# Master of Technology (IS)

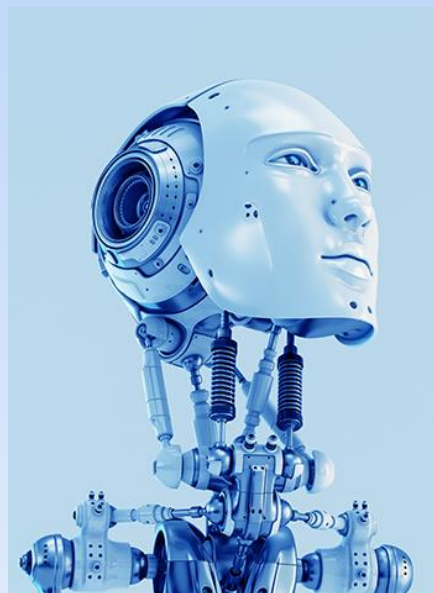## Pepper Project Group

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# Depression Screening System

# Project Report

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# Executive Summary

One in four 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. 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.

# 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.
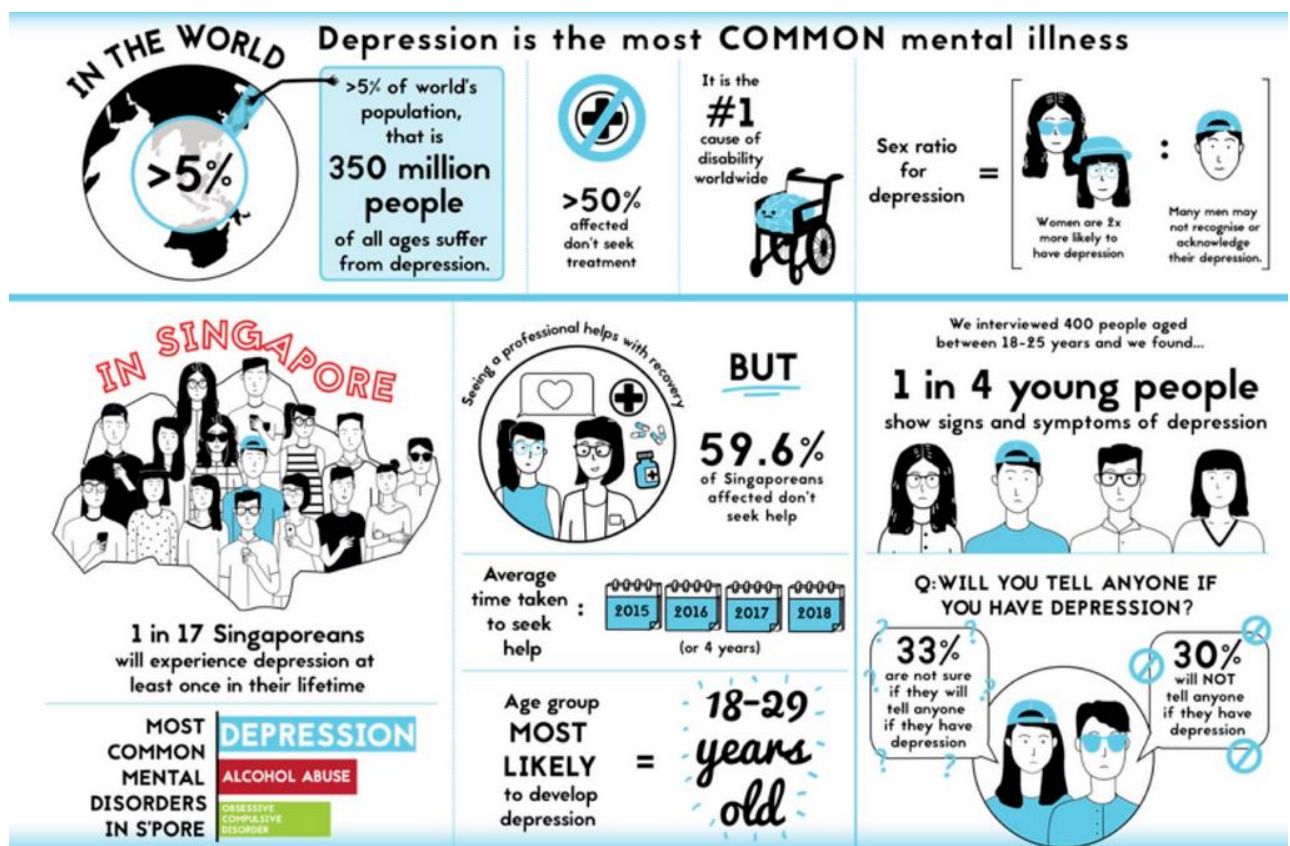
Severe depression can be readily recognized but it may be difficult to distinguish milder form of depression from emotional changes associated with everyday life. Life stresses such as job loss, divorce, and the death of a loved one can result in a sad mood of short duration. Clinical depression or Major 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

# Business Problem Background Cont.

One in four 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.

# 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.
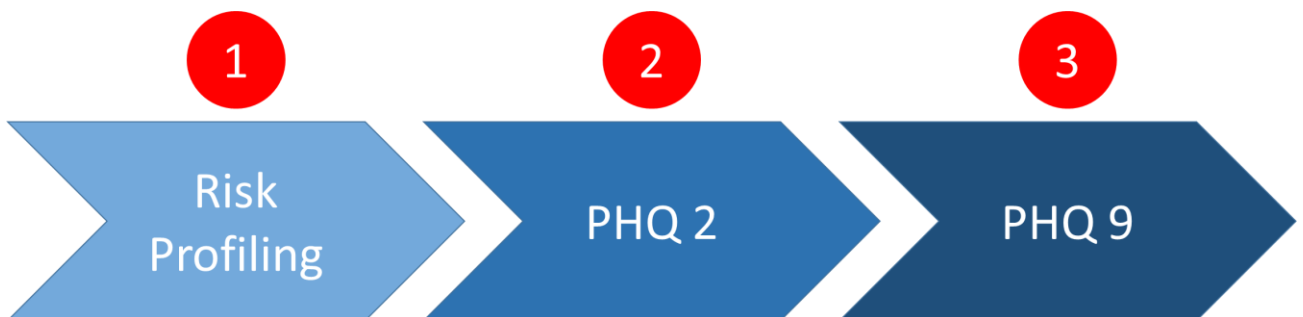
# Project Solution

The screening is done at three levels:
1)      Identifying the high risk group – Risk Profiling
2)      Doing a 2-question survey (PHQ2)
3)      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.

**1**

**2**

**3**

Risk
Profiling

PHQ 2

PHQ 9

# Project Solution

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:

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.

| 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.
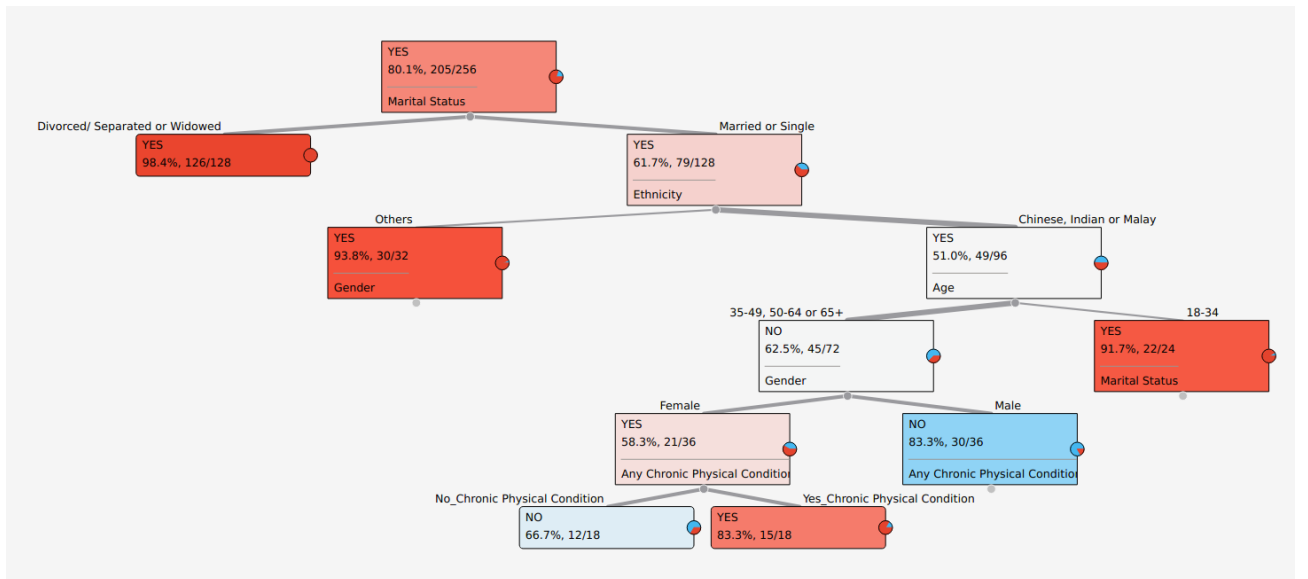
# Solution Design

## 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<br>*Patient Preferences should be considered* |
|---|---|---|
| 5-9 | Minimal Symptoms* | Support, educate to call if worse, return in one month |
| 10-14 | Minor depression ++<br>Dysthymia*<br>Major Depression, mild | Support, watchful waiting<br>Antidepressant or psychotherapy<br>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
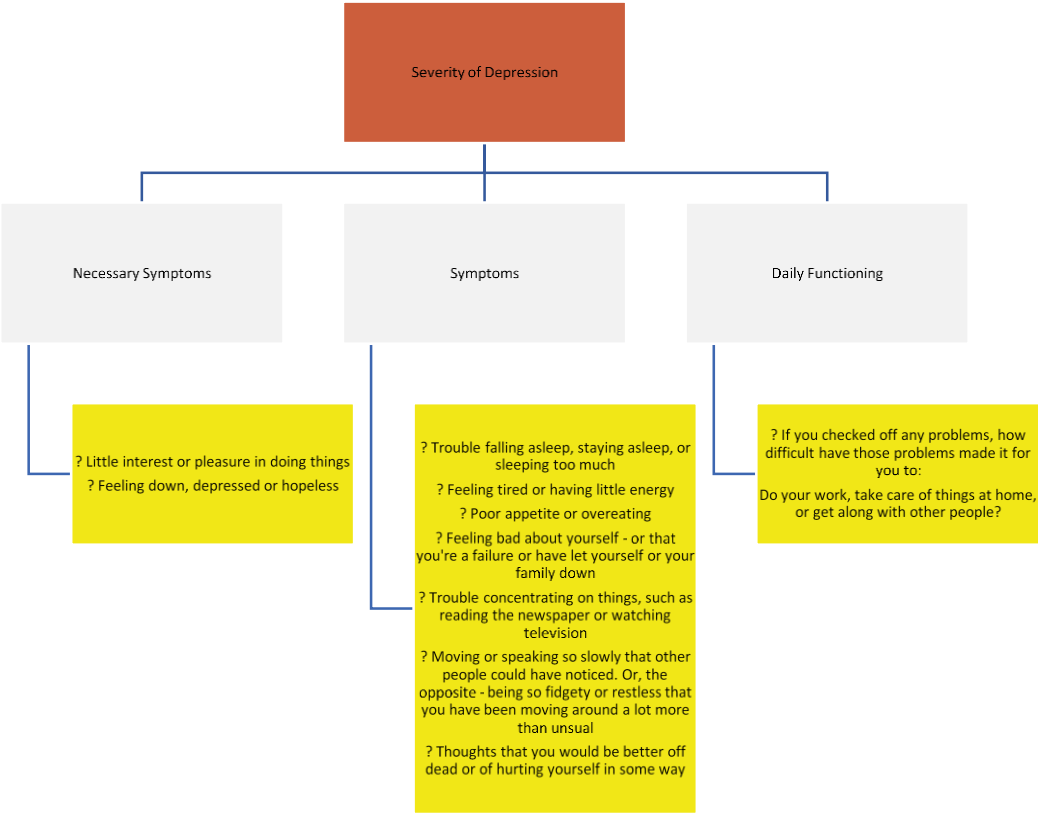
[1] Kroenke, K., Spitzer, R. L., & Williams, J., B., W. (2001). The PHQ-9: Validity of a brief depression severity measure. *Journal of General Internal Medicine, 16(9),* 606-613.

# 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

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
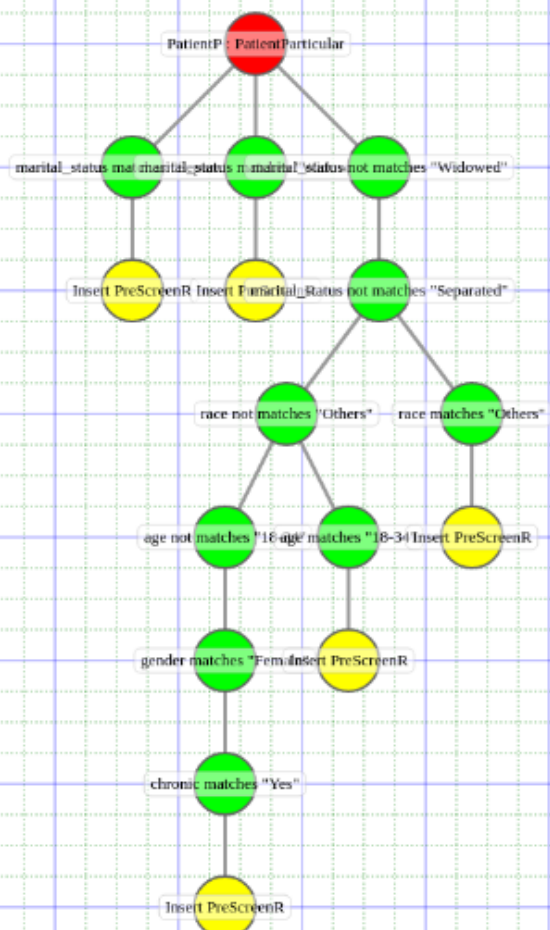
# Project Implementation

## 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.
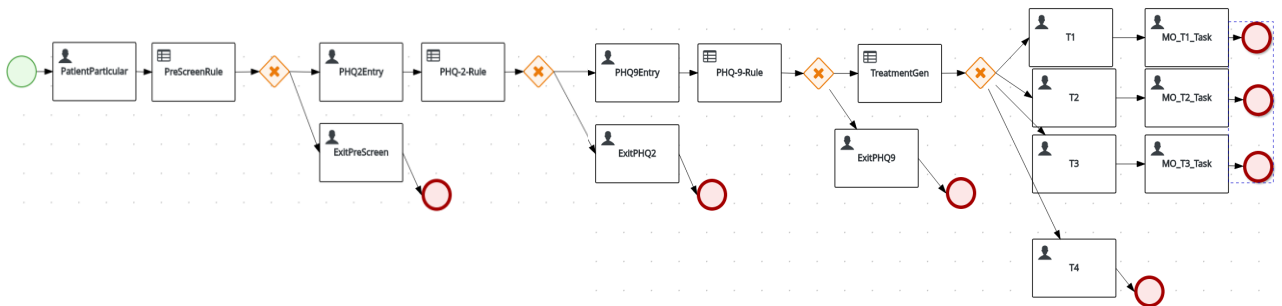
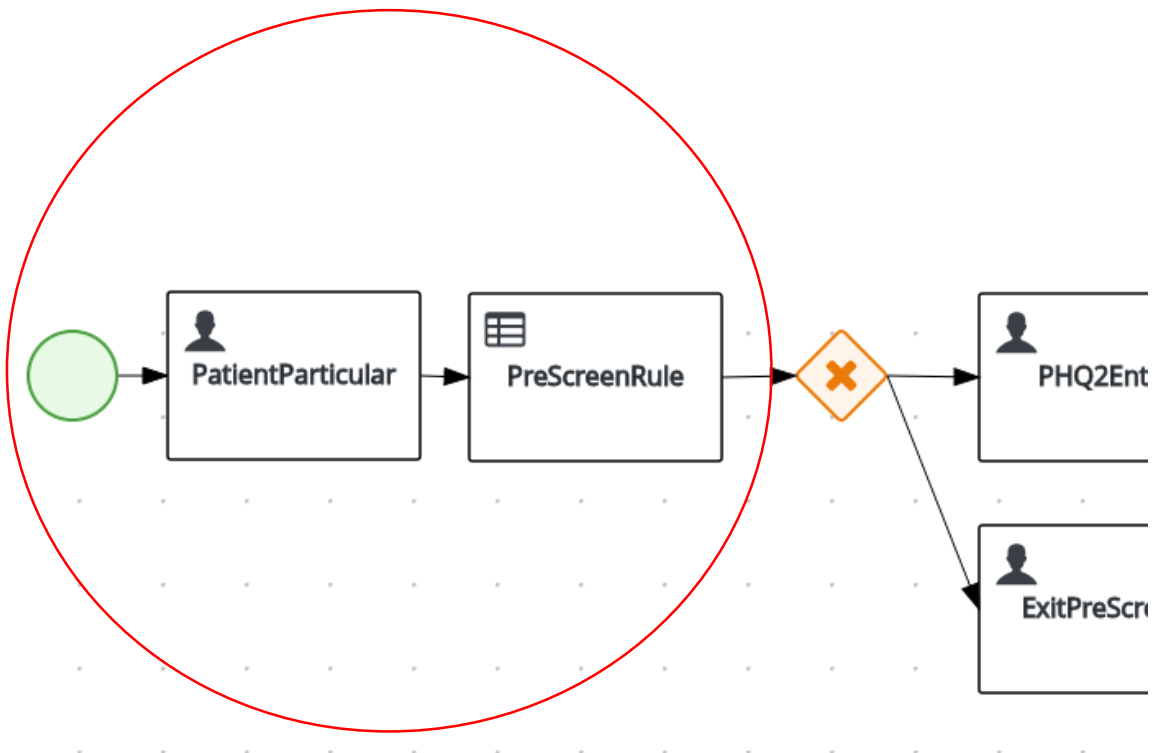# Project Implementation
## Risk Profiling

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.
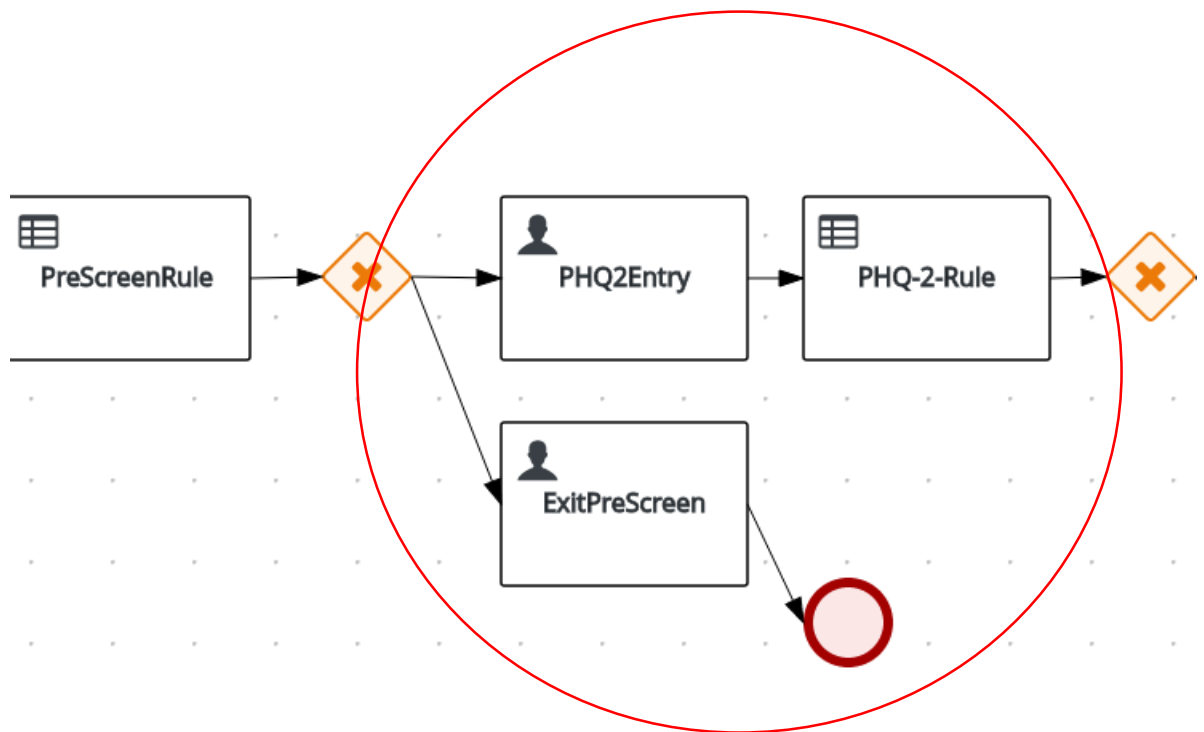
# Project Implementation

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.
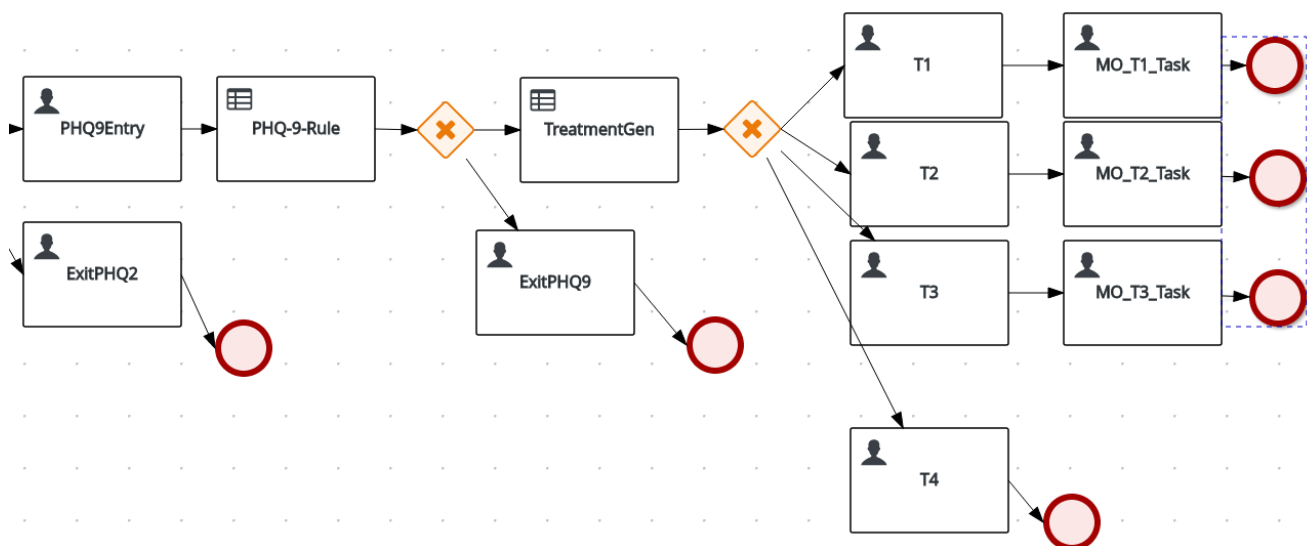
# Project Implementation
## PHQ-9

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.

Patients
Practitioners

KIE Forms

HTML Landing Page + Spring MVC

KIE JBPM

KIE DROOLS

JBOS Web Application Server

SPRING BOOT

SQLite