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An Artificial Neural Network Approach for Psychometric Assessment of Stress, Anxiety, and Depression in Women

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Abstract

This study was carried out to classify, and predict the presence and absence of illness among women of Wazirabad city based on stress, anxiety, and depression. A questionnaire of Depression, Anxiety and Stress Scale (DASS-21) was used to collect data. Two-stage cluster sampling was used, and size of sample was 334. In this study, 57 respondents were those who were suffering some illness whereas 277 respondents were those who reported the absence of illness. Results showed that 87.7%, 56%, and 49% cases of illness were with moderate and above levels of anxiety, stress, and depression respectively. The findings of the research supported the significant relationship of demographic variables and psychological factors with illness. Artificial Neural Network technique was used to assess the classification and prediction, and our model showed good classification in both categories of illness. Overall, correctly classified illness in women was 89.4%. Anxiety level was more contributory factor to perceive the illness in women among all the independent variables. Our model predicted that there is 94% chance of presence of illness within a woman, having extremely severe level of anxiety, and moderate levels of stress and depression.

Keywords: Anxiety, Artificial Neural Network, Depression, Illness, Stress.

1. Introduction

Depression is a disorder of temperament characterized by sense of despair, grief, decreased activity, despondency, sorrow and sadness. Such symptoms severely damage and affect an individual's well-being (Iyer & Khan, 2012). It is an emotional illness that classified as some negativity, lack of brainpower, reduction in daily actions and anything else that affect a person usual life (Eby & Eby, 2006). World Health Organization had mentioned that depression will be second highest public disease on earth by next decade, as one woman out of each 5 women, is already suffering from depression. Depression is foremost common reason that enforces someone to visit psychiatrist (Kessler et al., 1994; Zhang & Ye, 2020). Four types of symptoms of depression are physical, emotional, motivational and cognitive. An individual with more symptoms would have more chance to suffer from depression.

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Anxiety is a feeling of inner terror, worry and distress, which expresses itself in some behavioural, cognitive, and physiological sign. Anxiety often happens without any clear motivation, differentiating from panic (Ghaderi et al., 2009). However, any panic attack is a sudden flow of great anxiety, and it causes hesitation, getting worried, tension and fear (Clark & Beck, 2023).

Stress is feelings of worry, frustration, tension, and sadness that may last for some days (Ogazi et al., 2022; Seaward, 2017). Stress is identical to getting worried or is anything that makes you upset or frustrated. Any bad or good change in your routine life is stress (Walker, 2002). DASS-42 was used to evaluate the levels of stress, anxiety and depression (SA&D) among students of Turkey University. Students were reported with moderate, severe or above levels of SA&D. Further, the scores of stress and anxiety were higher among female students (Bayram & Bilgel, 2008). To test the construct validity of short-form version of Depression, Anxiety and Stress Scale (DASS-21), factor analysis was used and it concluded that DASS-21 can be used to measure the validity levels of SA&D (Henry & Crawford, 2005). Urdu version of DASS-21, having sound psychometric properties, was also found as a reliable measure to assess the SA&D levels. Its structural form of factors is consistent with original DASS-21 (Aslam & Kamal, 2017). In a survey of 'stress in America' Women reported high level of stress (Becker, 2013). Gao et al. (2020) also used DASS-21 to assess the prevalence of SA&D in female students and found that anxiety was most prevailing among them. Higher levels of SA&D among women were found to linked with hormonal, biological, and psychological factors (Dixon & Kurpius, 2008).

Physical illness of human body is greatly affected by the psychological condition of a person. Empirical results indicated the higher SA&D levels among people having physical illness (Kaplan & Nunes, 2003). Illness is any unhealthy feeling. It often accompanies some diseases but sometimes it exits even without any disease (Boyd, 2000). Significantly higher levels of SA&D were observed among the women of Wazirabad city for ill class (Riaz et al., 2013). Further the significant correlations of physical illness with SA&D in a proportional sample of 184 college undergraduates (Rawson et al., 1994) and between life stress and physical illness among young white females were found (Stewart & Salt, 1981).

Structural equation analysis was also used to examine the association between depression and physical illness among women and reported the indirect relationship between them (Hough et al., 1999). Moderate to severe levels of anxiety, depression and stress were observed among those females who were suffering any serious disease. The common psychiatric disorders among diseased women are SA&D (Alagizy et al., 2020). Moreover, the pandemic of COVID-19 increased the symptoms of SA&D among women particularly and it negatively affected their mental health. The stress level among Dutch women was highly increased rather than depression and anxiety during COVID-19 pandemic (Zilver et al., 2021). Mental health due to family history and medical illness has resulted the occurrence of anxiety among females (Nakie et al., 2022).

Therefore, the present study was designed to explore the relationship of physical illness with various demographics and SA&D levels such as: Is there any relationship

exist between physical illness and demographic variables (marital status, age, living family system)? Also, the existence of association between physical illness and levels of stress, anxiety, and depression is assessed in the study. Another important objective of this study was the classification and prediction of the presence and absence of illness among the women of Wazirabad city on the basis of SA&D levels and key demographic variables. These research objectives are addressed in the following sections and findings of the present study are compared with existing literature in the discussion section.

2. Methodology

The main focus of present study was to classify the presence and absence of illness among women of Wazirabad on the basis of SA&D and significant demographic variables. Two-stage cluster sampling was used to collect the data where women were the target population. At first stage, five union councils were chosen and from each union council, one colony was selected at second stage. Colonies were taken as clusters and houses were taken as sampling units. As in the selected clusters there were 334 houses, so size of sample was 334. A questionnaire based on demographic information and Urdu version of DASS-21 was used to collect the data. Reliability analysis of DASS-21 showed good internal consistency with the value of Cronbach's alpha 0.865.

Women with the presence of illness were taken as cases and the women with the absence of illness were taken as controls. In the present study 57 cases and 277 controls were observed which the ratio of 1:5 is. The reason behind less number of cases could be that the most respondents (67%) were in the age category of 21–30 years. As the statistical power of a study can be enhanced by increasing count of controls per case (Hennessy et al., 1999; Katki et al., 2023; Wacholder et al., 1992), so the 1:5 ratio is within suggested range and acceptable for the statistical validity.

Physical illness was measured as a categorical variable on a nominal scale. Chi-square was used to assess the association between the physical illness (yes or no) and marital status (married or unmarried), living family system (nuclear or joint) and for the categories of age. The relationship between illness and levels of SA&D were also measured using chi-square. The assumptions of normality and linearity between variables were assessed but the data did not fulfill these assumptions. So the traditional methods such as logistic regression were not applicable for the objectives of classification and prediction in this study. The technique of Artificial Neural Network (ANN) does not require these strong assumptions and oftenly preferred over the traditional approaches of classification and prediction of categorical response variable (Dreiseitl & Ohno-Machado, 2002; Karanika-Murray & Cox, 2010; Landi et al., 2010). Multi-layer Perceptron ANN technique was used to assess the classification and prediction of illness among the women of Wazirabad city on the basis of SA&D. Multi-layer Perceptron ANN contains 3 layers: input, hidden and output layer and its structure are shown in Figure 1.

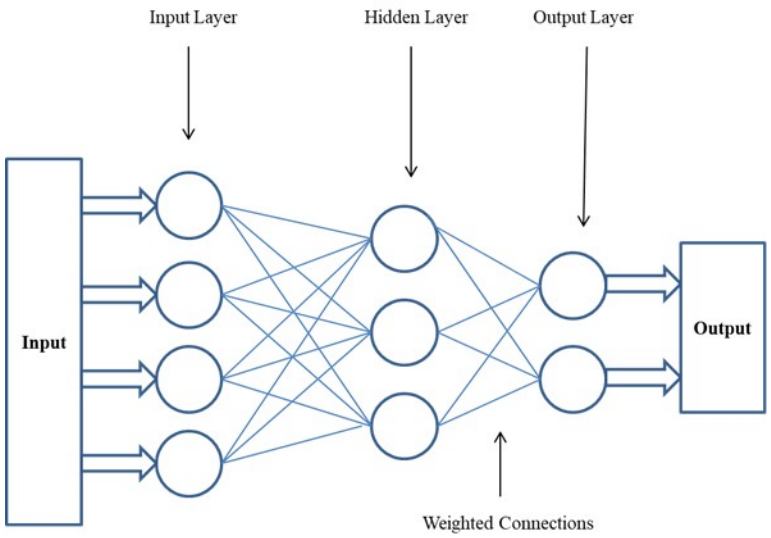

Figure 1: Structure of an Artificial Neural Network.

3. Results

The collected data was analyzed using SPSS 21. In the present study, 57 cases and 277 controls were reported, whereas 47.6% women who responded were married and 52.4% were unmarried. Further the four age categories of the respondent were taken where 67.4% of the respondents were in the age category of 21–30 years, 15.6% and 9.6% were in the age category of 31–40 and 41–50 years respectively. And 7.5% women were in the age category of above 50 years. 40% women were part of joint family system whereas 60% were living in a nuclear family system. 64.4%, 38.3%, and 32.3% respondents were with moderate and above level of anxiety, stress, and depression respectively. Moreover, 87.7%, 56%, and 49% respondents of cases were with moderate and above levels of anxiety, stress, and depression respectively. The descriptive statistics of the cases and controls were given in Table 1.

Linear-by-linear association showed significant relationship between illness and levels of stress, anxiety, and depression ($p-$value¡0.005). Chi-square showed significant association of illness with age and marital status ($p-$value=0.000*). Whereas the association between illness and living family system ($p-$value=0.546) was insignificant.

For the ANN, presence or absence of illness among the women of Wazirabad city was taken as dependent variable and SA&D along with demographics (age and marital status) were taken as the independent variables. We repeated our ANN model 100 times where the training and testing samples were 68% and 32% for every repetition and the average results were reported comprising the training sample of 227 respondents and testing sample of 107 respondents. The ANN comprised 9 units in input layer, hidden layer comprised 6 units and output layer comprised 2 units. Softmax function was used as activation function from hidden to outer layer by this model.

Table 1: Descriptive statistics (frequency) of cases and controls.

Variables	Category	Cases (n = 57)	Control (n = 277)
Age	20–30	9	216
	31–40	12	40
	41–50	18	14
	Above 50	18	7
Marital status	Married	51	108
	Unmarried	6	169
Depression	Normal & mild	29	197
	Moderate & above	28	80
Anxiety	Normal & mild	7	112
	Moderate & above	50	165
Stress	Normal & mild	25	181
	Moderate & above	32	96

Table 2 shows the results of classification for illness in women that was provided by the ANN model on the basis of SA&D and demographic variables: age, and marital status. Correct classification and misclassification for the absence and presence of illness in their corresponding categories, for both training and testing sample are shown in Table 2. The main diagonal cells of this table represent the correct classification and off-diagonal cells show the misclassification. In training sample, the presence category of illness was overall correctly classified in its own category by 61.0% due to independent variables, and 39.0% misclassified in other category. On the other hand, the absence category of illness was overall correctly classified in its own category by 95.7% and 4.3% misclassified in other category. Overall correct classification in the training and testing samples were 89.4% and 86.9% respectively. It means that ANN model showed good classification in both categories of illness due to the independent variables.

Table 2: Classification table with presently ill as dependent variable.

Sample		Predicted		
		Presence	Absence	Correct%
Training	Presence	25	16	61%
	Absence	8	178	95.7%
	Overall %	14.5%	85.5%	89.4%
Testing	Presence	9	7	56.3%
	Absence	7	84	92.3%
	Overall %	15%	85%	86.9%

In Figure 2, the area under the ROC curve closer to the upper left corner provided excellent discrimination of model.

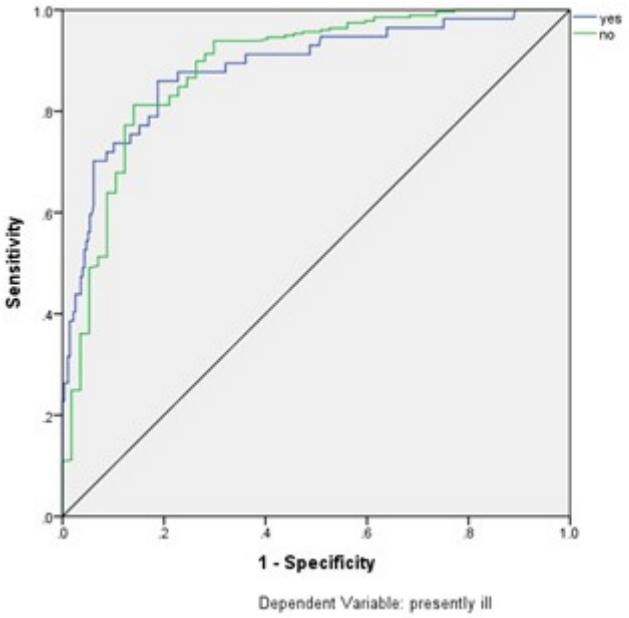

Figure 2: ROC Curve of ANN.

Figure 3 showed the significance of independent variables in predicting the illness among women. There were five independent variables shown in this figure and model provided anxiety level of the women to the highest importance which fully participated (100%) in the classification of illness. Age was the second important variable with 98.8% participation. Third and fourth important variables were depression and stress levels with 53.5% and 32.1% participation respectively and the least important variable was marital status having 22.1% participation in the classification of illness.

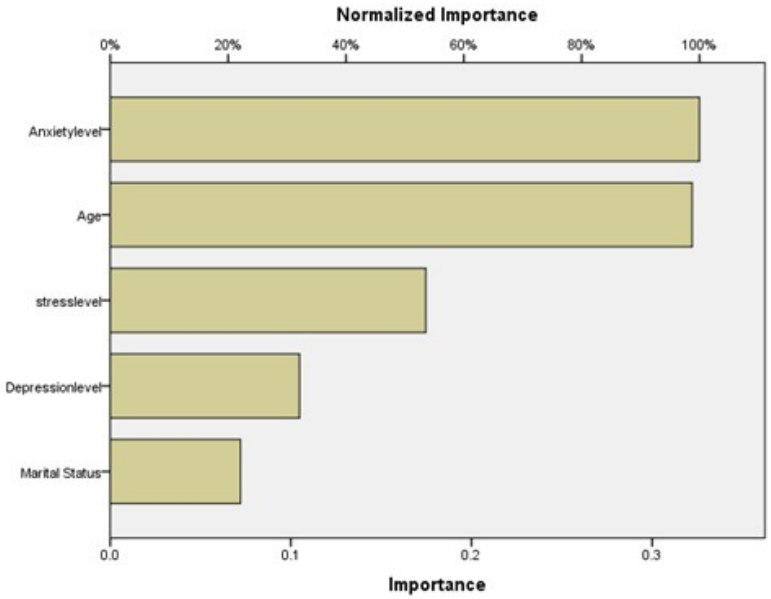

Figure 3: Importance of independent variables.

3.1. Prediction of illness

The ANN model can be used to predict the illness of women by taking prediction weights and relationships. One of the respondents within sample was taken for the prediction purpose. The independent variables denoted by x_i, w_i were weights and y_j is calculated as

$$y_j = bias + \sum w_i x_i. \tag{1}$$

Softmax function (given in Eq. (2)) is used in ANN to obtain the predicted probability for classification.

$$\gamma(Z_k) = \frac{e^{z_k}}{\sum_{k=1}^{2} e^{z_k}}, \tag{2}$$

where, $z_k = bias + \sum W_{ik} \tanh(y_j)$, and $\tanh(y_j)$ is the hyperbolic tangent of the calculated values of y_j (see Appendix A). By using ANN Model, a married woman with the extremely severe anxiety, and moderate levels of stress and depression will have 94% chance to be with the presence of illness and 6% chance of absence of illness.

4. Discussion

The first objective of the study was to explore the association between illness and demographic variables (marital status, age, and family living system). The results of the present study indicate that the association between illness and demographics (marital status, age) was significant but illness was not found to be associated with family living system. Literature indicated the strong relationship of illness with marital status, and age (Chaudhry et al., 2014; Kim et al., 2018; Qadir et al., 2013) which is consistent with the findings of the present study for the significant association of illness with marital status and age. For the relationship between illness and family system there are mixed results of strong association (Patrick et al., 1992) and no association (Leeman et al., 2016; Mylona et al., 2023). However, the recent studies are supporting the results of this study.

The second objective was to assess the relationship between illness and levels of stress, anxiety and depression and the significant relationship is also observed between Illness and levels of SA&D. Literature also reported the association between illness and SA&D. Strong relationship of SA&D with illness was found and it revealed that outcomes of SA&D are harmful to health (Gupta et al., 2008; Hildrum et al., 2008; Markovitz et al., 1993; Mushtaq & Najam, 2014; Nakanishi et al., 2001). Further the anxiety is found as the most serious factor that affects human body destructively (Hildrum et al., 2008).

ANN model showed good classification in both categories of illness due to the independent variables. Overall correct classification in the training sample was 89.4% and in the testing, sample was 86.9%. Among all the independent variables, most contributory factor to perceive the illness among the women was anxiety

level. Although ANN does not provide the insights as logistic regression provides about the role of predictors but the graph of importance of independent variables is useful to explore the most contributing factor. While we applied only model for the classification and prediction purposes due to our limitations, however, ANN has outperformed other methods like logistic regression in various studies (Arkin et al., 2020; Issitt et al., 2022; Khemphila & Boonjing, 2010; Kirişci, 2019; Purahong et al., 2023). Based on these findings we may conclude that ANN is a good approach to meet the objectives of classification and prediction.

5. Conclusion

A significant association was found between illness and marital status, age, stress, anxiety, and depression levels. ANN model showed good classification in both categories of illness due to the independent variables. Among all the independent variables, most contributory factor to perceive the illness among the women was anxiety level.

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Appendix

A. Prediction of one respondent by using MLP model

For the prediction weights and relationship were used. The values of one respondent for the presence of illness were:
Age= 41–50 years, Depression= 18 (moderate), Anxiety= 30 (extremely severe), Stress= 18 (moderate), marital status = married

Calculations from input to hidden layer:
Here Independent variable is denoted by x_i and w_{ij} are weights of ith independent variable and the jth hidden layer node. Late y_j represent the jth node of hidden

layer then in this case;

$$y_j = \text{bias} + \sum x_i w_{ij}, \qquad i = 1, 2, \ldots, n, \qquad j = 1, 2, 3, 4, 5, 6.$$
$$y_1 = -0.647 + 3(.073) + 1(-.436) + 18(-.192) + 30(.557) + 18(-.619)$$
$$y_2 = 0.226 + 3(-0.781) + 1(-0.405) + 18(.308) + 30(-.678) + 18(.000)$$
$$y_3 = 0.412 + 3(-.446) + 1(-.090) + 18(.308) + 30(-.189) + 18(-.118)$$
$$y_4 = 0.118 + 3(-.651) + 1(-.704) + 18(-.841) + 30(-.111) + 18(-.527)$$
$$y_5 = 0.240 + 3(-.340) + 1(-.846) + 18(.205) + 30(.291) + 18(.079)$$
$$y_6 = 0.240 + 3(-.149) + 1(-.128) + 18(.032) + 30(.643) + 18(-.435)$$

$$y_1 = 1.248, \quad y_2 = -17.318, \quad y_3 = -3.266$$
$$y_4 = -30.493, \quad y_5 = 12.216, \quad y_6 = 11.701$$

The hyperbolic tangent activation function for the results of each layer is

$$\tanh(y_1) = 0.8477, \quad \tanh(y_2) = -1, \quad \tanh(y_3) = -0.99$$
$$\tanh(y_4) = -1. \quad \tanh(y_5) = 1, \quad \tanh(y_6) = 0.99.$$

Let z_k denote the result for kth node of output layer for the calculation of hidden to output layer

$$z_k = \text{bias} + \sum_{j=1}^{6} w_{jk} \tanh(y_j)$$
$$z_1 = -0.046 + 0.8477(-0.950) + (-1)(-0.151) + (-0.99)(-0.910) + (-1)(0.196) + (1)(0.732) + (0.99)(0.688)$$
$$z_2 = 0.560 + 0.8477(0.179) + (-1)(0.674) + (-0.99)(0.535) + (-1)(0.088) + (1)(-0.654) + (0.99)(-0.050)$$
$$z_1 = 1.4177$$
$$z_2 = -1.2834$$

$$\gamma(Z_k) = \frac{e^{z_k}}{\sum_{k=1}^{2} e^{z_k}}$$

Predicted probability for the presence of illness using the Softmax function is

$$\gamma(Z_1) = \frac{e^{z_1}}{e^{z_1} + e^{z_2}} = 0.94.$$

Predicted probability for the absence of illness using the Softmax function is

$$\gamma(Z_1) = \frac{e^{z_2}}{e^{z_1} + e^{z_2}} = 0.06.$$

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