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Loneliness among adult cancer survivors in the United States: prevalence and correlates

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Loneliness is recognized as a significant public health concern, affecting quality of life and health outcomes, including cancer-related outcomes. Thus, it is essential to understand the prevalence and risk factors for loneliness in people with cancer. Through an exploratory analysis of secondary data from the Health Information National Trends Survey, we investigated the prevalence and correlates of loneliness among adult cancer survivors (*N* = 1,234). An estimated 35.9% of participants experienced moderate to severe loneliness. In a series of multiple logistic regression models, we identified differences in sociodemographic, cancer-related factors, non-cancer comorbidities, social isolation, social support, and social media use behaviors in the odds of reporting moderate-severe loneliness. In our fully adjusted model, years since cancer diagnosis, fair-poor overall health, moderate-high psychological distress, and having children living in the household were all positively and independently associated with moderate-severe loneliness. In this same model, being married and reporting some types of social support were negatively associated with moderate-severe loneliness. This study underscores the multifaceted nature of loneliness among cancer survivors, revealing a complex interplay of demographic, health-related, and social factors.

Background

In a 2023 report, the U.S. Surgeon General declared loneliness and social isolation as profound public health threats[1]. Social isolation and loneliness, while theoretically and empirically related, are distinct concepts. Social isolation is structural and defined as the objective lack of social contact (e.g., isolates in a social network, infrequent contact with others); whereas, loneliness is subjective and defined as the "unpleasant experience that occurs when a person's network of social relations is deficient in some important way, either quantitatively or qualitatively"[2]. The level of social interaction needed to prevent the subjective experience of loneliness is highly variable, with some individuals requiring much less social contact than others; evidence from genome-wide association studies suggest genetic factors that underly this variability[3,4]. From an evolutionary perspective, loneliness is thought to be adaptive by regulating social behavior (i.e., social homeostasis)[5]. At the population level, structural factors relevant to loneliness include social isolation proxies like marital status and living alone. The types and quality of social support derived from social contacts are functional outputs also related to an individual's perception of loneliness[6].

Estimates suggest that loneliness and social isolation increase the risk of all-cause mortality by 25% and 29%, respectively[7]. There is also empirical evidence of cancer specific mortality among those experiencing loneliness and social isolation[8–10]. For example, findings from the National Health and Nutrition Examination Survey show that the risk of cancer mortality was 25% higher among those reporting social isolation; however, this association was attenuated when adjusting for individual socioeconomic status[11]. In other studies, loneliness was associated with increased risk of cancer even after controlling for other known demographic and behavioral risk factors[12]. The proposed pathways in which loneliness and social isolation affect cancer outcomes specifically and health outcomes more broadly are not well understood. Fleisch and colleagues note that low-SES and

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minority populations in the U.S. may also systematically experience lower social support or less connected social networks[11]. These sociodemographic and contextual conditions create a complicated web of social determinants of health[13]. However, To add to this complexity, social isolation and loneliness are also significantly associated with health risk behaviors, sleep hygiene, blood pressure, inflammatory processes, and metabolic dysregulation, among others[1,14–16]. As loneliness is important to cancer-related outcomes, such as incidence and mortality, it is essential to understand the prevalence of and risk factors for loneliness in people with cancer.

Currently, population-based health studies of loneliness and social isolation in the U.S. are limited, but available data suggest that lack of social connection is an increasing societal problem. An analysis of the American Time Use Survey found that between 2003 and 2020 people in the U.S. spend more time alone, less time engaged with family members, less time engaged with friends, and less companionship time (i.e., time spent with anyone while engaged in socializing, relaxing, leisure, sports, exercise, recreation, and eating or drinking at a restaurant or bar)[17]. At the same time there are noted decreases in the number of close friends reported by adults[18], smaller family sizes, and decrease in marriage rates[19]. In addition to shrinking social networks, the percent of adults living alone in the U.S. has consistently increased since 1940[19,20].

Prior investigations have identified a complex, bimodal distribution of social isolation and loneliness peaking among younger and older age cohorts[21,22]; whereas other studies have found not effect of age[23]. Older adults may be vulnerable to social isolation and loneliness due to the death of family and friends, declining mobility, and limitations caused by chronic diseases (e.g., increased fatigue, inability to work). An analysis of the National Health and Aging Trends Study found that nearly 1 in 4 community-dwelling older adults were socially isolated[24]. Similarly, a 2018 population-based survey of U.S adults aged 45 or older found that more than one-third are lonely (based on UCLA loneliness scale)[25]. In this same study, chronic health conditions were associated with higher prevalence of loneliness; however, due to insufficient sample size, the study was unable to estimate the prevalence of loneliness in older adults with a history of cancer. In contrast, younger people, are delaying marriage, engaging is less face-to-face social interactions, spending more time on social media that has been linked to loneliness, and living alone[19,26,27]. Despite the evidence that social isolation and loneliness are associated with sociodemographic characters in addition to physical and psychological morbidity, little is known about how these risk factors impact specific at-risk populations like cancer survivors[6].

As the number of cancer survivors increases due to an aging population, early detection and treatment advances that increase survival, understanding the loneliness and social isolation as a social determinant of health is increasingly important. As demonstrated, social isolation and loneliness are important determinants of health outcomes, but also significantly impact quality of life. A systematic review and meta-analysis conducted in 2014 reported that 32–47% of patients with cancer reported moderate levels of loneliness and only 2% reported severe loneliness[28]. They also found that marital status was the only consistent predictor of loneliness in cancer patients, with higher loneliness among unmarried patients. The association of age and other demographic factors with loneliness was equivocal across studies. The associations of cancer-related variables, like late and long-term effects of treatments (e.g., pain and fatigue), were also equivocal; however, evidence suggest that social support is consistently protective. In addition, no studies have examined social media use a correlate of loneliness in older cancer survivors, despite existing evidence suggesting that this population is using social media for a variety of reasons and that social media may be positively or negatively associated with loneliness depending on the context[26,27,29]. Collectively the extant literature on loneliness and social isolation in people with cancer is limited using non-probability samples, which limit their generalizability to the U.S. cancer-population.

The National Academies of Sciences, Engineering, and Medicine (NASEM) called for research that builds a scientific foundation for clinical and public health interventions to reduce the health and medical impacts of social isolation and loneliness[6]. The purpose of this retrospective study was to estimate the prevalence of loneliness among cancer survivors in the U.S. and to identify theoretically relevant correlates of loneliness. This study was informed by the conceptual framework outlined by the Committee on the Health and Medical Dimensions of Social Isolation and Loneliness in Older Adults (Fig. 1; NASEM). While there is a proposed causal flow (indicated by thicker arrows), the actual relationships are assumed to be bidirectional. Ultimately the risk factors structure and determine social connections, which in turn affect mediators (e.g., biopsychosocial responses) that lead to specific health impacts (e.g., hypertension) and subsequent risk for mortality. Central to this study, the framework proposes that the most proximal correlates of loneliness are social isolation and social support. Distal predictors (i.e., risk factors) can include sociodemographic characteristics but also late and long-term effects of cancer treatments (e.g., fatigue). Thus, in this exploratory study, the following research question was addressed: What are the independent risk factors of loneliness among U.S. adult cancer survivors across the following theoretically relevant domains: (a) sociodemographic characteristics, (b) cancer-related factors, (c) non-cancer health comorbidities, (d) social isolation proxies, (e) available social support, and (f) social media use behaviors?

Methods

This was a secondary data analysis of a special cycle of the Health Information National Trends Survey (HINTS-SEER)[30]. In this cycle, the National Cancer Institute randomly sampled cancer survivors from three SEER cancer registries (i.e., the Surveillance, Epidemiology, and End Results program). These included registries representing cancer cases from Iowa, New Mexico, and the Greater Bay Area of California. Inclusion criteria were (1) alive at the time of data collection, (2) diagnosed with an advanced cancer, and (3) 18 or older as of December 2020. Individuals with sole diagnoses of nonmelanoma skin cancer were excluded from the analysis. Data collection for the HINTS-SEER took place from January 2021 to July 2021. The survey was mailed to participants using an addressed-based sampling frame and a $2 pre-paid incentive. The complete methodology report is available elsewhere[30]. The National Cancer Institute provided the data for this research under a data use agreement. This secondary data analysis was not considered human subjects research. Primary data collection for HINTS-

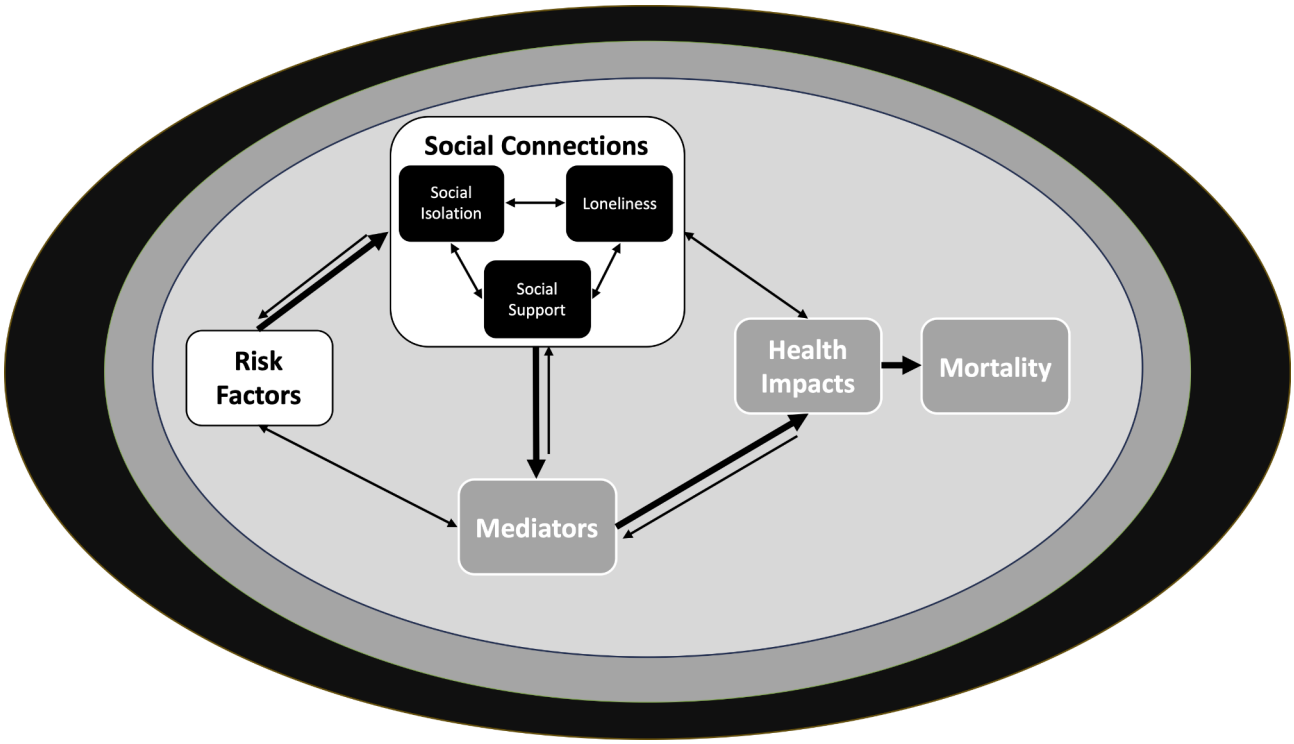

Fig. 1. Conceptual framework informed by the Committee on the Health and Medical Dimensions of Social Isolation and Loneliness in Older Adults, National Academies of Sciences, Engineering, and Medicine.

SEER was approved by the Westat Institutional Review Board (Project Number 6048.14). All methods were approved by and carried out in accordance with the IRB guidelines and regulations including informed consent of participants during primary data collection.

The final sample for this analysis comprised 1,234 cancer survivors, with a completion rate of 68.3% (i.e., the proportion of individuals who completed the survey among those who started it). Response rates were 24.6%, 24.1%, and 6.3% for the New Mexico, Greater Bay Area, and Iowa tumor registries, respectively. For our prevalence analyses, an additional 49 participants were excluded due to missing data on the loneliness variables. Another 180 were excluded from regression modeling due to missing data on the selected covariates.

Measures

Loneliness. The primary outcome was the validated PROMIS Social Isolation Short form 4a V2.0. This consisted of four items with an ordinal frequency 5-point response (Never to Always). The items are worded in the present tense ("I feel left out"), but no time frame is specified. Raw scores ranged from 4 to 20. The measure captures aspects of social and emotional loneliness and is not actually a measure of objective social isolation[31]. Thus, we refer to this construct as loneliness. The raw scores were highly positively skewed with many in the *never*category. To categorize the raw scores we employed spline regression to identify inflection points in the raw scores and then applied a common-sense test proposed by Karania to reverse-engineer the data-driven classifications[32,33]. This enabled us to compare low (e.g., none/mild) to high (e.g., moderate/severe) levels of loneliness.

Sociodemographic characteristics. Standard demographic characteristics were assessed to include age, race, ethnicity, state of residence, and educational attainment. Sex at birth and current gender identity were assessed separately, but less than 10 respondents reported any difference between these two items; thus, we used sex at birth to classify males and females in this study. Sexual orientation identity was assessed by asking "Do you think of yourself as…" with the following response options: (1) Heterosexual, or straight; (2) Homosexual, or gay or lesbian; (3) Bisexual; or (4) Something else. Participants choosing 2 or 3 were classified as "LGB" and compared to all others. The National Center for Health Statistics Urban–Rural Classification Scheme for Counties classification system was used to classify respondents are rural, sub-metropolitan, metropolitan/urban[34]. A standard measure of subjective income used by Gallup was used to measure financial status (Table 1)[35].

Cancer-related factors. Time since cancer diagnosis was derived from participant reports on the year and their age of their first cancer diagnosis. Responses were coded as 5 or less years vs. >5 years since diagnosis. Respondents were considered to have received active treatment (compared to active surveillance) if they responded yes to the following question: "Did you ever receive any treatment for your cancer?" The SEER registry summary stage was used to classify advanced (i.e., summary stage 2–7) vs. localized (i.e., summary stage 1) cancers. Cancer and treatment related impacts were measured by asking participants, "Have you ever experienced any of the following conditions as a result of your cancer diagnosis or cancer treatment?" They responded *Yes* or *No* to

	Total Sample	None/Mild	Moderate/Severe
	% (95% CIs)	% (95% CIs)	% (95% CIs)
Total		64.1 (61.2, 67.0)	35.9 (33.0, 38.8)
Socio-demographics			
Age			
18–64	29.1 (27.7, 30.5)	60.6 (53.7, 67.6)	39.3 (32.4, 46.3)
65–75	31.5 (28.9, 34.0)	60.8 (55.6, 65.9)	39.2 (34.1, 44.4)
75+	39.5 (37.2, 41.6)	69.6 (65.3, 73.9)	30.4 (26.1, 34.7)
Sex at birth			
Female	54.9 (53.9, 55.8)	60.2 (55.8, 64.5)	39.8 (35.5, 44.2)
Male	45.1 (44.2, 46.1)	68.9 (64.7, 73.2)	31.1 (26.8, 35.3)
Race/Ethnicity			
Another race/Ethnicity	11.2 (8.3, 14.1)	73.6 (61.0, 86.1)	26.4 (13.9, 39.0)
Hispanic	11.9 (10.4, 13.4)	72.6 (62.7, 82.6)	27.4 (17.4, 37.3)
Non, Hispanic White	76.8 (74.0, 79.6)	60.7 (56.9, 64.6)	39.3 (35.4, 43.1)
Lesbian, gay, or bisexual			
No	97.5 (96.4, 98.5)	64.3 (61.1, 67.5)	35.7 (32.5, 38.9)
Yes	2.5 (1.5, 3.6)	58.3 (34.0, 82.5)	41.7 (17.5, 66.0)
County classification			
Rural	17.3 (15.2, 19.5)	63.9 (57.3, 70.4)	36.1 (29.6, 42.7)
Sub, Metropolitan	33.3 (30.5, 36.1)	64.4 (59.1, 69.7)	35.6 (30.3, 40.9)
Metropolitan/Urban	49.3 (47.2, 51.5)	64.0 (59.3, 68.7)	36.0 (31.3, 40.7)
State of Residence			
California	55.7 (54.9, 56.4)	63.1 (58.6, 67.6)	36.9 (32.4, 41.4)
Iowa	28.5 (27.5, 29.5)	65.4 (60.5, 70.2)	34.6 (29.8, 39.5)
New Mexico	14.5 (14.0, 14.9)	65.4 (60.4, 70.3)	34.6 (29.7, 39.6)
Another state	1.4 (0.7, 2.1)	66.8 (34.2, 99.3)	33.2 (0.6, 65.8)
Educational attainment			
High school or less	14.3 (12.4, 16.2)	70.0 (60.7, 79.3)	30.0 (20.7, 39.3)
Some college	26.7 (23.3, 30.0)	59.8 (53.9, 65.8)	40.2 (34.2, 46.1)
College graduate or more	56.0 (55.7, 62.3)	65.0 (60.6, 69.3)	35.0 (30.7, 39.4)
Financial precarity			
Living comfortably or getting by on present income	92.1 (90.3, 93.9)	65.8 (62.6, 69.0)	34.2 (31.0, 37.4)
Difficult/very difficult on present income	7.9 (6.1, 9.7)	46.8 (32.8, 60.9)	53.2 (39.1, 67.2)
Cancer health impact			
Years since diagnosis			
0–5 years	18.2 (15.7, 20.7)	72.6 (65.1, 80.1)	27.4 (19.9, 34.9)
>5 years	81.8 (79.3, 84.3)	62.0 (58.6, 65.4)	38.0 (34.6, 41.4)
Received active treatment			
No	7.0 (5.3, 8.6)	68.3 (55.8, 80.8)	31.7 (19.2, 44.2)
Yes	93.0 (91.4, 94.7)	63.9 (60.7, 67.0)	36.1 (33.0, 39.3)
Advanced stage cancer diagnosis			
No	70.5 (67.8, 73.2)	64.5 (61.1, 67.9)	35.5 (32.1, 38.9)
Yes	29.5 (26.8, 32.2)	63.4 (57.2, 69.7)	36.6 (30.3, 42.8)
Cognitive impairment from cancer or treatments			
No	79.6 (77.0, 82.1)	66.3 (62.7, 69.9)	33.7 (30.1, 37.3)
Yes	20.4 (17.9, 23.0)	56.3 (47.9, 64.6)	43.7 (35.4, 52.1)
Severe fatigue from cancer or treatments			
No	66.2 (62.4, 70.0)	68.3 (64.9, 71.6)	31.7 (28.4, 35.1)
Yes	33.8 (30.0, 37.6)	56.4 (50.9, 62.0)	43.6 (38.0, 49.1)
Nausea from cancer or treatments			
No	79.0 (76.6, 81.3)	66.6 (63.4, 69.8)	33.4 (30.2, 36.6)
Yes	21.0 (18.7, 23.4)	55.6 (48.4, 62.8)	44.4 (37.2, 51.6)
Current health impact			
Overall health			
Excellent, very good, or good	85.4 (82.9, 87.9)	67.2 (63.9, 70.5)	32.8 (29.5, 36.1)
Poor or fair	14.6 (12.1, 17.1)	46.4 (38.6, 54.1)	53.6 (45.9, 61.4)

Continued

	Total Sample	None/Mild	Moderate/Severe
Severe Obesity			
No	96.2 (94.9, 97.5)	64.6 (61.6, 67.5)	35.4 (32.5, 38.4)
Yes	3.8 (2.5, 5.1)	54.1 (36.5, 71.8)	45.9 (28.2, 63.5)
PHQ, 4: Distress			
No/low	93.8 (92.1, 95.4)	66.8 (63.7, 69.9)	33.2 (30.1, 36.3)
Moderate/High	6.2 (4.6, 7.9)	29.9 (18.4, 41.5)	70.1 (58.5, 81.6)
Diabetes			
No	73.9 (71.1, 76.7)	66.1 (62.6, 69.6)	33.9 (30.4, 37.4)
Yes	26.1 (23.3, 28.9)	57.9 (50.7, 65.1)	42.1 (34.9, 49.3)
High blood pressure			
No	44.4 (41.1, 47.7)	61.5 (56.7, 66.2)	38.5 (33.8, 43.3)
Yes	55.6 (52.3, 58.9)	66.0 (62.0, 69.9)	34.0 (30.1, 38.0)
Heart disease			
No	83.5 (81.0, 86.0)	64.9 (61.6, 68.1)	35.1 (31.9, 38.4)
Yes	16.5 (14.0, 19.0)	61.0 (53.5, 68.5)	39.0 (31.5, 46.5)
Lung disease			
No	84.5 (82.1, 86.9)	65.5 (62.1, 68.9)	34.5 (31.1, 37.9)
Yes	15.5 (13.1, 17.9)	57.2 (48.6, 65.8)	42.8 (34.2, 51.4)
Social isolation			
Marital Status			
Single, separated, widowed, or divorced	30.1 (27.7, 32.5)	51.3 (44.6, 57.9)	48.7 (42.1, 55.4)
Living as married or with a romantic partner	3.3 (2.0, 4.6)	66.9 (48.6, 85.2)	33.1 (14.8, 51.4)
Married	66.6 (63.8, 69.4)	69.7 (65.8, 73.6)	30.3 (26.4, 34.2)
Lives alone			
No	78.4 (75.3, 81.5)	66.7 (63.0, 70.4)	33.3 (29.6, 37.0)
Yes	21.6 (18.5, 24.7)	56.0 (49.6, 62.3)	44.0 (37.7, 50.4)
Children in household			
No	91.1 (89.0, 93.2)	65.9 (63.2, 68.6)	34.1 (31.4, 36.8)
Yes	8.9 (6.8, 11.0)	50.9 (39.0, 62.8)	49.1 (37.2, 61.0)
Social support			
Friends to talk about health			
No	6.1 (4.6, 7.7)	38.8 (22.1, 55.4)	61.2 (44.6, 77.9)
Yes	93.9 (92.3, 95.4)	65.8 (62.8, 68.9)	34.2 (31.1, 37.2)
Help with chores			
No	14.1 (12.0, 16.2)	43.1 (34.9, 51.3)	56.9 (48.7, 65.1)
Yes	85.9 (83.8, 88.0)	67.8 (64.5, 71.0)	32.2 (29.0, 35.5)
Emotional support			
No	7.0 (5.2, 8.8)	31.8 (21.1, 42.5)	68.2 (57.5, 78.9)
Yes	93.0 (91.2, 94.8)	66.8 (63.8, 69.7)	33.2 (30.3, 36.2)
Social media use			
Visited social network site			
No	44.8 (42.1, 47.6)	66.8 (62.3, 71.3)	33.2 (28.7, 37.7)
Yes	55.2 (52.4, 57.9)	61.9 (57.5, 66.3)	38.1 (33.7, 42.5)
Shared health information on social media			
No	90.7 (89.0, 92.4)	65.3 (62.3, 68.3)	34.7 (31.7, 37.7)
Yes	9.3 (7.6, 11.0)	52.3 (39.6, 64.9)	47.7 (35.1, 60.4)
Participated in online health support group			
Continued			

	Total Sample	None/Mild	Moderate/Severe
No	91.9 (90.1, 93.8)	64.6 (61.6, 67.5)	35.4 (32.5, 38.4)
Yes	8.1 (6.2, 9.9)	58.9 (46.5, 71.3)	41.1 (28.7, 53.5)
Watched health related videos on YouTube			
No	69.7 (66.6, 72.8)	64.7 (61.6, 67.9)	35.3 (32.1, 38.4)
Yes	30.3 (27.2, 33.4)	62.7 (55.7, 69.6)	37.3 (30.4, 44.3)

Table 1. Sample characteristics stratified by self, reported loneliness ($N = 1,185$). Note. Percentages are calculated using complete case analysis with missing data ranging from 0.25% (help with chores) to 6.9% (race/ethnicity).

the following items: Cognitive impairment (for example, having difficulty remembering things, Severe fatigue (always tired or sleepy), and Nausea.

Non-cancer health comorbidities. A standard measure of overall health was used to categorize participants in excellent/very good, good, and fair and poor health[36]. Severe obesity was operationalized according to the Centers for Disease Control and Prevention of a Body Mass Index of 40 or higher[37]. Mental health was measured using the PHQ4, which is a brief self-report composite measure of depression and anxiety symptoms occurring "over the past 2 week"[38]. The following comorbidities were assessed using a yes/no item which asked: "Has a doctor or other health professional ever told you that you had any of the following medical conditions" followed by "diabetes or high blood sugar," "High blood pressure or hypertension," "A heart condition such as heart attack, angina, or congestive heart failure," and "Chronic lung disease, asthma, emphysema, or chronic bronchitis."

Social isolation. Three proxy measures of social isolation were included: current marital status, current adult household composition, and current child household composition. Married was classified as those indicating "Married" or "Living as married or living with a romantic partner" to one item about marital status. Household composition was assessed using two separate questions: "How many people live in your household? and "How many children under the age of 18 live in your household?"

Social support. Instrumental, information, and emotional support were assessed with the following three items: "Is there anyone you can count on to provide you with emotional support when you need it, such as talking over problems," "Do you have friends or family member that you talk to about your health?," and "If you needed help with your daily chores, is there someone who can help you?" Reponses were recorded as *yes* or *no.*

Social media use behaviors. Four social media use behaviors were assessed in response to this item: "Sometimes people use the Internet to connect with other people online through social networks like Facebook or Twitter. This is often called 'social media'. In the last 12 months, have you used the Internet for any of the following reasons?" The reasons provided were (1) to visit a social networking site, such as Facebook or LinkedIn; (2) To share health information on social networking sites, such as Facebook or Twitter; (3) To participate in an online forum or support group for people with a similar health or medical issue; (4) To watch a health-related video on YouTube. Reponses were recorded as *yes* or *no.*

Data analysis

Data were analyzed using SAS 9.4. Population-level weighted point estimates were obtained by using full sample weights and standard errors for statistical modeling were generated using the 50 jackknife replicate weights. Logistic regression was used to model the binary outcome (i.e., moderate/severe loneliness compared to mild/none as the reference group). First, bivariate models were estimated for each variable. Next, models were run separately for sociodemographic (model 1), cancer-related factors (model 2), non-cancer health comorbidities (model 3), social isolation proxies (model 4), available social support (model 5), and social media use behaviors (model 7). A fully adjusted model was run simultaneously on all variables that were statistically significant ($p < 0.05$) in models 1–6. Given the exploratory purpose of this study, we report results and interpret findings from each model.

Results

The sample characteristics are reported in Table 1. Overall, 35.9% (95% CI: 33.0–38.8) of the sample reported moderate or severe loneliness. There were four variables with confidence intervals exceeding the overall average. First, 53.2% (95% CI:39.1–67.2) of individuals facing financial hardship were more likely to report moderate-severe loneliness. Similarly, high prevalence of moderate-severe loneliness was also evident among individuals with poor or fair health (53.6%; 95% CI:45.9–61.4) and those experiencing psychological distress (70.1%; 95% CI:58.5–81.6). Nearly half of unmarried individuals (48.7%; 95% CI:42.1–55.4) also more likely to report moderate-severe loneliness.

The results from logistic regression analyses and their respective odds ratio (aOR) are reported in Table 2. A number of sociodemographic (age, sex at birth, financial precarity), cancer-related health impacts (years since cancer diagnosis, cognitive impairments, severe fatigue, nausea), current health (overall health, mental distress), social isolation (marital status, living alone, children in the household), social support (friends to talk with about health, help with chores, and emotional support), and social media use (shared health information on social media) variables had statistically significant bivariate associations with moderate-server loneliness, After adjusting for other variables within each domain, there were notable changes. For instance, in the socio-demographics model (model 1), age and sex emerged as significant predictors of moderate-severe loneliness,

	Bivariate associations	Model 1: Sociodemographic	Model 2: Cancer Health impacts	Model 3: Current health and comorbidities	Model 4: Social isolation	Model 5: Social support	Model 6: Social media use	Model 7: Fully adjusted model
	OR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)	aOR (95% CI)
Sociodemographic								
Age								
18–64	1.00	1.00						1.00
65–75	0.99 (0.71, 1.40)	0.95 (0.64, 1.40)						0.97 (0.62, 1.52)
75+	**0.67 (0.46, 0.99)**	**0.67 (0.45, 0.98)**						0.68 (0.44, 1.03)
Sex at birth								
Female	1.00	1.00						1.00
Male	**0.68 (0.51, 0.90)**	**0.75 (0.56, 1.00)**						0.97 (0.71, 1.33)
Race/Ethnicity								
Another race/Ethnicity	1.05 (0.44, 2.53)							
Non, Hispanic White	1.80 (0.90, 3.62)							
Lesbian, gay, or bisexual								
No	1.00							
Yes	1.29 (0.45, 3.68)							
County classification								
Rural	1.00							
Sub, Metropolitan	0.98 (0.67, 1.43)							
Metropolitan/Urban	0.99 (0.70, 1.41)							
State of Residence								
California	1.00							
Iowa	0.91 (0.68, 1.20)							
New Mexico	0.91 (0.67, 1.23)							
Another state	0.85 (0.18, 4.12)							
Educational attainment								
High school or less	1.00							
Some college	1.57 (0.93, 2.65)							
College graduate or more	1.26 (0.75, 2.12)							
Financial precarity								
Living comfortably or getting by on present income	1.00	1.00						1.00
Difficult/very difficult on present income	**2.18 (1.21, 3.92)**	**2.30 (1.14, 4.66)**						1.26 (0.55, 2.88)
Cancer health impact								
Years since diagnosis								
0–5 years	1.00		1.00					1.00
>5 years	**1.62 (1.07, 2.46)**		**1.70 (1.17, 2.47)**					**2.21 (1.41, 3.48)**
Received active treatment								
No	1.00							
Yes	1.22 (0.66, 2.26)							
Advanced stage diagnosis								
No	1.00							
Yes	1.05 (0.77, 1.43)							
Cognitive impairment from cancer or treatments								
No	1.00		1.00					
Yes	**1.53 (1.02, 2.30)**		1.13 (0.68, 1.90)					
Severe fatigue from cancer or treatments								
No	1.00		1.00					1.00
Yes	**1.66 (1.27, 2.16)**		**1.61 (1.14, 2.28)**					1.31 (0.95, 1.81)
Nausea from cancer or treatments								
No	1.00		1.00					
Continued								

	Bivariate associations	Model 1: Sociodemographic	Model 2: Cancer Health impacts	Model 3: Current health and comorbidities	Model 4: Social isolation	Model 5: Social support	Model 6: Social media use	Model 7: Fully adjusted model
Yes	**1.59 (1.16, 2.19)**		1.16 (0.77, 1.74)					
Current health impact								
Overall health								
Excellent, very good, or good	1.00			1.00				1.00
Poor or fair	**2.37 (1.66, 3.37)**			**2.30 (1.51, 3.51)**				**2.08 (1.24, 3.47)**
BMI								
Non, obese	1.00							
Obese	1.54 (0.75, 3.19)							
PHQ, 4: Distress								
No/low	1.00			1.00				1.00
Moderate/High	**4.71 (2.62, 8.46)**			**4.55 (1.97, 10.52)**				**4.13 (1.90, 8.98)**
Diabetes								
No	1.00							
Yes	1.42 (0.99, 2.04)							
High blood pressure								
No	1.00							
Yes	0.82 (0.62, 1.09)							
Heart disease								
No	1.00							
Yes	1.18 (0.83, 1.69)							
Lung disease								
No	1.00							
Yes	1.42 (0.94, 2.14)							
Social isolation								
Marital Status								
Single, separated, widowed, or divorced	1.00				1.00			1.00
Living as married or with a romantic partner	0.52 (0.22, 1.24)				0.46 (0.17, 1.23)			0.72 (0.26, 1.98)
Married	**0.46 (0.32, 0.66)**				**0.38 (0.22, 0.66)**			**0.60 (0.37, 0.96)**
Lives alone								
No	1.00				1.00			
Yes	**1.58 (1.13, 2.21)**				0.80 (0.48, 1.33)			
Children in household								
No	1.00				1.00			
Yes	**1.87 (1.17, 2.98)**				**2.31 (1.41, 3.80)**			**2.27 (1.37, 3.75)**
Social support								
Friends to talk about health								
No	1.00					1.00		
Yes	**0.33 (0.16, 0.67)**					0.84 (0.37, 1.87)		
Help with chores								
No	1.00					1.00		1.00
Yes	**0.36 (0.25, 0.53)**					**0.51 (0.33, 0.78)**		**0.54 (0.33, 0.89)**
Emotional support								
No	1.00					1.00		1.00
Yes	**0.23 (0.14, 0.39)**					**0.29 (0.15, 0.55)**		**0.39 (0.20, 0.76)**
Social media use								
Visited social network site								
No	1.00							
Yes	1.24 (0.92, 1.67)							

Continued

	Bivariate associations	Model 1: Sociodemographic	Model 2: Cancer Health impacts	Model 3: Current health and comorbidities	Model 4: Social isolation	Model 5: Social support	Model 6: Social media use	Model 7: Fully adjusted model
Shared health information on social media								
No	1.00						1.00	1.00
Yes	**1.72 (1.02, 2.91)**						**1.72 (1.02, 2.91)**	1.53 (0.83, 2.82)
Participated in online health support group								
No	1.00							
Yes	1.27 (0.75, 2.16)							
Watched health related videos on YouTube								
No	1.00							
Yes	1.10 (0.78, 1.54)							

Table 2. Variables associated with severe/moderate loneliness in adult cancer survivors. Note. OR = Odds ratio; aOR = Adjusted odds ratios; Bolded odds ratios are statistically significant based on confidence intervals. 1 = reference category.

where individuals aged 75 and above had significantly lower odds (aOR = 0.67; 95% CI: 0.45, 0.98) compared to the 18–64 age group as did males compared to females (aOR = 0.75; 95% CI: 0.56, 1.00). Financial precarity was another significant factor in this model, with those finding it difficult or very difficult to live on their present income showing higher adjusted odds of moderate-severe loneliness (aOR = 2.30; 95% CI: 1.14, 4.66).

In terms of cancer-related variables (model 2), those diagnosed over 5 years ago had increased odds (aOR = 1.70; 95% CI: 1.17, 2.47) of moderate-severe loneliness compared to those with a more recent cancer diagnosis. Severe fatigue due to cancer or treatments was also an independent predictor of moderate-severe loneliness in this model (aOR = 1.61; 95% CI: 1.14, 2.28). Poor/fair overall health (aOR = 2.30; 95% CI: 1.51, 3.51) and psychological distress (aOR = 4.55; 95% CI: 1.97, 10.52) were significantly associated with moderate-severe loneliness (model 3). In the social isolation model (model 4), respondents who were married had lower odds moderate-severe loneliness (aOR = 0.38; 95% CI; 0.22, 0.66) compared to those who were single, separated, widowed, or divorced. In contrast, having children in the household was associated with higher odds of moderate-severe loneliness (aOR = 2.31; 95% CI: 1.41, 3.80). For social support (model 5), having help with chores (aOR = 0.51; 95% CI: 0.33, 0.78) and someone to count on for emotional support (aOR = 0.29; 95% CI: 0.15, 0.55) were negatively associated with moderate-severe loneliness. For social media use (model 6), respondents who shared health information on social media had higher odds of moderate-severe loneliness compared to those who did not (aOR = 1.72; 95% CI: 1.02, 2.91).

In the fully adjusted model (model 7), being diagnosed with cancer more than 5 years prior (aOR = 2.21; 95% CI:1.41, 3.48), reporting poor/fair overall health (aOR = 2.08; 95% CI:1.24, 3.47), moderate-high psychological distress (aOR = 4.13; 95% CI:1.90, 8.98) and having children in the household (aOR = 2.27; 95% CI:1.37, 3.75) were positively associated with moderate-severe loneliness. In contrast, being married (aOR = 0.60; 95% CI: 0.37, 0.96), having help with chores (aOR = 0.54; 95% CI: 0.33, 0.89), and reporting the availability of emotional support (aOR = 0.39; 95% CI:0.20, 0.76) were all inversely associated with moderate-severe loneliness.

Discussion

This representative retrospective study of cancer survivors from three SEER registries suggests that moderate to severe loneliness is a common issue, affecting over 1 out of 3 survivors. This estimate is similar to those from other population-based studies of adults in the general population that used different measures of loneliness[24,25]. And while the findings reported here are exploratory and warrant further study, our findings suggest that loneliness is a significant issue for cancer survivors and may be associated with specific risk and protective factors, in addition to important health correlates.

In line with our theoretical framework, some social isolation and social support related factors were correlated with loneliness independent of other variables in models 4, 5, and in the fully adjusted model. And while living alone had a significant bivariate association with loneliness, that association was fully attenuated by marital status and whether or not the household included children. As proposed in our framework, social isolation and support are likely the most proximal correlates of loneliness. Our analysis also suggests that marriage is protective against loneliness, but living as married was not; however, this should be interpreted with caution because this was a small group in the sample. In addition, instrumental (i.e., help with chores) and emotional social support were both protective factors and were independent of structural characteristics like marital status (having friends to talk to about health issues was not significant), suggesting that this support can come from different sources within an individual's social network. The reason for the independent association of living with children in the household and a higher likelihood of moderate-severe loneliness is not clear, nor is the relationship of the respondent to the children (e.g., parent, grandparent, etc.). Cancer survivors may experience

several role conflicts, including those associated with caring for minor children. This is an interesting finding that warrants further study.

Other risk factors for moderate-severe loneliness included demographic characters like age and sex (i.e., males and those older than 75 had lowest rates); however, these factors did not remain significant correlates in the fully adjusted model. Given that the causal paths of distal risk factors and the proximal predictors of loneliness (i.e., social connections) are not fully explicated, it is likely that the fully adjusted model is over adjusting for variables in the causal path (e.g., age is correlated with marital status, which is a proximal predictor of loneliness). A previous review of the risk factors for loneliness found a bimodal association with age and loneliness with higher prevalence in young and older adults, but that study did not focus on cancer survivors[39]. The effects of sex and gender on loneliness suggest that women report higher levels of loneliness when compared to men[39]. It is likely that there are important interactions when considering demographic risk factors for loneliness. A small qualitative study focused on breast cancer survivors described a distinct 'survivor loneliness' that were attributed to heightened isolation, mortality awareness, and identity changes[40].

The results of this study also draw compelling connections to existing research on the financial struggles of cancer survivors[41], particularly in a study of breast cancer patients who reported feeling isolated when facing financial difficulties[42]. We found a notable correlation in the bivariate and sociodemographic models indicating that cancer survivors experiencing financial precarity may be more at risk for moderate-severe loneliness; however, this variable did not remain significant in the fully adjusted model. More research is needed to explore the mechanisms by which cancer related financial precarity may impact social connections.

Previous qualitative research described the difficulties in maintaining social connections after a major change in life course due to a long-term illness[43]. These difficulties are likely driven, in part, by changes in functional status. In this study, ever having experienced cancer-related fatigue was associated with loneliness in model 2, but not the fully adjusted model. It is possible that the challenges of maintaining social connections in the face of adverse cancer-related treatment effects have long-lasting impacts on social networks; however, we do not know the timing of cancer fatigue in the current study. Interestingly, ever having cancer related fatigue, cognitive impairments, and nausea each had bivariate correlations with moderate-severe loneliness, but fatigue was the only variable to exhibit independence from other cancer related health impacts (i.e., model 2). And yet in the fully adjusted model, being more than 5 years post diagnosis was the only cancer-related correlate of moderate-severe loneliness. Social support may decline following initial treatment, leaving long-term survivors more socially isolated then they were during and immediately after treatment[44]. Longitudinal studies are needed to fully describe changes in social support following cancer diagnosis and treatment, and how treatment related impairments impact support overtime.

The study also highlights the significant role that poor overall health and psychological distress have in the experience of loneliness among cancer survivors. There is likely a bidirectional relationship between health-related factors and loneliness[45]. A recent prospective assessment of social isolation, loneliness, and depression found that social isolation was associated with depression, which had a bidirectional relationship with loneliness[8]. In that study, social isolation, loneliness, and depression all independently predicted worse health outcomes. While more evidence is needed, it is likely that multi-level interventions that address psychological distress, social isolation, and loneliness would result in the most beneficial improvements.

In a recent scoping review, only one intervention study was identified[45]. The intervention used a psychological approach with psychotherapy sessions focused, in part, on cognitive reappraisal, include one session on loneliness[46]. While the intervention improved mental health it had no effect on loneliness, which was not the primary outcome. There is some evidence that social media based interventions can increase social support in young adult cancer survivors[47], but these types of interventions may be more appealing to those with lower quantity and quality of face-to-face social support[48]. Our analysis suggests that sharing health information on social media was associated with increased loneliness, which might lend support to idea that social media is used by those unhappy with offline support. While research has found that young adults who engage with fellow cancer survivors online report reduced social isolation and enhanced feelings of connectedness[49,50], other studies found that social media use may lead to increased isolation[26]. More research is needed to determine the effect of social media interventions on social isolation and loneliness, in addition to the demographic groups for whom it might be beneficial. Other approaches might focus more directly on facilitate social connection. One example is Groups4Health, which demonstrated promise in facilitating the development and maintenance of social relationships and positive social identities[51].

The findings from this exploratory study should be interpreted considering several important limitations. Notably, the low response rates and the absence of national representation restrict the generalizability of the findings. The exclusive use of English in survey materials likely excluded limited- or non-English speaking cancer survivors, potentially biasing the sample. Self-reported data may introduce social desirability bias. Also, the unique context of the COVID-19 pandemic could have also influenced the reported prevalence of loneliness, adding a layer of complexity to interpreting the results. Regarding measurement, the use of a short-form scale to measure loneliness captures it as a unidimensional phenomenon when in fact there may be different risk factors for various dimensions of loneliness. In addition, cancer-related symptoms were dichotomous measures framed in terms of "ever" having experienced these problems. The timing and duration of these symptoms is an important consideration that were not present in this dataset potentially impacting the findings. This was a cross-sectional study, so we were unable to draw causal inferences. Also, there was very limited information about cancer diagnoses and treatments (e.g., type of malignancy, recurrence status, currently on vs. off-treatment, curative vs. palliative care, etc.), which prevented a nuanced clinical description of the survey respondents and the inclusion of potential confounders.

These limitations notwithstanding, the insights gained from the study offer valuable contributions to understanding loneliness among cancer survivors. The conceptual framework outlined by the Committee

on the Health and Medical Dimensions of Social Isolation and Loneliness in Older Adults (Fig. 1; NASEM) provided useful in identifying correlates of loneliness in this study, but the framework in its current form is too general. Several variables in the current study, which were identified in previous research to be significantly associated with loneliness, had no significant bivariate correlations (e.g., LGB identity, ethnoracial minorities, obesity)[13,52,53]. In addition, cancer-specific factors, including characteristics of cancer diagnoses and treatments, should be considered. Future longitudinal studies are needed to determine temporal relationships, examine causal pathways, and identify the most effective points for intervention. Studies employing social network methodology may be particularly informative, as they can enable the analysis of structural changes to social networks (e.g., changes to alters, weakened relational ties, etc.), in addition to changes in function (e.g., received support) and quality (e.g., relational strain).

This study underscores the multifaceted nature of loneliness among cancer survivors, revealing a complex interplay of demographic, health-related, and social factors. Importantly, it highlights the prevalence of moderate-severe loneliness in this vulnerable population. And while existing frameworks are informative in guiding research, there is a need for nuanced models that elucidate causal pathways and identify targets for interventions.

Data availability

The datasets generated and/or analyzed during the current study are available from the National Cancer Institute HINTS repository, https://hints.cancer.gov/data/download-data.aspx.

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Author contributions

C.W. conceptualized the study and conducted the data analysis. C.W. and Y.S. wrote the first draft and prepared tables and figures. A.C., B.M., J.A.D interpreted data, provided feedback on implications, and made edits to the manuscript. All authors revised and approved the final manuscript.

Declarations

Competing interests

The authors declare no competing interests.

Additional information

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