CS 514 - Applied Artificial Intelligence
Project -4 Automated Decision Making in Bayesian Networks (NETICA)
Diagnosis and Treatment decision for Tuberculosis

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Problem Specification: Diagnosis of Tuberculosis and automated decisioning of the treatment using Bayesian Networks in NETICA

Abstract:

The Bayesian Network is designed using NETICA and it can diagnose the presence of Tuberculosis for a given individual. In this network, based on the risk factors of an individual and the tests performed, the probability of having Tuberculosis is computed. Based on the computed probability and the treatment measure (the utility function), the treatment decision is made. This network can be used for probability reasoning for the presence or absence of Tuberculosis and also the automated decisioning of the treatment.
In this network, the parameters used for determining the risk for TB disease are - Age, HIV Positive, Previously Infected, Sick with other diseases. Similarly the parameters used for determining the risk for TB infection are - Age, From Country where TB is common, Living or working in High Risk settings, Exposed to Infected, Exposed to people with High Risk for TB. I have considered these variables, as they are the most common risk factors that determine the presence or absence of Tuberculosis.
The network performs reasoning, based on the prior probabilities, risk factor values and results of various tests, to find the probability of presence or absence of Tuberculosis, and probability whether it is latent TB Infection or TB Disease. And based on the probability and the value of the treatment measure, the treatment decision/action is selected.

Nodes and dependencies in the network:

Nature Nodes:

1. **Age** - No parent, Has prior probability
   HIV Positive - No parent, Has prior probability
   Previously Infected - No parent, Has prior probability

Sick with Other diseases - No parent, Has prior probability
From Country where TB is Common - No parent, Has prior probability
Living or Working In High Risk Settings - No parent, Has prior probability
Exposed to Infected - No parent, Has prior probability
Exposed to people with High Risk for TB - No parent, Has prior probability
All the above nodes impact the probability of whether a person is at high risk for Latent TB Infection or TB Disease.

2. **High Risk For TB Disease** - Parent nodes are Age, HIV Positive, Previously Infected, Sick with Other diseases.
   The probability of whether a person is at high risk for TB disease is determined by all the parents of the node.
   High Risk For TB Infection - Parent nodes are Age, From Country where TB is Common, Living or Working In High Risk Settings, Exposed to Infected, Exposed to people with High Risk for TB.
   The probability of whether a person is at high risk for TB infection is determined by all the parents of the node.

3. **BCG Vaccine** - No parent nodes. Has Prior probability. Vaccination with BCG may cause a false positive reaction to a TB skin test.
   TB skin test - Parent nodes are High Risk For TB Disease, High Risk For TB Infection.
   TB Blood test - Parent nodes are High Risk For TB Disease, High Risk For TB Infection.
   Presence of AFB in Sputum smear - Parent nodes are High Risk For TB Disease, High Risk For TB Infection.
   Chest radiograph - Parent nodes are High Risk For TB Disease, High Risk For TB Infection.
   A person who is at high risk for TB Infection or TB Disease undergoes these four tests to diagnose the presence or absence of Tuberculosis.
   So, the probability of each of these four nodes depends on whether the person is at high risk for TB disease or TB infection.

4. **TB disease** - Parent nodes are TB skin test, TB Blood test, Presence of AFB in Sputum smear, Chest radiograph

Latent TB Infection - Parent nodes are TB skin test, TB Blood test, Presence of AFB in Sputum smear, Chest radiograph
Since there are two types of Tuberculosis, there are two nodes one for latent TB Infection and other for TB disease. These nodes indicate the presence or absence of latent TB Infection or TB disease. The results of the tests determine the probability of TB disease or Latent TB infection.
So, TB disease or Latent TB infection depends on the four tests.

5. **Weight loss** - Parent nodes are TB disease.
   Chest pain - Parent nodes are TB disease.
   Fever - Parent nodes are TB disease.
   Weakness - Parent nodes are TB disease.
   Coughing - Parent nodes are TB disease.
   Night Sweats - Parent nodes are TB disease.
   The presence of TB disease causes few symptoms like Weight loss, Fever, Coughing, Chest pain, Night Sweats and Weakness.
   So, the probability of having theses symptoms depends on the presence or absence of TB disease or Latent TB infection.

Utility/Value Nodes:

1. **Treatment_Measure** - Parents are TB Disease, Latent TB Infection, Treatment. For each combination of the parents probabilities, the values of the Treatment_Measure(utility function) are determined. The best treatment is the one that maximizes the value of the Treatment_Measure.

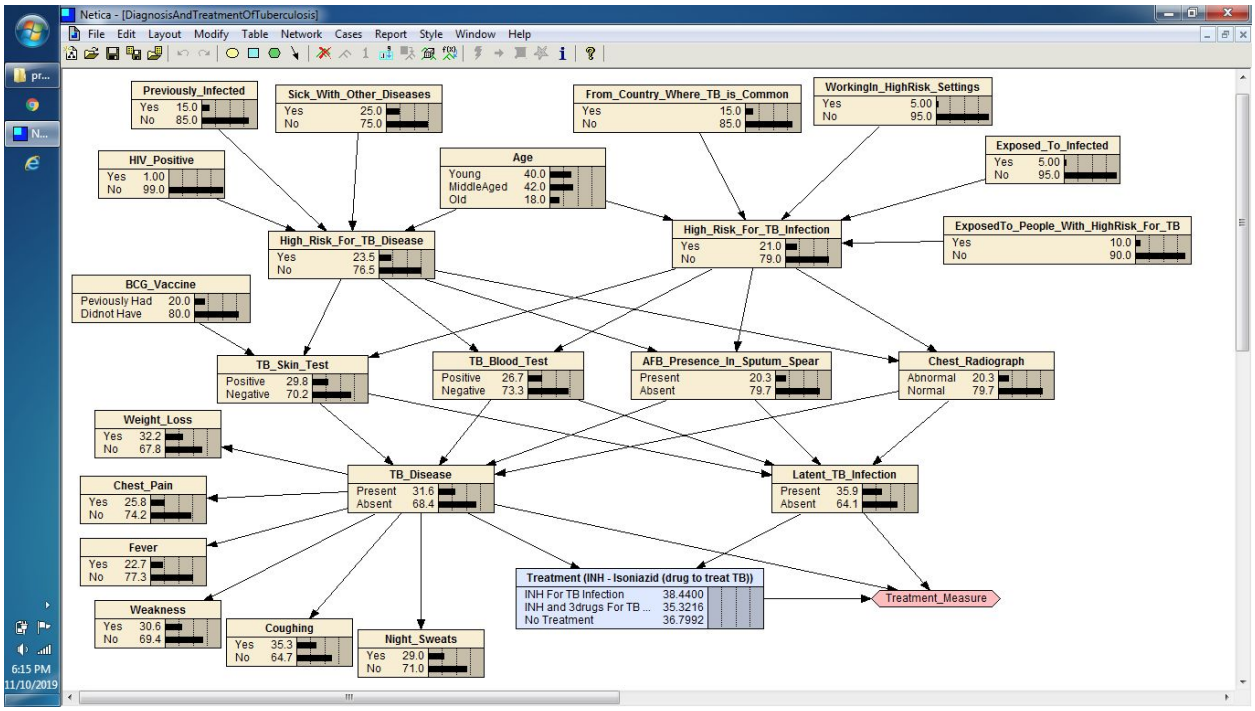
Decision/Action Nodes:

1. **Treatment** - Based on the probability of presence or absence of the TB Disease or TB Infection and the treatment measure, the treatment decision that maximizes the value of treatment measure is selected.

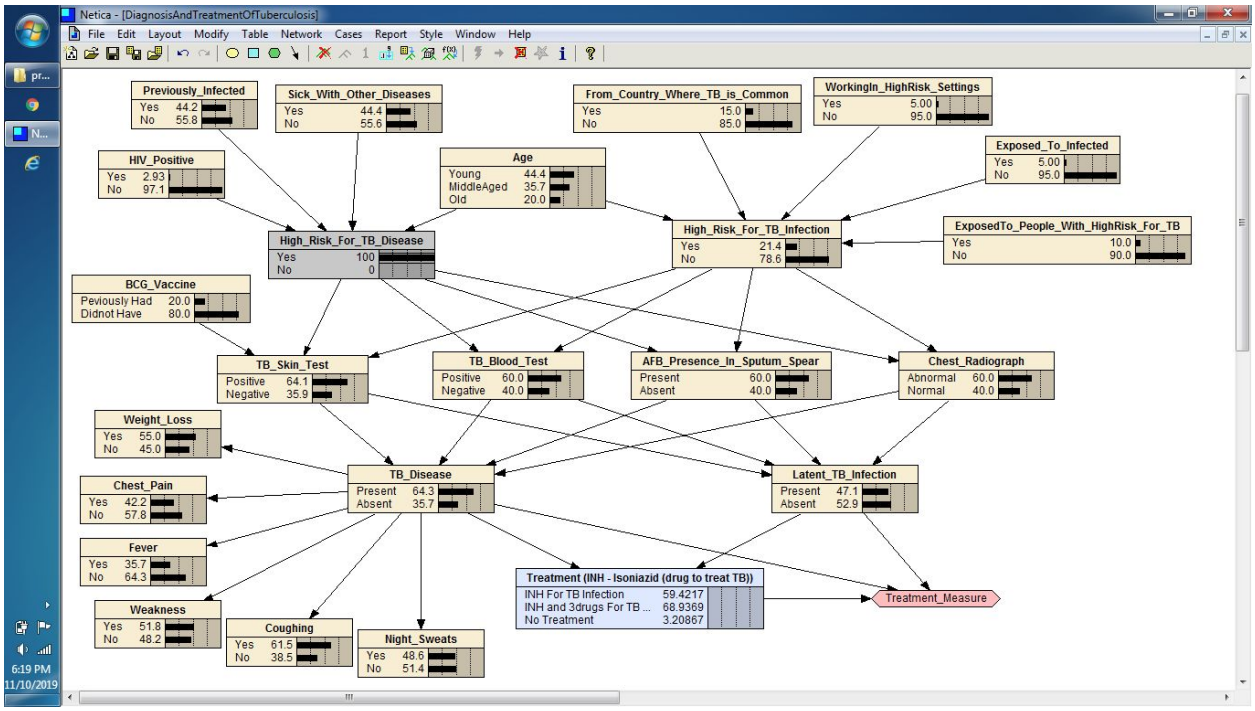
Note : Most of the probabilities are as close to reality as possible, while some have been formulated while hypothesizing the general trend.

Test Cases :

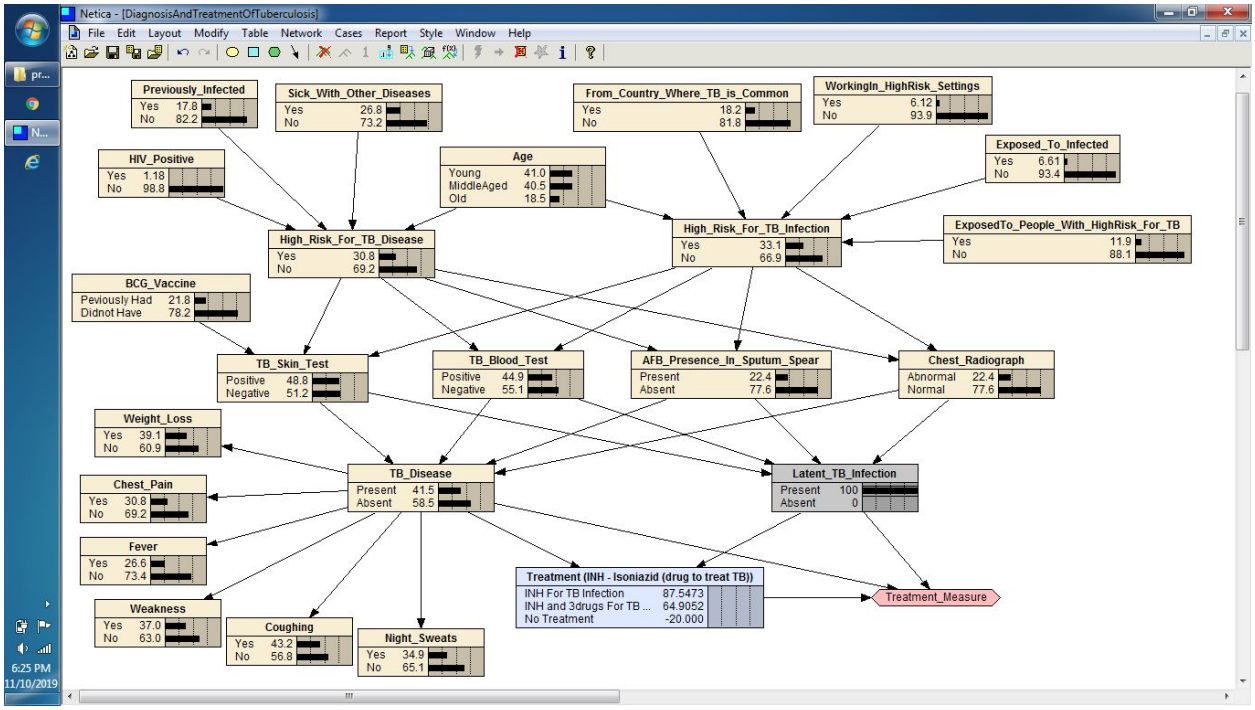
1. Probability of latent TB infection and TB disease without any evidence.



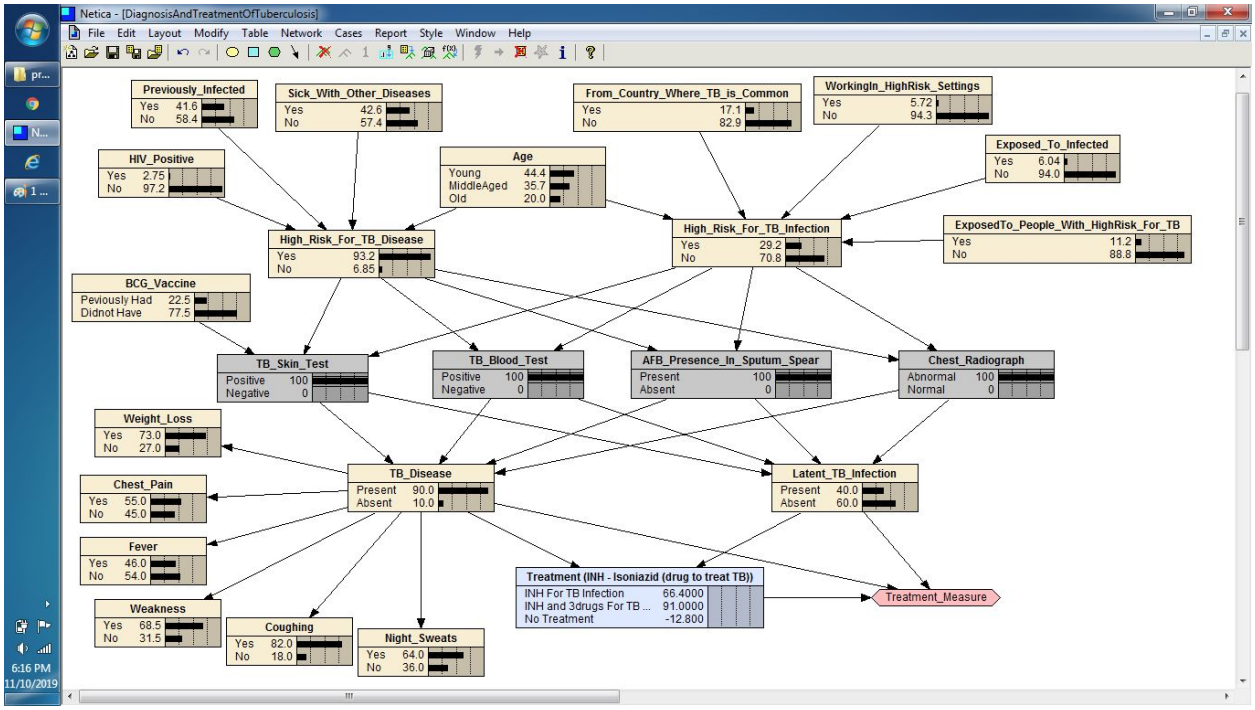
2. Probability of TB disease with evidence of high risk for TB disease.



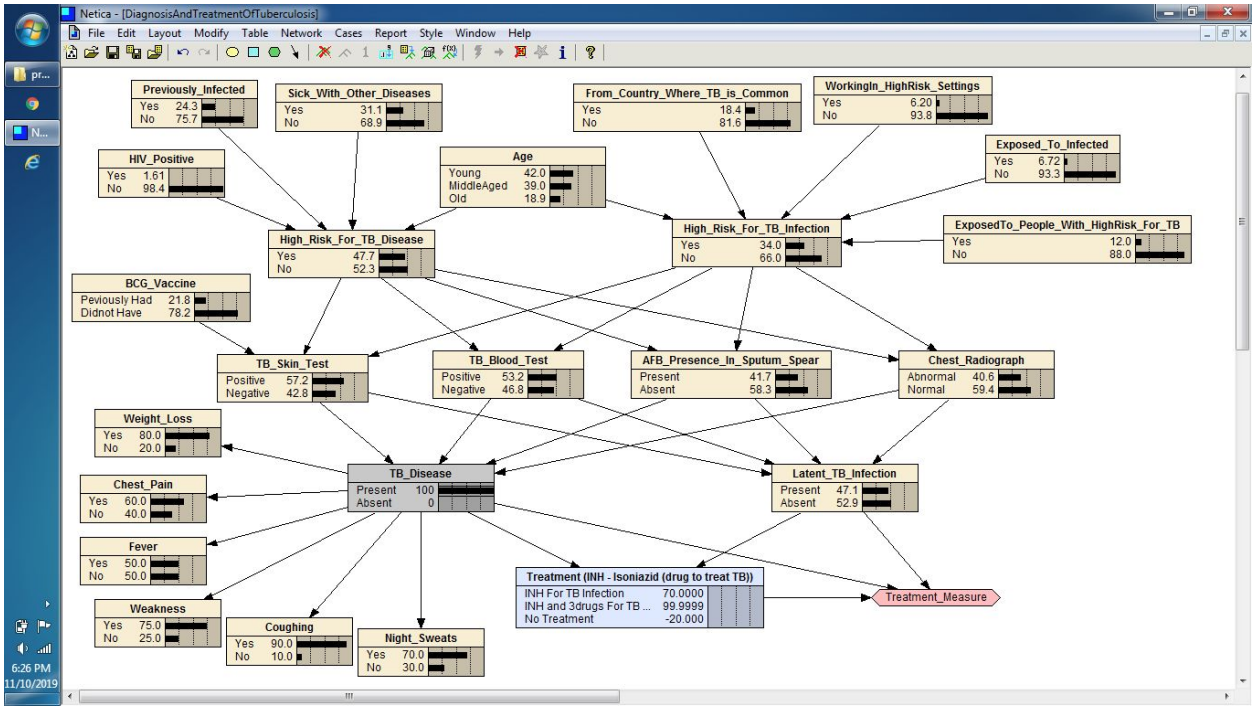
3. Treatment Decision with evidence of Latent TB Infection.



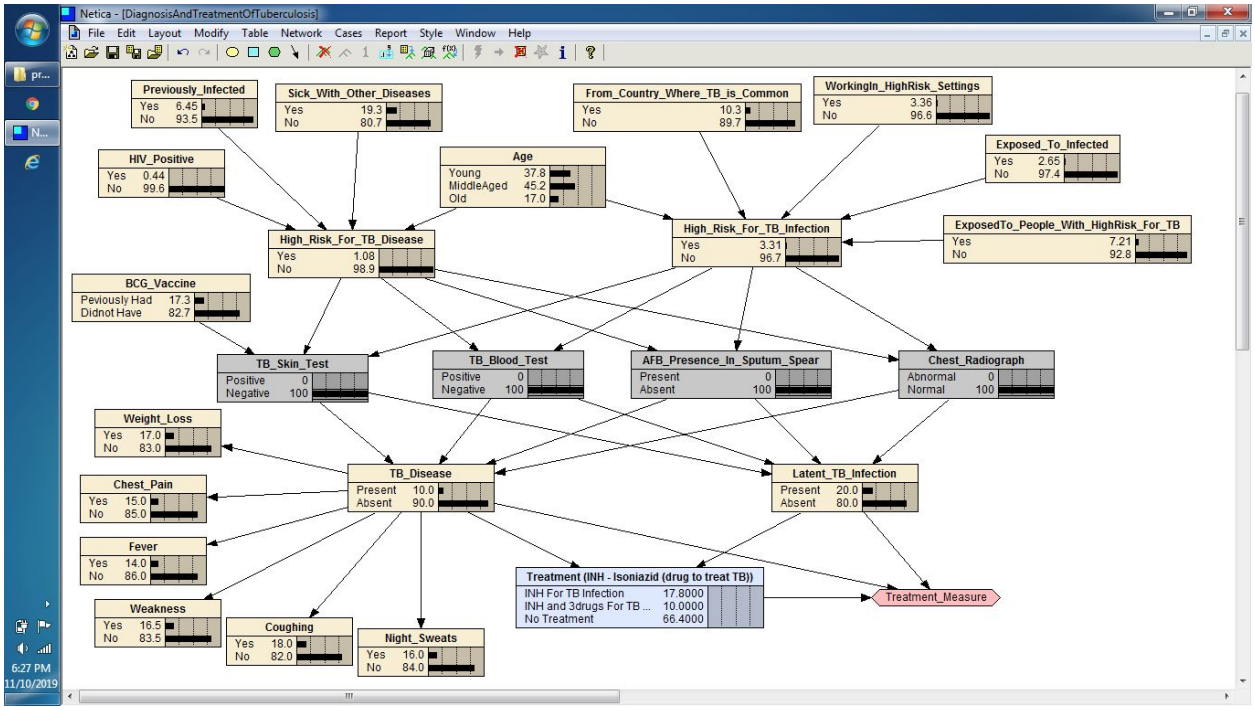
4. Treatment Decision with evidence of positive results in all tests.



5. Treatment Decision with evidence of TB disease.



6. Treatment Decision with evidence of negative results in all tests (TB is absent).



Instructions to run :

1. Download and place “DiagnosisAndTreatmentOfTuberculosis.neta” in any directory and open it through NETICA application.
2. Compile the project.
3. After the network is initialized, modify and set the values and see how the network adapts to the change in the values.
4. To check the decisioning, give evidence of the presence or absence of Tuberculosis and see the automated decision made by the network.

References :

1. https://www.cdc.gov/tb/default.htm