ORIGINAL ARTICLE

CONTENTS

Clinical and sociodemographic predictors of psychological health outcomes in cancer patients undergoing active treatment at the National Teaching Cancer Hospital, Najaf: AI-assisted predictive analysis

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ABSTRACT

Aim: To identify clinical and sociodemographic predictors of anxiety and depression among cancer patients undergoing active treatment using XGBoost algorithm.

Materials and Methods: A cross-sectional study was conducted among 323 cancer patients undergoing active treatment at National Teaching Hospital for Oncology, Iraq, selected by systematic sampling. Psychological status was assessed using Hospital Anxiety and Depression Scale (HADS). Clinical and Sociodemographic data were collected through patient interviews and clinical records. Linear regression analysis was employed to determine predictive power of age, cancer type, treatment modality, disease stage, duration, and comorbidities. An XGBoost machine learning classifier was applied to improve prediction of depression and anxiety based on identified clinical and Sociodemographic features.

Results: Anxiety prevalence was 78.4% (was estimated as severe: 47.7% and moderate: 30.7%), while depression 80.2% (severe: 50.5% and moderate: 29.7%). Age, cancer type, and treatment modality (chemotherapy and radiotherapy) were significant predictors ($P<0.001$). First year after diagnosis of disease, active treatment period, and disease stage II were identified as critical periods for psychological instability. Patients with chronic comorbidities demonstrated significantly higher psychological levels, indicating a cumulative physical and functional burden. The XGBoost model achieved high predictive performance (accuracy 1.0%, confirming the reliability of Sociodemographic and clinical indicators in predicting high-risk patients.

Conclusions: Cancer patients are vulnerable to anxiety and depression during early stages of diagnosis and treatment, exacerbated by chronic comorbidities. Incorporating routine psychological screening using HADS, with advanced predictive models like XGBoost, may facilitate early identification of high-risk patients and support targeted interventions to improve quality of life.

KEYWORDS: cancer, depression, anxiety, HADS, predictors, machine learning XGBoost

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INTRODUCTION

Cancer remains one of the leading causes of death worldwide, with approximately 10 million deaths in 2020, and the global burden is expected to increase in the coming decades [1]. Beyond its physical impact, cancer imposes a substantial psychological burden that adversely affects quality of life, treatment adherence, and clinical outcomes [2]. Depression and anxiety are among the most common psychological disorders in cancer patients, with prevalence rates significantly higher than those observed in the general population [3]. In the Middle East and North Africa (MENA) region, pooled estimates indicate depression and anxiety rates 44% and 47%, respectively [4]. In Iraq, cancer patients also experience considerable levels of anxiety 38.9% and depression 34.7%, influenced by sociodemographic and clinical factors such as gender, marital status, employment status, pain and disease-related conditions [5]. Untreated psychological distress has significant clinical consequences and has been associated with increased cancer-specific mortality and poorer health outcomes [6]. Furthermore, psychological symptoms frequently remain underrecognized and undertreated among cancer patients [7]. Despite the growing recognition of psychosocial care in oncology, there remains limited evidence regarding the sociodemographic and clinical predictors of anxiety and depression among Iraqi cancer patients. Therefore, this study aims to identify key predictors of anxiety and depression among patients undergoing active treatment at the National Teaching Hospital for Oncology in Najaf,

Iraq. In addition, the XGBoost algorithm was employed to improve predictive accuracy, as machine learning approaches can better capture complex relationships among clinical and sociodemographic variables compared with traditional statistical methods [8].

AIM

The aim of this research is to identify clinical and Sociodemographic predictors of anxiety and depression among cancer patients undergoing active treatment using XGBoost algorithm.

MATERIALS AND METHODS

STUDY SETTING AND STUDY SAMPLE

A cross-sectional study was conducted at the National Teaching Hospital for Oncology in Najaf, Iraq. between October 2025 and January 2026. The study included adult cancer patients undergoing active treatment during the study period. A total of 323 participants were selected using systematic random sampling. Sample size was calculated using the single population proportion formula with a 20% non-response rate [9].

ELIGIBILITY CRITERIA

Inclusion criteria: Adults with any confirmed cancer type undergoing active treatment and able to provide verbal informed consent were selected.

Exclusion criteria: Patients younger than 18 years, with cognitive or mental disorders, critical medical conditions, ICU admission, or refusal to participate were excluded.

DATA COLLECTION

Data were collected using a standardized questionnaire that was back-to-back translated into Arabic. The researchers conducted direct interviews with participants and reviewed medical records to complete the first three sections, while participants themselves completed the fourth section (self-report). The questionnaire has the following information:

Section 1. Socio-demographic characteristics of cancer patients involves 9 items: such as age, sex, marital status, educational level, occupational status, and income level. It also detailed the geographical distribution by governorate (covering all Iraqi provinces) and housing status (categorized as owned, rented, shared, or agricultural), residence (categorized as urban or rural).

Section 2. Clinical variables of cancer patients, involves 6 items such as cancer type, disease duration, TNM (Tumor–Node–Metastasis) stage, type and duration of active treatment, and comorbidities.

Section 3. presents the laboratory findings such as Hb (hemoglobin), WBC (white blood cells), platelets, AST (Aspartate Aminotransferase), ALT (Alanine Aminotransferase), creatinine, and cortisol.

Section 4. Psychological assessment tools, using a standardized questionnaire after translating it into an Arabic version, included the HADS (Hospital Anxiety and Depression Scale), used to assess the severity of depression and anxiety symptoms.

MEASUREMENT AND SCORING

It is a 14-item self-assessment scale aimed at detecting anxiety and depression cases and measuring their severity in patients. The tool is divided into two subscales, each consisting of seven items: one dedicated to assessing anxiety (HADS-A) and the other to depression (HADS-D), with a primary focus on psychological rather than physical symptoms. This scale measures the state that respondents felt during the past week, with items evaluated using a 4-point Likert scale, ranging from 0 to 3. The total score for each subscale can range from 0 to 21, where higher numbers indicate higher levels of psychological distress. According to standardized verification tests, the overall score for each subscale can be interpreted as indicating a normal state 0–7, the presence of borderline symptoms 8–10, or severe symptoms 11–21. In this work, the subscales for both depression and anxiety indicated high internal consistency, with a Cronbach's alpha of 0.80 and 0.79, respectively. This scale was developed by [10].

DATA PREPROCESSING AND AUGMENTATION

The original dataset included 323 clinical samples. Preprocessing steps included encoding for categorical variables, imputation for missing data, normalization, and class balancing using SMOTE. Data augmentation of continuous variables with small random perturbations, for example, by adding Gaussian noise. The dataset was then balanced to a total of 1000 samples. The data were split into training (80%) and testing (20%) sets, and XGBoost was selected for predictive modeling. The model was trained two times, once on the original and once on the augmented datasets, to compare the effects of data processing on the model performance. The evaluation metrics were accuracy, precision, recall, F1-score, specificity, and AUC.

STATISTICAL ANALYSIS

The analysis was performed based on a two-framework methodology. The first framework was descriptive statistics, and inferential statistics using IBM SPSS Statistics version 28. The second framework was prediction modeling using the machine learning libraries in Python within the Google Collab environment and the XGBoost algorithm to predict levels of depression and anxiety.

ETHICAL CONSIDERATIONS

Written informed consent was acquired from the Ethics Committee of Al-Furat Al-Awsat Technical University, College of Health and Medical Techniques, Kufa (Ref. No. 4805 in 24/9/2025), while ethical approval was granted by the Al-Najaf Health Directorate (Ref. No. 36558 in 5/10/2025). Additionally, verbal consent was obtained from all participants.

RESULTS

SOCIODEMOGRAPHIC CHARACTERISTICS

A total of 323 cancer patients undergoing active treatment participated in this study, with an age range of 18-87 years and a mean ± STD of 52.95 ± 12.79, and the response rate was 100%. Most participants were female, married, and unemployed. The majority had a low educational level and were residents of rural areas, with most participants living in Najaf Governorate. Sociodemographic characteristics showed statistically significant variation (P>0.05) (Table 1).

CLINICAL CHARACTERISTICS

Table 2 summarizes the clinical characteristics of participants. Breast cancer was the most common cancer type. Regarding the disease period, most patients had been diagnosed for less than one year, were diagnosed in stage II of the disease, and were receiving chemotherapy. The majority had undergone active treatment for one year or less, while approximately one-third had chronic comorbidities, primarily hypertension and diabetes mellitus.

PREVALENCE OF DEPRESSION AND ANXIETY

According to the HADS score, depression and anxiety were highly prevalent among participants. Clinically significant depression and anxiety represented the largest categories, followed by borderline levels, while normal scores were observed in a smaller proportion of patients. The detailed distribution is presented in Table 3.

ASSOCIATION OF DEMOGRAPHIC AND CLINICAL FACTORS WITH DEPRESSION AND ANXIETY LEVELS

As shown in Table 4, the results revealed that all examined sociodemographic and clinical variables were significantly associated with depression and anxiety levels p<0.001. Detailed regression results are presented in Table 4.

RESULTS OF DEPRESSION AND ANXIETY LEVELS ANALYSIS USING AI MODELS

The XGBoost model demonstrated excellent predictive performance with an accuracy of 100% and a log loss of 0.0019. Precision, Recall, F1-score, and ROC-AUC were reached 1.00 across all classes, indicating outstanding discrimination between positive, borderline, and normal cases. These findings support the utility of machine learning approaches in identifying patients at risk of depression and anxiety (Table 5).

IMPORTANT FEATURES IN THE PREDICTION OF DEPRESSION AND ANXIETY CLASSES

The results of data modeling using the XGBoost algorithm showed a hierarchy of the most influential features in the process of predicting classes of anxiety and depression. Stages top the list of the most contributing features of classification accuracy, followed immediately by chronic diseases and types of cancer as the most important clinical determinants. In the subsequent grades, the variables include the sex, age, period of active treatment, and type of treatment. The duration of disease is considered one of the least influential features, as depicted in Figure 1.

DISCUSSION

Research on the psychological health of cancer patients has experienced progressive advancement. Nevertheless, research primarily focusing on the active therapy phase remains inadequate. This study is the first study in Al-Najaf Al-Ashraf to identify the predictors of depression as well as anxiety in cancer patients undergoing active therapy through the application of XGBoost algorithms. Among 323 cancer patients, age was significantly associated with depression and anxiety (P<0.001), with older patients experiencing greater psychological burden. The association between age and depression and anxiety observed

Table 1. Distribution of respondents according to socio-demographic characteristics

Variables		Freq. N=323	Percent	P. value
Age Groups (years)	18-27 Y	28	8.7	0.005*
	28-37 Y	25	7.7	
	38-47 Y	52	16.1	
	48-57 Y	76	23.5	
	58-67 Y	88	27.2	
	68-77 Y	41	12.7	
	78-87 Y	13	4.1	
Sex	Male	113	35.0	0.001**
	Female	210	65.0	
Marital Status	Single	26	8.1	0.001*
	Married	212	65.6	
	Divorced	23	7.1	
	Widowed	61	18.9	
	Separate	1	0.3	
Education level	Not read or write	98	30.3	0.001*
	Read and write	17	5.3	
	Primary	111	34.4	
	Secondary	29	9.0	
	Tertiary	15	4.6	
	Diploma	23	7.1	
	Bachelor	26	8.1	
	High degree	4	1.2	
Employment Status	Government Employee	54	16.7	0.001*
	Self-employed	25	7.7	
	Not working/ House-wife	206	63.8	
	Retired	38	11.8	
Governorate	Najaf	219	67.8	0.001*
	Diwaniya	41	12.7	
	Bable	32	9.9	
	Karbala	5	1.5	
	Samawa	12	3.7	
	Kut	9	2.8	
	Salah Aldine	5	1.6	
Residence	Urban	147	45.5	0.001**
	Rural	176	54.5	
Monthly Income Level	More than Sufficient	44	13.6	0.001*
	Somewhat sufficient	147	45.5	
	Insufficient	132	40.9	
Housing Status	Owner	118	36.5	0.001*
	Rent	29	9.0	
	Share with	90	27.9	
	Agriculture	86	26.6	

* Kruskal-Wallis Test, significant at 0.05. ** Mann-Whitney U, significant at 0.05.
Source: Authors' own work

Table 2. Distribution of patients according to clinical information

Variables		Frequency	Percent	P. value
Type of cancer	Leukemia	40	12.4	0.001*
	Tongue Cancer	4	1.2	
	Breast	101	31.3	
	Bladder	18	5.6	
	Uterus	5	1.6	
	Lung cancer	35	10.8	
	Prostate	9	2.8	
	Lymphoma	20	6.2	
	Kidney	5	1.5	
	Brian	9	2.8	
	Ovaries	9	2.8	
	Liver	4	1.2	
	Colon	21	6.5	
	Bone marrow	13	4.0	
	Pancreases	8	2.5	
	Squamous Melanoma	1	.3	
	Stomach	10	3.1	
	Soft Tissue Sarcoma	9	2.8	
	Rectuoma	2	.60	
Period of disease	Less than 1 y	166	51.4	0.001*
	From 1-3Y	87	26.9	
	More than 3	70	21.7	
Disease stages	1st	65	20.1	0.001*
	2nd	133	41.2	
	3rd	68	21.1	
	4th	57	17.7	
Type of treatment	Chemotherapy	163	50.5	0.001*
	Radiotherapy	76	23.5	
	Surgery	1	.30	
	Hormonal	68	21.1	
	Compound	15	4.6	
Period of active treatment	≥1Y	257	79.6	0.001*
	1-3Y	40	12.4	
	More than	26	8.0	
Chronic diseases	Yes	116	35.9	0.001*
	No	207	64.1	
Types of chronic diseases	Not	207	64.1	0.001*
	Hypertension	68	21.1	
	Diabetes	43	13.3	
	EHD	5	1.5	

* Kruskal-Wallis Test, significant at 0.05.
Source: Authors' own work

in this study is consistent with previous studies [11-12], which reported a significant relationship between age and psychological distress among cancer patients. However, this finding contrasts with other studies [13-14], where different age groups were identified as being at risk of psychological distress. Such differences may reflect variations

Table 3. Distribution of cancer patients by overall level of depression and anxiety (N=323)

Category	Score	Freq. (%) Depression	Freq. (%) Anxiety	Df	P. value
Normal	0-7	64 (19.8)	70 (21.6)	2	0.001*
Borderline	8-10	96 (29.7)	99 (30.7)		
Positive	11-21	163 (50.5)	154 (47.7)		
Total		323 (100.0)	323 (100.0)		

* Kruskal-Wallis Test, significant at 0.05

Source: Authors' own work

Table 4. Linear regression coefficients for depression and anxiety according to sociodemographic and clinical factors

Predictor	R (Depression)	Prediction	R (Anxiety)	Prediction	Sig.
Age	0.020	2.253	0.128	11.985	> 0.001
Type Of Cancer	0.108	2.415	0.108	10.906	< 0.001
Duration	0.082	2.443	0.098	11.156	> 0.001
Disease stage	0.004	2.314	0.056	10.837	> 0.001
Type Of Treatment	0.023	2.588	0.272	11.910	> 0.001
Period of Active Treatment	0.087	2.450	0.118	11.306	> 0.001
Chronic Diseases	0.053	2.449	0.045	9.878	> 0.001

Source: Authors' own work

Table 5. Performance metrics of the XGBoost model for depression and anxiety levels

Accuracy: 1.00 Log Loss: 0.0019					
Classification report					
Depression and anxiety level	**Precision**	**Recall**	**F1-score**	**Support depression**	**Support anxiety**
Normal	1.00	1.00	1.00	41	45
Borderline	1.00	1.00	1.00	59	61
Positive	1.00	1.00	1.00	100	94
Accuracy			1.00	200	200
Macro avg.	1.00	1.00	1.00	200	200
Weighted avg.	1.00	1.00	1.00	200	200

Source: Authors' own work

in socio-cultural healthcare contexts. Cancer type was also significantly associated with both depression and anxiety (p<0.001), with breast cancer being the most common diagnosis. This result contrasts with studies that reported no significant association [15, 16], it supports evidence suggesting that specific cancer diagnosis may increase vulnerability to psychological distress. Furthermore, type of treatment emerged as another significant predictor of depression and anxiety (p<.001). More than half of participants receiving chemotherapy, which may explain the observed psychological burden. These results similar findings have been reported in previous studies highlighting the influence of treatment type and intensity on psychological outcomes [17, 18]. Stage of disease was significantly associated with depression and anxiety (p<0.001), with the highest prevalence observed among patients in Stage II. This result in line with the predictive ability of the disease stage found by Geremew et al. [19]. Disease duration since diagnosis was also significantly associated predictor with depression and anxiety (p<0.001), particularly during the first year after diagnosis, suggesting that this period represents a critical phase for psychological vulnerability. These results contradict a previous study by Alfadhul [20] in Najaf, and aligns with study of Mols et al. [21], which did not identify a significant temporal association. Similarly, duration of active treatment emerged as a significant predictor of psychological disorders (P<0.001). reflecting the cumulative impact of the first-year post-diagnosis. The cumulative burden of ongoing chemotherapy and radiotherapy may contribute to increased depression and anxiety levels during the treatment period. This result is consistent with study found an inverse association between the time of treatment completion and psychological problems; that is, suffering is highest during the active treatment phase and only falls after its termination [13]. And finally, our results disclosed a significant association

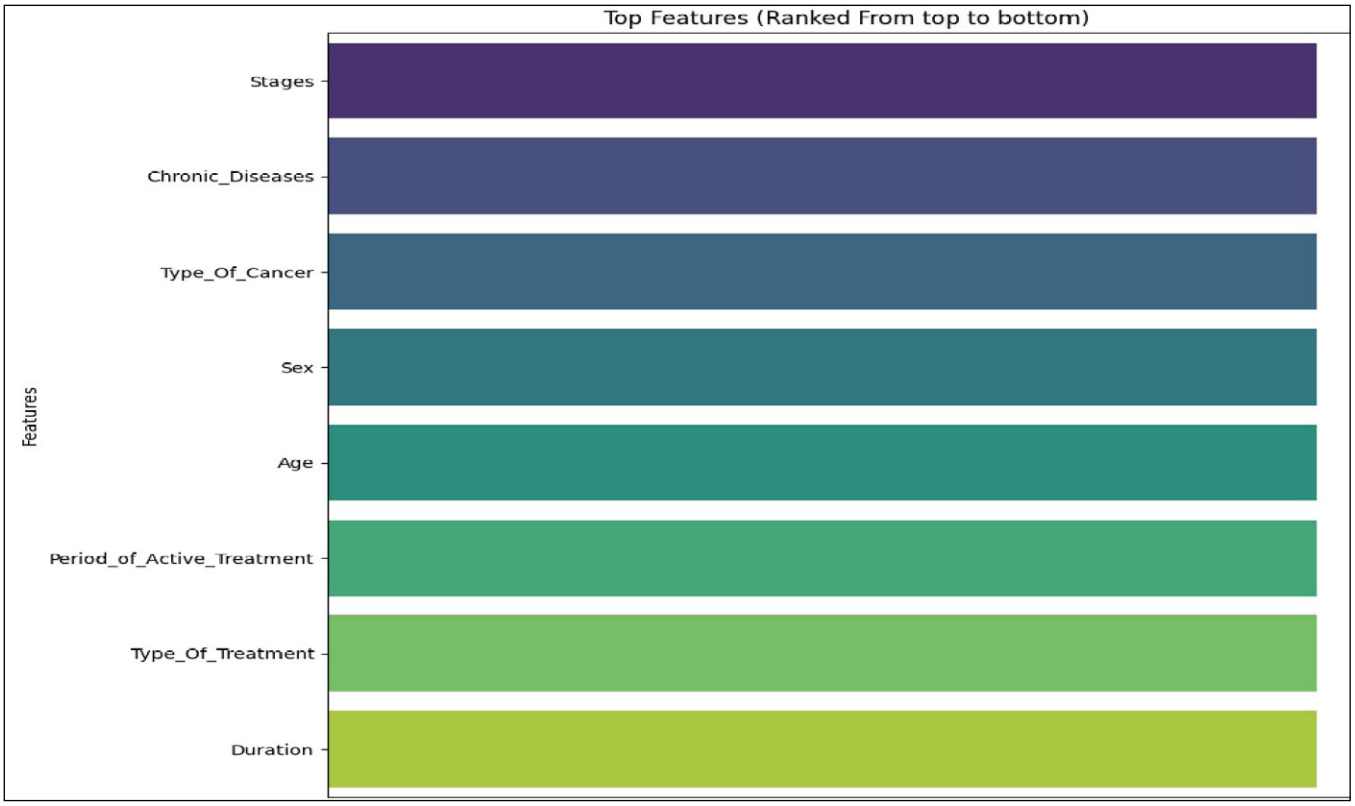


Fig. 1. Important features in the prediction of depression and anxiety classes
Source: Own materials

between the presence of comorbid chronic diseases and increased levels of depression and anxiety (P<0.001). This may reflect the presence of additional physical and psychological burden imposed by conditions such as diabetes and hypertension. Similar associations have been reported previously [22, 23]. The prevalence of clinically significant depression and anxiety was 50.5% and 47.7%, respectively. These findings fall within the ranges reported in prior research indicating anxiety prevalence ranging from 19.9% to 64.9% [24, 25] and depression prevalence spanning from 21.0% to 70.0% [26, 27]. Nevertheless, our findings surpass those of a Greek study of Arvanitou et al. [28], potentially attributable to cultural variations, access to psychological support, and socioeconomic conditions. The AI analysis found several factors that may contribute to psychological disturbances. Among them, age, cancer type, treatment modality, disease stage and its duration, period of active treatment, and chronic comorbidities emerged as significant predictors of depression and anxiety. In this study, XGBoost algorithms demonstrated excellent predictive performance in predict depression and anxiety levels among cancer patients, consistent with recent studies employed machine-learning approaches in psychological health prediction [29-31]. The high predictive accuracy may be attributed to the selected of clinically relevant features, such as the type of treatment and the stage of the disease, etc., a finding that agrees with previous study conducted in China showing that appropriate features selection substantially improves model performance and predictive accuracy [31]. These findings highlight the potential of artificial intelligence to facilitate early identification of patients at high risk of psychological disorders and support more objective, evidence-based psychological care within oncology settings [32].

CONCLUSIONS

The present report notes there is a strong association between cancer and high levels of depression and anxiety in patients under active therapy, with nearly half of the study group being categorized as positive for depression and anxiety. The rationale for considering clinical and sociodemographic factors as effective predictors of patients' psychological conditions was confirmed by the finding that the artificial intelligence model based on XGBoost demonstrated better predictive performance. The results show that the introduction of such types of AI systems in the healthcare system can be helpful in detecting high-risk patients, which will allow intervention in the process of psychological treatment. Overall, the use of AI-based solutions can be considered an important step forward in providing more objective, evidence-based mental health care to cancer patients as opposed to the subjective way.

RECOMMENDATIONS

Based on the findings of the current study, we recommend the implementation of a psychological assessment program by adopting one of the machine learning algorithms as a standard procedure for cancer patients from the point of diagnosis in the hospital, with enhanced support for breast cancer patients during the first year of disease and in the second stage to navigate the adaptation crisis. It also emphasizes the activation of specialized psychological support units to reduce the burden resulting from active treatment. Furthermore, the adoption of a holistic care strategy for patients with concurrent chronic illnesses diminishes the dual burden, and, ultimately, the study advocates for the enhancement of educational initiatives for patients and their families alongside the execution of future longitudinal studies to track psychological variables throughout the treatment process.

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CONFLICT OF INTEREST

The Authors declare no conflict of interest

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