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Online Health Information Seeking, Electronic Health Literacy, and Quality of Life Among Breast Cancer Survivors: A Mixed-Methods Study

Shu-Ya Chen
Tzu Chi University
Chuan-Hsiu Tsai
janechtsai@gms.tcu.edu.tw
Tzu Chi University
Tsung-Cheng Hsieh
Tzu Chi University
Ching-Chun Ho
Hualien Tzu Chi Hospital
Chia-Chen Yang
National Defense Medical University
Ming-Shen Dai
Tri-Service General Hospital
Han-Ting Liu
Taitung Christian Hospital
Chien-Yi Ma
Taitung Christian Hospital
Hsuen-Fu Lin
Mennonite Christian Hospital
Cheng-Chih Tsai
Taitung Mackay Memorial Hospital
Chang-Fen Lai
Tzu Chi University
Shu Hu Chin
Tzu Chi University
Sin-Yi Jheng
Tri-Service General Hospital, Songhshan Branch

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Abstract

Background

Breast cancer remains a major global and regional health concern. Although early detection and advanced therapies have extended survival, many breast cancer survivors (BCS) continue to experience persistent symptom burden and functional limitations. Online health information seeking (OHIS) and electronic health literacy (eHL) may support symptom self-management, yet their independent contributions to health-related quality of life (QoL) remain unclear. This study examined how eHL, OHIS, and exercise task self-efficacy (ESE) relate to QoL among BCS.

Methods

A concurrent mixed-methods design integrated a cross-sectional survey (N = 478) with semi-structured focus groups (N = 27). QoL was assessed using the EORTC QLQ-C30 and dichotomized into high and low groups based on an empirical cutoff of 57.14 derived from two-cluster K-means analysis. Predictors of high QoL were identified through multivariable logistic regression, and focus group data were analyzed using thematic analysis.

Results

The mean global QoL score was 58.59 (SD = 18.14). Financial status was the strongest independent predictor of high QoL (adequate: AOR = 4.777, 95% CI 1.765–12.925; fair: AOR = 3.728, 95% CI 1.532–9.073). Higher QoL was also associated with intensive OHIS (≥ 7 hours/week; AOR = 2.253, 95% CI 1.146–4.429) and greater ESE (AOR = 1.031, 95% CI 1.018–1.054), while eHL showed a statistically significant but modest association (AOR = 1.010, 95% CI 1.001–1.018). Symptom interference (AOR = 0.942, 95% CI 0.918–0.967) and recent chemotherapy (AOR = 0.407, 95% CI 0.231–0.715) were associated with lower odds of high QoL. Thematic analysis identified four themes and ten subthemes, encompassing seeking explanations for illness, information appraisal and decision support, using digital resources for self-management, and barriers and supports in digital engagement. Survivors used online resources to inform clinical decisions and manage menopausal and treatment-related symptoms, while some described protective disconnection from information overload and reliance on family members as digital proxies.

Conclusions

Intensive OHIS and exercise self-efficacy function as modifiable behavioral assets for QoL, whereas eHL showed a modest direct association, suggesting its benefit may depend on active mobilization into self-care. Findings support stage-sensitive digital resources, more accessible health information platforms, and family-centered support to promote digital equity in survivorship care.

Introduction

Breast cancer remains the most prevalent malignancy among women globally and in Taiwan [1]. While advances in early detection and adjuvant therapies have substantially improved survival, breast cancer survivors (BCS)

frequently encounter persistent physical symptoms, treatment toxicities, and psychological sequelae that profoundly impair their health-related quality of life (QoL) [2]. Among BCS, the majority of those with hormone receptor–positive disease receive adjuvant endocrine therapy (AET) with aromatase inhibitors or tamoxifen, which is typically prescribed for 5–10 years to reduce the risk of cancer recurrence. Although AET has substantially improved long-term survival outcomes, prolonged treatment is frequently associated with a high burden of concurrent adverse effects. These include natural or iatrogenic menopausal symptoms and impaired physical functioning, such as joint pain, arthralgia, and genitourinary symptoms, all of which can severely affect survivors' daily functioning and QoL [3].

As survivorship extends, cultivating capacity for sustained self-management across physiological and lifestyle domains becomes critical to long-term recovery. Within this context, the COVID-19 pandemic served as a structural inflection point. To mitigate infection risks, healthcare delivery rapidly transitioned toward web-based services, accelerating telemedicine adoption for acute and chronic disease management [4].

In Taiwan, this crisis acted as a critical catalyst for digital transformation [5]. To protect medical staff and patients, healthcare consumer behaviors shifted sharply from traditional in-person visits toward internet-based digital services and online health information seeking (OHIS) [6]. Although this digital pivot compelled survivors to actively navigate online resources, potentially empowering patients, it simultaneously exposed a persistent, skills-based digital divide. This divide disproportionately disadvantages older adults, rural residents, and individuals of lower socioeconomic status, who are already at a heightened risk for poor survivorship outcomes [4, 7].

To bridge these disparities, contemporary electronic health literacy (eHL) is viewed as a multifaceted construct connecting individual capabilities with the structural design of health information technology (IT), specifically regarding capabilities, accessibility, experience, user-centered alignment, and situational context [8]. Currently, eHL is recognized as an essential competency for navigating the digital components of oncology care [9, 10]. It enables BCS to transition from passive recipients of clinical care to proactive self-managers who leverage digital tools for medical information, psychosocial support, and symptom monitoring. While evidence indicates that survivors actively engaging in online searching report superior QoL [11, 12], merely possessing eHL does not automatically confer health benefits. Instead, digital solutions must respond to user goals, values, and competencies; it is the frequency, intentionality, and critical appraisal of engagement that drive meaningful QoL outcomes across varying eHL levels.

This behavioral transition is deeply anchored in self-efficacy, a key construct of Social Cognitive Theory (SCT) representing an individual’s perceived capacity to execute health-related behaviors [13]. In oncology settings, higher self-efficacy consistently drives greater physical activity [14], more effective symptom self-management [4, 15, 16], and improved QoL [4, 17]. In this study, exercise task self-efficacy (ESE) was examined as a behavioral factor relevant to QoL among BCS. To manage symptoms interference, survivors utilize web-based resources to access disease information, self-care strategies, and social support. Ultimately, these experiences aid post-treatment adaptation, reinforced by older adults' increasing familiarity with digital health platforms [6, 7, 18].

Despite growing scholarly interest, several research gaps remain. While clinical and demographic factors, including educational attainment, financial impact, and chemotherapy exposure, are associated with QoL, their influence is notably heterogeneous, digital health-dependent, and context-specific [19–25]. Furthermore, how digital engagement shapes survivorship well-being under different clinical circumstances remains incompletely understood. Prior quantitative studies have established statistical associations between eHL and health

outcomes, yet they have rarely captured the lived experiences through which survivors translate digital information into actionable self-management practices.

To address these gaps, this mixed-methods study integrated cross-sectional survey data with qualitative focus group findings among BCS in northern and eastern Taiwan. Drawing upon SCT, this study aimed to: (1) assess eHL levels, OHIS patterns, and exercise self-efficacy among BCS; (2) examine the associations between eHL, OHIS, symptom burden, exercise self-efficacy, and QoL; (3) explore survivors' lived experiences of digital health engagement; and (4) explore how online resources may facilitate or impede survivorship well-being. By bridging quantitative associations with qualitative narratives, this study advances the understanding of how digital engagement, when actively mobilized, can serve as a catalyst for self-management and QoL optimization among BCS.

Methods

This study employed a concurrent mixed-methods design [26], following the approach described by Shim et al., in which quantitative and qualitative data were collected simultaneously, analyzed independently, and integrated during interpretation.

Procedures and Setting

Data collection was conducted between November 2022 and October 2023, during the later phase of the COVID-19 pandemic in Taiwan and the early post-pandemic period.

Participants

Participants were recruited through healthcare providers, case managers, LINE groups, and patient support network leaders. Convenience and snowball sampling were also utilized to expand the sample. To ensure geographic diversity for the quantitative survey, participants were recruited from both metropolitan northern Taiwan and rural eastern Taiwan. In contrast, the qualitative focus groups were conducted exclusively in eastern Taiwan, and this variation in geographic scope is addressed in the Limitations section.

This network-driven recruitment approach helped capture individuals with diverse digital health experiences, thereby enhancing the data's richness regarding eHL and OHIS.

Eligibility criteria required participants to be female, aged ≥ 18 years, diagnosed with breast cancer (Stages 0–IV), and fluent in Mandarin or Taiwanese.

Quantitative Survey

Quantitative data were collected using convenience sampling through face-to-face administration in quiet outpatient clinic areas or offices, or via a web-based questionnaire using Google Forms, including 4 questionnaires. Participants completed the survey independently or with assistance if needed.

Electronic health literacy Assessed using the eHealth Literacy Questionnaire (eHLQ) [27], a 35-item instrument encompassing seven dimensions of perceived skills. Items were rated on a 4-point Likert scale, with higher

scores indicating higher perceived literacy.

Symptom burden Measured using the Taiwanese version of the MD Anderson Symptom Inventory (MDASI) [28]. The scale assesses symptom severity (SS) and symptom interference (SI) across life domains.

Exercise self-efficacy Developed by Rogers et al. [29] based on Bandura's Social Cognitive Theory, this 13-item scale consists of two subscales. The 9-item exercise barriers (EB) subscale assesses perceived obstacles to weekly exercise, while the 4-item exercise tasks self-efficacy (ESE) subscale evaluates overall confidence. Both subscales are rated on a scale from 0 (no barrier/confidence) to 10 (severe barrier/complete confidence). Higher summed scores for each subscale reflect greater exercise difficulty or higher self-confidence in their respective domains

Quality of life QoL was assessed using the Chinese version of the European Organization for Research and Treatment of Cancer Quality of Life Questionnaire Core 30 (EORTC QLQ-C30) [30]. This widely validated 30-item instrument includes five functional scales, nine symptom subscales, and a global health status scale on 7-point scales, linearly transformed to 0 to 100. This study primarily utilized the two-item global health status/QoL scale (Items 29 and 30) as the main outcome, with scores linearly transformed to a 0–100 scale according to the EORTC manual. In the present study, a cutoff score of 57.14 was used to categorize participants into high- and low-QoL groups.

Quantitative data analysis

Descriptive statistics were used to summarize participant characteristics. Categorical variables were expressed as frequencies and percentages, whereas continuous variables were presented as means and standard deviations (SD). Bivariate analyses, including chi-square tests and analysis of variance (ANOVA), were performed, as appropriate, to examine the associations between demographic and clinical characteristics and eHL and QoL. To identify independent predictors of high QoL (1 = yes, 0 = no), multivariable logistic regression analyses [31,32] were performed to estimate crude odds ratios (COR) and adjusted odds ratios (AOR) with 95% confidence intervals (CI). The multivariable logistic regression model controlled for potential confounding factors, including age group, education level, marital status, living arrangement, place of residence, financial status, cancer stage, recent treatment (within the past 3 months), and involvement in shared decision-making (1 = yes, 0 = no). The model included the following key independent variables: OHIS duration (≥ 7 hours/week; 1 = yes, 0 = no), eHL, symptom burden, and self-efficacy. No problematic multicollinearity was detected. All statistical analyses were performed using IBM SPSS Statistics version 23.0 (IBM Corp., Armonk, NY, USA), and statistical significance was set at $p < 0.05$.

Qualitative Interviews

Procedure Following the quantitative survey, participants were invited to attend focus group discussions exploring their experiences with OHIS and the use of health technologies. A total of 27 breast cancer survivors were recruited from an oncology outpatient clinic in eastern Taiwan and participated in four focus group sessions. Sessions were conducted in private setting. Each session lasted approximately 80 minutes, was audio-recorded, and transcribed verbatim. All participants received a small token of appreciation (NTD 200) for their participation.

Semi-structured interview guide (1) What initially drives you to search for health information online? (2) How do you use online tools (such as videos or support communities) to manage symptoms like treatment side effects or menopause? What specific digital self-care skills have helped you reduce your symptom burden and improve your daily quality of life ? (3) Have you faced challenges while seeking health information online? What specific digital resources or professional support do you hope to see in the future to help you navigate these barriers?

Qualitative analysis

Focus group data underwent thematic analysis following Braun and Clarke's framework [33]. To ensure analytical rigor and minimize interpretive bias, two researchers independently coded the transcripts to identify recurring patterns expanding upon the quantitative outcomes. Discrepancies in coding or thematic interpretation were resolved through peer debriefing and consensus. Trustworthiness was maintained via prolonged data engagement and an external audit by a senior professor who provided critical feedback on the thematic structure. Representative verbatim quotations were selected to illustrate four themes and ten subthemes, and a thematic map was constructed to visualize conceptual interrelationships (Fig. 1).

Ethical Considerations

Ethical approval

was obtained from the ethics committee of Hualien Tzu-Chi Hospital and Taitung Hospital (IRB No. 111227B), Taitung MacKay Memorial Hospital (Approval No. 22MMHIS394c), Mennonite Christian Hospital (Approval No. 22-12-07), and Tri-Service General Hospital (Approval No. TSGHIRB B202305039). Written informed consent was obtained; data were anonymized in accordance with the Declaration of Helsinki.

Results

Quantitative Findings

Demographic, medical characteristic

For the quantitative phase, 478 BCS completed the survey (mean age: 57.3 ± 10.8 years; Table 1). The predominant age group was 45–54 years (31.8%), followed by 55–64 years (31.0%). Most participants were married (66.7%) and lived with others (90.8%). Over half (53.3%) had completed college or above, 54.8% resided in rural areas, and 92.3% reported a fair or adequate financial status. Clinically, 89.1% had early-stage cancer (Stages 0–III), with AET (48.1%) and chemotherapy (26.2%) the two most frequent recent treatments. Finally, 17.2% reported weekly OHIS ≥ 7 hours.

Table 1
Demographic characteristics, medical profiles, and internet use among breast cancer survivors (N = 478)

Characteristics	Mean ± SD or n (%)
Age (years), mean ± SD	57.3 ± 10.8
Age group	
<45 years	58 (12.1)
45–54 years	152 (31.8)
55–64 years	148 (31.0)
≥65 years	120 (25.1)
Education level	
College or above	255 (53.3)
High school or below	223 (46.7)
Marital status	
Married	319 (66.7)
Single / Unmarried	67 (14.0)
Other(Divorced, separated, widowed, etc.)	92 (19.2)
Living with others	
Yes	434 (90.8)
Place of residence	
Urban	216 (45.2)
Rural	262 (54.8)
Financial status	
Adequate	127 (26.6)
Fair	314 (65.7)
Insufficient	37 (7.7)
Cancer stage	
Stage 0–III	426 (89.1)
Stage IV	52 (10.9)
Survival time since cancer diagnosis (years), mean ± SD	6.47 ± 5.64
Current treatment within the past 3 months (multiple responses)	
Surgery	65 (13.6)
Chemotherapy	125 (26.2)

Characteristics	Mean ± SD or n (%)
Radiotherapy	46 (9.5)
Adjuvant endocrine therapy	230 (48.1)
Adjuvant targeted therapy	72 (15.1)
Shared decision-making participation	391 (81.8)
Weekly online health information-seeking time ≥ 7 hours	82 (17.2)

Descriptive statistics of eHL, symptom burden, self-efficacy, and QoL

Participants' mean eHLQ and SI scores were 76.29 ± 32.41 and 15.82 ± 14.81, respectively. The mean score for ESE was 23.76 ± 11.23. Regarding QoL, the mean global health status score was 58.59 ± 18.14. Among the functional subscales, role functioning scored the highest (86.64 ± 18.48), with all other subscale scores also exceeding a mean of 50. Insomnia, tiredness, and pain were identified as the top three symptom subscales. Using a two-cluster K-means clustering analysis (resulting in an empirical cutoff of 57.14), participants were stratified into high (n = 318, 66.5%) and low (n = 160, 33.5%) QoL groups (Table 2).

Table 2
Electronic health literacy, symptom burden, self-efficacy, and quality of life scores of participants (N = 478)

Variable	Mean ± SD
eHealth Literacy Questionnaire	76.29 ± 32.41
MD Anderson Symptom Inventory	
Symptom Severity	36.36 ± 29.64
Symptom interference	15.82 ± 14.81
Exercise self-efficacy	
Exercise barriers self-efficacy	41.67 ± 24.83
Exercise task self-efficacy	23.76 ± 11.23
EORTC QLQ-C30	
Somatic function	84.97 ± 14.52
Role function	86.64 ± 18.48
Emotional function	81.59 ± 15.13
Cognitive function	80.44 ± 15.92
Social function	80.44 ± 19.84
Tiredness	25.98 ± 16.86
Nausea and vomiting	10.17 ± 14.84
Pain	21.34 ± 18.48
Shortness of breath	13.02 ± 16.95
Insomnia	30.75 ± 23.76
Anorexia	13.34 ± 18.63
Constipation	18.93 ± 20.79
Diarrhea	14.64 ± 16.74
Economic hardship	16.89 ± 20.69
Global health status	58.59 ± 18.14
Higher QoL group (n = 318)	68.87 ± 9.92
Lower QoL group (n = 160)	38.17 ± 12.67
Abbreviations: EORTC QLQ-C30, European Organization for Research and	
Treatment of Cancer Quality of Life Questionnaire Core 30	

Comparison the scores of eHL, symptom burden, self-efficacy and QoL

Scores of eHL, symptom burden, ESE, and QoL varied significantly across distinct demographic and clinical subgroups. Specifically, eHL scores differed by education, residence, cancer stage, and chemotherapy status, while symptom burden varied by residence and financial status. ESE was associated with age, marital status, financial status, stage, and chemotherapy. Furthermore, significantly higher QoL scores were reported by participants with adequate or fair financial status, those at stage 0–3, and those not currently undergoing surgery or chemotherapy. Detailed comparisons are provided in Table 3.

Table 3
Comparison of electronic health literacy, symptom burden, self-efficacy, and quality of life scores (N = 478)

Age	Electronic health literacy	Symptom Severity	Symptom interference	Exercise barriers self-efficacy	Exercise task self-efficacy	Quality of life
<45 yr	79.97 ± 32.42	40.05 ± 31.08	17.95 ± 14.33	50.45 ± 23.20	22.79 ± 11.34	54.93 ± 15.62
45–54 yr	79.10 ± 34.78	34.55 ± 29.16	14.14 ± 13.85	44.42 ± 23.58	24.81 ± 10.70	60.34 ± 16.68
55 ~ 64 yr	77.18 ± 32.73	37.09 ± 30.72	16.41 ± 15.35	39.80 ± 24.11	25.62 ± 10.97	59.46 ± 20.26
≥ 65 yr	69.86 ± 28.10	35.97 ± 28.32	16.20 ± 15.52	36.23 ± 26.61	20.62 ± 11.58	57.08 ± 18.13
H/F	2.259	0.525	1.151	5.379	5.208	1.655
p	0.081	0.665	0.328	0.001 **	0.002 **	0.176
Education level						
Colleage (above)	82.69 ± 32.33	35.77 ± 29.53	16.25 ± 14.90	45.70 ± 23.42	24.45 ± 10.41	59.50 ± 16.68
High school (below)	68.98 ± 31.0	37.03 ± 29.81	15.33 ± 14.73	37.05 ± 25.63	22.98 ± 12.08	57.56 ± 19.67
t	4.715	-0.463	0.676	3.831	1.418	1.152
p	< 0.001 **	0.644	0.499	< 0.001 **	0.157	0.250
Marital status						
Married	76.60 ± 31.88	37.10 ± 30.08	16.28 ± 14.90	41.21 ± 24.20	24.55 ± 10.94	59.02 ± 17.42
Unmarried or Single	78.31 ± 34.34	28.76 ± 27.03	12.87 ± 13.13	47.45 ± 24.85	24.07 ± 11.10	60.13 ± 17.46
Other	73.76 ± 33.0	39.32 ± 29.30	16.40 ± 15.55	39.03 ± 26.55	20.83 ± 11.95	55.98 ± 20.84
H/F	0.424	2.780	1.558	2.401	3.995	1.287
p	0.655	0.063	0.212	0.092	0.019 *	0.277
Living arrangement						
Living with other	76.51 ± 32.21	36.12 ± 29.64	15.94 ± 14.81	42.17 ± 24.63	23.52 ± 11.21	58.48 ± 17.59

*Statistically significant differences at $p < 0.05$, **Statistically significant differences at $p < 10.01$

Age	Electronic health literacy	Symptom Severity	Symptom interference	Exercise barriers self-efficacy	Exercise task self-efficacy	Quality of life
Living alone	74.16 ± 34.68	38.75 ± 29.86	14.64 ± 15.01	36.70 ± 26.46	26.18 ± 11.30	59.74 ± 23.11
t	.457	-0.561	0.557	1.393	-1.501	-0.353
p	.648	0.575	0.578	0.164	0.134	0.726
Place of residence						
Urban	93.88 ± 25.35	32.53 ± 30.20	14.10 ± 14.61	44.00 ± 24.25	23.32 ± 11.20	58.96 ± 17.35
Rural	61.79 ± 30.39	39.52 ± 28.84	17.24 ± 14.86	39.75 ± 25.18	24.13 ± 11.27	58.29 ± 18.80
t	12.591	-2.579	-2.316	1.866	-0.785	0.404
p	< 0.001 **	0.01**	0.021*	0.063	0.433	0.607
Financial status						
Adequate	78.82 ± 34.19	32.98 ± 27.72	14.43 ± 14.33	41.12 ± 23.04	25.69 ± 10.07	61.93 ± 15.95
Fair	75.74 ± 31.59	35.55 ± 29.74	15.22 ± 14.53	41.13 ± 25.47	23.75 ± 11.52	59.17 ± 17.76
Insufficient	72.27 ± 33.33	54.84 ± 29.36	25.68 ± 15.61	48.14 ± 25.02	17.32 ± 10.33	42.28 ± 20.30
H/F	0.715	8.388	9.313	1.363	8.178	18.526
p	0.490	< 0.001 **	< 0.001 **	0.257	< 0.001 **	< 0.001 **
Stage						
0–III	75.28 ± 32.69	36.31 ± 29.64	15.46 ± 14.50	41.21 ± 24.79	24.51 ± 10.77	59.29 ± 17.67
IV	84.56 ± 29.01	36.73 ± 29.92	18.79 ± 17.04	45.38 ± 25.08	17.65 ± 13.07	52.88 ± 20.95
t	-2.145	-0.096	-1.350	-1.144	3.636	2.415
p	0.036 *	0.924	0.182	0.253	.001 **	0.016 *
Current 3-month surgery						
Yes	76.66 ± 33.89	42.77 ± 33.14	16.17 ± 14.73	45.31 ± 22.83	21.86 ± 11.45	53.52 ± 18.65

*Statistically significant differences at $p < 0.05$, **Statistically significant differences at $p < 10.01$

Age	Electronic health literacy	Symptom Severity	Symptom interference	Exercise barriers self-efficacy	Exercise task self-efficacy	Quality of life
No	76.23 ± 32.21	35.35 ± 28.96	15.77 ± 14.84	41.09 ± 25.11	24.06 ± 11.18	59.39 ± 17.95
t	0.099	1.705	0.203	1.272	-1.471	-2.439
p	0.921	0.092	0.839	0.204	0.142	0.015*
Current 3-month chemotherapy						
Yes	84.11 ± 31.72	38.66 ± 29.31	17.17 ± 16.06	43.77 ± 23.14	21.21 ± 12.28	54.06 ± 18.20
No	73.52 ± 32.25	35.55 ± 29.75	15.35 ± 14.34	40.92 ± 25.39	24.67 ± 10.71	60.20 ± 17.88
t	3.169	1.018	1.182	1.151	-2.797	-3.285
p	0.002 **	0.314	0.238	0.251	0.006 **	0.001**
Shared decision making						
Yes	77.44 ± 32.76	36.51 ± 29.95	15.71 ± 14.83	41.69 ± 24.58	24.14 ± 10.97	58.77 ± 17.66
No	71.13 ± 30.46	35.67 ± 28.37	16.32 ± 14.81	41.57 ± 26.07	22.07 ± 12.28	57.80 ± 20.25
t	1.646	0.241	-0.348	0.038	1.558	0.450
p	0.100	0.810	0.729	0.969	0.120	0.653
Weekly OHIS ≥ 7 hours						
Yes	79.66 ± 35.39	36.48 ± 30.73	16.17 ± 14.65	39.87 ± 24.08	25.60 ± 11.15	62.10 ± 18.36
No	75.59 ± 31.76	36.34 ± 29.45	15.75 ± 14.86	42.04 ± 25.0	23.38 ± 11.22	57.86 ± 18.03
t	1.034	0.039	0.236	− .721	1.634	1.933
p	0.302	0.969	0.814	0.471	0.105	0.054

*Statistically significant differences at $p < 0.05$, **Statistically significant differences at $p < 10.01$

Associations between eHL, symptom burden, self-efficacy, and QoL

Table 4 presents Spearman's correlation coefficients examining the associations among eHL, symptom burden, EB, ESE, and health-related QoL domains (N = 478). Notably, eHL scores showed no statistically significant correlation with any functional scale, symptom subscale, or global health status (all $p > 0.05$). In contrast, both SS and SI demonstrated significant negative correlations with all five functional scales and global health status,

while exhibiting significant positive correlations with all symptom subscales (all $p < 0.01$). Regarding self-efficacy, EB was significantly negatively correlated with functional scales and global QoL, but positively associated with symptom subscales (all $p < 0.01$). Conversely, ESE showed the opposite pattern, correlating positively with functional scales and global health status, and inversely with symptom burden (all $p < 0.01$). These findings suggest that SI and ESE serve as moderate yet significant correlates of QoL in participants.

Table 4 Associations between electronic health literacy, symptom burden, self-efficacy, and quality of life (N = 478)

EORTC QLQ-C30 Domain	Electronic Health Literacy	Symptom Severity	Symptom Interference	Exercise Barriers Self-Efficacy	Exercise Task Self-Efficacy
Functional Scales					
Physical Functioning	-0.009	-.464**	-.588**	-.431**	.553**
Role Functioning	0.012	-.387**	-.585**	-.346**	.388**
Emotional Functioning	-0.002	-.548**	-.573**	-.375**	.284**
Cognitive Functioning	-0.032	-.481**	-.528**	-.326**	.251**
Social Functioning	0.013	-.517**	-.636**	-.384**	.322**
Symptom Scales					
Fatigue	0.045	.603**	.642**	.422**	-.389**
Nausea & Vomiting	0.036	.511**	.443**	.262**	-.275**
Pain	-0.033	.552**	.596**	.364**	-.353**
Dyspnea	0.015	.405**	.421**	.219**	-.368**
Insomnia	0.012	.475**	.463**	.190**	-.204**
Appetite Loss	0.027	.515**	.523**	.304**	-.329**
Constipation	0.079	.357**	.382**	.316**	-.235**
Diarrhea	0.078	.411**	.376**	.316**	-.211**
Financial Difficulties	-0.064	.372**	.395**	.223**	-.173**
Global Quality o Life	0.05	-.432**	-.550**	-.315**	.412**

Note. Values are Spearman's correlation coefficients (r).

** p < 0.01 (two-tailed). * p < 0.05 (two-tailed).

Notably, the absence of a direct relationship between eHL and QoL implies that a higher eHL level does not necessarily guarantee better QoL outcomes.

Regression analysis of quality of life

Multivariable logistic regression identified independent predictors of high QoL among BCSs (Table 5). Adequate financial status yielded the highest odds (AOR = 4.777, 95% CI: 1.765–12.925), followed by fair financial status (AOR = 3.728, 95% CI: 1.532–9.073). Behavioral factors including weekly OHIS ≥ 7 hours (AOR = 2.253, 95% CI: 1.146–4.429) and higher ESE (AOR = 1.031, 95% CI: 1.018–1.054) also increased high QoL odds. Conversely, recent chemotherapy substantially lowered QoL odds (AOR = 0.407, 95% CI: 0.231–0.715), while higher SI was associated with slightly decreased odds (AOR = 0.942, 95% CI: 0.918–0.967). Notably, eHL showed a statistically significant but modest positive association (AOR = 1.010, 95% CI: 1.001–1.018), indicating a limited direct contribution to QoL.

Table 5 Estimated odds ratio and 95% CI for high quality of life (N = 478)

Variable	Unadjusted Model			Adjusted Model		
	UOR	95% CI	*p*	AOR	95% CI	*p*
Age			0.556			0.802
< 45 yr (Ref.)	1	–		1	–	
45–54 yr	1.529	0.819–2.856		1.251	0.583–2.685	
55–64 yr	1.517	0.811–2.839		1.337	0.607–2.943	
≥ 65 yr	1.360	0.714–2.591		1.024	0.433–2.425	
Education Level			0.217			0.679
College or above	1.271	0.868–1.860		1.118	0.658–1.900	
High school or below (Ref.)	1	–		1	–	
Marital Status			0.526			0.572
Married (Ref.)	1	–		1	–	
Unmarried / Single	1.275	0.714–2.277		1.366	0.660–2.829	
Other	0.861	0.531–1.396		1.328	0.675–2.612	
Living Arrangement			0.807			0.810
Living with others	0.921	0.473–1.790		1.116	0.454–2.745	
Living alone (Ref.)	1	–		1	–	
Place of Residence			0.654			0.238
Urban	1.091	0.745–1.600		0.718	0.414–1.245	
Rural (Ref.)	1	–		1	–	
Financial Status			< 0.001 *			0.007 *
Adequate	7.017	3.119–15.787		4.777	1.765–12.925	
Fair	4.913	2.336–10.332		3.728	1.532–9.073	
Insufficient (Ref.)	1	–		1	–	
Cancer Stage			0.155			0.956
Stage 0–III	1.530	0.851–2.751		0.978	0.449–2.133	
Stage IV (Ref.)	1	–		1	–	
Current 3-month Surgery			0.002 *			0.124
Yes	0.431	0.254–0.731		0.581	0.291–1.160	
No (Ref.)	1	–		1	–	

Current 3-month chemotherapy			< 0.001 *			0.002 *
Yes	0.409	0.269–0.623		0.407	0.231–0.715	
No (Ref.)	1	–		1	–	
Shared Decision-Making			0.825			0.507
Yes	1.057	0.648–1.724		0.814	0.443–1.496	
No (Ref.)	1	–		1	–	
Weekly OHIS ≥ 7 hours			0.032 *			0.019 *
Yes	1.833	1.055–3.186		2.253	1.146–4.429	
No (Ref.)	1	–		1	–	
Continuous Variables (per unit increase)						
eHealth Literacy	1.005	0.999–1.011	0.098	1.010	1.001–1.018	0.031 *
Symptom Severity	0.977	0.970–0.983	0.001 *	1.004	0.992–1.016	0.530
Symptom Interference	0.937	0.923–0.951	0.001 *	0.942	0.918–0.967	< 0.001 *
Exercise Barriers Self-Efficacy	0.975	0.967–0.983	< 0.001 *	0.989	0.978–1.001	0.057
Exercise Task Self-Efficacy	1.062	1.043–1.082	< 0.001 *	1.031	1.018–1.054	0.009 *

Note. OHIS = online health information seeking; UOR = crude odds ratio; AOR = adjusted odds ratio; CI = confidence interval.

* Statistically significant association ($p < 0.05$).

Statistical significance for odds ratios was determined based on whether the 95% confidence intervals excluded 1.0.

The Adjusted Model controls for all listed demographic, socioeconomic, clinical, and behavioral variables simultaneously.

Qualitative Findings

The demographics characters of participants

For the qualitative phase, a purposive subsample of 27 breast cancer survivors participated in focus groups (mean age: 58.1 ± 8.7 years; Table 6). 85.2% had early-stage cancer (Stages 0–III).The most recent treatments were AET (37%) and chemotherapy (25.9%). Regarding digital engagement and OHIS patterns, 59.3% had utilized health-related apps, and 25.9% engaged in online searching for ≥ 7 hours weekly, focusing predominantly on diet and exercise (66.7%).

Table 6
Characteristics of focus group participants (N = 27)

Characteristics	Category	N	%
Age (years), Mean (SD)	58.1 (8.7)		
Age range (years)	37–73		
Cancer Stage	Stage 0–III	23	85.2
	Stage IV	4	14.8
Current Treatments*	Surgery	5	18.5
	Chemotherapy	7	25.9
	Radiotherapy	6	22.2
	Adjuvant endocrine therapy	10	37.0
	Adjuvant Targeted Therapy	3	11.1
Financial Status	Adequate	8	29.6
	Fair	16	59.3
	Poor	3	11.1
Self-Decision Making	Self-decided	24	88.9
	Not self-decided	3	11.1
Use of Digital Devices*	Smartphone	27	100.0
	Tablet	8	29.6
	Desktop / Laptop	8	29.6
	Smartwatch	2	7.4
	Smart Band	1	3.7
Use of Health-Related Apps	Yes	16	59.3
	No	11	40.7
Weekly Online Health Information Seeking	≥ 7 hours/week	7	25.9
	< 7 hours/week	20	74.1
Health-Promoting Information Searched Online*	Diet	18	66.7
	Exercise	18	66.7
	Medication	15	55.6
	Socializing	6	22.2
	Others	2	7.4

Note. SD = standard deviation. *Multiple choice question; percentages may not sum to 100%.

Theme 1: Seeking Explanations for Illness

A recurring concern across interviews was why cancer had occurred. Survivors sought explanations that could help them understand their illness, drawing on both biomedical information and reflections on stress, family relationships, and lifestyle.

Subtheme 1.1 Clarifying biomedical information

Participants actively sought to clarify complex medical information, such as pathology reports, by leveraging both online peer communities and authoritative digital platforms (including non-profit foundations, hospital health education portals, and national health agencies):

"*When I was initially confused about my pathology report, I first asked questions in our breast cancer support group on LINE. Over time, I learned to search independently across authoritative sources, such as breast cancer foundations, hospital health education portals, and official health administration webpages*. *"* (Participant BF, 48 years old)

Subtheme 1.2 Making psychosocial sense of illness

Some survivors also considered whether chronic psychosocial stressors, including work strain, caregiving burdens, and family relationships, might have contributed to their illness:

"*I went online to find information, wondering, 'Why did I get cancer?' I even bought over ten books. There's no single answer… but I think it might be due to family factors, which caused me a lot of pressure.*" (Participant P, 52 years old).

Online searching thus provided a means of exploring both medical explanations and personally meaningful interpretations of cancer, without necessarily producing a definitive causal answer.

Theme 2: Information Appraisal and Decision Support

Following diagnosis, participants searched online for information about treatment options, including surgery, radiotherapy, chemotherapy, AET, and traditional medicine. This information helped them compare available options, prepare for clinical consultations, and consider possible coping strategies.

Subtheme 2.1 Using online information to support clinical consultations and treatment decisions

Participants searched for information during and between clinical encounters to clarify unfamiliar recommendations and prepare for discussions with healthcare professionals. Some searched in real time while physicians explained treatment options:

"*The doctor told me the biopsy indicated a malignant phyllodes tumor (a rare fibroepithelial tumor of the breast) and suggested removing the lump with minimally invasive surgery. He also mentioned a new out-of-pocket drug. As he was speaking, I was scrolling on my phone ... I then chose to accept the drug, had the surgery the very next day, and got the injection on the second day.*" (Participant T, 45years old)

Others brought information obtained from hospital websites into subsequent consultations, particularly when discussing treatment-related symptoms and ongoing care:

"*I searched extensively for information online and discussed tamoxifen-related menopausal symptoms with my physician. I also visited hospital websites in Taiwan and overseas to obtain the latest information on breast cancer treatment.*" (Participant BC, 52 years old)

These accounts illustrate how online information supplemented clinical explanations and helped participants clarify treatment-related concerns and engage in discussions with healthcare professionals.

Subtheme 2.2 Apraising online health information

Participants evaluated both the credibility and personal relevance of online health information, particularly when seeking explanations and management strategies for long-term AET-related symptoms. They tended to prioritize authoritative sources, including hospital websites and nonprofit cancer organizations, over general online content.

"*When I first got cancer, I visited the Taiwan Breast Cancer Foundation... the medical content felt professional and correct. If I can't find answers in daily life, I go online... and then verify it*." (Participant P, 52 years old).

Participants used online information to distinguish possible treatment-related effects from menopausal symptoms and to seek ways of managing these concerns

"*After chemotherapy, I became menopausal... Honestly, I couldn't tell whether my physical changes were due to menopause or the medication. The most troubling was joint pain in my shoulders and hips… I went online to look for ways to manage these symptoms.*" (Participant BB, 49 years old)

Together, these accounts illustrate how participants considered both the credibility of online information and its relevance to their own treatment-related concerns.

Subtheme 2.3 Protective disconnection from information overload

Although online information could address knowledge gaps, excessive or alarming content sometimes increased anxiety. Some participants therefore deliberately reduced their exposure to online medical information.

"*I read messages every day about my chemotherapy... even a small pimple, I couldn't tolerate. Because I read too much, my mood was affected... I have now temporarily blocked all online news.*" (Participant T, 45years old).

This "protective disconnection" reflected participants' efforts to regulate information volume when online engagement became emotionally overwhelming.

Theme 3: Using Digital Resources for Self-Management

Participants recognized the inevitable advancement of digital technology and utilized online resources to support self-care in several areas of daily life, including diet, physical activity, emotional adjustment, and treatment-related symptom management. They searched for practical information, viewed instructional content, and incorporated selected online resources into their everyday routines.

Subtheme 3.1 Applying online information to diet and physical activity

Participants used online resources to learn about food choices, cooking methods, and physical activity. Some incorporated this information into practical lifestyle adjustments during treatment and recovery. One participant described changing her eating and cooking habits after diagnosis:

"I used to eat take-out because I had no time to cook, but after getting sick, I had to change. Now I cook for myself... I searched online and learned that steaming helps preserve nutrients...

There are many medical professionals on YouTube who make these videos." (Participant BB, 49 years old).

Participants also viewed online exercise content and combined this information with guidance from healthcare professionals. One survivor described using online resources while continuing physical activity during treatment:

"*The case manager reminded me that despite the grueling treatment, I should exercise if my stamina allowed. So, I started learning exercises online and even went hiking after chemotherapy. Once, the day after the radiation therapist finished my tumor positioning, I put on my protective gear, checked the weather, and hit the historic trail the very next day. I continued my radiation therapy after returning from the hike, and my body felt completely normal!*" (Participant H, 52 years old).

These accounts illustrate how participants applied online information to make practical adjustments to diet and physical activity.

Subtheme 3.2 Seeking emotional and spiritual support online

In addition to medical information, some participants used online spiritual programs, lectures, music, and other resources to address emotional and inner concerns:

"An online spiritual program made me realize I had neglected my heart... After that, I often

visited spiritual healing websites to calm my mind." (Participant R, 59 years old)

Another participant described how online health information and hymns helped her feel less emotionally distressed:

"You should go online to stay alert to symptoms and find solutions... The health info and hymns I found really lifted me out of that negative space." (Participant K, 50 years old).

These experiences show that online engagement sometimes extended beyond medical concerns to include emotional and spiritual support.

Subtheme 3.3 Applying online information to symptom management

Participants actively applied online information to address treatment-related side effects, particularly menopausal symptoms associated with cancer treatment. Some searched for practical products or behavioral strategies and incorporated them into their daily self-care routines:

"I had menopausal symptoms... I searched for products online, and they really worked. The vaginal dryness symptoms were relieved." (Participant C, 48 years old)

"As an older individual, I am not very tech-savvy. However, I still search online for menopausal information and look at the coping strategies shared by other members in our breast cancer support group. My most troublesome symptoms are hot flashes and insomnia, so I followed the online suggestions to use an electric fan to stay cool, and I also consulted a psychiatrist and took sleep aids. Learning online that these are all common menopausal symptoms helped relieve my anxiety." (Participant BG, 68 years old)

In addition to finding empathetic resonance and peer support in online breast cancer communities, participants actively pursued and cross-referenced specialized self-care strategies shared by fellow survivors. They executed purposeful online searches for these peer-derived solutions before discussing them with their healthcare providers, translating empathetic peer exchange into empowered, actionable health information seeking. Tangible health improvements further sustained their commitment to self-management.

"During targeted therapy, severe hand-foot syndrome caused dry, cracked skin. After hearing about essential oils, I searched online for skin care information and discussed it with my attending physician ... The search provided helpful insights, significantly improving my skin trouble." (Participant M, 56 years old)

These accounts illustrate how participants translated digital information into personalized self-care practices. Experiencing tangible relief from these online-derived strategies validated their information-seeking behaviors, transforming passive knowledge gathering into empowered, proactive health management.

Theme 4: Barriers and Supports in Digital Engagement

Participants described several barriers to digital engagement, including physical fatigue, limited familiarity with digital tools, difficulty understanding online health information, and text-heavy interfaces. Some addressed these barriers by using practical smartphone functions or relying on family members to search for and share health information.

Subtheme 4.1 Barriers to digital engagement among older survivors

Some older participants expressed limited interest in learning unfamiliar digital functions and difficulty understanding online information. When the effort required exceeded the perceived benefit, they chose not to continue searching and sometimes exhibited information avoidance.

"*I don't want to learn more ways to go online... when I lived in the countryside, I loved spending time outdoors. Sometimes I don't understand, so I won't look for more.*" (Participant J, 72 years old).

Participants also identified text-heavy formats as a barrier and emphasized the need for more

accessible online information:

"*I felt like I couldn't go on... but I opened my phone to show the psychiatrist photos of my medications. He understood immediately and simplified my prescription to just one pill.*" (Participant B, 70 years old).

These accounts indicate that digital barriers involved not only access to technology but also the comprehensibility and presentation of online health information.

Subtheme 4.2 Practical adaptations and family-mediated support

Some older survivors used simple smartphone functions to meet immediate healthcare needs. Rather than relying on text-based searching, one participant used photographs to communicate medication information during a clinical consultation:

"*I felt like I couldn't go on... but I opened my phone to show the psychiatrist photos of my medications. He understood immediately and simplified my prescription to just one pill.*" (Participant B, 70 years old).

Other participants relied on family members to search for, filter, and share online health information. This assistance enabled them to access useful content despite limited familiarity with digital tools:

"*It is my children who worry about me; they found some videos and sent them to my smartphone for me to watch... I just hold the smartphone and watch. Now, I can spend more time online browsing health videos to learn modern health concepts, and I also gradually use my smartphone to handle daily tasks and stay in touch with others.*" (Participant J, 72 years old)

These accounts suggest that digital health engagement was sometimes supported through practical device functions and shared within family relationships rather than carried out independently by survivors. Together, these forms of adaptation and assistance allowed some older participants to use digital resources in ways that matched their abilities and immediate needs.

Discussion

Overall, the findings indicate that the relationship between digital engagement and QoL is not uniform, but varies according to how online information is used and the clinical and social contexts in which that use occurs. The discussion therefore focuses on the distinct roles of eHL and OHIS, the supportive and burdensome aspects of online information seeking, and the contextual resources that shape survivors' digital engagement.

Digital engagement as a supportive strategy for self-management

A central finding of this study was that participants who reported OHIS for seven or more hours per week had more than twice the adjusted odds of better QoL (AOR = 2.253, 95% CI: 1.146–4.429). Greater exercise task self-efficacy was also independently associated with better QoL, while financial status showed the strongest association in the adjusted model. These findings suggest that digital engagement and confidence in performing exercise should be considered alongside broader socioeconomic resources when examining self-management and QoL during breast cancer survivorship. Qualitative accounts further showed that participants used online health information to support practical problem-solving, lifestyle modification (Subtheme 3.1), and treatment-related discussions with healthcare professionals (Subtheme 2.1).

This interpretation is consistent with Nouri et al., who suggested that digital health benefits may depend partly on individuals' ability to navigate and use online resources [4]. Although cancer stage was not independently

associated with QoL, both eHL and OHIS remained significant in the adjusted model. Taken together, these findings suggest that both the ability to use online information and actual engagement in information seeking may be relevant to survivorship QoL.

The qualitative findings provide contextual support for this interpretation. Participants used digital platforms to verify medical information, clarify treatment-related concerns, and incorporate symptom-management strategies into daily self-care (Subthemes 2.1, 2.2, and 3.3), consistent with prior evidence that eHealth interventions and digital tools can support treatment navigation and improve patient-reported outcomes among breast cancer patients [34, 35]. Some participants also searched for practical approaches to treatment-related symptoms, including dermatologic concerns, and discussed the information with healthcare professionals. These accounts suggest that online information was not merely accessed, but evaluated and applied in treatment discussions and personalized self-management.

Recent chemotherapy and greater symptom interference remained independently associated with lower QoL, suggesting that the relationship between digital engagement and QoL should be interpreted within the broader context of treatment and symptom burden. From an SCT perspective, the association between ESE and QoL supports the importance of confidence in performing health-related behaviors [13, 14]. Purposeful OHIS may provide information for treatment decisions and ongoing self-management [36, 37], although this study did not establish that OHIS improves QoL through self-efficacy or other behavioral mechanisms. Its value may therefore depend on survivors' ability and resources to apply online information to their needs.

The double-edged nature of OHIS during acute treatment phases

Our findings suggest that OHIS is not uniformly beneficial and may become emotionally burdensome under certain clinical circumstances. Recent chemotherapy and greater symptom interference were independently associated with lower QoL, suggesting that survivors undergoing active treatment or experiencing substantial symptom burden may be particularly vulnerable. The qualitative findings provided contextual insight into this pattern: some participants described online medical information as overwhelming rather than supportive during periods of treatment-related uncertainty and symptom concern, consistent with previous reports of health anxiety and information overload [38, 39].

Some participants deliberately limited their exposure to online medical information when it negatively affected their emotional well-being, a response identified as " protective disconnection " from information overload (Subtheme 2.3). This pattern suggests that intentional disengagement may function as a self-regulatory response when the volume or emotional intensity of information becomes difficult to manage.

Together, these findings suggest that the value of OHIS is context-dependent rather than uniformly beneficial. During active treatment or periods of greater symptom distress, excessive or complex online health information may increase cognitive and emotional burden by exceeding an individual's information-processing capacity, contributing to information overload and difficulties in self-management [40].

Our findings are also consistent with the stage-specific perspective proposed by Hopfe et al. [41], who reported that cancer survivors' information needs and preferences vary across the cancer continuum. Digital health guidance should therefore consider both treatment phase and symptom burden. Promoting balanced and

symptom-responsive online engagement, rather than unrestricted information seeking, may help survivors benefit from digital resources while reducing potential psychological burden.

Online information use and appraisal for symptom management

Subgroup analyses revealed no statistically significant differences in eHL scores across age groups ($p = 0.081$; Table 3). Nevertheless, qualitative narratives showed that several middle-aged participants described active use of online resources to manage treatment-induced or natural menopausal symptoms and adverse effects associated with AET. These accounts illustrate how digital tools were used as practical resources for symptom self-management during survivorship, when women may also be managing ongoing workplace and family responsibilities [42–45].

Specifically, participants described using online resources to distinguish treatment side effects from menopausal changes, identify practical coping strategies for symptoms such as hot flashes and insomnia, and refine their understanding of disease-related concerns (Subthemes 2.2 and 3.3). Furthermore, some participants cross-referenced information obtainred from online peer-support communities with their healthcare providers (Subtheme 2.1), demonstrating how professional consultation helped them critically evaluate and integrate digital health information into daily care.

Greater online engagement, however, may also increase exposure to misinformation or unverified health advice [46]. Notably, evidence from structured web-based interventions suggests such tools can modestly improve breast cancer patients' QoL when appropriately designed [42], underscoring that the benefits of OHIS depend not only on access to information but also on the quality of the digital resource and the user's ability to appraise its credibility.

The intersection of socio-demographics and digital equity in survivorship QoL

Digital engagement during breast cancer survivorship is shaped by both individual capabilities and broader socioeconomic circumstances. Higher educational attainment was associated with greater eHL in the univariate analyses; however, education was not independently associated with QoL in the adjusted model. In contrast, both adequate and fair financial status remained strongly associated with better QoL. These findings underscore the importance of socioeconomic circumstances in survivorship QoL. Previous research has similarly shown that socioeconomic disadvantage may restrict access to cancer-related information and support [41].

These findings can be interpreted within a digital equity framework, which extends beyond internet access to include the social, economic, and cognitive resources needed to derive meaningful benefits from digital health information [47–50]. Within this framework, eHL may reflect the cognitive resources involved in evaluating and using digital health information, whereas financial status represents broader socioeconomic resources associated with survivorship QoL.

The qualitative findings further illustrated how some survivors managed practical barriers to digital engagement (Theme 4). Older participants described limited confidence or difficulty in using digital tools, while some adopted practical strategies, such as using smartphone functions to support communication with healthcare professionals (Subtheme 4.2). Family members also assisted some participants in searching for and interpreting

online health information (Subtheme 4.1). These accounts suggest that digital engagement may sometimes operate as a shared rather than solely individual resource, with family support helping survivors navigate and understand online information [14, 15, 22, 49].

Therefore, promoting digital equity in survivorship care requires strategies beyond individual digital training. Interventions should incorporate age-friendly digital design, access to reliable health information, support for digital skills and information appraisal, and appropriate family support. Addressing these interconnected cognitive and social factors may help reduce digital disparities and information overload [4, 47–51].

Strengths and Limitations

Despite pandemic-related barriers, this mixed-methods study offers a timely empirical investigation into the interplay among eHL, OHIS, and QoL in breast cancer survivors. By dynamically integrating quantitative data and focus group narratives, this research highlights how survivors actively and resourcefully leveraged digital health platforms during COVID-19. While quantitative metrics established a distinct link between high-intensity searching and elevated QoL, qualitative narratives provided vital context. They demonstrated that survivors intentionally maximized online tools to foster clinical problem-solving, behavioral control, and personal agency, which are critical nuances that standardized instruments alone fail to capture.

Several limitations should be considered when interpreting these findings. First, the cross-sectional design of the quantitative survey precludes any causal inferences regarding the chronological relationships between digital competencies and long-term QoL outcomes. Methodologically, the reliance on self-report instruments (such as the eHLQ and MDASI) may introduce inherent recall or social desirability biases. Second, sample generalizability is constrained by selection bias; participants were recruited via convenience and snowball sampling through specific oncology clinics and network leaders across northern and eastern Taiwan, which may not fully represent other regional or cultural oncology settings.

Furthermore, this regional imbalance extends to the qualitative strand, where focus groups were conducted exclusively among survivors in eastern Taiwan, potentially missing the unique urban experiences of survivors in northern metropolitan areas. Finally, statistical stratification limitations warrant caution. The wide confidence interval for high-intensity OHIS (AOR = 2.253, 95% CI: 1.146–4.429) reflects the small sample size of this subgroup 82 (17.2%), increasing vulnerability to estimation instability. Similarly, the data-driven K-means clustering yielded an imbalanced distribution between the high- and low-QoL groups ($n = 318$ vs. $n = 160$), which may have affected the precision and stability of certain parameters within the multivariable logistic regression. Future research utilizing larger, multi-center longitudinal designs with more balanced statistical cohorts is required to validate these behavioral pathways.

Conclusion

This mixed-methods study clarifies the pivotal role of digital engagement in breast cancer survivorship, while situating it alongside broader socioeconomic determinants of QoL. Quantitative analyses identified intensive OHIS and ESE as robust behavioral predictors of better QoL, alongside financial status, which showed the strongest independent association in the adjusted model. By contrast, eHL demonstrated only a modest independent association with QoL. This divergence suggests that digital literacy may most meaningfully support survivorship well-being when translated into sustained self-management behavior, rather than through the passive

possession of digital skills alone. Qualitative narratives help contextualize this pattern, indicating that the value of digital competency is closely tied to survivors' ability to appraise online health information. Notably, some survivors described deliberately disengaging from online health content through protective disconnection when information became emotionally overwhelming during acute treatment. Together, these findings suggest that OHIS confers benefit primarily when its intensity and timing align with survivors' symptom burden and treatment phase, rather than through unrestricted information exposure.

Clinical and Structural Recommendations

To support survivors effectively, clinical and digital systems should implement the following multi-level strategies:

Stage-Sensitive eHL Guidance

Oncology clinicians should incorporate tailored digital navigation support into routine care. Interventions should emphasize source verification and symptom-paced information exposure, affirming protective disconnection as a legitimate, adaptive coping strategy during acute or highly symptomatic recovery periods.

Targeted Symptom Hubs

Dedicated, evidence-based digital resources addressing treatment-induced menopausal symptoms and endocrine side effects (Subtheme 1.1 and Subtheme 3.3) should be deployed to support the highly proactive middle-aged survivor cohort.

Age-Friendly and Family-Inclusive Platforms: Digital health developers should champion inclusive designs featuring simplified interfaces and visual guidance (Subtheme 4.1) to accommodate older or socioeconomically disadvantaged individuals, while formally integrating family members in their role as digital proxies (Subtheme 4.2).

In summary, bridging these digital inequalities through multi-level clinical-digital interventions, while recognizing both active engagement and intentional withdrawal as adaptive survivor behaviors, will help mitigate health disparities and optimize long-term survivorship outcomes.

Declarations

Ethical approval and informed consent

The study was approved by the Institutional Review Boards for the Protection of Human Subjects at the participating hospitals: Hualien Tzu-Chi Hospital and Taitung Hospital (IRB No. 111227B), Taitung MacKay Memorial Hospital (Approval No. 22MMHIS394c), Mennonite Christian Hospital (Approval No. 22-12-07), and Tri-Service General Hospital (Approval No. TSGHIRB B202305039). Informed consents were obtained from all participants involved in this study.

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Consent for publication

Not Applicable

Availability of data and materials

Data can be made available on reasonable requests to the corresponding author.

Conflicts of interest

The authors declare no competing interests.

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Authors' contribution

C.SY.: Conception, Design of the work, Acquisition, analysis, Interpretation of data, drafting manuscript.

Y.CC: Conception, design of the work, Interpretation of data

T. CH., H.TC.: Conception, Design of the work, acquisition, analysis.

H.CC., D.MS., L. HT., M.CY., L. HF., T.CC. : Conception, design of the work.

L. CF., C.SH., J. SY.: Material preparation, data collection.

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Figures

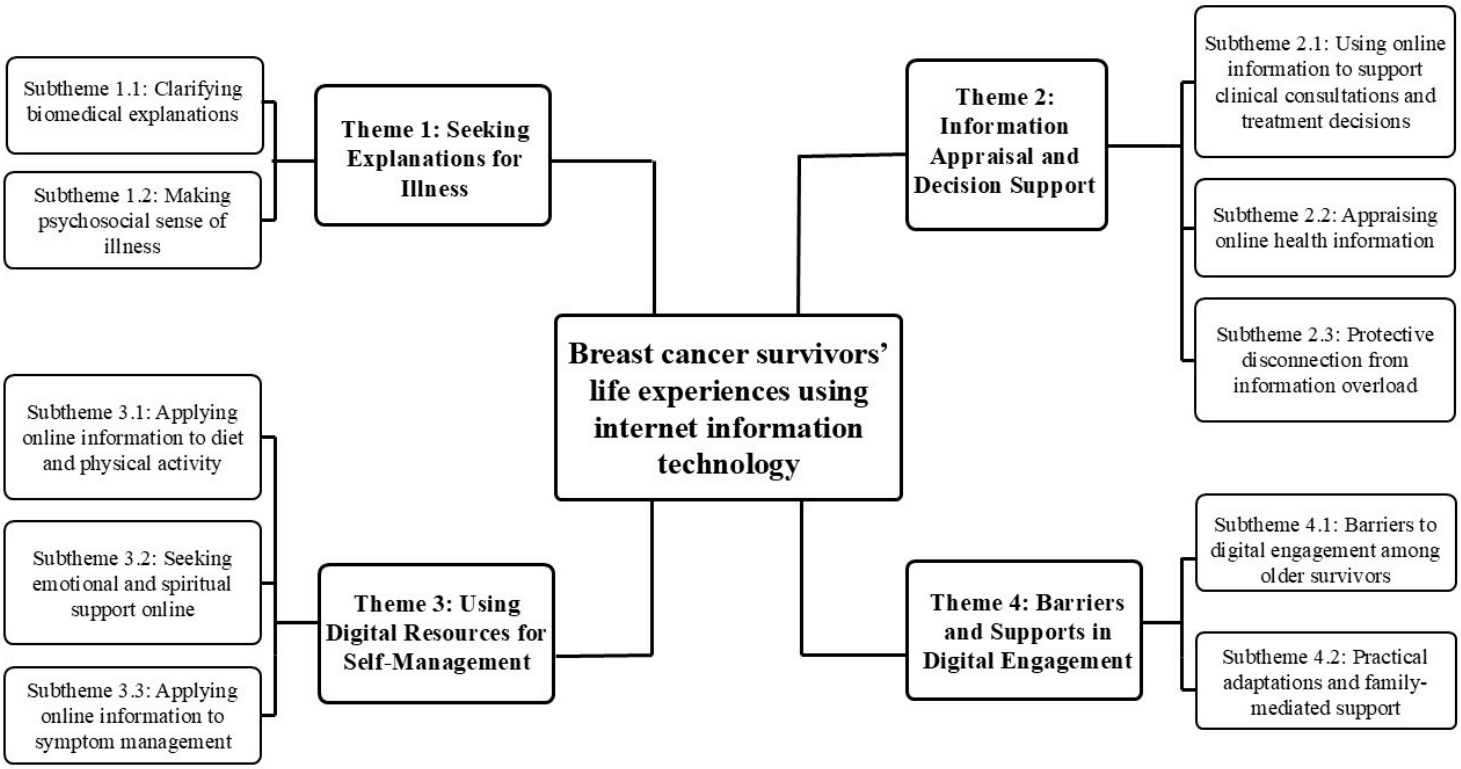


Figure 1

Qualitative finding

Thematic analysis map of breast cancer survivors' life experiences using internet information technology