Master of Technology (IS)

Pepper Project Group

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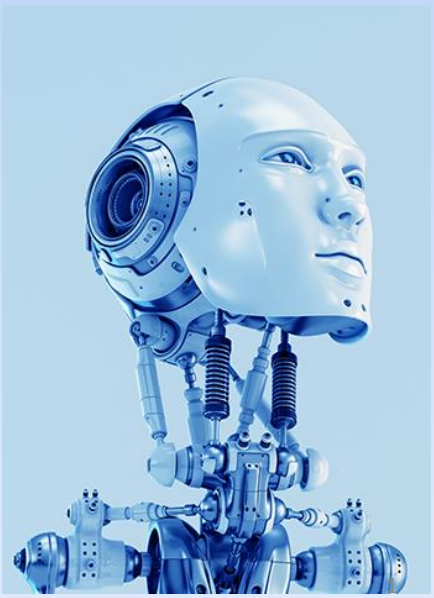
Depression Screening System

Depression Screening System

Project Report

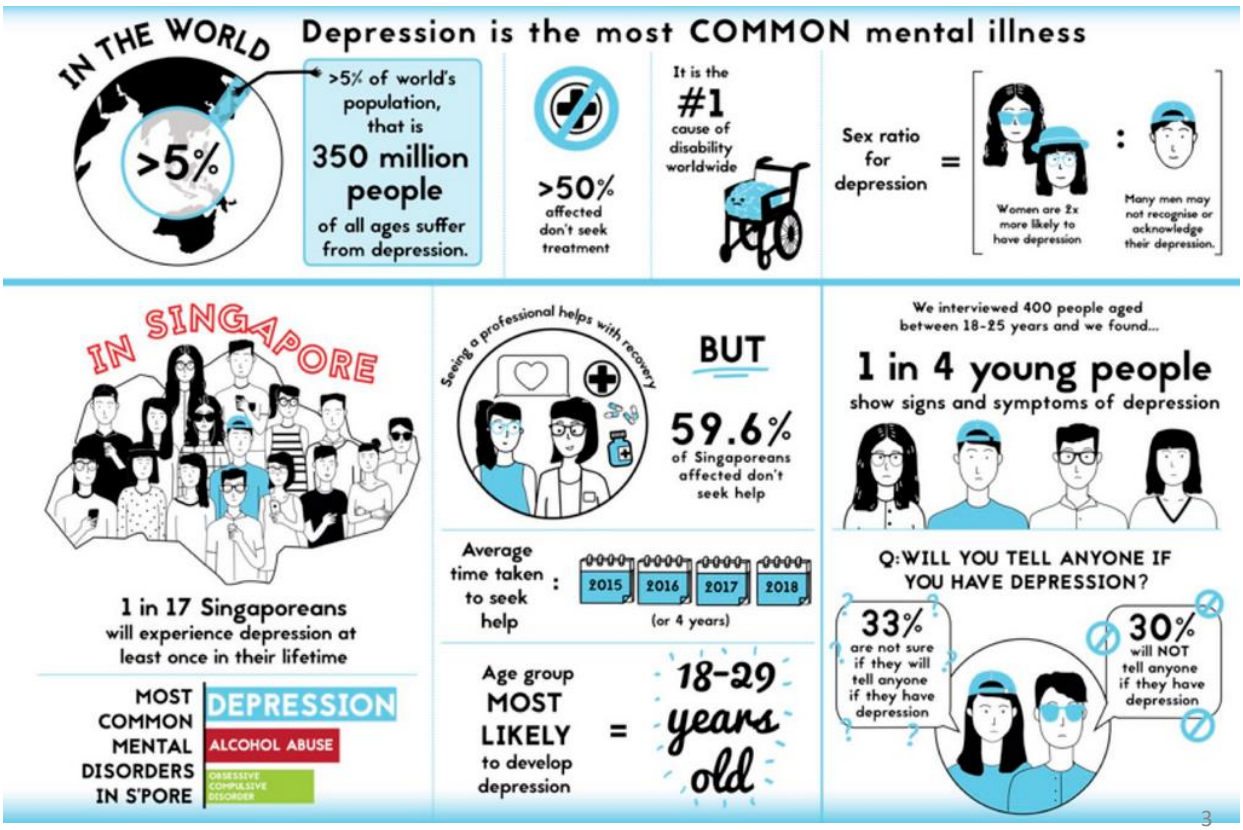


Contents

Executive Summary

Many young Singaporeans show signs of depression. IMH treated 600 youths between 20 to 29-years-old last year alone. And one out of four people admitted to suffering from multiple symptoms of depression in a recent survey of youths aged 18 to 25. The study was conducted by students from Wee Kim Wee School of Communication and Information in NTU. We know that depression may lead to suicide. But other times, its sufferers become less productive and are more at risk for other diseases. The latest statistics on depression don't paint a pretty picture of progress but it shows that the condition is more common than we think. Yet the stigma surrounding it walls off the victim who often suffers in silence. We need to seek out those who need help, and help them early. However, the challenge is that we do not have enough practitioners to do that.

This project serves to help Singapore tackle the immense problem of depression as well we alleviate the lack of practitioners to seek out those who need help. Using AI, we are trying to take a pro-active stand to detect depression condition in certain high-risk groups amongst the population, and as early on as possible. We leveraged tools like KIE Workbench, the Spring Boot etc to put together a framework for the application. This application can be used to seek out those who need professional assistance.



Business Problem Background

Depression is a chronic illness often with episodes lasting months and high rates of relapses. It is known to cause the patient much suffering, the family distress and significantly increase the risk of suicide. Most people with depression will seek help from their family doctors. Sometimes, they present to the doctors with only physical symptoms such as headaches, chest pains or body ache. This form of presentation is particularly common in people with chronic illness as well as in teens and the elderly. As a result, depression can often be masked and the diagnosis of depression may be missed or disregarded.

Severe depression can be readily recognized but it may be difficult to distinguish milder form of depression from emotional changes associated with everyday life. Life stresses such as job loss, divorce, and the death of a loved one can result in a sad mood of short duration. Clinical depression or Major Depressive Disorder develops when depressed mood becomes much worse and persistent and is accompanied by other symptoms and lasts for more than two weeks. When depressed, a person may start to have difficulties with his sleep. He feels unmotivated and will no longer be interested in his work and the usual things he liked. He can also have problems with his appetite and weight. When performing activities, he has little energy and cannot concentrate. He may feel guilty about things he has done wrong and ruminate excessively about the past. When the depression becomes more severe, he will feel that life is hopeless and may contemplate or even attempt suicide. Patients tell us that when they are suffering from Major Depressive Disorder, it is like wearing a pair of shades that cannot be removed and everything looks dark and gloomy.

Oftentimes, people with depression do not get help early enough or are not detected until its too late.

Given that the high risk groups are well studied and documented, and the symptoms are well known, we should be able to do better to improve the situation.

Project Objectives & Success Measurement

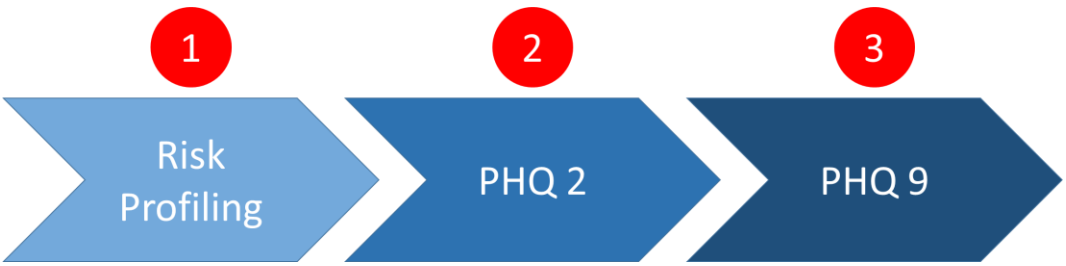
We need to seek out those who need help, and help them early. However, the challenge is that we do not have enough practitioners to do that.
One way to tackle this problem is to adopt a pro-active approach to seek out those who need professional assistance. The objective of this project serves to do just that with the help of Artificial Intelligence.

With AI, we could apply some techniques like Certainty Factor, Decision Tree, and Inference Diagram to automate the screening of candidates. The screening is done at three levels:

Identifying the high risk group – Risk Profiling
Doing a 2-question survey (PHQ2)
Doing a 7-question survey (PHQ9)

Level #1 can be applied to any organization, be it a school, a workplace, or even just targeting a segment of people. Once level #1 is done, those identified candidates can proceed to Level #2 and level #3 in a survey setting so that we can ascertain whether the candidate would likely be suffering from depression, and then recommending the next steps.

Success Measurement for this application would be based on its ability to flag a high risk individual as well as computing the score pertaining to the level of depression.



Project Solution

RISK PROFILING

In a survey done by the Annals Academy of Medicine Singapore from December 2009 to December 2010, some focus was placed on the profile of people who are at higher risking of suffering from depression.

The five indicators used for determining the risk profile are shown below.

This application will do the screening to assess if the candidate belongs to the high risk group. If so, he/she will proceed with the PHQ9 assessment.

Chronic Physical Condition

Marital Status

Ethnicity

Age

Gender

Chong, S. A., Abdin, E., Vaingankar, J. A., Heng, D., Sherbourne, C., Yap, M., … Subramaniam, M. (2012). A population-based survey of mental disorders in Singapore. Annals Academy of Medicine Singapore, 41, 49-66.

Project Solution

RISK PROFILING

Based on the survey done by the Annals Academy of Medicine Singapore, a table of Certainty Factors against each indicator is drawn up as follows.

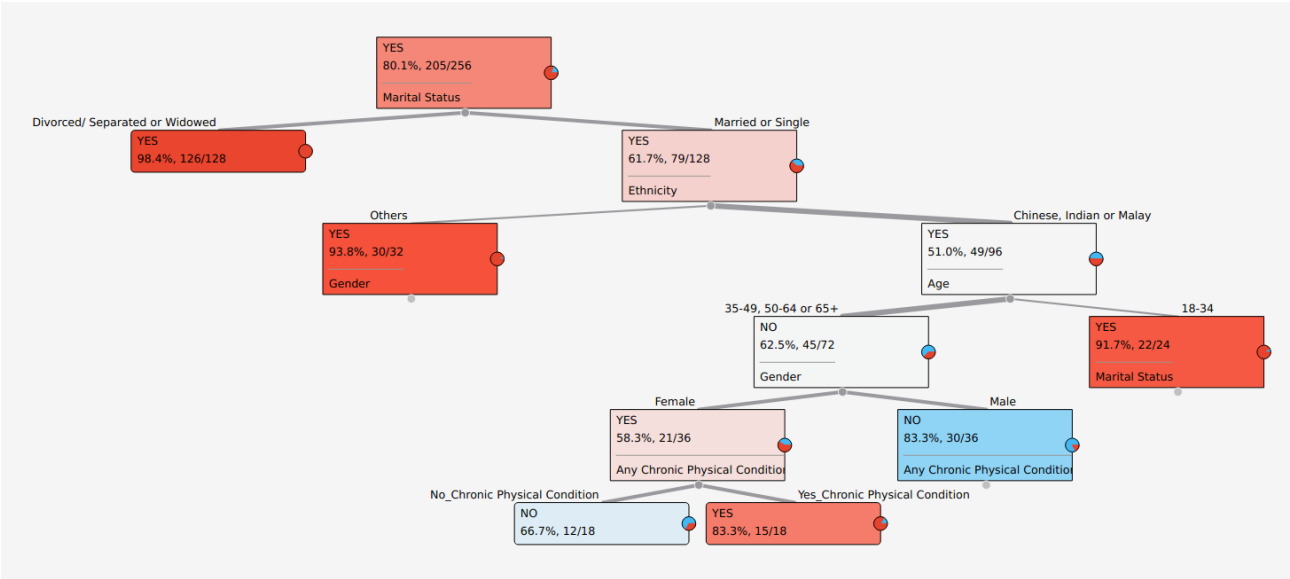
From this table, we could see that the female gender is more prone to depression than male. Ethnicity also plays a part in that the mixed race (under Others) are a more susceptible group. Also, Singles are slightly less prone than Married people, whereas those who are divorced, separated, or widowed find themselves at risk. Among the different age group, the one that has the highest Certainty Factor is between 18 and 24 years old. As for those with chronic physical condition, they are at risk too.

Using this information, we have incorporated the Certainty Factors into our logic for assessing if an individual belongs to the high risk group. This is part of the Risk Profiling function that the application performs.

RULES	RECOMMENDED FOR PHQ-2 SCREENING?	Certainty Factor
marital_status = DIVORCED/ SEPARATED OR marital_status = WIDOWED	YES	0.98
(marital_status = MARRIED OR marital_status = SINGLE) AND ethnicity = OTHERS	YES	0.94
(marital_status = MARRIED OR marital_status = SINGLE) AND (ethnicity = CHINESE OR ethnicity = INDIAN OR ethnicity = MALAY) AND age = 18-34	YES	0.92
(marital_status = MARRIED OR marital_status = SINGLE) AND (ethnicity = CHINESE OR ethnicity = INDIAN OR ethnicity = MALAY) AND (age = 35-49 OR age = 50-64 OR age = 65+) AND gender = MALE	NO	-0.83
(marital_status = MARRIED OR marital_status = SINGLE) AND (ethnicity = CHINESE OR ethnicity = INDIAN OR ethnicity = MALAY) AND (age = 35-49 OR age = 50-64 OR age = 65+) AND gender = FEMALE AND chronic physical condition = YES	YES	0.83
(marital_status = MARRIED OR marital_status = SINGLE) AND (ethnicity = CHINESE OR ethnicity = INDIAN OR ethnicity = MALAY) AND (age = 35-49 OR age = 50-64 OR age = 65+) AND gender = FEMALE AND chronic physical condition = NO	NO	-0.67

Solution Design

Using the Decision Tree, the assessment is carried out to determine whether the candidate belongs to the higher risk group. If so, this candidate will go on to the PHQ-2 survey.



Solution Design

FrameworkAdopted **PHQ9**

The PHQ-9 is a multipurpose survey for screening, diagnosing, monitoring and measuring the severity of depression. It is completed by the patient in minutes and is typically scored by the clinician. Scores of 5, 10, 15 and 20 represents mild, moderate, moderately severe and severe depression.

PHQ-2 comprises the first two questions of PHQ-9. When the candidate's response to the survey is less than 2 for both questions, then the candidate will not need to proceed with the survey. If any of the two questions has a score of 2 or more, then the rest of the survey questions must be completed.

The Patient Health Questionnaire (PHQ-9)

Patient Name _____ Date of Visit _____

Over the past 2 weeks, how often have you been bothered by any of the following problems?	Not At all	Several Days	More Than Half the Days	Nearly Every Day
1. Little interest or pleasure in doing things	0	1	2	3
2. Feeling down, depressed or hopeless	0	1	2	3
3. Trouble falling asleep, staying asleep, or sleeping too much	0	1	2	3
4. Feeling tired or having little energy	0	1	2	3
5. Poor appetite or overeating	0	1	2	3
6. Feeling bad about yourself - or that you're a failure or have let yourself or your family down	0	1	2	3
7. Trouble concentrating on things, such as reading the newspaper or watching television	0	1	2	3
8. Moving or speaking so slowly that other people could have noticed. Or, the opposite - being so fidgety or restless that you have been moving around a lot more than usual	0	1	2	3
9. Thoughts that you would be better off dead or of hurting yourself in some way	0	1	2	3

Column Totals _____ + _____ + _____

Add Totals Together _____

Solution Design - **PHQ9 in Detail**

Patient Health Quetionnaire-9 (PHQ-9)

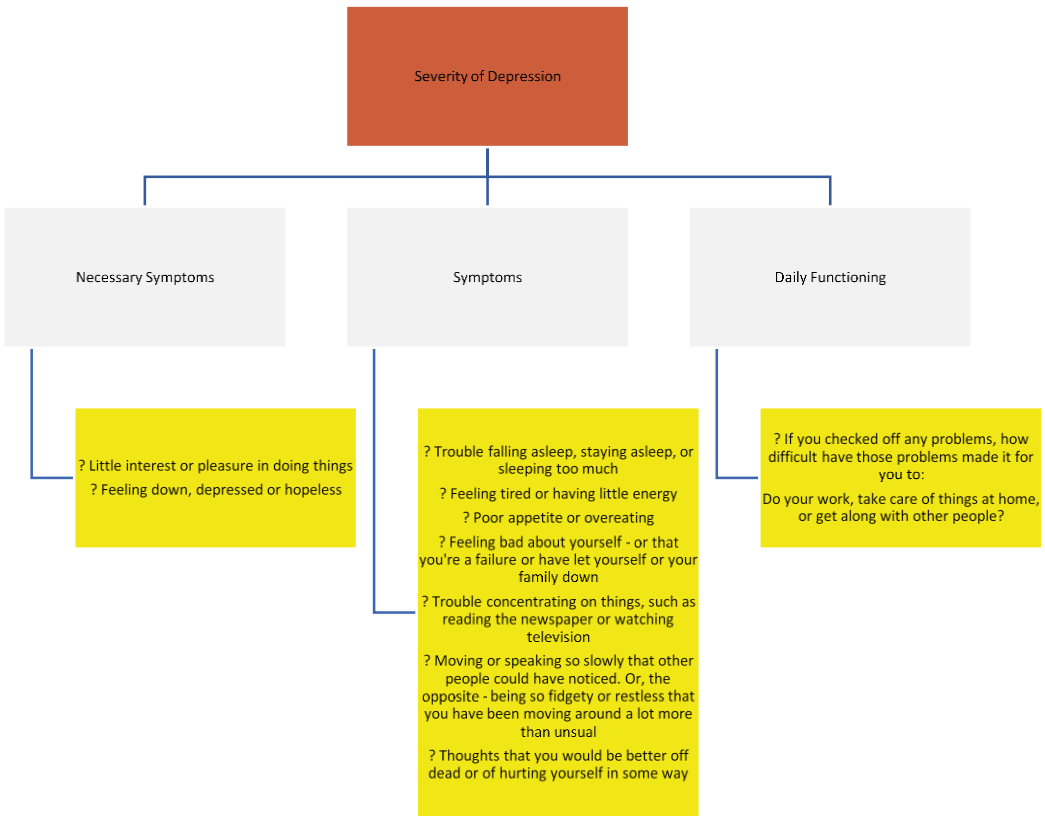
The PHQ-9 is a 9-items tool that screen for the severity of depression. Patient responds to each PHQ-9 item with 1 of 4 options: Not at all, Several days, More than half the days, and Nearly every day. Scoring the PHQ-9 is simple: Not at all is scored as a 0, Several days is scored as a 1, More than half the days is scored as a 2, and Nearly every day is scored as a 3.

To determine the presence of depression, at least item 1 or item 2 must be either a score of 2 or 3 and 5 or more items must be a score of 2 or 3; item 9 must be a score of 1, 2, or 3. The total score of all 9 items indicates the severity of the respondent's depressive symptoms (Table 1)[1].

Table 1.

PHQ-9 Score	Provisional Diagnosis	Treatment Recommendation *Patient Preferences should be considered*
5-9	Minimal Symptoms*	Support, educate to call if worse, return in one month
10-14	Minor depression ++ Dysthymia* Major Depression, mild	Support, watchful waiting Antidepressant or psychotherapy Antidepressant or psychotherapy
15-19	Major depression, moderately severe	Antidepressant or psychotherapy
>20	Major Depression, severe	Antidepressant and psychotherapy (especially if not improved on monotherapy)

Inference Diagram: Using PHQ-9 to determine the severity of depression



[1] Kroenke, K., Spitzer, R. L., & Williams, J., B., W. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine, 16(9),* 606-613.

Project Implementation

Data Setup

Sub-goal	Attribute	Inferable	KIE Field Type			Translation
KIE Data Object	KIE Object Field	KIE Form	Type	Value Range	Value unit	KIE Data Comment
PatientParticular	name	PatientParticular-Taskform	String	Any string	NA	Name
	age	PatientParticular-Taskform	String	18-34, 35-49, 49-64, 65+	NA	Age
	gender	PatientParticular-Taskform	String	Male, Female	NA	Gender
	marital_status	PatientParticular-Taskform	String	Single, Married, Separated,	NA	Marital Status
	race	PatientParticular-Taskform	String	Chinese, Malay, Indian, Others	NA	Race
	chronic	PatientParticular-Taskform	String	Yes, No	NA	Chronic Physical Condition
PHQ2Q	PHQQ1	PHQ2Entry-Taskform	Double	0,1,2,3	Unit Score	Little interest or pleasure in doing things?
	PHQQ2	PHQ2Entry-Taskform	Double	0,1,2,3	Unit Score	Feeling down, depressed, or hopeless?
PHQ9Q	PHQQ3	PHQ9Entry-Taskform	Double	0,1,2,3	Unit Score	Trouble falling or staying asleep, or sleeping too much?
	PHQQ4	PHQ9Entry-Taskform	Double	0,1,2,3	Unit Score	Feeling tired or having little energy?
	PHQQ5	PHQ9Entry-Taskform	Double	0,1,2,3	Unit Score	Poor appetite or overeating?
	PHQQ6	PHQ9Entry-Taskform	Double	0,1,2,3	Unit Score	Feeling bad about yourself — or that you are a failure or have let yourself or your family down?
	PHQQ7	PHQ9Entry-Taskform	Double	0,1,2,3	Unit Score	Trouble concentrating on things, such as reading the newspaper or watching television?
	PHQQ8	PHQ9Entry-Taskform	Double	0,1,2,3	Unit Score	Moving or speaking so slowly that other people could have noticed? Or so fidgety or restless that you have been moving a lot more than usual?
	PHQQ9	PHQ9Entry-Taskform	Double	0,1,2,3	Unit Score	Thoughts that you would be better off dead, or thoughts of hurting yourself in some way?
PHQ2R	PHQ2Result	NA	Boolean	true,false	NA	NA
PHQ9R	PHQ9Result	NA	Boolean	true,false	NA	NA
PreScreenR	PreScreenResult	NA	Boolean	true,false	NA	NA
Treatment1	Treat1	NA	Boolean	true,false	NA	NA
Treatment2	Treat2	NA	Boolean	true,false	NA	NA
Treatment3	Treat3	NA	Boolean	true,false	NA	NA
Treatment4	Treat4	NA	Boolean	true,false	NA	NA

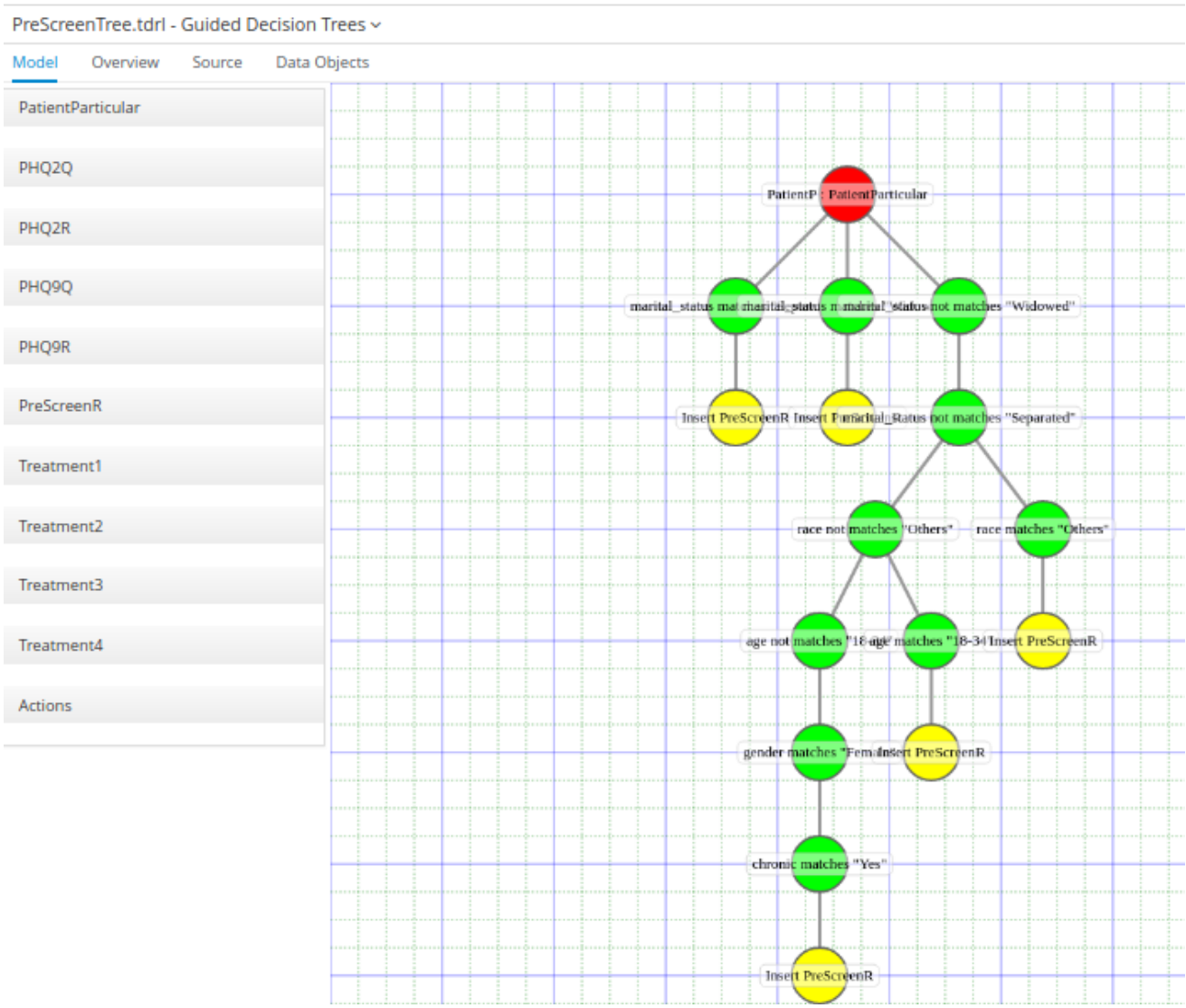
Project Implementation

Guided Decision Tree

Using the Guided Decision Tree in the KIE Workbench, the Risk Profiling logic is mapped out to assess whether a candidate falls into the High Risk category. If so, the candidate would go on to the next survey, that is the PHQ2.

Two roles are created for the application:

- Patient1
- Dr Hong – mental health practitioner

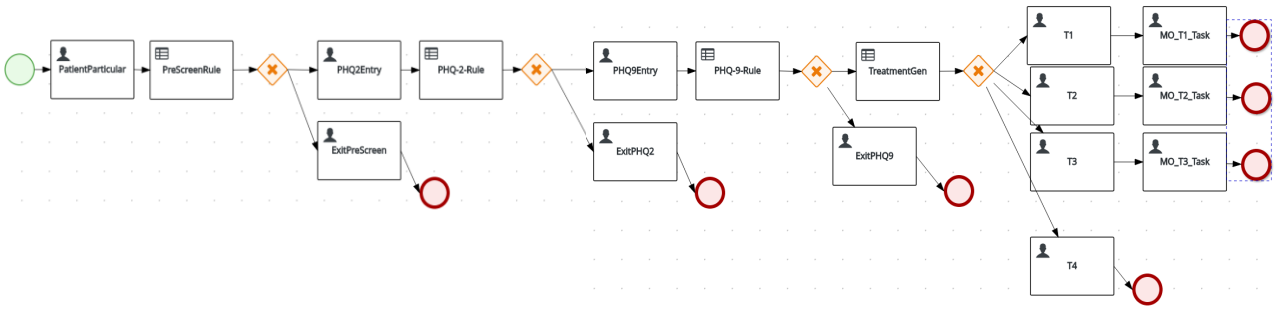


Project Implementation

Process Flow

Using the KIE Workbench, a Process Flow is created to map the various points of inference and assessments based on the Risk Profiling, PHQ-2 and PHQ-9 survey entries.

The logic engine performs in a way that determines if the candidate exhibit any symptom which may indicate a possibility of depression.



Project Implementation

Risk Profiling

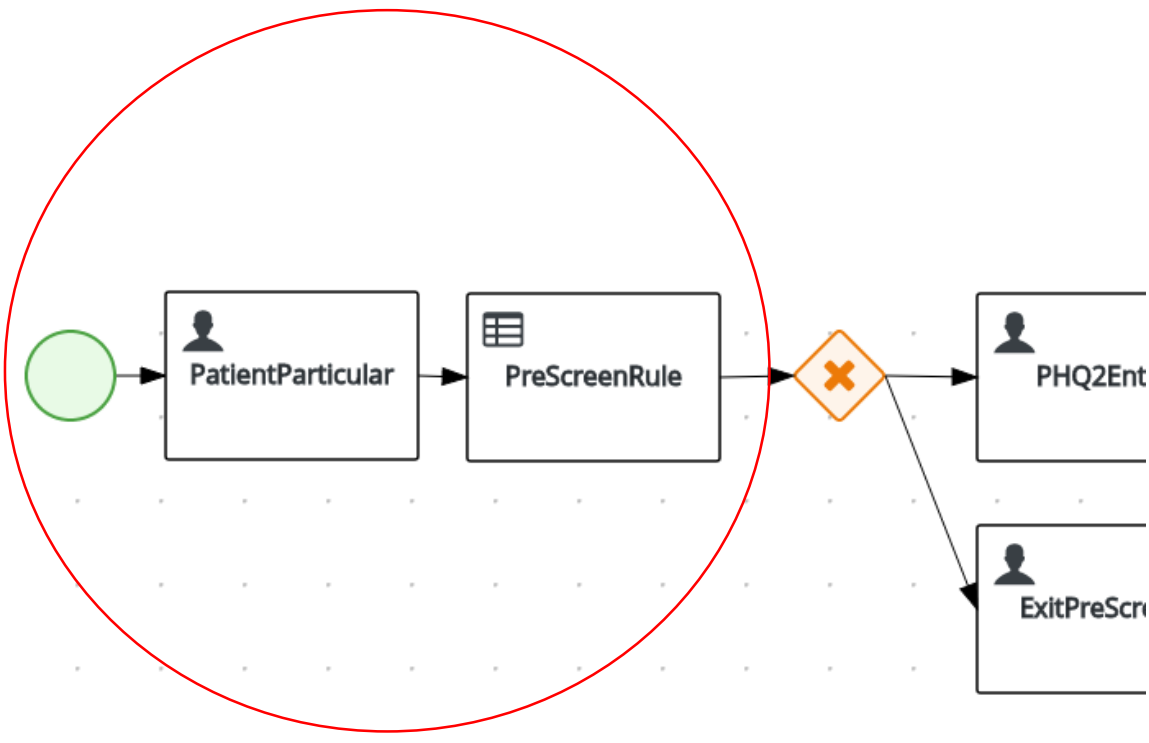
The process flow starts with a pre-survey check to determine if the candidate belongs to the High Risk group.

In this flow, the actor Patient1 keys in his particulars.

This Patient Particular will be pre-screened using rules generated from data mining.

In the rule, the fact will be inserted only if the conditions are met. Otherwise, the flow will send a message to the user to indicate that he/she is clear and does not need to proceed with PHQ2.

If the fact is inserted, Q1 and Q2 of PHQ2 will be presented to task actor Patient1.



Project Implementation

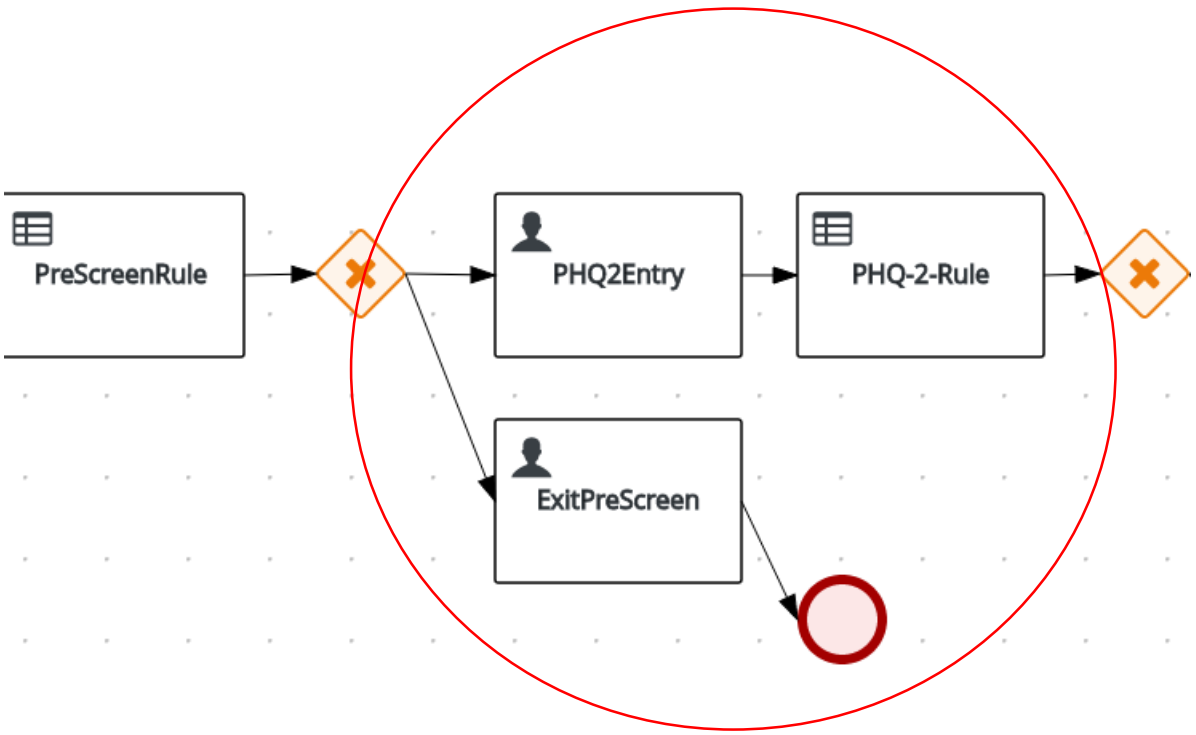
PHQ-2

The PHQ-2 rule will then be invoked.

PHQ-2 screens the candidate to determine whether the following two symptoms occur :

1) Loss of interest in things
2) Feeling down

If Q1 or Q2 scores 2 or more, the flow will proceed to PHQ9. Else, a message will be sent to Patient1 to indicate that he/she is clear and the flow ends.

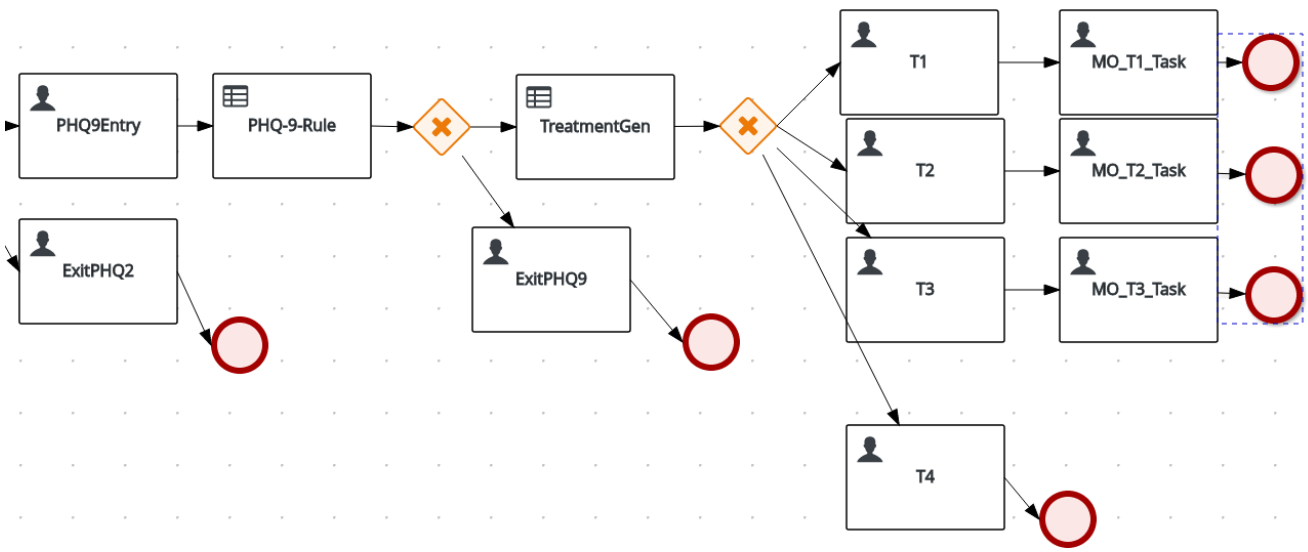


Project Implementation

PHQ-9

PHQ-9 goes into further detail of assessment. The logic behind PHQ-9 is such that the candidate will be sorted into four categories of severity depending on the overall score computed for the survey.

- The result will be assessed. If 5 questions are scoring more than 2 each (except for Q9, the threshold mark is set to more than 1), then proceed. If not, a message will be sent to Patient1 to indicate that the flow is ended with no problem detected.
- The TreatmentGen rule task will then compute the total score. The total score will determine which of the treatment level in the 4 leves of treatment is chosen.
- Treatment level 4 is least severe, user will be given message to advice taking PHQ9 again later.
- For Treatment level 1,2,3, Patient 1 will be given advice to seek doctors health. The medical officer will be triggered after Patient1 read the message. The medical officer will then key in the treatment required based on different level of message that he received in the task inbox.
- After medical officer read give the treatment, the flow is completed.



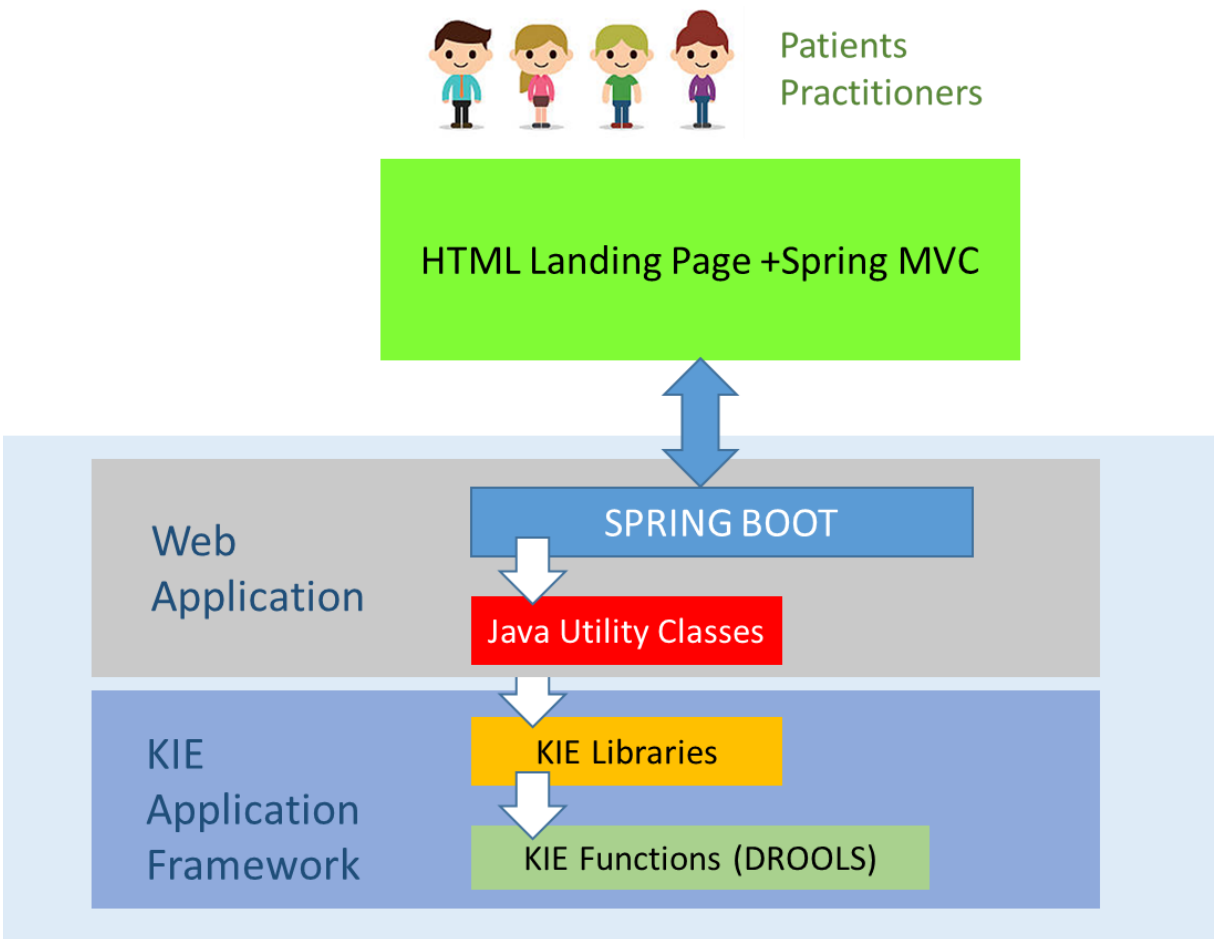
Project Implementation

Architecture

This application leverages the KIE Workbench as the main framework for development and deployment. With the KIE Workbench, we utilize the JBPM for metadata and workflow, DROOLS for rules engine and the JBOS Web Server to provide the web application server functions. In addition, we are using the Spring Boot to program the landing page, front-end screens and interface with KIE.

A lot of effort was spent on integrating the Spring Boot web application with the KIE framework through our self-coded Java classes.

This allows the user to not only interface with an external HTML page but also stay on the HTML frontend throughout the entire process. Behind this frontend, our custom built web application interfaces with the KIE libraries via the Java classes.

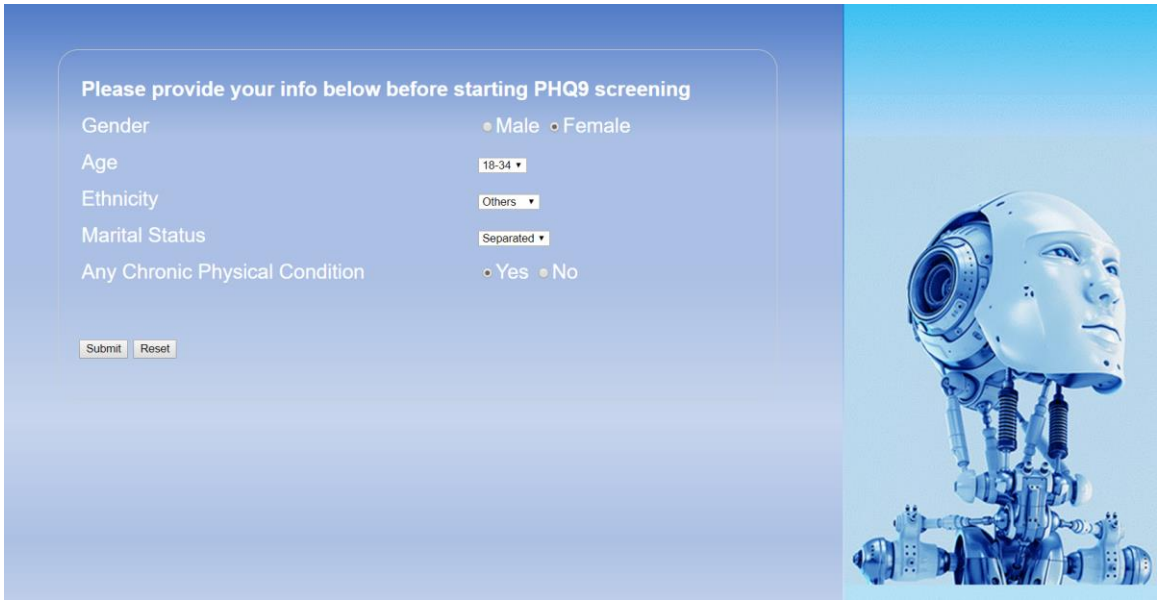


Project Performance & Validation

As mentioned in this document, Success Measurement for this application would be based on its ability to flag a high risk individual as well as computing the score pertaining to the level of depression.

During our test of the system, we simulated a survey done on a candidate. The following describes the entire test flow.

1. Risk Profiling

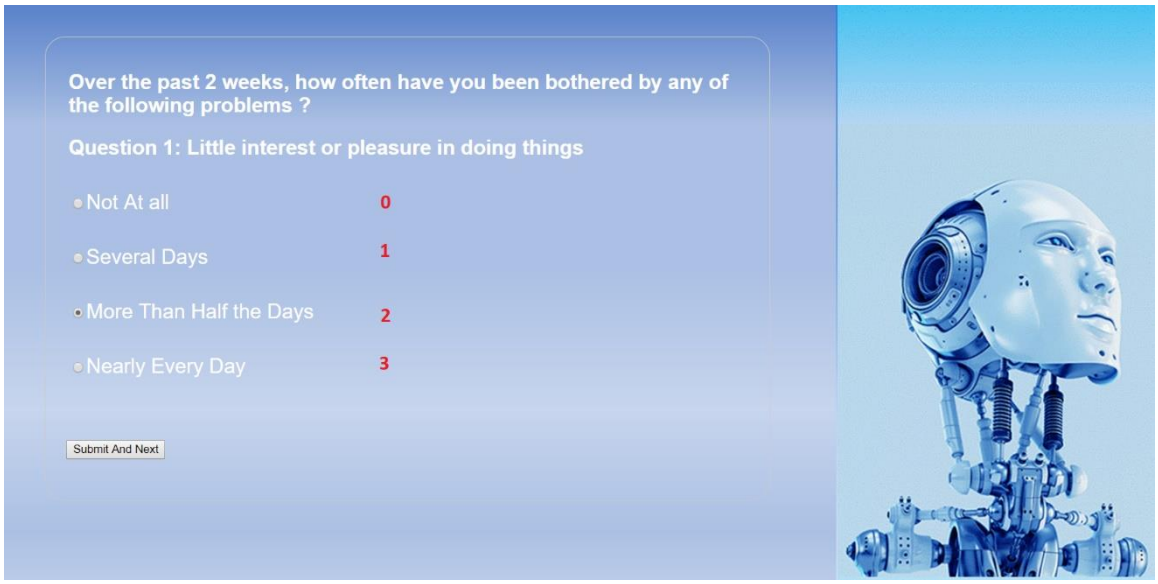


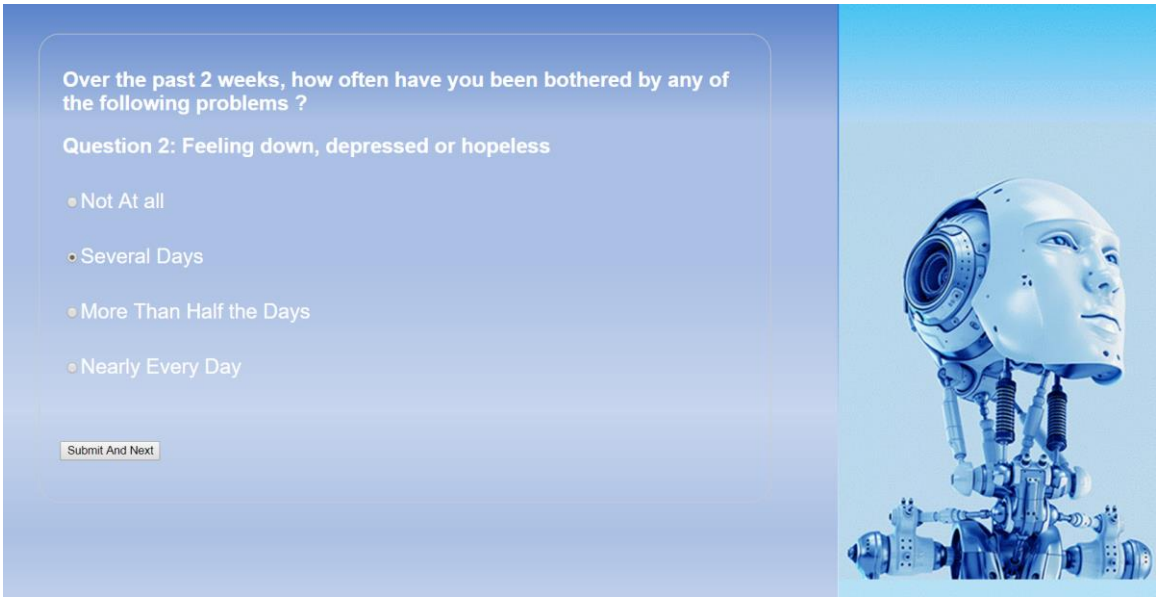
The candidate first of all performs the Risk Profiling in which the 5 risk factors (Age, Gender, Ethnicity, Marital Status and Chronic Physical Condition) are covered.

Given that the input during this test run corresponds to the high risk group, candidate proceeds with PHQ2.

Project Performance & Validation

2. PHQ2



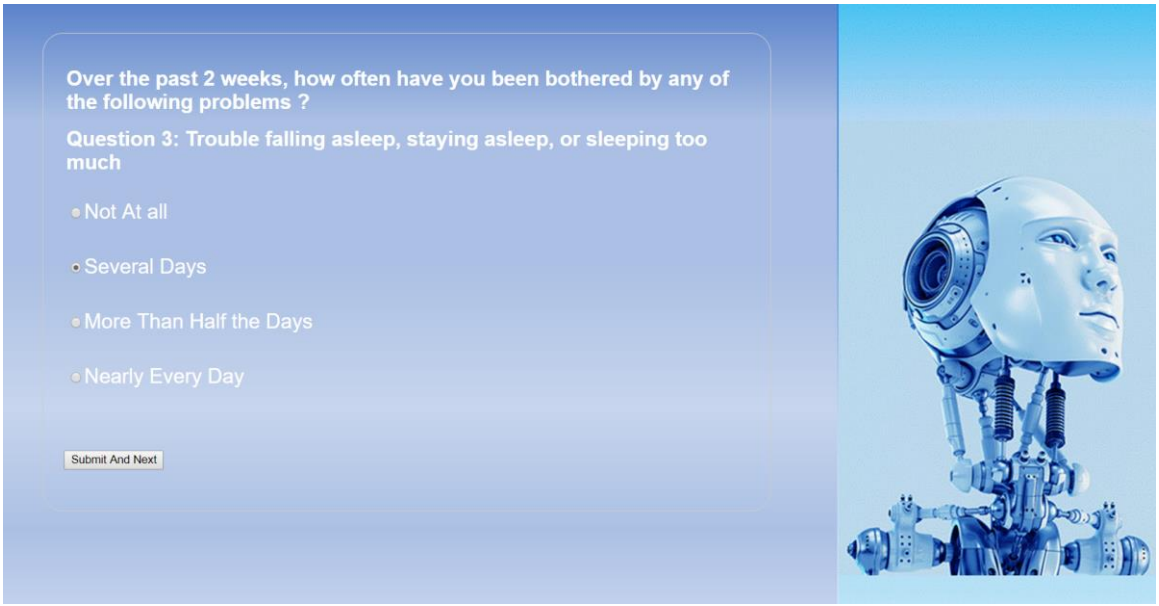


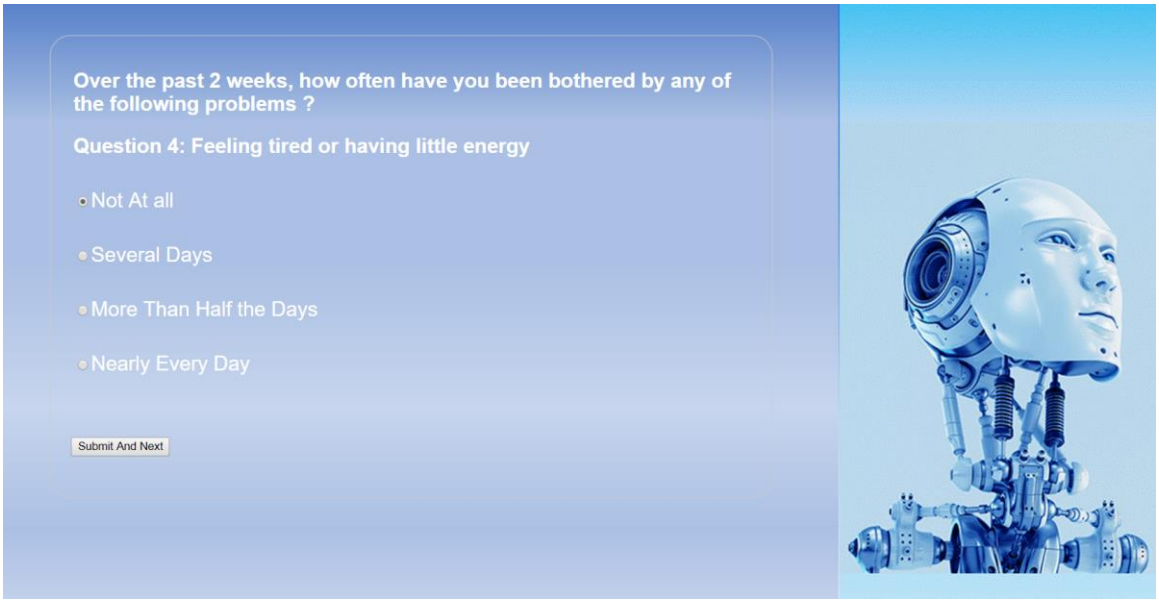
Next, the candidate answers the first 2 questions of PHQ9 (called PHQ2). The answers are given such that there are symptoms of depression. The system is able to assess that this candidate needs to proceed with PHQ9.

Project Performance & Validation

3. PHQ9

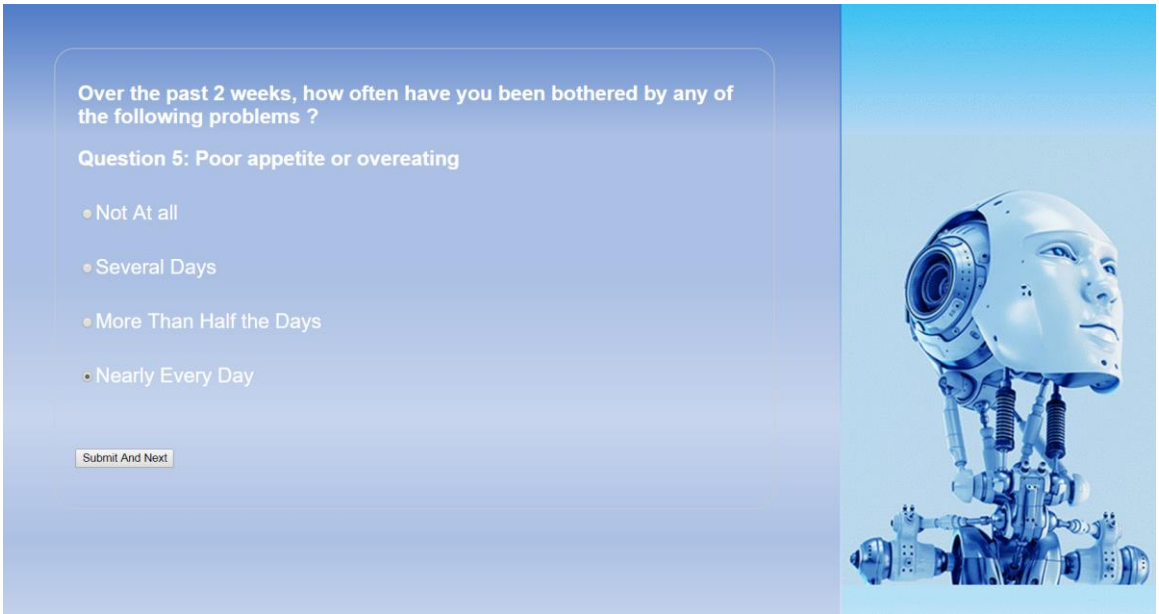
In PHQ9, the candidate gets to answer all the 7 questions as depicted in the following screens.

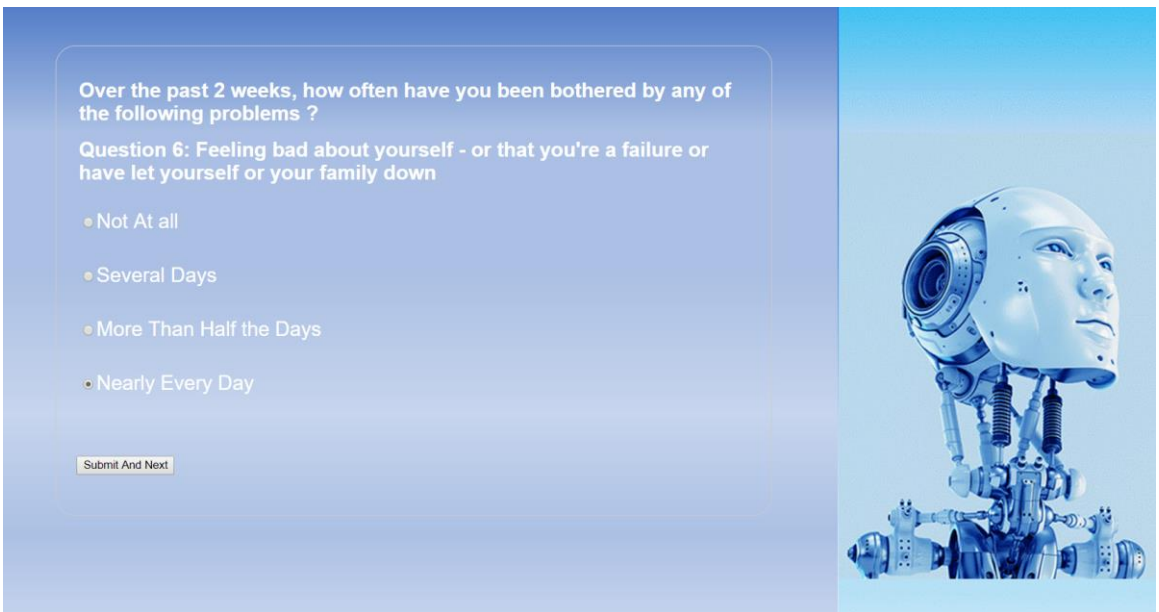




Project Performance & Validation

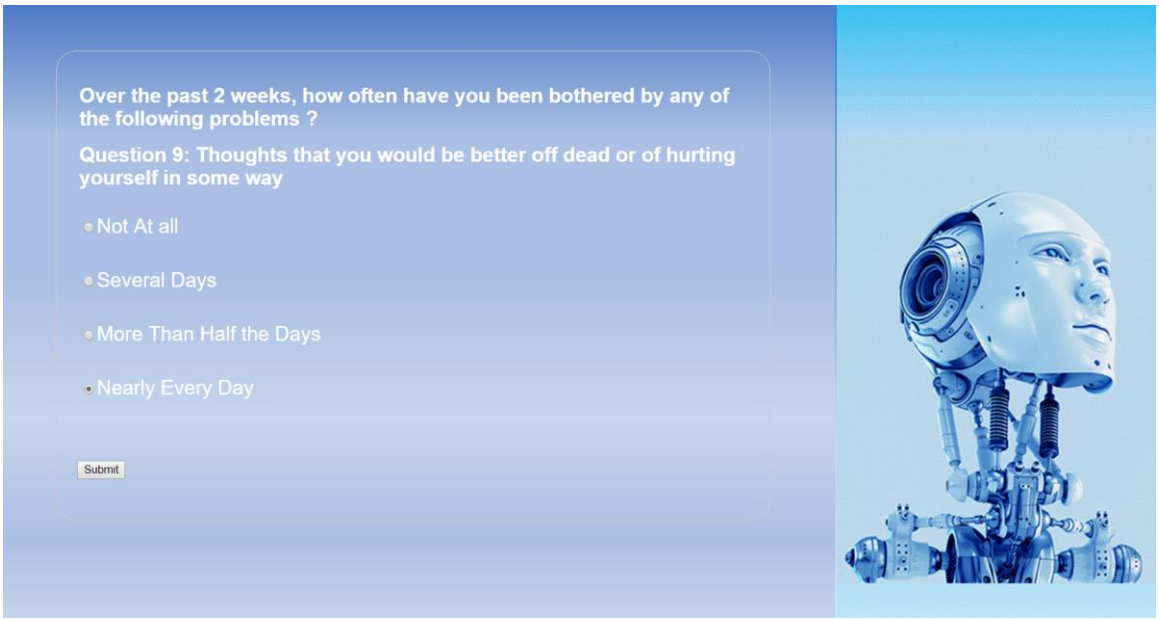
3. PHQ9

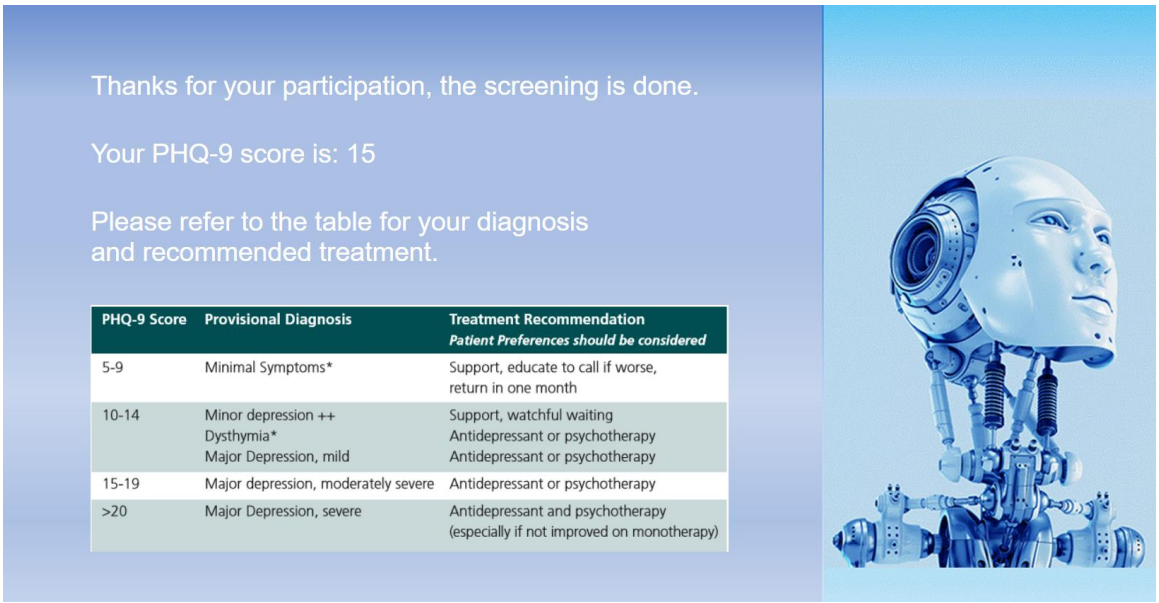




Project Performance & Validation

3. PHQ9





PHQ-9 Score	Provisional Diagnosis	Treatment Recommendation *Patient Preferences should be considered*
5-9	Minimal Symptoms*	Support, educate to call if worse, return in one month
10-14	Minor depression ++ Dysthymia* Major Depression, mild	Support, watchful waiting Antidepressant or psychotherapy Antidepressant or psychotherapy
15-19	Major depression, moderately severe	Antidepressant or psychotherapy
>20	Major Depression, severe	Antidepressant and psychotherapy (especially if not improved on monotherapy)

At the end of PHQ9, a screen showing the result of the survey is displayed. This is accompanied with the diagnosis table which contains the corresponding recommendations.

The score is consistent with the computation logic and in line with the entries given by the candidate. Given that the entries are skewed towards a moderately severe level of depression, the ensuing score and recommendation is consistent with the expected result.

We deem the test successful in that this high risk candidate with a moderately severe depression is flagged for the PHQ9 survey and is assessed accurately.

Project Conclusions: Findings & Recommendation

From this project, we are able to put some of the AI techniques to practice. The techniques are Certainty Factor, Decision Tree and Inference Diagram. In addition, this project demonstrates the many possibilities that AI can be put to good use. This use case involving helping people with depression is one of the things we can do for people with mental illness which is becoming more prevalent in our societies.

In this respect, our application can play a useful role to adopt a proactive approach in helping people with depression and treating them earlier. We recommend that schools of higher learning and places with concentration of youths consider using this tool for screening.

At the same time, this application has the potential to be extended with more functionalities and our team look forward to doing that as we learn new techniques in this course at ISS NUS.