Artificial Intelligence Assignment 1
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Introduction

Background

My gym (Maties Gymnasium) - a high performance training centre recently decided to turn off their water fountain(s) that were providing gym goers such as myself a means by which to remain hydrated during training sessions. It is very important to remain properly hydrated while exercising since our body loses fluids through sweat and we need to replenish these fluids to avoid dehydration which can cause hospitalisation and in extreme cases - death.

I took it upon myself to talk to multiple staff members and fellow gym members to ask their opinion on the decision to disable the water fountain(s). Most agreed that there was no significant reason to do this since the risk of getting Covid-19 from the water fountain faucet while refilling a bottle is no greater than using the same fingerprint scanner that we use on the way in or contraction through the air or any other gym equipment. I completely understand that people should not drink directly from the outlet - but this is more common courtesy and decent hygiene than Covid-19 related. If people were bringing in their own water bottles - which they were then I could not see the “obvious health impact” that keeping the water fountain(s) on would cause, so I decided to draw upon this real life occurrence to create this bayesian network to visualise and demonstrate the utility of having the water fountain(s) on vs having them off in the context of South African gyms. I shall send Maties Gymnasium as well as other gyms that have shut down their water the findings if this project is successful in proving my hypothesis that 1. The risk of dehydration from a lack of access to water is significantly greater than the risk of catching Covid-19 from the water fountain(s), 2. The expected utility is greater having the water fountain(s) accessible vs not. .

Objective

The network will be used to determine whether South African gyms should turn off access to their water fountain(s) or whether they should continue to allow easy access to water to avoid the risk to their members of becoming dehydrated vs the potential risk of catching Covid-19 from these water fountain(s).

Potential user community

All South Africans that go to public gyms that have water fountain(s). These people that have been denied access to water can use these findings to strengthen their arguments against gyms that closed their water facilities.

Public gyms could use these findings to strengthen their stance (if they had opted to keep water fountain(s) open) and provide support for keeping their water facilities open or possibly see the results and change their mind and reopen water fountain(s) if they had previously closed them.

Problem analysis

Potential factors to considered

Current probabilities such as: likelihood of a South African to have Covid-19, likelihood that the person is a gym goer, likelihood that the person gets through the symptom checkpoint at the gym, risk of catching Covid-19 from a surface.

The other side is determining a weighting for the probability of catching Covid-19 from a water fountain vs the probability of becoming dehydrated.

Calculating the average risk of catching Covid-19 from a contaminated water fountain in a South African Gym:

Node 1:

According to the Harvard Health article [2], Covid-19 is contagious for up to 10 days after Symptoms occur, but a 14 day quarantine is still recommended to avoid contaminating others so I shall use 2 weeks as a time window for this evaluation.

I shall use the time frame from the 1st of October 2021 to the 14th of October for this evaluation. I shall use new cases as the measurement as this data is readily available. This is not necessarily totally accurate as it does not include people who have been reported just before this time frame and are still recovering with symptoms. It also does not include unreported cases.

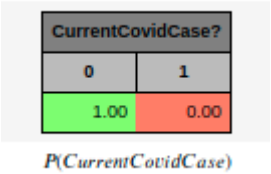
Day	New Cases
1	1635
2	1306
3	809
4	429
5	768
6	1149
7	989
8	924
9	816
10	648
11	201
12	592
13	942
14	947
Total Days: 14	Total New Cases: 12155

(Average New Cases per day for the 2 week period of October 1st to October 14th: 12155/14 = 868.2 ~> 869 New Cases per day.) Not useful, just interesting.

Let's use the total number of New Cases as our statistic for calculating the probability that any one gym goer is infected. I shall be using the time frame from the 15th of October onwards since this will be inclusive for all the past 14 days worth of new infections and anyone infected prior to that time will not be infectious and therefore does not matter for our calculations. I understand that not everyone infected will be documented so that is another shortcoming. It also does not include new cases so it assumes a similar/constant New Case rate.

Current Cases in South Africa (12155) / South African Population (51.39 million) [2020]:

12155/59310000 = **0.00020494014** chance that any one South African has an infectious case of Covid-19. All numbers are out of 1.0 (1.0 = 100%, 0.1=10% etc).



[0.99979505986,0.00020494014]
Unfortunately PyAgrum sometimes does automatic rounding as demonstrated above.

Node 2:
Next let's calculate the probability that any one of the 12155 Covid-19 infected people will be going to the gym on a specific day. I shall use a daily rate with the hopes that the water fountain(s) will be cleaned daily.

According to a 2006 study by Draper et al [3]:

The study believed that there are 750 gyms in South Africa, but only 442 were included in the study (59%).

The total number of members in the 442 facilities that reported their membership came to 813012, only 1.73% of the total South. Africa

So let's assume that the remaining 308 are similarly sized to the other 442 that would equate to a total of 333876.928~>333877 more gym members for a total of 1146889 total gym members in 2005. Let us assume that gym numbers have remained stable since then so I can take the total population of South Africa in 2005 and use this ratio to estimate the current number of gym goers in 2021.

The total population of South Africa in 2005 was 47.88 million. So the ratio of gym goers was
1146889/47880000 = 0.02395340434. Let's assume this ratio has remained constant. It probably has not with Covid-19 restrictions and lockdown etc but it would probably be much less so let us be generous in our calculations.
0.02395340434*59310000 = 1420676.41141~>1420677 South African gym goers in 2020 (latest population statistic) Let's assume the population has remained constant from 2020 to 2021.

Total South African Gym Goers/Total South African Population
So 1420677/59310000 = **0.02395341426** chance that a South African is a gym goer.

Node 3:

Symptoms checkpoint at the gyms were temperature is taken:

Article [4] Showed that 98.6% of Covid-19 symptoms included a fever which would be picked up by thermometer at the entrance to the gym with a confidence interval of 95% [5].

0.95*0.986 = 0.9367

So let's assume a 90% accuracy due to human error and poor conditions.

Gyms would have a 0.9 chance for detecting a fever that could be Covid-19 related and sending the person home.

So **0.1** chance of missing a Covid-19 infected person at the symptom checkpoint at a gym.

Node 4:

Risk of catching from surface:
(Assumption is infected person infected water fountain)
According to [6] in updated surface cleaning guidelines, the CDC says the risk for contracting the virus from a contaminated surface is less than 1 in 10,000, The New York Times reported.

Risk of catching Covid-19 from a water fountain = **0.0001**

Therefore the total risk of a single average gym goer catching Covid-19 from an infected water fountain is: P(Node 1)*P(Node 3|Node 1)*P(Node 4|Node 1, Node 3)= **0.00020494014*0.1*0.0001=0.0000000020494014 -** however this calculation is only for a single person who visits the gym so this number must be multiplied by everyone who visits the gym in a single day which will be shown later.

We can ignore Node 2 since the person is already a gym goer - this Node is set to true in the inference to show this.

Calculating the average risk of dehydration due to a lack of access to water fountain(s) in a South African Gym depending on time spent per session at gym:

Please note that this risk calculation is highly variable and it is not based solely on statistics due to a lack of available literature, but rather on a combination of anecdotal evidence and statistics.

Node 1:

Calculating probability that gym goer will bring enough water on their own accord to remain properly hydrated for their entire workout:

According to [7] which reviewed the 8 best water bottles, the sizes ranged from 17 ounces (~0.5 litres) to 25 ounces (~0.75 litres). Let's remember that some bottles are smaller (0.33 litres) and some are bigger (1 litre) obviously these are not the only options for bottle sizes but let us assume that the average bottle size is 0.5 litres for simplicity.

According to [8], the typical single-use plastic water bottle is 16.9 ounces (~0.5 litres). Let us hope for the sake of the environment that most gym goers are not using single-use plastic, but anyway this strengthens the argument for using 0.5 litres as our standard average bottle size.

When I asked the gym staff at Maties Gymnasium on the logic behind turning off the water fountain(s) they responded saying that it was a Covid-19 risk and that we should bring our own water. This may seem strange when I work out the risk above vs the risk for dehydration and I hope that this paper will make gyms reopen water facilities.

[I would like to note that many gym goers use supplements such as pre-workout which would require ~0.3 litres of water and this is taken before the workout begins so this is another bottle that they gym goer is 'required' to take as well as a water bottle so these gym goers already have 2 bottles to carry around with them… Many gym goers use other supplements for intra workout such as amino acids: Branched Chain Amino Acids and Essential Amino Acids or electrolyte supplements or energy drinks so this would require yet another bottle. 3 total so far. Many gym goers want to take their post workout shake directly after training to restore glycogen levels and get protein so 4 bottles might be needed for some gym goers - yet they would only need 1 if the fountain(s) was open. Bringing more than 2 bottles is cumbersome and many gym goers would not bring more than this number of bottles.]

I totally agree that every gym goer should have at least one water bottle to remain hydrated and to prevent infection from putting their mouth over the faucet. I believe that these faucet only taps should be turned off/not used and only people with bottles should be able to use the gym water facilities.

Dehydration accounts for 0.55% of all hospital visits according to [9].

One could argue that you could go to the bathroom to get water but this makes little to no sense as to why these water taps are on and yet the water fountain(s) are not. The risk of fecal matter and germs here is far greater!

One could also argue that the gym goer could purchase from the tuckshop/shop by the gym but these places are not always available/feasible or open at all times that people are gymming.

The following few paragraphs are according to [10], “Dehydration impairs your body's ability to regulate heat, which causes your body temperature and heart rate to rise. This causes you to feel more tired during exercise”.

Dehydration also weakens your mental function. This can negatively affect your: motor control, decision making, and concentration. When your body is dehydrated, your stomach also passes food into the small intestine more slowly than normal. This can cause your stomach to hurt. All of these differences in your body can reduce your performance during exercise.

How to prevent dehydration: "If you drink regularly during exercise, you can prevent the worst side effects of dehydration. Drinking enough water will prevent a decline in your concentration and skill level".

Drinking the right amount of water can also: prevent your heart rate from rising, prevent body temperature from rising, and improve performance during exercise.

How much fluid do you need during exercise: during exercise, you should drink 120-150 ml (4-5 ounces) of water every 10-15 minutes.

Let us split gym goers into 4 categories based on their time spent at gym: 30 minutes and less/60 minutes/90 minutes/120 minutes or more. However, some gym goers spend up to 3 hours at the gym so let’s assume that the average person spends 1.5 hours (90 minutes).

Category	Time spent at gym
1	30 minutes or less
2	60 minutes
3	90 minutes
4	120 minutes or more

The article [10] says that one should drink 0.12-0.15 litres so let's average that to 0.135 litres every 10-15 minutes so let's average that to every 12.5 minutes.

Let us remember that everyone is different and these averages are a shortcoming but are useful as a general idea for water consumption.

1:
30/12.5 = 2.4 ~ 3 water breaks of 0.135 litres which means that one 0.5 litre bottle is sufficient for group 1

2:
60/12.5 = 4.8 ~ 5 water breaks of 0.135 litres which means that one 0.5 litre bottle is not sufficient for group 2. They would have a deficit of 0.675-0.5 = 0.175 litres.

3:
90/12.5 = 7.2 ~ 8 water breaks of 0.135 litres which means that one 0.5 litre bottle is not sufficient for group 3. They would have a deficit of 1.08-0.5 = 0.508 litres. It is important to note that even with 2 full 0.5 litre bottles, this group would still not have enough water to completely prevent dehydration

4:
120/12.5 =9.6 ~ 10 water breaks of 0.135 litres which means that one 0.5 litre bottle is not sufficient for group 4. They would have a deficit of 1.35-0.5 = 0.85 litres under the recommended amount of water intake. Even with 2 water bottles this group would fall short of the recommended average water intake. It is important to note that this gets worse the longer these individuals train.

Some larger gym goers and heavy sweaters require even more water to hydrate adequately and this shows that people will not be able to do this without easy access to water fountain(s).

The above back of the hand calculations show that “bringing your own filled water bottle” is not a sufficient or sustainable solution to gym goers and it should be required that they have easy access to water points so they can refill their bottles and stay hydrated.

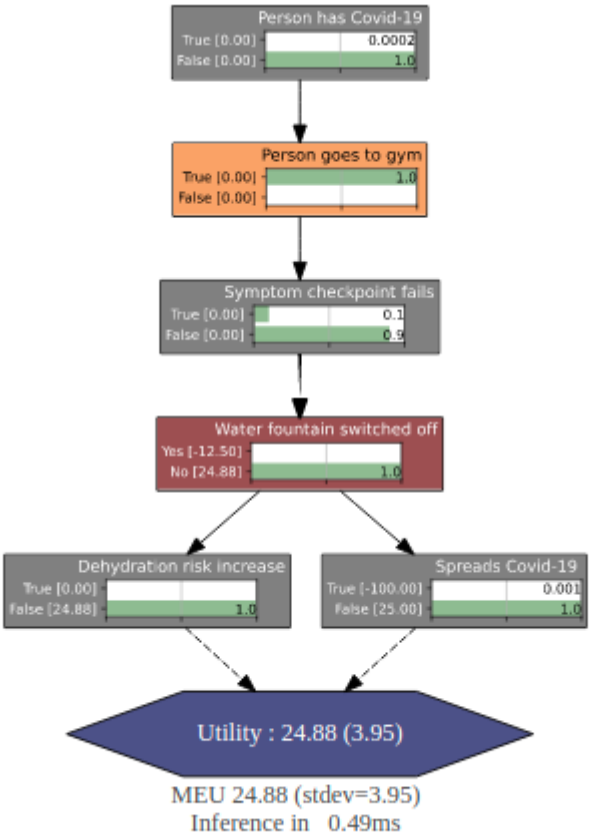
Due to the fact that ¾ of the four groups above would experience dehydration I can estimate that the probability of dehydration due to lack of access to water in gyms being **0.75** - at the very least - the risk for dehydration has increased significantly.

[According to [11], the bill of rights lists access to water as a basic human right so denying it is actually an act against the constitution of South Africa: Chapter 2 of the Constitution of South Africa provides that: “Everyone has the right to have access to sufficient food and water.”

Sufficient access is being prohibited by turning off the water fountain(s) in gyms.]

Decision Network model

Final model diagram created using pyAgrum below ->



A deeper dive into each individual node is provided in the problem analysis section. The action node is “Water fountain switched off” and it represents the action of having the fountain(s) on or off.

The linear structure is an easy way to demonstrate the follow-on variables needed to get to the bottom (leaf) nodes. The likelihood of each case being reached decreases as one moves through the network.

I used a utility weighting system of -100 (worst case scenario) to 100 (best case scenario). Negative is bad utility and Positive is good utility.

-100 represents the worst thing that could happen in the network (in this case spreading Covid-19)

I set the increase of risk of dehydration to be weighted at -25.

100 represents an imaginary case of curing Covid-19 (so this weight will not be used, but it is that to remain neutral) I used a utility weight of 25 as the max utility weighting which was for the prevention of dehydration. I made it 25 as opposed to 100 as I deemed catching Covid-19 4 times worse than becoming dehydrated for multiple reasons which included: dehydration does not last as long as Covid-19, you cannot spread dehydration to other people, it is much easier to cure dehydration than it is to cure Covid-19.

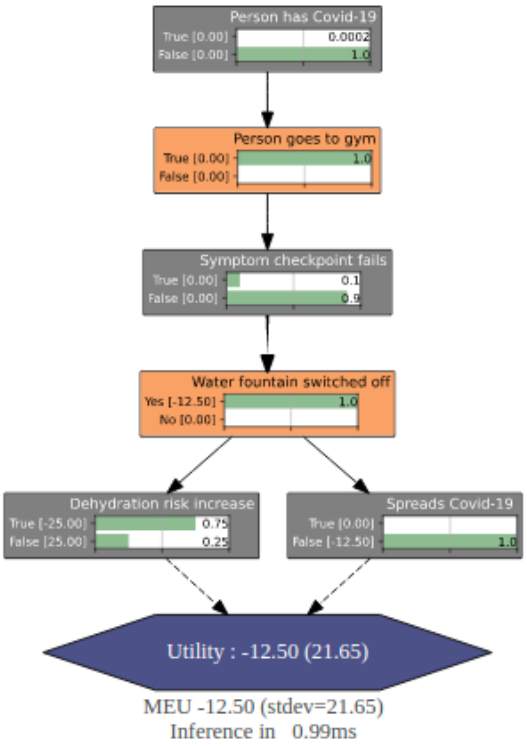
Model testing and evaluation

I set inference on the person being a gym goer to True since the symptom check would not occur otherwise.

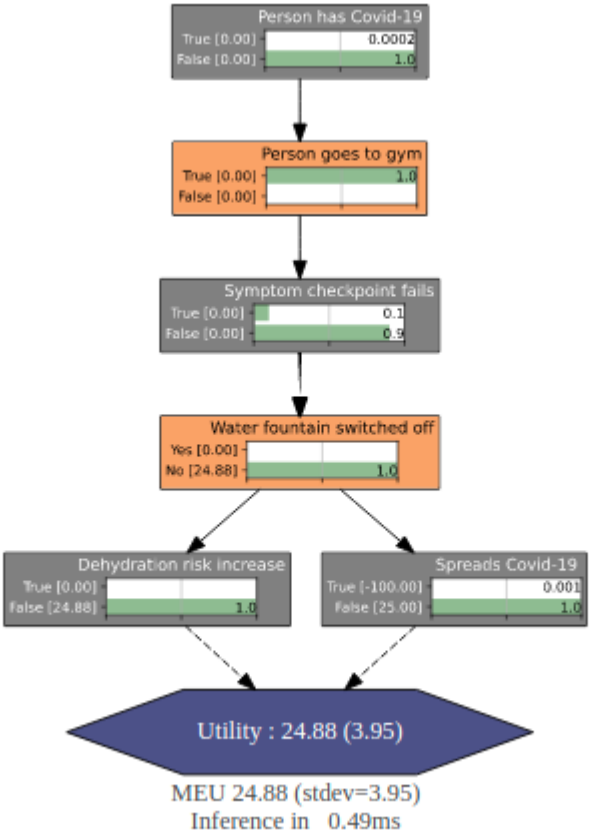
Inference does not change if any of the 3 initial variables are set to True. The initial 3 nodes are all independent in the network.

How it can be applied as a decision network to achieve the objective

Scenario 1: Water fountain is switched off : Yes



Scenario 2: Water fountain is switched off: No



This utility shows that it is effective and useful to keep the water fountain(s) on in South African gyms.

Conclusion

The probability of a person contracting Covid-19 from a water fountain is as follows according to the chain rule is as follows:

Letter representation	**Node**	**Probability of node**
A	Person has Covid-19	0.00020494014
B	Person goes to gym	0.02395341426
C	Symptom checkpoint fails	0.10
D	Dehydration risk increase	0.25 | Water fountain is switched off = False
E	Spreads Covid-19	0.001 | Water fountain is switched off = False

P(A)*P(B|A)*P(C|B,A)*P(E|A,B,C)=0.00020494014*0.02395341426*0.10*0.001 = **00000.000000004909016072** chance of a random person catching Covid-19 from a water fountain at a gym in South Africa.

Probability of a person attending a gym: (Assuming that everyone goes every day)
P(B) = 0.02395341426

Probability of a person having Covid-19:
P(A) = 0.00020494014

Probability of a person having Covid-19 given that they attend the gym P(A|B) = P(A)*P(B) = 0.00000490901

Let's assume the gym operates for 16 hours a day at half capacity throughout (restrictions were set to 250 people at a time) so let's use 125 as the mean capacity each hour. 16*250 = 4000.
Let us assume that the gym operates at an average amount of half capacity (2000).

16*125=2000 people at a specific gym that is operating at half capacity and is open 16 hours every day.

Probability that Covid-19 is spread at a gym water fountain: x*2000

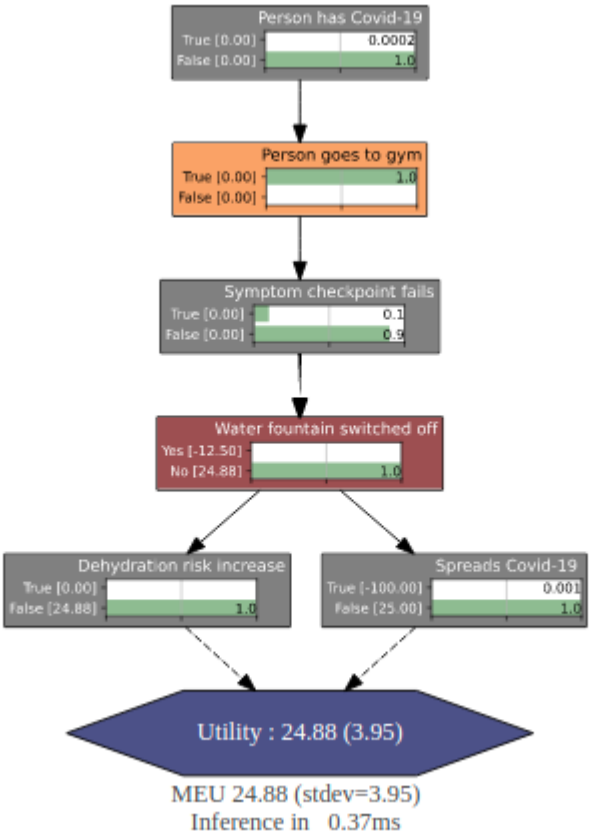
x=0.00020494014*0.02395341426*0.10*0.001=4.9090161e-10

Everyone at the gym goes to the gym.

So we can exclude that variable:
0.00020494014*0.10*0.001=2.0494014e-8
2.0494014e-8*2000=**0.00004098802** chance of any single gym goer spreading Covid-19 through the water fountain(s) on a particular day.

So given the above findings of **0.00004098802** chance of spreading Covid-19 via the water fountain(s) vs the much higher estimated probability of increasing the risk of dehydration **0.75**, it would make sense for gyms to allow access to their water facilities even during Covid-19 times.

Given the utility weighting of **-12.50** for fountain(s) off vs **24.88** for fountain(s) on - gyms should keep the water on.



References

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2. https://www.health.harvard.edu/diseases-and-conditions/if-youve-been-exposed-to-the-coronavirus#:~:text=By%20the%2010th%20day%20after,and%20their%20fever%20has%20resolved. (Harvard Health article)
3. Draper, Catherine & Grobler, Liesl & Kilian, GA & Micklesfield, Lisa & Lambert, Estelle & Noakes, Timothy. (2006). An inventory of the South african fitness industry. South African Sports Medicine Association. 18. 10.17159/2078-516X/2006/v18i3a240. https://www.researchgate.net/publication/277792119_An_inventory_of_the_South_african_fitness_industry
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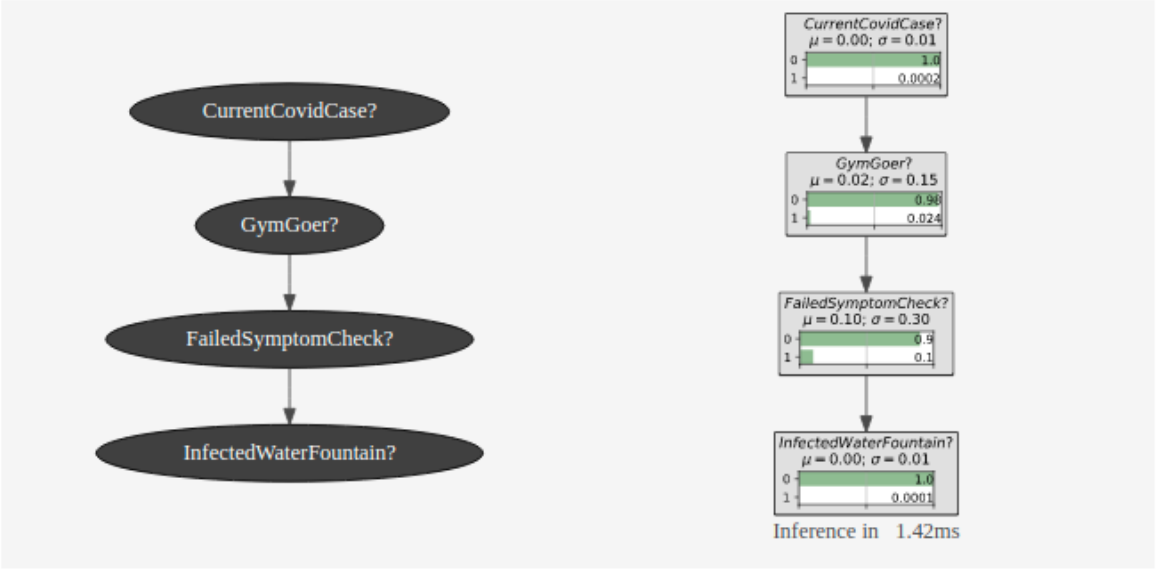
11. https://www.sahrc.org.za/home/21/files/SAHRC%20Water%20and%20Sanitation%20revised%20pamphlet%2020%20March%202018.pdf

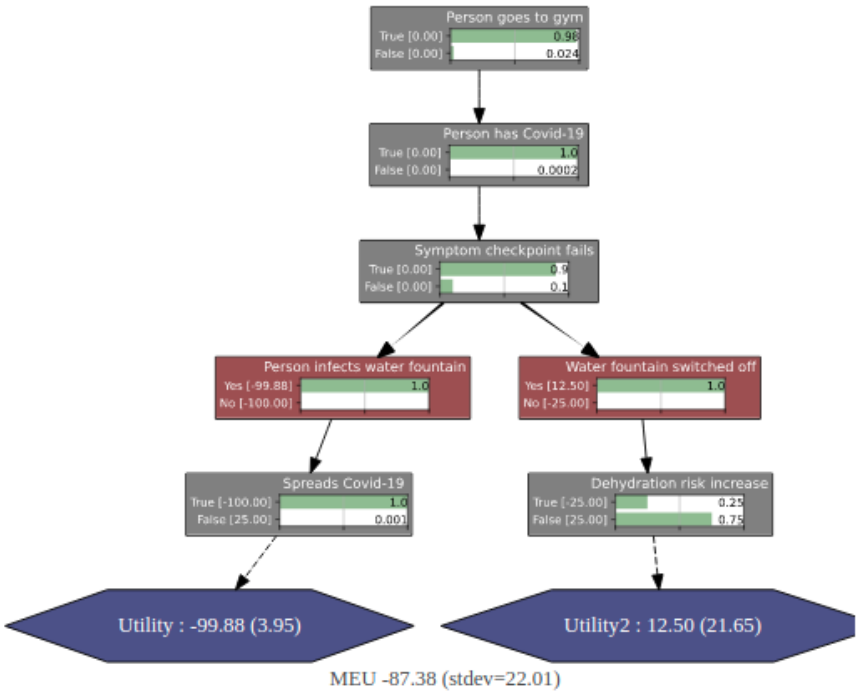
```
from pylab import *
import matplotlib.pyplot as plt
import os
import pyAgrum as gum
import pyAgrum.lib.notebook as gnb

bn = gum.fastID("Person has Covid-19{True|False}->Person goes to
gym{True|False}->Symptom checkpoint fails{True|False}->*Water fountain
switched off{Yes|No}->Dehydration risk increase{True|False}->$Utility;*Water
fountain switched off{Yes|No}->Spreads Covid-19{True|False}->$Utility")

bn.cpt("Person has Covid-19")[{}]=[0.00020494014,0.99979505986]

bn.cpt("Person goes to gym")[{"Person has Covid-19":
"True"}]=[0.02395341426,0.97604658574] #assuming person will go to gym with
Covid-19
bn.cpt("Person goes to gym")[{"Person has Covid-19":
"False"}]=[0.02395341426,0.97604658574] #we shall assume that going to gym is
independent of having Covide-19 (might be asymptomatic)

bn.cpt("Symptom checkpoint fails")[{"Person goes to gym": "True"}]=[0.10,0.90]
#checkpoint failure not affected by Covid-19
bn.cpt("Symptom checkpoint fails")[{"Person goes to gym": "False"}]=[0.10,0.90]
#assume independence (could be flu or hot weather etc)

bn.cpt("Spreads Covid-19")[{"Water fountain switched off": "No"}]=[0.001,0.999]
bn.cpt("Spreads Covid-19")[{"Water fountain switched off": "Yes"}]=[0.00,1.00]
#impossible to spread Covid-19 at the fountain if they don't infect the fountain

bn.cpt("Dehydration risk increase")[{"Water fountain switched off": "Yes"}]=[0.75,
0.25]
bn.cpt("Dehydration risk increase")[{"Water fountain switched off":
"No"}]=[0.00,1.00] #water fountain is on so no increase in dehydration risk

bn.utility("Utility")[{"Dehydration risk increase": "True"}]=-25
bn.utility("Utility")[{"Dehydration risk increase": "False"}]=25

bn.utility("Utility")[{"Spreads Covid-19": "True"}]=-100

gnb.showInference(bn,evs={"Person goes to gym":"True"}) #person goes to gym is
required to get to the symptom checkpoint
#gnb.showInference(bn,evs={"Person goes to gym":"True", "Water fountain
switched off": "No"}) #toggle No and Yes to see difference in utility between having
fountain access on vs off
```

pyAgrum Code Above

Appendix:

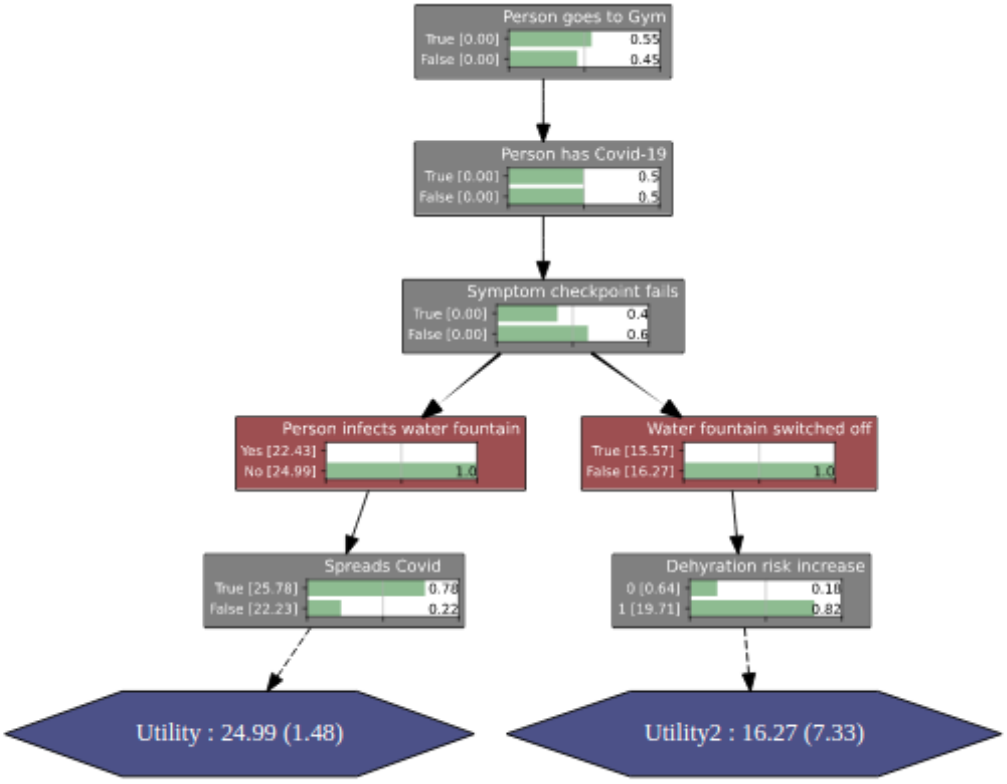
Earlier iterations of model to show continuous change and improvement:



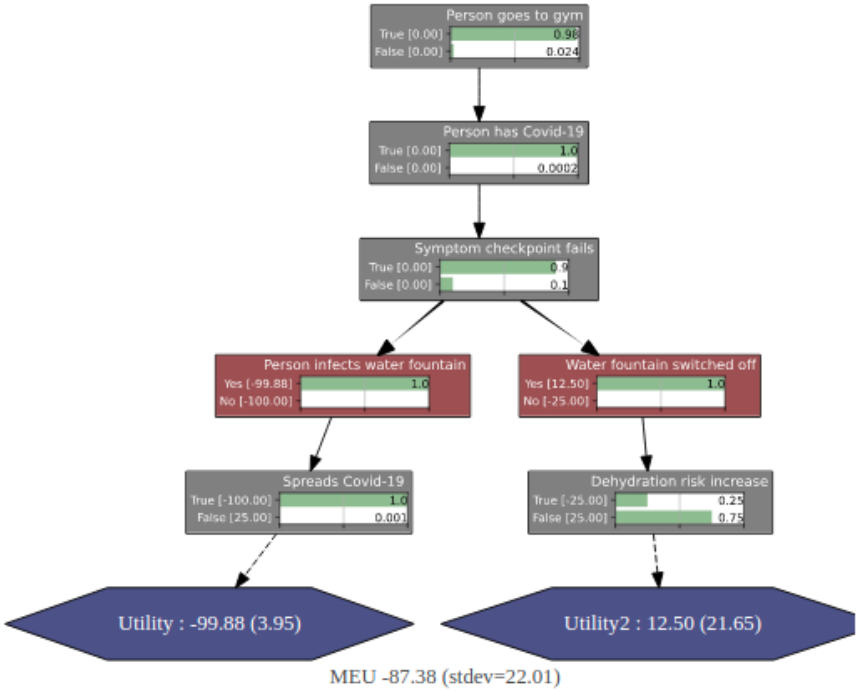


Inference does not change if any of the 3 initial variables are set to True. Utility remains constant. The utilities without any evidence for Utility 1 is -99.88 and for Utility 2 is 12.50.

MEU 30.38 (stdev=12.39)
Inference in 1.05ms



MEU 41.26 (stdev=7.47)
Inference in 1.01ms



Excluded Node: (One can just divide the findings by 8 for chance of catching Covid-19 from the water fountain(s) if they are vaccinated)

Total South African Vaccinated/Total South African Population:

According to https://covid19.who.int/region/afro/country/za
10797755 people have been fully vaccinated in South Africa.

10797755/59310000 = 0.18205622997% has been vaccinated. However due to an efficacy of 86% according to
https://www.yalemedicine.org/news/covid-19-vaccine-comparison

Let's reduce that to 0.86*0.18205622997 =0.15656835777% Effectively Vaccinated people in South Africa. Reduce risk of hospitalisation by 86% according to https://www.healthline.com/health-news/what-is-your-actual-risk-of-getting-covid-19-if-youre-vaccinated#Which-vaccine-is-better-to-reduce-risk-of-breakthrough-infection

Studies so far show that vaccinated people are 8 times less likely to be infected according to
https://www.cdc.gov/coronavirus/2019-ncov/vaccines/effectiveness/why-measure-effectiveness/breakthrough-cases.html

So I shall use Node 1 12155/59310000 divided by 8 = **0.00002561751** likely to get it from an infected person if vaccinated.