work has demonstrated understanding of the adult PROMIS items among adolescent survivors.[32,33] Fourth, the MID thresholds were developed in advanced-stage, adult cancer survivors and may not describe clinically meaningful differences among AYA populations. However, many of the observed differences in symptoms and functioning were higher or lower by more than half a SD, a well-established benchmark for meaningful differences on PRO measures.[26] Fifth, there may be unmeasured confounding variables not assessed in our current analyses (e.g. rural/urban status).

4.2 | Clinical implications

In planning for the transition from active treatment to survivorship,[34,35] we need to utilize tailored approaches that consider developmental stage in addition to treatment exposure. Our results suggest that emerging adults and young adults are most at-risk for poor HRQOL outcomes after treatment, regardless of cancer type or treatment exposure. Developmental stage needs to be a piece of information used in the creation of risk-stratified survivorship care pathways in AYA survivors.[36] Currently, few symptom monitoring tools, like smartphone apps, are tailored to the needs of older AYA survivors,[37] and this must change.

5 | CONCLUSIONS

Developmental stage has often been an ignored variable in AYA survivorship research, and it needs to be better integrated into cancer care delivery. Additionally, existing HRQOL measures are limited in AYA survivors because they do not measure all important domains (e.g., body image) and are often validated in pediatric (<18 years) or adult (≥18 years) populations, but not both. Linking efforts suggest that pediatric and adult PROMIS measures are comparable,[32,33] but efforts are needed to improve these gaps.[38] The current study represents a starting point for recognizing the importance of HRQOL and developmental stage in AYA survivorship care and research. Future efforts to improve HRQOL assessment, integrate flexible survivorship care approaches, and consider developmental stage in research continue to be needed.

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CONFLICT OF INTEREST

The authors have no conflicts of interest to declare.

DATA AVAILABILITY STATEMENT

Data available on request from the authors.

ORCID

Elizabeth J. Siembida https://orcid.org/0000-0003-1131-8359

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SUPPORTING INFORMATION

Additional supporting information may be found online in the Supporting Information section at the end of this article.

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