



CSINTSY MCO2: ChatBot

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I. Introduction

In recent years, the Philippines has made sizable investments and advancements in healthcare. The Philippines' rapid economic growth and robust national capacity have made Filipinos healthier and longer-lived (World Health Organization, 2017). However, the health system is still fragmented and not all the advantages of this growth have reached the most vulnerable populations—the poor and rural communities of the country. According to the country's Department of Health (2021), the most common killers of Filipino residents are heart and vascular diseases, pneumonia, malignant neoplasms/cancers, all types of tuberculosis, accidents, COPD and related conditions, diabetes mellitus, nephritis/nephritic syndrome, and other respiratory illnesses. Based on this information, together with additional research of related literature and websites on the Philippines' rural health, the group has identified 10 prevalent diseases namely: (1) Dengue fever, (2) Tuberculosis, (3) Malaria, (4) Leptospirosis, (5) Typhoid Fever, (6) Hepatitis B, (7) Rabies, (8) Pneumonia, (9) Influenza, and (10) Cholera.

Much like every health concern, the previously mentioned diseases all have some common symptoms that can be mistaken for a different disease—especially if without access to quality healthcare diagnostic systems. Symptoms such as fever, nausea, headache, fatigue, vomiting, cough, body malaise, etc. are all examples of common illness symptoms. As such, the 10 previously mentioned prevalent poor and rural area diseases also have a few of these symptoms in common, and therefore, are hard to differentiate when lacking knowledge. Leptospirosis, Typhoid fever, and Rabies, for example, all have High-Fever and Headache as their common symptoms (Centers for Disease Control and Prevention, n.d.; Cleveland Clinic, 2022; Dayco, Garcia, & Ventura, n.d.). However, despite having this commonality, these diseases have their own unique set of additional symptoms as rules for diagnosis accuracy—all of which are included in the chatbot's knowledge base. Thus, as a small medical diagnostic expert system, the chatbot's purpose is to help automate and provide an accurate disease diagnosis for the poor and rural Philippine communities that lack the knowledge and advantages of the country's healthcare progress.

In order to be able to provide an accurate diagnosis of diseases, having a wide knowledge of the matter is imperative especially since it is a topic that involves the well-being of human life. An error in diagnosis can be a cause of wrong-provided treatments that may lead to adverse effects. However, if successfully implemented, the expert system will be significant to poor communities in the sense that it will be able to provide residents with an immediate diagnosis that could potentially save and prolong a person's life. For example, in Muslim Mindanao's Autonomous Region (ARMM), the province called Lanao Del Sur is considered to rank among the poorest (Writer, 2022) in

the Philippines. According to the Philippine Statistics Authority (2010), this province has experienced a sharp decline in population by a 6.98% decrease—most of which are attributed to migration, hunger, and diseases. Correspondingly, an expert system is significant in communities like Lanao Del Sur to help aide the prevention of irreversible diseases despite being struck by poverty.

II. Knowledge Base and Chatbot

Translating real-world information about the diseases to the knowledge base involves getting specific information, the symptoms. There is a wide array of symptoms that may identify multiple diseases, so it is critical to identify more specific ones that cater to a specific disease. Influenza makes it easier to translate as it involves flu-like symptoms such as Fever, Sore Throat, Cough, Muscle pain, or Joint pain. It involved translating the information that whenever the user experiences Fever, Headache, Sore Throat, and Pains, then the user might be diagnosed with Influenza to the knowledge base.

$$LFever(x) \wedge Headache(x) \wedge SThroat(x) \wedge (DCough(x) \vee MPain(x) \vee JPain(x)) \rightarrow Influenza(x)$$

During translation, the disease should be the first one to be identified before branching out to the symptoms. There are diseases where all the symptoms are felt by the patient. However, there are other diseases where not all symptoms are always present. There are also situations where the severity of the symptom is considered. For example, the symptom of fever can branch out on how severe it is based on the temperature.

HFever(x)	“x experiences High-grade Fever reaching 40C”
LFever(x)	“x experiences Low-grade Fever reaching 38C”
LTemp(x)	“x experiences Low Body Temperature than Normal”

There are also cases where a specific situation should happen before diagnosing the disease. For example, the disease Rabies is situational as it only occurs when the patient is bitten by an animal with rabies.

$$(HFever(x) \wedge Fatigue(x) \wedge Headache(x)) \wedge (Hallucinations(x) \vee Hydrophobia(x) \vee Anxiety(x) \vee Agitation(x)) \rightarrow Rabies(x)$$

$$RabBite(x) \rightarrow Rabies(x)$$

Finalizing the knowledge base took some time because the symptoms of each disease should be taken into consideration. There are multiple diseases with similar symptoms. The easiest to identify and finalize for the knowledge base is Influenza. Diseases that happened due to situations and circumstances are also easier to finalize as it involves a situation to happen before getting the disease such as Rabies and Leptospirosis.

Leptospirosis	
IF: <ul style="list-style-type: none"> ● Wound(x) Open Wound ● Flood(x) Contact with Flood Water ● HFever(x) High-grade Fever ● Headache(x) Headache ● Chills(x) Chills ● MPain(x) Muscle Pain ● OR APain(x) Abdominal Pain ● Diarrhea(x) Diarrhea ● Vomiting(x) Vomiting ● REyes(x) Red Eyes ● Rashes(x) Rashes ● SBreath(x) Shortness of Breath 	
OR <ul style="list-style-type: none"> ● CBlood(x) Coughing Blood ● OR PBlood(x) Blood in Pee ● OR Jaundice(x) Jaundice 	
THEN x has Leptospirosis $(Wound(x) \wedge Flood(x)) \wedge (HFever(x) \wedge Headache(x) \wedge Chills(x)) \wedge (MPain(x) \vee APain(x)) \wedge (Diarrhea(x) \wedge Vomiting(x) \wedge REyes(x) \wedge Rashes(x) \wedge SBreath(x)) \wedge (CBlood(x) \vee PBlood(x) \vee Jaundice(x)) \rightarrow Leptos(x)$	
Rabies	
IF: <ul style="list-style-type: none"> ● HFever(x) High-grade Fever ● Fatigue(x) Fatigue ● Headache(x) Headache 	

OR	
Hallucinations(x)	Hallucinations
OR Hydrophobia(x)	Hydrophobia
OR Anxiety(x)	Anxiety
OR Agitation(x)	Agitation
THEN x has Rabies	
IF:	
RabBite(x)	“x has been bitten by a rabies infected Animal”
THEN x has Rabies	
$(HFever(x) \wedge Fatigue(x) \wedge Headache(x)) \wedge$ $(Hallucinations(x) \vee Hydrophobia(x) \vee Anxiety(x) \vee Agitation(x))$ $\rightarrow Rabies(x)$	
$RabBite(x) \rightarrow Rabies(x)$	

The hardest part to finalize in the knowledge base is the diseases with similar symptoms. Diseases like Dengue and Malaria have similar symptoms but to work around them is to identify the specific symptoms for it. However, some specific symptoms are also connected with other diseases like Malaria and Hepatitis B with Jaundice. Most of the diseases involved Fever, Cough, Chills, and Fatigue. At first, all of the diseases are connected with AND, but some symptoms do not show for every patient and so it has to be revised. During early revisions, Malaria, and Dengue have similar symptoms and so adjustments were done by getting specific symptoms for both. For example, Dengue has rashes and eye pain behind the eyes, while Malaria has night sweats and jaundice.

Implementation

The front-end of the program is written in Python 3 and uses the terminal to display information to the user, while the backend/knowledge base is a single prolog file. The chatbot was designed to be able to diagnose all the diseases the patient has instead of only a single disease.

On the front-end, the user is asked a series of yes-or-no questions about whether they experience a particular symptom, compiling all symptoms experienced by the patient in a list. Afterwards, a query is sent to the back-end to generate the final diagnosis. Querying the knowledge base is made possible using the swiplserver API.

The back-end contains the rules for diagnosis. Given a list of symptoms, representing all the symptoms the patient experiences, it can generate a diagnosis in the form of a list of diseases, representing all the diseases the patient is afflicted with.

III. Results and Analysis

```
-----  
MEDICAL DIAGNOSIS SYSTEM  
-----  
  
The only valid answers to questions are 'y', 'yes', 'n', and 'no')  
  
Have you experienced high fever recently? n  
Have you experienced low fever recently? n  
Have you experienced fatigue recently? n  
Have you experienced headaches recently? n  
Have you experienced being bitten by a rabid animal recently? n  
Have you experienced hallucinations recently? n  
Have you experienced hydrophobia recently? n  
Have you experienced anxiety recently? n  
Have you experienced agitation recently? n  
Have you experienced appetite loss recently? n  
Have you experienced dehydration recently? n  
  
DIAGNOSIS: YOU ARE HEALTHY
```

Figure (1): Asking of symptoms get narrowed down

The bot clearly displays intelligence when asking the user for their symptoms. It ensures that a symptom will never be asked more than once. It also exploits the fact that most diseases have one or more ‘required’ symptoms – symptoms that must be present for it to diagnose the patient with that disease. Diseases with one or more of their required symptoms not experienced by the patient are ruled out. Symptoms of ruled out diseases will not be asked, unless they are also symptoms of other diseases which have not been ruled out.

MEDICAL DIAGNOSIS SYSTEM

The only valid answers to questions are 'y', 'yes', 'n', and 'no')

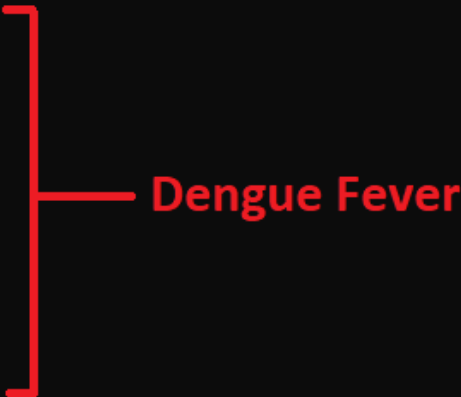
Have you experienced high fever recently? y
Have you experienced nose bleeds recently? y
Have you experienced paleness recently? y
Have you experienced malaise recently? y
Have you experienced joint pain recently? y
Have you experienced muscle pain recently? y
Have you experienced abdominal pain recently? y
Have you experienced nausea recently? y
Have you experienced vomiting recently? y
Have you experienced rashes recently? y
Have you experienced pain behind the eyes recently? y
Have you experienced swollen glands recently? y
Have you experienced chills recently? y
Have you experienced heavy sweating recently? n
Have you experienced low fever recently? n
Have you experienced having an open wound recently? y
Have you experienced being in contact with flood water recently? y
Have you experienced headaches recently? y
Have you experienced diarrhea recently? y
Have you experienced red eyes recently? y
Have you experienced shortness of breath recently? y
Have you experienced coughing blood recently? y
Have you experienced blood in urine recently? n
Have you experienced jaundice recently? n
Have you experienced dry cough recently? y
Have you experienced appetite loss recently? y
Have you experienced fatigue recently? y
Have you experienced being bitten by a rabid animal recently? y
Have you experienced hallucinations recently? n
Have you experienced hydrophobia recently? n
Have you experienced anxiety recently? y
Have you experienced agitation recently? y
Have you experienced chest pain recently? n
Have you experienced dehydration recently? n

DIAGNOSIS: YOU HAVE DENGUE FEVER, LEPTOSPIROSIS, RABIES, AND TYPHOID FEVER

Figure (2): Diagnosis of multiple diseases

The bot is not only able to diagnose multiple diseases that the patient may have, but all of them, making it more useful.

```
-----  
MEDICAL DIAGNOSIS SYSTEM  
-----  
  
The only valid answers to questions are 'y', 'yes', 'n', and 'no')  
  
Have you experienced high fever recently? y  
Have you experienced nose bleeds recently? y  
Have you experienced paleness recently? y  
Have you experienced malaise recently? y  
Have you experienced joint pain recently? y  
Have you experienced muscle pain recently? y  
Have you experienced abdominal pain recently? n  
Have you experienced nausea recently? y  
Have you experienced vomiting recently? n  
Have you experienced rashes recently? y  
Have you experienced pain behind the eyes recently? n  
Have you experienced swollen glands recently? y  
Have you experienced chills recently? n  
Have you experienced having multiple sexual partners recently? n  
Have you experienced fatigue recently? n  
Have you experienced headaches recently? n  
Have you experienced being bitten by a rabid animal recently? n  
Have you experienced hallucinations recently? n  
Have you experienced hydrophobia recently? n  
Have you experienced anxiety recently? n  
Have you experienced agitation recently? n  
Have you experienced appetite loss recently? n  
Have you experienced dehydration recently? n  
  
DIAGNOSIS: YOU HAVE DENGUE FEVER
```



Dengue Fever

Figure (3): *The patient only has Dengue Fever, and enough information is known to diagnose them with it, but the bot still has to go through more symptoms of other diseases.*

This design choice comes with the drawback that the bot does not stop when it has enough information to diagnose a disease, it will continue until all diseases have either been diagnosed or ruled out. This has implications on the time-complexity of the algorithm used. In the cases where enough information is known to diagnose a disease before all symptoms have been asked, the bot will take longer to finish than if it were designed to only diagnose 1 disease, because it will continue to ask symptoms when the other version would have stopped. Fortunately, in the worst case, when no symptoms are experienced by the patient and all disease symptoms are unique and not required, both versions have the same time complexity as they both have to ask all the symptoms.

IV. Recommendations

A clear weakness of the bot is that its implementation relies on what are essentially ‘hard-coded’ values to function. This makes it time consuming to extend in the event that we would like to add more diseases to its knowledge base or change existing rules for diagnosis, and makes the process prone to human error. Unfortunately, there is not really a way to eliminate this weakness as it is part of the nature of logic-based models.

An area in which the chatbot could be better is the way it asks symptoms from the user. Though it does exhibit intelligence when ruling out diseases, it sometimes fails to rule out a disease when it would make sense logically. For example, let's say disease A is diagnosed with the rule $(a \vee b) \wedge c \rightarrow has(X, D)$ where a, b, and c are symptoms. The only ‘required symptom’ the bot can identify is c, since the negation of a does not rule out the patient having D and the same for b. This means that if the bot knows that the patient does not experience a nor b, but does not know whether c is experienced, it will still ask the user whether they experience c. This fault may be fixed by changing the way the bot rules out diseases from the ‘required symptoms’ system to something more sophisticated that can represent disjunctions.

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VI. Contributions of Each Members

Asturiano, Christian Emmanuel S.

Handled formulation of rules, assisted with the implementation, and provided the screenshots for the results and analysis.

Cheng, Samuel Vincent T.

Handled implementation of the bot and wrote the part of the report about implementation and recommendations.

Custer, Mark John T.

Researched the symptoms for each disease, helped formulate the rules of the knowledge base, and wrote the report on the formulation of the knowledge base.

De Ramos, Ghrazielle Rei A.

Researched the symptoms for each disease, and wrote part of the report about the introduction of the domain, the chatbot's purpose, and significance to poor communities.

Appendix A

Let:

Has(x, y) “x has y disease”

Diseases:

Dengue(x)	“x has dengue fever”
Malaria(x)	“x has malaria”
Tuberculosis(x)	“x has tuberculosis”
Leptos(x)	“x has leptospirosis”
Typhoid(x)	“x has typhoid fever”
HBV(x)	“x has hepatitis B”
Rabies(x)	“x has rabies”
Pneumonia(x)	“x has pneumonia”
Influenza(x)	“x has influenza”
Cholera(x)	“x has cholera”

Symptoms:

HFever(x)	“x experiences High-grade Fever reaching 40C”
LFever(x)	“x experiences Low-grade Fever reaching 38C”
LTemp(x)	“x experiences Low Body Temperature than Normal”
Headache(x)	“x experiences a Headache”
Fatigue(x)	“x experiences Fatigue”
Malaise(x)	“x experiences Body Malaise”
Nausea(x)	“x experiences Nausea”
Vomiting(x)	“x experiences Vomiting”
Diarrhea(x)	“x experiences Diarrhea”
Dehydration(x)	“x experiences Dehydration”
Sweat(x)	“x experiences Heavy Sweating”
NSweat(x)	“x experiences Night Sweats”
Chills(x)	“x experiences Chills”
Rashes(x)	“x experiences Rashes”
BPain(x)	“x experiences Pain in Breathing”
SBreath(x)	“x experiences Shortness of Breath”
SGlands(x)	“x experiences Swollen Glands”
PCough(x)	“x experiences cough with phlegm”
DCough(x)	“x experiences dry cough”
Wheezing(x)	“x experiences wheezing”
SThroat(x)	“x experiences Sore Throat”

APain(x)	“x experiences abdominal pain”
MPain(x)	“x experiences muscle pain”
CPain(x)	“x experiences chest pain”
JPain(x)	“x experiences joint pain”
EPain(x)	“x experiences Pain behind Eyes”
ALoss(x)	“x experiences loss of appetite”
WLoss(x)	“x experiences weight loss”
NBleed(x)	“x experiences nose bleeding”
CBlood(x)	”x experiences coughing blood”
Pale(x)	“x experiences paler skin”
Jaundice(x)	“x experiences jaundice”
REyes(x)	“x experiences Red Eyes”
PBlood(x)	“x experiences Blood in Pee”
BSkin(x)	“x experiences bluish skin”
Hallucinations(x)	“x experiences hallucinations”
Sunken(x)	“x experiences Sunken Eyes”
LPressure(x)	“x experiences Low Blood Pressure”
Hydrophobia(x)	“x experiencesHydrophobia”
Anxiety(x)	“x experiences Anxiety”
Agitation(x)	“x experiences Agitation”
Situations:	
RabBite(x)	“x has been bitten by a rabies infected animal”
Flood(x)	“x had contact with flood water”
Wound(x)	“x has an open wound”
Unsafe(x)	“x has drank unsafe water”
Unsanitary(x)	“x has been living in an unsanitary condition”
Multiple(x)	“x has Multiple Sexual Partners”
PartnerHBV(x)	“x has a partner with Hepatitis B”
Shared(x)	“ x has shared needles, syringes, or drug equipments”
NHBV(x)	“x hasn’t been vaccinated with Hepatitis B vaccines”

Disease	Rules
Dengue fever	<p>IF:</p> <ul style="list-style-type: none"> • HFever(x) High-grade Fever • JPain(x) Joint Pain • OR MPain(x) Muscle Pain • OR APain(x) Abdominal Pain • NBleed(x) Nose Bleed • Pale(x) Paler Skin • Malaise(x) Malaise • Nausea(x) Nausea • OR Vomiting(x) Vomiting • Rashes(x) Rashes • OR EPain(x) Pain behind Eyes • OR SGlands(x) Swollen Glands <p>THEN x has Dengue.</p> <p> $(HFever(x) \wedge (JPain(x) \vee MPain(x) \vee APain(x)) \wedge NBleed(x) \wedge Pale(x) \wedge Malaise(x) \wedge (Nausea(x) \vee Vomiting(x)) \wedge (Rashes(x) \vee EPain(x) \vee SGlands(x))) \rightarrow Dengue(x)$ </p>
Malaria	<p>IF:</p> <ul style="list-style-type: none"> • HFever(x) High-grade Fever • Nausea(x) Nausea • OR Vomiting(x) Vomiting • OR Diarrhea(x) Diarrhea • JPain(x) Joint Pain • OR MPain(x) Muscle Pain • OR APain(x) Abdominal Pain • Malaise(x) Malaise • Chills(x) Chills • Sweat(x) Heavy Sweating • Jaundice(x) Jaundice

	<p>THEN x has Malaria.</p> $((HFever(x) \wedge (Nausea(x) \vee Vomiting(x) \vee Diarrhea(x)) \wedge (JPain(x) \vee MPain(x) \vee APain(x)) \wedge Malaise(x) \wedge Chills(x) \wedge Sweat(x)) \wedge Jaundice(x)) \rightarrow Malaria(x)$
Tuberculosis	<p>IF:</p> <ul style="list-style-type: none"> • LFever(x) Low-grade Fever • Fatigue(x) Fatigue • Chills(x) Chills • NSweat(x) Night Sweats • WLoss(x) Weight Loss • OR ALoss(x) Loss of Appetite • PCough(x) Cough with Phlegm • OR DCough(x) Dry Cough • CBlood(x) Coughing Blood • CPain(x) Chest Pain • BPain(x) Pain in Breathing <p>THEN x has Tuberculosis</p> $(LFever(x) \wedge Fatigue(x) \wedge Chills(x) \wedge NSweat(x) \wedge (WLoss(x) \vee ALoss(x)) \wedge (PCough(x) \vee DCough(x)) \wedge CBlood(x) \wedge CPain(x) \wedge BPain(x)) \rightarrow Tuberculosis(x)$
Leptospirosis	<p>IF:</p> <ul style="list-style-type: none"> • Wound(x) Open Wound • Flood(x) Contact with Flood Water • HFever(x) High-grade Fever • Headache(x) Headache • Chills(x) Chills • MPain(x) Muscle Pain • OR APain(x) Abdominal Pain • Diarrhea(x) Diarrhea • Vomiting(x) Vomiting • REyes(x) Red Eyes • Rashes(x) Rashes

	<ul style="list-style-type: none"> • SBreath(x) Shortness of Breath <p>⊕</p> <ul style="list-style-type: none"> • CBlood(x) Coughing Blood • OR PBlood(x) Blood in Pee • OR Jaundice(x) Jaundice <p>THEN x has Leptospirosis</p> <p> $(Wound(x) \wedge Flood(x)) \wedge (HFever(x) \wedge Headache(x) \wedge Chills(x)) \wedge (MPain(x) \vee APain(x)) \wedge (Diarrhea(x) \wedge Vomiting(x) \wedge REyes(x) \wedge Rashes(x) \wedge SBreath(x)) \wedge (CBlood(x) \vee PBlood(x) \vee Jaundice(x)) \rightarrow Leptos(x)$ </p>
Typhoid Fever	<p>IF:</p> <ul style="list-style-type: none"> - HFever(x) High-grade Fever - Chills(x) Chills - Headache(x) Headache - APain(x) Abdominal Pain - JPain(x) Joint Pain - OR MPain(x) Muscle Pain - Diarrhea(x) Diarrhea - OR Nausea(x) Nausea - OR Vomiting(x) Vomiting <p>⊕</p> <ul style="list-style-type: none"> - DCough(x) Dry Cough - OR ALoss(x) Loss of Appetite - OR Rashes(x) Rashes <p>THEN x has Typhoid Fever</p> <p> $(HFever(x) \wedge Chills(x) \wedge Headache(x) \wedge APain(x) \wedge (JPain(x) \vee MPain(x)) \wedge (Diarrhea(x) \vee Nausea(x) \vee Vomiting(x))) \wedge (DCough(x) \vee ALoss(x) \vee Rashes(x)) \rightarrow Typhoid(x)$ </p>
Hepatitis B	<p>IF:</p> <ul style="list-style-type: none"> - Multiple(x) “x has Multiple Sexual Partners” - PartnerHBV(x) “x has a partner with Hepatitis B” - Shared(x) “x has shared needles, syringes, or drug equipments” - NHBV(x) “x hasn’t been vaccinated with Hepatitis B”

	<p>vaccines”</p> <ul style="list-style-type: none"> - LFever(x) Low-grade Fever - Fatigue(x) Fatigue - JPain(x) Joint Pain - Nausea(x) Nausea - OR Vomiting(x) Vomiting - OR APain(x) Abdominal Pain <p>OR</p> <ul style="list-style-type: none"> - Jaundice(x) Jaundice - OR DUrine(x) Dark Urine - OR WLoss(x) Weight Loss - OR ALoss(x) Loss of Appetite <p>THEN x has Hepatitis B</p> <p><i>(Multiple(x) ∨ PartnerHBV(x) ∨ Shared(x) ∨ NHBV(x)) ∧ LFever(x) ∧ Fatigue(x) ∧ JPain(x) ∧ (Nausea(x) ∨ Vomiting(x) ∨ APain(x)) ∧ (Jaundice(x) ∨ DUrine(x) ∨ WLoss(x) ∨ ALoss(x)) → HB</i></p>
Rabies	<p>IF:</p> <ul style="list-style-type: none"> • HFever(x) High-grade Fever • Fatigue(x) Fatigue • Headache(x) Headache <p>OR</p> <ul style="list-style-type: none"> Hallucinations(x) Hallucinations OR Hydrophobia(x) Hydrophobia OR Anxiety(x) Anxiety OR Agitation(x) Agitation <p>THEN x has Rabies</p> <p>IF:</p> <ul style="list-style-type: none"> RabBite(x) “x has been bitten by a rabies infected Animal” <p>THEN x has Rabies</p> <p><i>(HFever(x) ∧ Fatigue(x) ∧ Headache(x)) ∧</i></p>

	$(Hallucinations(x) \vee Hydrophobia(x) \vee Anxiety(x) \vee Agitation(x)) \rightarrow Rabies(x)$ $RabBite(x) \rightarrow Rabies(x)$
Pneumonia	<p>IF:</p> <ul style="list-style-type: none"> - DCough(x) Dry Cough - OR PCough(x) Cough with Phlegm - LFever(x) Low-grade Fever - OR HFever(x) High-grade Fever - OR LTemp(x) Low Body Temperature - Chills(x) Chills - OR Fatigue(x) Fatigue - OR Malaise(x) Malaise - ALoss(x) Loss of Appetite - SBreath(x) Shortness of Breath - MPain(x) Muscle Pain - CPain(x) Chest Pain <p>OR</p> <ul style="list-style-type: none"> - BSkin(x) Bluish Skin Color - OR Wheezing(x) Wheezing <p>THEN x has Pneumonia</p> $(DCough(x) \vee PCough(x)) \wedge (LFever(x) \vee HFever(x) \vee LTemp(x)) \wedge (Chills(x) \vee Fatigue(x) \vee Malaise(x)) \wedge ALoss(x) \wedge SBreath(x) \wedge MPain(x) \wedge CPain(x) \wedge (BSkin(x) \vee Wheezing(x)) \rightarrow Pneumonia(x)$
Influenza	<p>IF:</p> <ul style="list-style-type: none"> - LFever(x) Low-grade Fever - Headache(x) Headache - SThroat(x) Sore Throat - DCough(x) Dry Cough - OR MPain(x) Muscle Pain - OR JPain(x) Joint Pain <p>THEN x has Influenza</p> $LFever(x) \wedge Headache(x) \wedge SThroat(x) \wedge (DCough(x) \vee$

	$MPain(x) \vee JPain(x) \rightarrow Influenza(x)$
Cholera	<p>IF:</p> <ul style="list-style-type: none"> - Unsafe(x) “x has drank unsafe water” - OR Unsanitary(x) “x has been living in an unsanitary condition” - Dehydration(x) Dehydration - Diarrhea(x) Diarrhea - Nausea(x) Nausea - OR Vomiting(x) Vomiting - Sunken(x) Sunken Eyes - OR APain(x) Abdominal Pain - OR LPressure(x) Low Blood Pressure <p>THEN x has Cholera</p> <p>$(Unsafe(x) \vee Unsanitary(x)) \wedge Dehydration(x) \wedge$ $Diarrhea(x) \wedge (Nausea(x) \vee Vomiting(x)) \wedge$ $(Sunken(x) \vee APain(x) \vee LPressure(x)) \rightarrow Cholera(x)$</p>