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What Is the Cognitive Profile of Individuals with Breast Cancer?

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ABSTRACT

Cancer survivors experience cognitive difficulties such as brain fog, memory impairment, and executive functioning deficits. These problems often emerge as consequences of pharmacological treatments and chemotherapy, reducing individuals' capacity to cope effectively with daily challenges. Despite their clinical importance, these cognitive problems have not been adequately examined with consideration of Iranian cultural context and demographic characteristics. Therefore, the present study investigated the cognitive profile of individuals with breast cancer in relation to demographic variables. The research design was causal–comparative and descriptive. Participants were assessed using a demographic information questionnaire. The statistical population consisted of all women diagnosed with breast cancer undergoing chemotherapy, as well as non-cancer individuals, in Rafsanjan County in 2022. The study sample included 38 individuals with breast cancer and 38 healthy individuals, selected through convenience sampling. Participants were evaluated using the Neurocognitive Assessment (NeuroCog), the Brain Fog Scale, and the Multidimensional Fatigue Scale. Data analysis was performed using SPSS version 26. The findings indicated that individuals with breast cancer exhibited symptoms of brain fog and cognitive impairment, particularly in attention and memory domains. A statistically significant difference was observed between patients and healthy individuals across cognitive scores. Detailed analyses demonstrated that patients who had undergone chemotherapy showed substantial impairments in attention, memory, and executive functioning compared with the healthy control group, which was closely associated with the presence of brain fog symptoms. Furthermore, individuals with breast cancer reported considerable experiences of brain fog, distractibility, and forgetfulness.

Keywords: Cognitive impairments, Brain fog, Breast cancer.

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Introduction

Breast cancer is one of the most prevalent malignancies among women worldwide and represents a major public health concern due to its increasing incidence, prolonged treatment courses, and multidimensional consequences extending beyond physical health. According to global health surveillance data, cancer continues to rank among the leading causes of morbidity and mortality, and breast cancer constitutes a substantial proportion of female cancer diagnoses globally (1). Epidemiological evidence indicates that improvements in early detection and treatment have increased survival rates, transforming cancer into a chronic condition for many patients rather than an immediately fatal disease (2). Similar trends have been reported in Iran, where rising incidence rates accompanied by improved treatment outcomes have created a growing population of breast cancer survivors who must cope with long-term psychological, neurological, and cognitive consequences of both the disease and its treatments (3). As survival improves, attention has shifted from mortality alone toward quality of life, cognitive functioning, and psychosocial adaptation following cancer diagnosis and treatment.

Cancer diagnosis is not merely a biological event but a complex biopsychosocial experience associated with emotional distress, existential concerns, and substantial cognitive burden. Patients frequently encounter anxiety, uncertainty about prognosis, and psychological suffering that may influence cognitive processing and daily functioning (4). Evidence suggests that cancer diagnosis can trigger new-onset mental health disorders and neuropsychological symptoms that persist long after treatment completion (5). These psychological responses interact with neurobiological mechanisms, inflammatory processes, and treatment-related neurotoxicity, contributing to cognitive dysfunction in cancer survivors. Consequently, cognitive impairment has emerged as a significant domain within psycho-oncology research, emphasizing the necessity of understanding how cancer and its treatments influence higher-order mental functions.

Among the most widely reported complications in breast cancer survivors is chemotherapy-related cognitive impairment, often described colloquially as "chemobrain" or "brain fog." Brain fog refers to a cluster of subjective cognitive symptoms including reduced attention, memory lapses, slowed information processing, and diminished executive functioning (6). The concept was systematically examined in clinical contexts as a multidimensional cognitive complaint affecting concentration, mental clarity, and functional efficiency in daily activities (7). Although initially considered transient, growing evidence indicates that these symptoms may persist months or even years following treatment, significantly influencing occupational performance, social participation, and emotional wellbeing. Understanding brain fog is therefore essential for comprehensively evaluating survivorship outcomes in breast cancer populations.

Chemotherapy remains a cornerstone of breast cancer treatment; however, accumulating research demonstrates that cytotoxic agents may negatively affect neural integrity and cognitive functioning. Neuroimaging and neuropsychological investigations reveal impairments in executive functioning, working memory, and attentional control among patients undergoing chemotherapy (8). Functional MRI studies have shown alterations in brain activation patterns associated with executive networks, suggesting that chemotherapy may disrupt neural circuits responsible for cognitive regulation. These findings are supported by clinical investigations demonstrating measurable declines in memory performance before and after chemotherapy treatment among women with breast cancer (9). Such impairments are not limited to memory alone but extend to multiple cognitive domains essential for independent functioning.

Research across oncology populations further indicates that cognitive deficits are not exclusive to central nervous system cancers. Survivors of non-CNS malignancies also demonstrate alterations in working memory networks and reduced cognitive efficiency, highlighting the systemic nature of cancer-related neurocognitive effects (10). These findings reinforce the understanding that cancer treatment may induce widespread neuropsychological consequences mediated by inflammatory responses, hormonal changes, and psychosocial stressors. The persistence of cognitive impairment underscores the need for detailed cognitive profiling to identify vulnerable domains and guide targeted rehabilitation strategies.

Beyond biological mechanisms, psychological resilience and adaptive coping play significant roles in determining cognitive outcomes among patients with chronic illness. Studies examining resilience frameworks emphasize that psychological resources influence individuals' ability to adapt to stress, maintain cognitive engagement, and preserve functional performance despite adversity (11). Cancer patients often face cumulative stressors including treatment burden, uncertainty, and lifestyle disruption, which may exacerbate attentional fatigue and cognitive overload. These psychosocial dynamics interact with physiological factors, suggesting that cognitive impairment in breast cancer is a multifactorial phenomenon requiring integrative assessment approaches.

Fatigue represents another central symptom strongly associated with brain fog and cognitive dysfunction in oncology populations. Cancer-related fatigue differs qualitatively from ordinary tiredness, encompassing physical exhaustion, mental fatigue, reduced motivation, and decreased activity levels. Multidimensional models of fatigue demonstrate that cognitive inefficiency frequently accompanies persistent fatigue symptoms (12). Fatigue may impair attentional capacity, working memory performance, and executive regulation, thereby intensifying subjective experiences of cognitive decline. Given the close relationship between fatigue and brain fog, simultaneous assessment of these constructs is essential for accurately characterizing cognitive profiles in breast cancer patients.

Emerging intervention research highlights the possibility of mitigating chemotherapy-related cognitive impairment through psychological and behavioral approaches. Programs such as Managing Cancer and Living Meaningfully (CALM) have demonstrated effectiveness in reducing cognitive distress and improving psychological adjustment among breast cancer survivors (13). Similarly, structured executive function training interventions have shown promise in alleviating brain fog symptoms and improving cognitive regulation capacities (14). These findings indicate that cognitive impairments are not irreversible consequences of cancer treatment but may respond to targeted therapeutic strategies when accurately identified and assessed.

Accurate evaluation of cognitive functioning requires reliable and valid neuropsychological assessment tools capable of capturing multidimensional cognitive performance. Traditional cognitive screening instruments such as the Mini-Mental State Examination provide clinicians with practical methods for assessing overall cognitive status (15). However, contemporary research emphasizes the importance of domain-specific assessments that evaluate attention, memory, language, visuospatial abilities, and executive functioning separately. The Neuropsychiatry Unit Cognitive Assessment (NUCOG) represents one such comprehensive instrument designed to produce detailed cognitive profiles across multiple domains (16). Compared with global intelligence or abbreviated neuropsychological measures, multidimensional assessments offer enhanced sensitivity for detecting subtle cognitive changes associated with medical conditions (17).

In addition to objective cognitive testing, subjective cognitive complaints must also be considered. Patients' self-reported experiences of mental inefficiency often precede measurable deficits and may reflect early neuropsychological changes or psychological distress. Studies examining chemotherapy-induced cognitive impairment have demonstrated discrepancies between subjective symptoms and objective test performance, underscoring the necessity of combining both assessment approaches (18). Integrating subjective measures of brain fog with standardized cognitive testing provides a more comprehensive understanding of patients' functional cognitive realities.

Lifestyle and physiological factors may also influence cognitive outcomes in breast cancer populations. Experimental studies suggest that physical activity and metabolic regulation can modulate tumor biology and potentially affect neurocognitive functioning through hormonal and inflammatory pathways (19). Such findings highlight the interconnected nature of physical health, treatment effects, and cognitive performance. Consequently, demographic and health-related variables should be incorporated into cognitive investigations to better understand variability among patients.

Despite expanding international research on cancer-related cognitive impairment, important contextual gaps remain. Cultural, demographic, and healthcare-system differences may influence symptom reporting, coping strategies, and access to cognitive rehabilitation services. Iranian populations, in particular, have been underrepresented in neuropsychological oncology research, limiting the generalizability of existing findings. Given increasing survival rates and the growing number of breast cancer survivors in Iran, systematic investigation of cognitive functioning within this cultural context is both timely and necessary. Understanding how demographic characteristics intersect with cognitive symptoms may facilitate culturally responsive assessment and intervention planning.

Collectively, prior literature demonstrates that breast cancer survivors frequently experience cognitive impairments characterized by attention deficits, memory disturbances, executive dysfunction, fatigue, and subjective brain fog symptoms. These impairments arise from complex interactions among chemotherapy effects, psychological stress, neurobiological changes, and sociocultural factors. Although significant progress has been made in identifying chemotherapy-related cognitive impairment, comprehensive cognitive profiling integrating objective neuropsychological assessment, subjective brain fog evaluation, and demographic considerations remains limited, particularly within Iranian clinical populations.

Therefore, the aim of the present study was to investigate the cognitive profile of individuals with breast cancer based on demographic characteristics through comparative evaluation of cognitive functioning, brain fog symptoms, and multidimensional fatigue in comparison with healthy individuals.

Methods and Materials

Study Design and Participants

The present study employed a causal–comparative and descriptive research design. During the assessment phase, participants were evaluated using a demographic information questionnaire developed by the researcher to determine eligibility for inclusion in the study. Inclusion criteria consisted of an age range between 20 and 50 years, absence of any physical illness other than cancer, and willingness to participate in the study. The statistical population included all women diagnosed with breast cancer undergoing chemotherapy treatment at cancer treatment hospitals in Rafsanjan County, as well as non-cancer individuals residing in Rafsanjan County in 2022. The study sample comprised 38 women diagnosed with breast cancer and 38 women without cancer, selected through convenience sampling. Prior to implementation, ethical approval was obtained from the Research Ethics Committee of the University of Isfahan. Participants completed informed consent forms. Participation in the study was entirely voluntary, and participants were assured that any concerns or objections regarding the research process could be communicated verbally or in writing to the Research Ethics Committee of the University of Isfahan. Participants were also informed that all collected information would remain confidential.

Participants who met the inclusion criteria entered the study, including 38 women with breast cancer and 38 women without cancer within the age range of 20–50 years. Demographic variables such as age, marital status, economic status, insurance coverage, and occupational conditions were thoroughly examined to facilitate accurate interpretation of the findings. Subsequently, cognitive functioning of both groups was comprehensively assessed using the Neuropsychiatry Unit Cognitive Assessment (NUCOG), the Brain Fog Scale, and the Multidimensional Fatigue Inventory. The Multidimensional Fatigue Inventory was included because fatigue represents one of the primary symptoms associated with brain fog.

Data Collection

Demographic Information Form: The demographic questionnaire was developed by the researcher based on the requirements of the study and was used to assess age, marital status, economic status, insurance coverage, occupational conditions, social withdrawal, and factors influencing cognitive status among individuals with breast cancer and healthy participants.

Neuropsychiatry Unit Cognitive Assessment (NUCOG): The NUCOG was used to assess overall cognitive functioning. The Neuropsychiatry Unit Cognitive Assessment (NUCOG) evaluates cognition across five domains—attention, visuospatial abilities, memory, executive functioning, and language—through 21 items. Separate scores are calculated for each cognitive domain based on the assumption that overall cognition is distributed across relatively independent domains. The test provides a cognitive profile useful for identifying cognitive impairments (Walterfang et al., 2003). Walterfang et al. (2006) examined the NUCOG in Australia and reported validity and reliability coefficients of 0.91 and 0.96, respectively, with an inter-rater reliability of 0.91. In another study, internal consistency reliability of the NUCOG yielded a Cronbach's alpha of 0.919, and convergent validity with the Mini-Mental State Examination (MMSE) showed a Pearson correlation coefficient of 0.92 (Berekhtin et al., 2010). Additionally, Mirzaei and Tavakoli (2022) reported Cronbach's alpha coefficients above 0.60 for the NUCOG and its subscales among individuals with breast cancer.

Brain Fog

a) Multidimensional Fatigue Inventory (MFI): The Multidimensional Fatigue Inventory (MFI) was originally developed by Smets in 1996 and is applicable to both patients and healthy individuals. The instrument contains 20 items rated on a 5-point Likert scale and assesses five dimensions of fatigue: general fatigue (4 items), physical fatigue (4 items), mental fatigue (4 items), reduced activity (4 items), and reduced motivation (4 items). The validity and reliability of the questionnaire have been evaluated across various demographic groups, including cancer patients undergoing radiotherapy, individuals with chronic fatigue syndrome, first-year psychology and medical students, soldiers, and third-year medical students. Confirmatory factor analysis demonstrated that items within each dimension adequately represented their respective constructs, indicating satisfactory internal consistency. Alpha coefficients exceeded 0.80 for general, physical, and mental fatigue, and were above 0.65 for reduced activity and reduced motivation. Findings from other studies have also confirmed the instrument's adequate reliability and validity. The questionnaire has been translated into Persian, and its psychometric properties have been confirmed (Khani

Jazani et al., 2012). Mirzaei and Tavakoli (2022) reported Cronbach's alpha coefficients above 0.90 for the MFI and its subscales among individuals with breast cancer.

b) Brain Fog Scale: The Brain Fog Scale was used to assess symptoms of brain fog and was developed by Ross et al. (2013). The purpose of the scale is to evaluate brain fog symptoms and provide deeper insight into this condition. The instrument includes 19 items representing core symptoms of brain fog, the sum of which constitutes the total brain fog score. Additionally, the scale contains six supplementary items, one assessing severity of brain fog and five qualitative (nominal) questions. Mirzaei and Tavakoli (2022) reported a Cronbach's alpha coefficient of 0.98 for the 19-item Brain Fog Scale, and its face validity was confirmed by expert evaluation.

Data Analysis

For data analysis, the collected data were analyzed using SPSS version 26, employing univariate and multivariate analyses of variance (ANOVA).

Findings and Results

The demographic characteristics of the studied sample are presented in Table 1. All participants were married. The mean age and standard deviation of the breast cancer group were 42 years and 3 years, respectively.

Table 1. Demographic Characteristics Including Age, Education Level, Duration of Breast Cancer Diagnosis, and Healthy Individuals

Group	N	Mean Age	SD	Diploma	Bachelor's Degree	< 6 Months	6 Months–1 Year	> 1 Year	Social Security Insurance	Social Security + Supplementary	Health Insurance	Armed Forces	Good Economic Status	Moderate	Weak
Cancer	38	42.00	3.00	28	10	10	17	11	18	15	5	0	7	23	8
Healthy	38	43.43	2.00	28	10	–	–	–	13	14	11	0	10	25	3

After sample selection and administration of the assessment procedures, cognitive functioning levels of individuals with breast cancer and healthy participants were evaluated using the Neuropsychiatry Unit Cognitive Assessment (NUCOG), the Brain Fog Scale and its severity index, and the Multidimensional Fatigue Inventory along with its subscales including general fatigue, physical fatigue, reduced activity, reduced motivation, and mental fatigue. The results are reported in Table 2.

Table 2. Means and Standard Deviations of NUCOG, Brain Fog, Multidimensional Fatigue, and Their Subscales in Individuals with Breast Cancer and Healthy Participants

Variable	Group	N	Mean	SD	N	Mean	SD
		Breast Cancer Group			Healthy Group		
NUCOG Total Score		38	83.00	4.00	38	93.00	4.00
Attention		38	14.00	1.00	38	17.00	1.00
Visuospatial		38	18.00	1.00	38	19.00	1.00
Memory		38	14.00	1.00	38	18.00	1.00
Executive Function		38	16.00	1.00	38	19.00	1.00
Language		38	19.00	0.00	38	20.00	0.00
Fatigue Total Score		38	87.00	5.00	38	25.85	5.00
General Fatigue		38	16.00	2.00	38	6.00	1.00

Physical Fatigue	38	16.00	1.00	38	6.28	1.00
Reduced Activity	38	17.00	1.043	38	1.14	1.00
Reduced Motivation	38	17.02	1.00	38	8.00	2.00
Mental Fatigue	38	17.00	1.00	38	7.00	2.00
Brain Fog Score	38	61.14	4.00	38	13.00	6.00
Brain Fog Severity	38	76.00	7.00	38	22.00	8.00

To evaluate brain fog, both the Brain Fog Scale and the Multidimensional Fatigue Inventory were used. The Brain Fog Scale includes both quantitative and qualitative items. Five items are qualitative (nominal), while the quantitative section—comprising the total score derived from 19 items and one item measuring brain fog severity—was analyzed alongside multidimensional fatigue scores and their subscales. The five qualitative items were analyzed separately. The results related to the first five qualitative items of the Brain Fog questionnaire are presented in Table 3.

Table 3. Frequency of Responses to Questions on Brain Fog Frequency, Brain Fog Variability, Time of Maximum Severity, Impaired Activity, and Sleep Disturbance in Individuals with Breast Cancer and Healthy Participants

Question	Response Category	Breast Cancer Group (Frequency)	Healthy Group (Frequency)
Frequency of Brain Fog	Never	0	28
	Once per month	3	6
	Once per week	3	1
	2–3 times per week	24	3
	Daily	3	0
	Once per day	1	0
	Several hours per day	5	0
	Most of the day	0	0
	All day	0	0
Brain Fog Variability	Fluctuating	0	0
	Non-fluctuating	38	38
Time of Greater Severity	Morning	0	0
	Afternoon	0	0
	Evening	0	0
	Night	10	0
	No specific pattern	28	38
Impaired Activity	Work/School	0	0
	Efficiency	0	0
	Social functioning	38	38
Sleep Disturbance	Present	10	4
	Absent	28	34

To test the research hypothesis, statistical assumptions were first examined. One prerequisite of parametric testing is normal distribution of research variables. The Shapiro–Wilk test was used to evaluate normality of distribution. The results indicated that all variables followed a normal distribution, as significance levels exceeded 0.05 for all variables. Additionally, Levene's test demonstrated that the assumption of homogeneity of variances was satisfied for all three variables, with significance levels greater than 0.05.

The overall comparison of the presence of brain fog and NUCOG performance between individuals with breast cancer and the healthy group using analysis of variance is reported in Table 4. According to the results presented in Table 4, individuals with breast cancer exhibited symptoms of brain fog and cognitive impairments, and a statistically significant difference was observed between the breast cancer group and the healthy group ($p < .001$). A more detailed examination of brain fog and NUCOG variables is presented in

Table 5. Based on the results shown in Table 5, significant differences were observed between the two groups ($p < .001$), indicating that individuals with breast cancer experienced both cognitive dysfunction and brain fog symptoms.

Table 4. Overall Multivariate Analysis of Variance (MANOVA) Results for Brain Fog and NUCOG Variables in Individuals with Breast Cancer and Healthy Participants

Test Name	Value	F	Hypothesis df	Error df	Significance
Pillai's Trace	0.98	6541.00	4	34	.001
Wilks' Lambda	0.01	6541.00	4	34	.001
Hotelling's Trace	53.28	6541.00	4	34	.001
Roy's Largest Root	53.28	6541.00	4	34	.001

Table 5. MANOVA Results for Posttest Scores of Brain Fog and NUCOG Variables in Individuals with Breast Cancer and Healthy Participants

Variable	Sum of Squares	df	Mean Square	F	Significance	Effect Size	Statistical Power
Attention	466.87	1	466.87	177.14	.001	0.88	1.00
Visuospatial	522.57	1	522.57	103.94	.001	0.69	1.00
Memory	466.87	1	466.87	156.44	.001	0.76	1.00
Executive Function	493.77	1	493.77	143.34	.001	0.74	1.00
Language	633.57	1	633.57	179.12	.001	0.78	1.00
General Fatigue	457.14	1	457.14	102.12	.001	0.89	1.00
Physical Fatigue	434.57	1	434.57	178.94	.001	0.93	1.00
Reduced Activity	490.07	1	490.07	160.20	.001	0.90	1.00
Reduced Motivation	216.07	1	216.07	46.26	.001	0.77	1.00
Mental Fatigue	434.57	1	434.57	133.22	.001	0.93	1.00
Brain Fog	145,452.00	1	145,452.00	7,368.00	.001	0.96	1.00
Brain Fog Severity	224,071.00	1	224,071.00	3,733.00	.001	0.95	1.00

The remaining five items of the Brain Fog questionnaire assessed frequency of brain fog, variability of symptoms, time of symptom exacerbation, type of impaired activity, and presence or absence of sleep disturbance. Among these variables, symptom variability and type of impaired activity were completely identical between individuals with breast cancer and healthy participants; therefore, these variables were not suitable for statistical analysis. However, the variables of symptom frequency, time of symptom exacerbation, and sleep disturbance were analyzed using the chi-square test. The results indicated statistically significant differences between the two groups across all examined variables.

Discussion and Conclusion

The present study aimed to investigate the cognitive profile of women with breast cancer by comparing cognitive functioning, brain fog symptoms, and multidimensional fatigue with those of healthy individuals. The findings demonstrated that women with breast cancer exhibited significantly higher levels of brain fog and fatigue alongside lower cognitive performance across several domains, including attention, memory, executive functioning, visuospatial abilities, and language. The multivariate analysis confirmed statistically significant differences between the clinical and healthy groups, suggesting that breast cancer and its treatment are strongly associated with measurable neurocognitive disruption. These findings align with the growing body of psycho-oncology research emphasizing that cancer survivorship involves not only physical recovery but also persistent cognitive and psychological challenges affecting daily functioning and quality of life (1, 2).

One of the most prominent findings of this study was the presence of substantial brain fog symptoms among patients with breast cancer. Participants reported frequent experiences of mental confusion, distractibility, and forgetfulness, which were reflected both in subjective assessments and objective cognitive performance scores. Brain fog has been conceptualized as a multifaceted cognitive syndrome characterized by reduced mental clarity, impaired concentration, and slowed information processing (7). The present findings reinforce the clinical validity of this construct in oncology populations and support earlier theoretical descriptions suggesting that brain fog represents an interaction between neurobiological effects of treatment and psychological distress (6). The significant differences observed between groups indicate that brain fog is not merely a subjective complaint but corresponds with measurable cognitive deficits.

The observed impairments in attention and working memory among breast cancer patients were particularly notable. Attention serves as a foundational cognitive process underlying learning, memory encoding, and executive regulation; therefore, disturbances in attentional capacity may produce cascading effects across other cognitive domains. Neuroimaging research has demonstrated that chemotherapy can alter neural networks responsible for working memory and attentional control, leading to persistent cognitive inefficiency even after treatment completion (10). Similarly, functional MRI investigations have identified disrupted executive networks in breast cancer patients receiving chemotherapy, supporting the interpretation that treatment-related neurotoxicity contributes to executive dysfunction (8). The present study's findings are consistent with these results, suggesting that attentional deficits may represent a central mechanism underlying broader cognitive impairment.

Memory impairment was another major outcome identified in this research. Women with breast cancer showed significantly lower memory scores compared with healthy individuals, confirming earlier evidence that chemotherapy exposure negatively affects memory performance. Previous investigations examining cognitive status before and after chemotherapy have reported similar declines in memory functioning among breast cancer patients (9). These deficits may arise from inflammatory responses, oxidative stress, or alterations in neurotransmitter functioning induced by systemic cancer treatments. Memory disturbances may further exacerbate patients' emotional distress, as difficulties in recalling information or maintaining concentration can interfere with occupational roles, treatment adherence, and interpersonal interactions.

Executive functioning deficits observed in the present study further highlight the complexity of cancer-related cognitive impairment. Executive functions encompass planning, cognitive flexibility, inhibition, and goal-directed behavior, all of which are essential for independent functioning. Evidence suggests that chemotherapy-related cognitive impairment is strongly associated with executive dysfunction due to disruption of prefrontal neural circuits (8). The significant reductions in executive performance found in this study support this perspective and suggest that executive deficits may underlie many daily-life difficulties reported by breast cancer survivors, including reduced productivity and decreased problem-solving efficiency.

Another important finding involved elevated fatigue levels among breast cancer patients across all dimensions of multidimensional fatigue. Cancer-related fatigue has been described as one of the most prevalent and distressing symptoms experienced during and after treatment, often persisting long beyond medical recovery. Multidimensional models emphasize that fatigue includes physical exhaustion, mental fatigue, decreased activity, and motivational decline (12). The strong association between fatigue and brain fog observed in this study supports theoretical models proposing that cognitive impairment and fatigue share overlapping neuropsychological mechanisms. Mental fatigue may reduce cognitive resource availability, thereby impairing attentional control and information processing speed.

The relationship between fatigue and cognitive impairment may also be interpreted within a broader psychosocial framework. Cancer diagnosis introduces existential stress, uncertainty, and emotional burden that may contribute to cognitive inefficiency. Patients experiencing psychological suffering frequently report difficulties maintaining concentration and decision-making capacity (4). Moreover, large cohort studies have shown increased risk of mental health disorders following cancer diagnosis, suggesting that emotional distress interacts with biological factors to influence cognitive outcomes (5). The findings of the present study therefore support an integrative biopsychosocial explanation of cognitive impairment rather than a purely neurological model.

The significant differences in subjective brain fog frequency, symptom severity, and sleep disturbance further reinforce the multidimensional nature of cognitive dysfunction in breast cancer survivors. Sleep disturbances observed among patients may contribute to impaired attention and memory consolidation, thereby intensifying cognitive complaints. Previous research indicates that chemotherapy-induced cognitive impairment involves interactions between sleep quality, fatigue, and emotional regulation, suggesting that these factors should be evaluated simultaneously when assessing cognitive health (18). The present results extend these findings by demonstrating that subjective symptoms correspond with objective neuropsychological outcomes measured through standardized assessment tools.

The use of the NUCOG instrument enabled detailed examination of domain-specific cognitive functioning, revealing impairments across multiple cognitive domains rather than isolated deficits. The NUCOG has demonstrated strong psychometric properties and sensitivity in detecting cognitive disturbances across clinical populations (16). Compared with traditional screening instruments such as the Mini-Mental State Examination, which primarily assesses global cognitive status (15), multidimensional tools provide richer clinical information and may be particularly useful in oncology settings where cognitive changes are subtle but functionally significant. The comprehensive cognitive profile identified in this study underscores the value of multidomain assessment approaches.

Beyond neurobiological explanations, adaptive coping and resilience processes may influence cognitive outcomes among breast cancer survivors. Psychological resilience has been associated with improved adaptation to stress and better maintenance of cognitive functioning under adverse conditions (11). Patients with stronger coping resources may experience reduced cognitive vulnerability despite similar medical treatment exposure. This interpretation aligns with intervention research demonstrating that psychological programs targeting meaning-making and emotional adjustment can reduce cognitive distress and improve perceived mental functioning among cancer survivors (13).

Encouragingly, emerging evidence suggests that cognitive impairment associated with breast cancer may be modifiable. Interventions focused on executive functioning training have shown effectiveness in reducing brain fog symptoms and improving cognitive performance in affected patients (14). These findings imply that early identification of cognitive deficits through systematic screening could enable targeted rehabilitation strategies, potentially improving long-term psychosocial outcomes. Additionally, lifestyle interventions such as structured physical activity programs have demonstrated beneficial physiological effects in breast cancer models, suggesting potential indirect benefits for cognitive health through metabolic and inflammatory regulation (19).

Taken together, the results of the present study are consistent with international research demonstrating that breast cancer survivors frequently experience multidimensional cognitive impairment associated with chemotherapy exposure, psychological distress, and fatigue. The convergence of subjective brain fog reports, objective cognitive deficits, and elevated fatigue levels provides strong evidence supporting the ecological validity of patients' cognitive complaints. Importantly, the findings contribute culturally relevant evidence from an Iranian population, addressing a notable gap in the literature and emphasizing the importance of context-sensitive assessment of cancer survivorship outcomes.

The present findings also highlight the clinical necessity of incorporating cognitive assessment into routine oncological care. As survival rates continue to improve globally, healthcare systems must increasingly address long-term cognitive and psychological consequences of cancer treatment. Comprehensive evaluation of attention, memory, executive functioning, fatigue, and brain fog may allow clinicians to design personalized supportive interventions aimed at restoring functional independence and improving overall quality of life among breast cancer survivors.

One limitation of the present study concerns the relatively small sample size and the use of convenience sampling, which may limit generalizability of findings to broader populations of breast cancer patients. Additionally, the cross-sectional design prevents causal interpretation regarding whether cognitive impairment results directly from chemotherapy, psychological distress, or preexisting cognitive differences. Another limitation involves reliance on self-report measures for certain variables, which may introduce response bias. Furthermore, potential moderating variables such as treatment stage, hormonal therapy, and comorbid psychological conditions were not examined in detail, which may influence cognitive outcomes.

Future research should employ longitudinal designs to examine cognitive trajectories before, during, and after chemotherapy in order to clarify temporal relationships between treatment exposure and cognitive decline. Larger multicenter studies are recommended to enhance representativeness and enable subgroup analyses based on demographic, medical, and psychosocial factors. Incorporating neuroimaging techniques alongside neuropsychological assessment may also provide deeper understanding of neural mechanisms underlying brain fog. Moreover, future investigations should evaluate the effectiveness of cognitive rehabilitation, psychological interventions, and lifestyle-based programs in reducing cognitive impairment among breast cancer survivors.

From a practical perspective, the findings emphasize the importance of routine cognitive screening within oncology services. Healthcare providers should educate patients and families about the possibility of cognitive changes during treatment to reduce anxiety and enhance coping readiness. Multidisciplinary care models integrating psychologists, oncologists, and rehabilitation specialists may help address cognitive and emotional needs simultaneously. Developing culturally adapted cognitive rehabilitation programs and fatigue management interventions could improve daily functioning, treatment adherence, and psychosocial wellbeing among women living with breast cancer.

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Authors' Contributions

All authors equally contributed to this study.

Declaration of Interest

The authors of this article declared no conflict of interest.

Ethical Considerations

The study protocol adhered to the principles outlined in the Helsinki Declaration, which provides guidelines for ethical research involving human participants.

Transparency of Data

In accordance with the principles of transparency and open research, we declare that all data and materials used in this study are available upon request.

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