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Knowledge Extraction Methods as a Measurement Tool of Depression Discovery in Saudi Society

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Abstract: Depression is a widespread and serious phenomenon in public health in all societies. In Saudi society, depression is one of the diseases that the community is may refuse to disclose it. There are no studies have analyzed this disease within the Saudi community. The main research objective is to discover the depression level of Saudi People's. In addition to analyzing the age group and the most gender type affected by the depression in this society. The data collected from social media achieved indirectly without any communication with patients as a sample from this society people. It analyzed using Machine Learning algorithms that give accurate results for this disease. Three classification models have been established to diagnose this disease and the findings of this study presented that the depression levels include five classes and the most affected age group in depression was in the age group from 20-26 years. The results show that young Saudi women are more likely to be depressed. The obtained results are very important to the medical field. Researchers and people working in this field can get benefits out of this research. Especially those who want to understand the depression disease in Saudi society and searching for real solutions to overcome this problem.

Index Terms: Depression, Saudi Arabia, Machine Learning, Data Mining, Support Vector Machine, Social Media.

1. Introduction

Depression is a mental disorder that affects the person with loss of pleasure, lack of activity, feeling tired, fatigue, sleep disorder, and increased appetite or decreased with a sense of self-denial and self-blame. In Saudi society, depression is one of the most spread diseases, where the members of the Society are may refuse to disclose it. The main limitation of this study is the difficulty to collect the required data directly from society members. This difficulty has been overcome by collecting the required data from social media.

In regards to this disease, until now, there are no studies have been achieved about this society. The main objective is to analyze data of various age groups in regards to depression disease and identify the most type of gender affected by the depression in Saudi society.

There are many types of depression [1]. These symptoms appear on the individual depression affects people in different ways and cause a wide range of symptoms. For instance, continuous feeling of heartache and despair, loss of interest in things that people are accustomed to enjoying and the tendency to speed of crying. Symptoms of anxiety also might appear as well in many people who suffer from depression [2]. The person may also have physical symptoms, such as not sleeping for long periods, a reduced appetite for food, poor sexual drive, and complaining of various pains in the body. The severity of symptoms of depression can vary. In its mildest state, it may be a persistent feeling of despair [3]. While severe depression may make a person think of committing suicide. depression is one of the leading causes of mortality and morbidity worldwide [4]. depression is one of the most common maladies worldwide, affecting more than 300 million people [5]. In Saudi Arabia, the risk of developing depression among Saudi society did

not appear to be high [6]. It could be due to the difficulty to obtain the study results in Saudi Arabia about the proportion of people with a mental health condition. This is because a high percentage of people in Saudi society refuses to disclose this type of information. Therefore, the sample of data gathered via social media indirectly, after excluding any personal information. Many studies have shown the differences in the level and diagnosis of depression on a patient according to the presence of several behavioural symptoms that appear on him [7]. Beck Depression Inventory-II (BDI-II) is a scale used to evaluate the depression severity in adolescents and adults as well [2]. According to [8] BDI-II is considered among the most famous scales for evaluating the severity of depression. This encourages us to apply BDI-II [9], to determine the level and diagnosis of depression in a person according to behavioural symptoms using Data Mining methods. We assume this will help us to know the age group and the most gender affected by the depression in Saudi society. Several studies showed that males are less likely to be depressed compared to women as in [10]. This paper is organized as follows; Section II introduces the literature review, section III explains the research methodology, section IV describes the classification for depression level, section V includes the discussion of the results and finally, section VI present the conclusions and future work.

2. Literature Review

Stress is a common experience in everybody's life. It is hard to imagine a person who had not to experiment stress at some time on his life [11]. Stress may occur if individuals felt that they were unable to adapt to their situation.

According to the duration of stress, psychological stresses may be divided into two classes; acute stress (surgical operation and examination, for example) it is common and short-term in nature and chronic stress (such as financial, health, or personal issues) that occurs when stressful situations become a long-term constant [12, 13].

However, long-term exposure to stress stimuli can have numerous pathological consequences. As a result, it may lead to various somatic diseases and mental disorders like cardiovascular system diseases (hypertension, atherosclerosis), brain stroke, various digestive diseases, and irritable bowel syndrome, and that depression may be a predisposing factor for gastric cancer [14].

The relation between depression and stressful life events have been proved and confirmed by numerous tests. The stress can cause a significant negative change in the life of a person. There are serval studies reported that chronic high-level stress could be leading to depression [12]. It becomes a widespread problem among adolescents [15, 16]. In addition, Minchekar and Vikas found a relation between permanent stress at work and depression occurrence. They described the stress levels among the employed population aged from 18 to 75 and examines the associations between stress and depression [17]. The positive relation found between high levels of general day-to-day stress and low levels of co-worker support was associated with higher odds of depression [18, 19]. Similarly, Shields and Margot Examined a positive relationship found between academic stress and depression among college students [20]. Currently, the Major Depressive Disorder (MDD) is a widespread problem, which has been increasing in recent years in the world and a major public health problem, having symptoms including depressed mood, tiredness, sadness, sleep problems, poor concentration, lost interest in activities, feelings of guilt, reduced energy, reduced motivation to work, and suicidal ideation [21].

Currently, there is a variety of different methods to identify and diagnose depression. The most common type is self-rated questioner such as the BDI [10]. It contains a 21-item self-report measure of depression. It designed for use in multisite survey research [22], the questionnaire has been widely used to evaluate depression in many types of research, for example, a study was performed to determine the prevalence rate of depression with a number of 1003 Erciyes University students in Turkey, the prevalence rate of depression was 21.2%. The depression was higher among the students who had a physical illness, who were not satisfied with their body image or their faculty, and who rated the economic level of their families as poor [23].

Similarly, a survey was conducted in Jordan, with a sample contains 3,292 adolescents [24], In Emergency ambulance staff, the BDI was used as a data collection tool where they found a higher posttraumatic stress disorder and depression in women compared to men [25], as well with university students [26, 27].

There are many studies conducted to discuss depression in the Middle East. For instance, the case discussed in [28], consists of a sample of 55 children and adolescents of Yazidi Minority Group who immigrated to Turkey from Iraq, the result shows that most of the refugee children had experienced serious traumatic events in their home country. Posttraumatic stress disorder (PTSD) detected in 20 children (36.4%), depression in (32.7%) and comorbid mental problems are frequently seen in refugee children. In [29, 30], a survey was conducted in a high school in Saudi Arabia and the prevalence of depression between the students was 17% and 33.4%. Besides, the survey achieved by [24] was carried out in Jordan with a sample of 3,292 adolescents, also another research with 92 adolescents [31, 32], it presents a systematic review of studies conducted on the UAE population relating to depression.

Many research works have shown that Machine Learning algorithms are employed as technologies in Data Mining, which have played an important role in the application of classification, analysis, prediction and pattern recognition on many health issues [33-36]. Especially in diagnosis of disease, such as the cancer, heart, diabetes and Alzheimer disease, etc. furthermore, the Machine Learning algorithms enable computers to learn from an experience in the form of training data or training examples that are then converted into a model [37, 38], that can be used to solve problems and produce

accurate predictions for future using new data.

In addition, There are many machine-learning algorithms used in the application of mental health issues [39], such as the association rules [40, 41], that present a method to detect depression from collected Time-series mobile data via association rule mining. As well, the search work in [42] provides a review of the latest works on depression detection systems.

On the other hand, Vapnik used the classification algorithms decision tree and the Support Vector Machine (SVM) in [43], for the patient's X-ray images classification. The results have been provided with a good indication of the disease analysis [44], as well text analysis [45] and document classification [46], and give good results when classifying depression [47] and other health issues [48].

In this research, our focus on the diagnosis/ prediction of the depression disease using a set of perfect Machine Learning algorithms according to a text dataset of a set of people collected from Social media. The used algorithms are SVM, PDL function, and the J48 classifier, from the literature of the previous works above, it found that these algorithms are the most suitable classifiers that can be applied in this research.

3. Research Method

The overall steps of the methodology used in this research are as follows:

1. Data collection: using an online questionnaire, which designed and published over social media to collect the research dataset (the selection of questionnaire audience was random). Also, the BDI-II depression test using Arabic language applied to the sample
2. Data cleaning: Noisy data removal to increase the data quality, that effect positively on the results accuracy.
3. Data transformation to and the data converted to the English language to make it easier to deal with the programming environment.
4. Classifiers application: Classify the data using PDL function to diagnose the depression level.
5. Knowledge discovery: It includes results extraction from the data to find if a person depressed after traumatic stress happened to him/her and what his level of depression on five diagnoses. In addition to knowing the age group and the most gender affected by the depression in Saudi society.

Figure 1 shows the methodology steps used in this research.

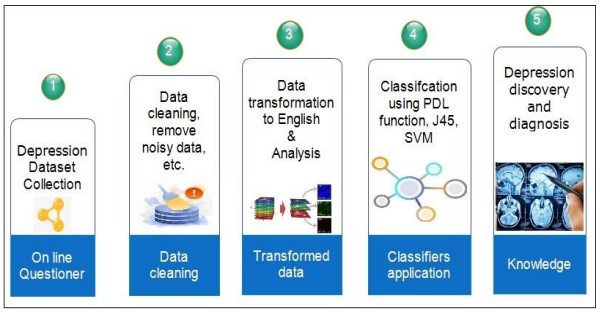

Fig.1. Methodology steps.

Figure 1. comprise the overall steps of the methodology that include: (1) dataset gathering online. (2) data cleaning. (3) mining process and analysis. (4) classification. (5) results generation.

3.1. Data set

An online questionnaire is conducted to collect information about the depression level of stressed people. The questionnaire website was active and available from 1 to 31 October-2019. It was distributed through multiple channels to reach a diverse population of stressed people in Saudi Arabia. Social media networks used such as Twitter, WhatsApp, Telegram and others.

The questionnaire instrument consisted of two-part. First part is the sociodemographic features of the participants. It includes gender, age, region, and nationality. The second part includes the test. BDI-II is 21 behavioural features, which is a self-rated scale that evaluates key symptoms of depression. DBI-II includes mood, pessimism, sense of failure, self-dissatisfaction, self-dislike, indecisiveness, self-accusation, suicide, crying, irritability, social withdrawal, body image change, work difficulty, insomnia, fatigability, loss of appetite, weight loss, somatic preoccupation guilt, punishment, and loss of libido. Arabic version of BDI-II was used. A total number of 427 participants with age between 16–82 years have covered by the questionnaire. About 64% of participants were females and 36% were males. All participants were Saudi citizens refer to Table 1.

Table 1. Demographic Characteristics of Participants.

Item	Variable	Number	(%)
Gender	Male	154	(36%)
	Female	273	(64%)
Age	≤30	269	(63%)
	31-40	79	(18.5%)
	>40	79	(18.5%)
Region	Center	161	(38%)
	West	59	(14%)
	East	15	(4%)
	North	9	(2%)
	South	10	(2%)
	Not specified	173	(40%)

3.2. Data Preprocessing

The Pre-processing task is a step in knowledge discovery using machine-learning methods. Pre-processing step includes various tasks; remove inconsistent data, noisy data, attributes coding, transformation, and loading [49]. After the dataset collected, it was in the Arabic language, then it transformed into English. After that, all data contains errors or not useful were deleted.

4. Depression-level Classification

Data classification has become an important part of many things in our life, so many functions and applications used Data Mining depending on a set of training data. The goal of classification is to accurately predict/diagnose the target class for each case in the data.

Table 2. Samples of depression level classified using PDL.

ATTRIBUTES	**SUM**	**CLASS After applying PDL function**
I don't feel sad, I am not particularly discouraged about the future, I feel I have failed more than the average person, I enjoy, I feel guilty sometimes, I do not deserve punished, I disappointed in myself sometimes, I don't feel worse than anybody, I don't have any thoughts of killing myself, I cry more now more than usual, I feel anger yes more than usual, I have not lost interest in other people, I make my decisions as best I can, I look perfect as before, I can work as before, I do not sleep well, as usual, I became more tired than usual, My appetite, as usual, I don't loss any weight, I am no more worried about my health than usual, I have not noticed any recent change in my interest in sports.	7	There is no depression
I feel sad, I am always discouraged about the future, I feel I have weak more than my colleagues, I don't enjoy as I was before, I feel guilty sometimes, I deserve punished sometime, I am disappointed in myself, I criticize myself for my weaknesses, I don't have any thoughts of killing myself, but sometimes I think about that, I cry more now more than usual, my feelings have not worn off. I lost all interest of others, I cannot make a decision at all, I try to look perfect as I was before, I can't work as before, I do not sleep well, as usual, I became more tired than usual, my appetite and my weight have lost, I am no more worried about my health than usual, I have almost no interest in sports.	17	There is a depression

4.1. Classification using PDL function

The Parallel Linear Dichotomizers (PLD) function [50] is a function we build to predict depression level class for each person using people's reactions to 21 behaviours in their daily life. Each of these attributes value (person behaviours) has a value from 0-3 according to the severity of the behaviour. For example, if a person works, as usual, the value will be 0, if he needed extra effort to start my work the value is 1 and, etc. For the previous example, the function that gives attribute value is:

SWITCH (Q2, ″yes I can″, 0, ″I need extra effort to start working″, 1, ″I have to push myself very hard to do anything″, 2, ″I cannot work or do anything at all″, 3)

The classes' results will be on five levels: simple, moderate, severe, and extreme and there is no depression depending on the Beck depression criteria in the Arabic language. Using the PDL function give like this:

IF S (AND (T6>0, T6<=16), ″low″, AND (16<T6, T6<=32), ″medium″, AND (32<T6, T6<=48), ″high″)

Where ″T6″ is a cell shows the sum of all 21-attributes behaviours like feel guilty, feel like a failure, trying to suicide, etc. Table 2 illustrated a sample of depression level classified using PDL

4.2. Classification using the J48 algorithm

The classification of depression achieved using the J48 classifier algorithm is a simple C4.5 decision tree for classification. It is the most useful classifier for this data. After applying this algorithm, the classes created in a binary tree, which constructed to model the classification process.

Once the tree is built, it is applied to each tuple in the database and results in classification for that tuple [51]. The generated classes specified depression level using the most effective attributes that give better and clearer results. According to the evaluation of the model, the results correctly classified on the dataset in 91.3165% and the mean absolute error was 0.0669. The classification results are shown as paths, each path represents one rule, here only some of the rules:

1. If Thinking about suicide = yes but I will not do it AND cry = more than usual AND Weight loss = No as it is THEN Moderate.
2. If Thinking about suicide = yes but I will not do it AND cry = more than usual AND Weight loss = yes more than 6 kg THEN Severe.
3. If Thinking about suicide = yes but I will not do it AND cry = more than usual AND Weight loss = yes more than 2 kg THEN Moderate.
4. If Thinking about suicide = yes but I will not do it AND cry = more than usual AND Weight loss = yes more than 4 kg THEN Moderate.
5. If Thinking about suicide = yes but I will not do it AND cry = I had the ability to cry but nowadays I can't cry even though I want to THEN Severe.
6. If Thinking about suicide = yes but I will not do it AND cry = Crying all-time THEN Severe.
7. If Thinking about suicide = I want to, AND cry = I had the ability to cry but nowadays I can't cry even though I want to THEN Severe.
8. If Thinking about suicide = I want to, AND cry = Crying all-time THEN Extreme.
9. If Thinking about suicide = I will if I have chance THEN Extreme.
10. If Thinking about suicide = never, AND cry = more than usual AND Weight loss = No as it is AND Anger = yes feel so excited all the time THEN Simple.
11. If Thinking about suicide = never, AND cry = more than usual AND Weight loss = No as it is Anger = Not more than usual AND Ability to work = yes I can THEN There is no depression.
12. If Thinking about suicide = never, AND cry = no as usual AND Ability to work = yes I can THEN There is no depression.

If Thinking about suicide = never, AND cry = no as usual AND Ability to work = I need extra effort to start working AND Anger = Not more than usual AND Sleep = I do not sleep well as usual: Simple.

4.3. Classification using the SVM algorithm

The SVM maps the input vector, x, to a high dimensional feature space through a pre-selected non-linear mapping, ϕ. In this space, the optimal classification is satisfied, so that the samples can be correctly partitioned and the distance between two points closest to the hyperplane. Fig 2, shows the receiver operating characteristic (ROC) curves for the SVM tested model for each target class. A new test data of five patients achieved to see how this model can do depression level class prediction as shown in Fig 3, the details are shown in Appendix A.

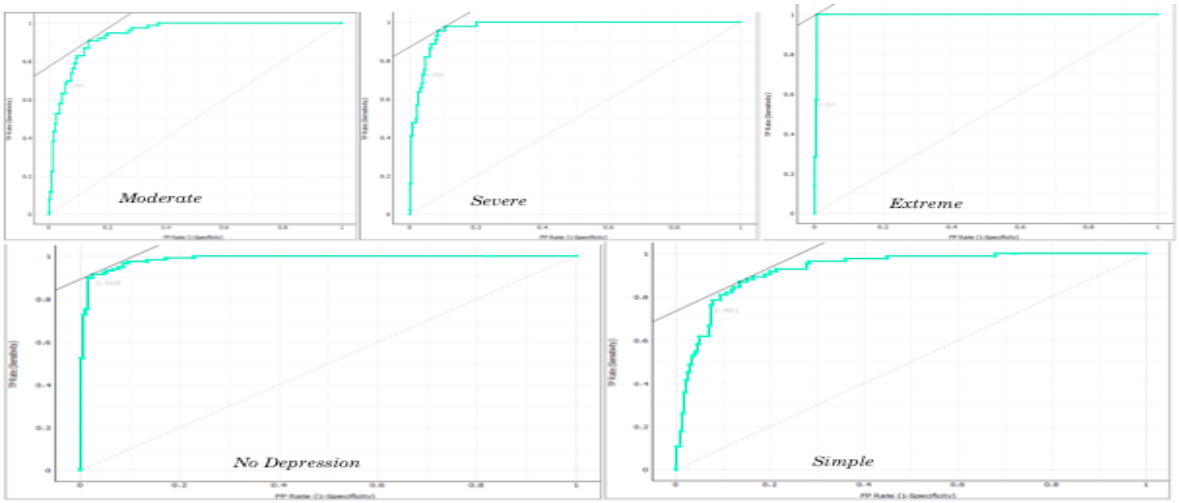

Fig.2. ROC curves for the SVM model.

	SVM	Caring of others	lity to w	felling tierd	Weight loss	gende	age	feeling sad	ism of the	eling faili	Feeling fun	eling gui	ient to pun	ng disappoi	ing worse than ot	i
1	0.00 : 0.01 : 0.00 : 0.19 : 0.80 → There is no depression	less care of oth...	yes i can	No	yes more than ...	male	22.0	sometime	yes	No	yes as it is	No	I do not ...	No	No	r
2	0.00 : 0.00 : 0.00 : 0.01 : 0.99 → There is no depression	yes i care of oth...	yes i can	yes from doing ...	yes more than ...	fem...	43.0	No	No	No	yes as it is	No	I do not ...	No	No	r
3	0.00 : 0.83 : 0.01 : 0.14 : 0.02 → Moderate	lost most intere...	I need ...	yes too tired to ...	No as it is	fem...	27.0	sometime	No	yes a l...	Not as be...	yes a lot	sometime	sometime	No	r
4	0.00 : 0.02 : 0.96 : 0.01 : 0.01 → Severe	less care of oth...	I have ...	I became more ...	yes more than ...	fem...	26.0	mostTime	_very fr...	yes i fa...	Not as be...	No	I do not ...	sometime	I criticize mysel...	y
5	0.97 : 0.01 : 0.00 : 0.00 : 0.01 → Severe	lost all interest ...	I can n...	yes too tired to ...	yes more than ...	fem...	20.0	mostTime	yes	yes a l...	Nothing ...	No	I do not ...	I hate my...	I blame myself ...	I

Fig.3. A new test data using the SVM model.

5. Result and Discussion

The research results can be discussed in the following points:

1. The results using SVM With a 10-fold cross-validation method, are shown in Table 3. the table presents the results accuracy, depends on the precision, and recall of the SVM classifier in classifying the cases. Also, choosing the SVM method gives a good accuracy score above 90%.

Table 3. Evolution Metrix

Model	AUC	CA	F1	Precision	Recall
SVM model	0.959	0.78	0.781	0.778	0.787

2. The generated results demonstrate a set of rules, that gives accurate indications/classes about the depression after analysing a number of behaviours that appear with persons after traumatic stress happened for persons in the daily life within Saudi society.
3. The results show males are less likely to be depressed compared to females in Saudi society.
4. The predication using PLD function gives more accurate than the results of the rules concluded after applying the J48 classifier and SVM classifier because the PLD function that has built on well thought out bases using BDI principles.
5. As well as it found that the most affected age group by depression is from 20-26 and then the age from 14-20, as shown in Fig 4.

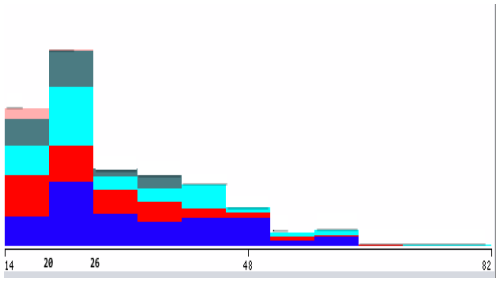

Fig.4. Age group distribution

6. The results from the J48 classifier showed the people who want to commit suicide to have a high level of depression, accordingly the rules from 1 to 9.
7. Also, the results showed that the probability of prevalence depression levels was at the rate of 3% for the extreme level, 15% for severe level, moderate level in 23%, simple level in 25% and no depression 34%, as illustrated in Table 4.

Table 4. Depression levels

Item	Levels	People #	Rate
depression disease levels	No-depression	146	34%
	Simple	106	25%
	Moderate	100	23%
	Severe	64	15%
	Extreme	11	3%

8. The results showed that the depression levels organized in five classes; extreme level, severe level, moderate level, simple level and level of there is no depression. The first model was the PLD classifier, the second model is build using the J48 classifier algorithm, and the last model using the SVM classifier. PLD is build using BDI criteria's and it results depending on the self-rated scale of person to diagnose his /her case. The J48 classifier model is build using decision tree algorithms; accordingly, It can predict the type and depression level of new patients.

Likewise, the SVM model can extract knowledge and predict class the same as the J48 classifier model but in a better and strictly way based on the knowledge extracted by the models.

9. The obtained results are leading to achieve the goal of this research. These results are very important to the medical field. researchers and people working in this field, where they can get many benefits out of this research, especially those who want to study, understand depression, control it in Saudi society and searching for real solutions to overcome this problem in early time.

6. Conclusion

This paper presents very important results related to the diagnosis of depression disease in Saudi society. Accordingly, a number of models generated with the aim of classifying and predicting the depression level in a way of serving this community. Furthermore, the research findings can be applied widely to other communities. in this study, three types of classification algorithms have used to build models that can predict depression levels in the future for new patients at any environment based on a new and real dataset. This, in turn, will support the medical field ،and researchers, and the Saudi Government, This, in turn, will help to understand and discover depression in the society. where this study concluded that the most affected age group in depression was from 20-26 years, especially with the females, in addition, it found that if a person has the desire to commit suicide this means he has a high depression level.

The future work can improve the results by using other data contents of people like their emails messages, and personal blogs and others. The prediction models application can be improved to be used directly online for real-time analysis of people data.

Likewise, the research idea also can be applied to discover more details about other diseases, such as detection of the obsessive-compulsive disorder, sorrow, fear, schizophrenia, anxiety, and other similar problems for the different age groups.

The early diagnosis will help both the patient and society to avoid reaching critical depression and start direct and early treatment, which saves people effort and cost and keeps society safe and coherent.

According to the results, this research is considered as a valuable scientific contribution in the field of medical informatics for community service.

Appendix A: additional testing data, 5 instances.

Task: Classification using SVM, showing probabilities for Extreme, Moderate, Severe, Simple, There is no depression

SVM	1	2	3	4	5
Levels of depression	0.00 : 0.01 : 0.00 : 0.18 : 0.80 → There is no depression	0.00 : 0.00 : 0.00 : 0.01 : 0.99 → There is no depression	0.00 : 0.81 : 0.01 : 0.16 : 0.02 → Moderate	0.02 : 0.03 : 0.94 : 0.01 : 0.01 → Severe	0.79 : 0.01 : 0.19 : 0.00 : 0.01 → Severe
Caring for others	less care of others than before	yes I care of others	lost most interest of others	less care of others than before	lost all interest of others
Ability to work	yes I can	yes I can	I need extra effort to start working	I have to strongly urge myself to do anything.	I can not work or do anything at all
feeling tired	No	yes from doing almost anything	yes too tired to do anything	I became more tired than usual	yes too tired to do anything
Weight loss	yes more than 6 kg	yes more than 4 kg	No, as it is	yes more than 4 kg	yes more than 2 kg
Gender	male	female	female	female	female
Age	22	43	27	26	20
Feeling sad	sometime	No	sometime	Most Time	Most Time
Pessimism of the future	yes	No	No	_very frustrating and hopeless	yes
Feeling failure	No	No	yes a lot of failures	yes I failed more than others	yes a lot of failures
Feeling fun	yes as it is	yes as it is	Not as before	Not as before	Nothing fun
feeling guilty	No	No	yes a lot	No	No
Entitlement to punishment	I do not deserve	I do not deserve	sometime	I do not deserve	I do not deserve
Feeling disappointed	No	No	sometime	sometime	I hate myself all the time
Feeling worse than others	No	No	No	I criticize myself for my weaknesses	I blame myself for everything happens
Thinking about suicide	never	never	never	yes but I will not do it	I will if I have a chance
Cry	no as usual	no as usual	no as usual	more than usual	I had the ability to cry but nowadays I can not cry even though I want to
Anger	yes more than usual	Not more than usual	yes more than usual	yes more than usual	my feelings have worn off and nothing is angering me anymore
Make a decision	I make my decisions as best I can	I make my decisions as best I can	I postpone decisions more than I usually do	I postpone decisions more than I usually do	I can not make a decision at all
How you look	perfect as before	perfect as before	I am upset that I look old or unattractive	perfect as before	I look ugly
Sleep	I do not sleep well as usual	I do not sleep well as usual	yes I can sleep well	wake up many hours earlier than usual and I can not go back to sleep	wake up many hours earlier than usual and I can not go back to sleep
Appetite	as usual	as usual	as usual	much worse now	much worse now
Worried about health	no more than usual.	no more than usual.	no more than usual.	worried about physical problems	worried about physical problems and it is hard to think of much else
Sexual ability	I have not noticed any change	I have not noticed any change	I have not noticed any change	I have not noticed any change	I have lost it completely

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