FIT3080 Assignment 2 Part 1 Report

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Author Note

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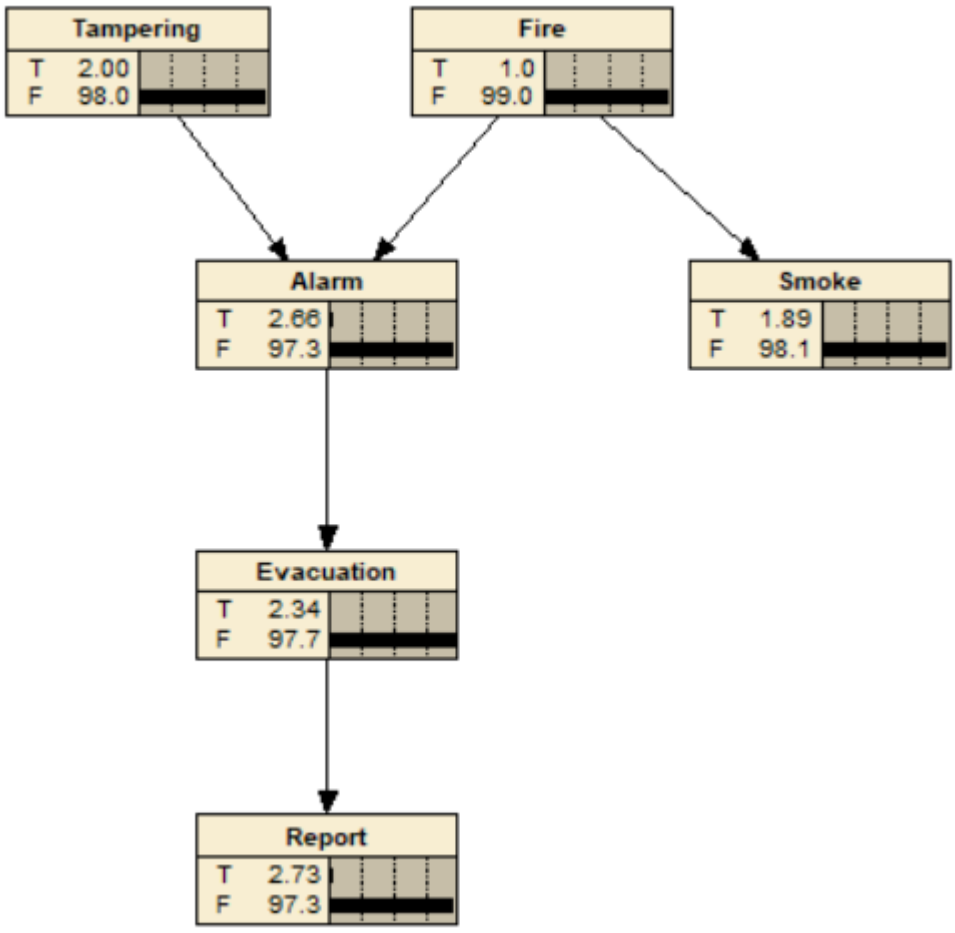
1(a)



Fire	$P(S \mid F)$ **Smoke** $P(\neg S \mid F)$	
	T	F
T	0.9	0.1
F	0.01	0.99

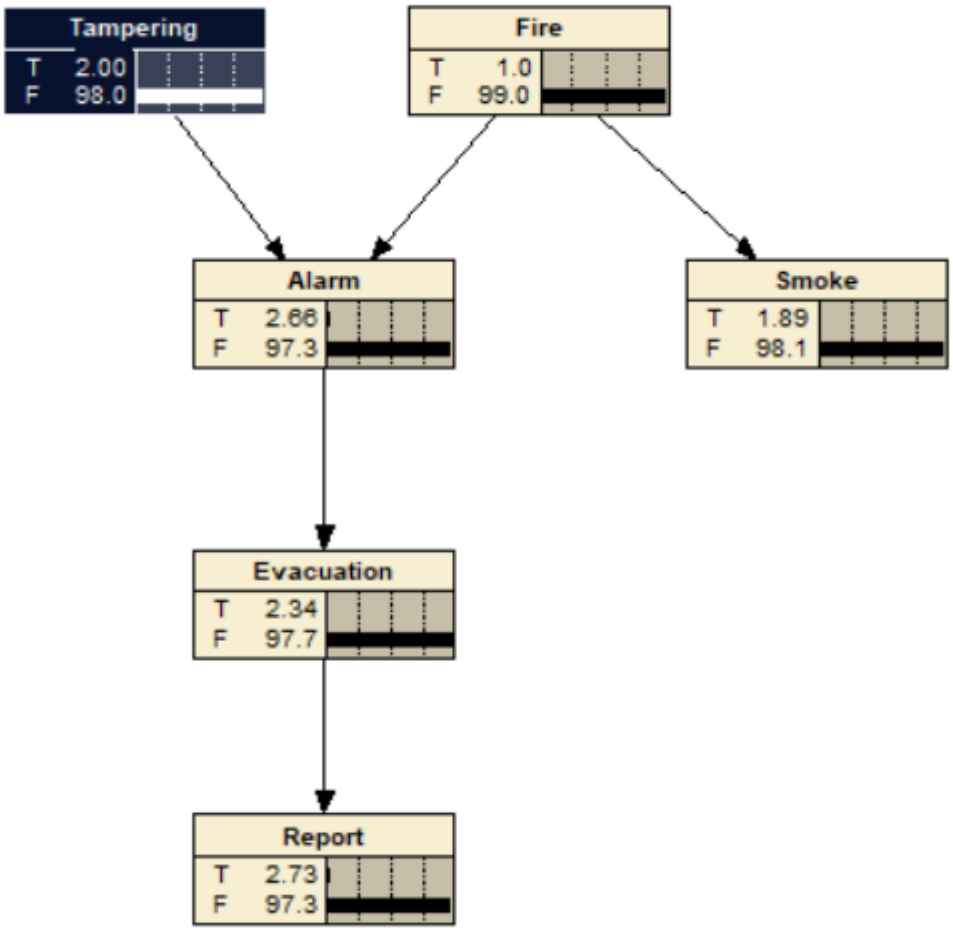
Alarm	$P(E \mid A)$ **Evacuation** $P(\neg E \mid A)$	
	T	F
T	0.88	0.12
F	0	1.0

Evacuation	$P(R \mid E)$ **Report** $P(\neg R \mid E)$	
	T	F
T	0.75	0.25
F	0.01	0.99

The Bayesian network is a directed graph in which each node represents a random variable X. An arrow from node X to Y indicates X as the parent of Y. Each node has a conditional

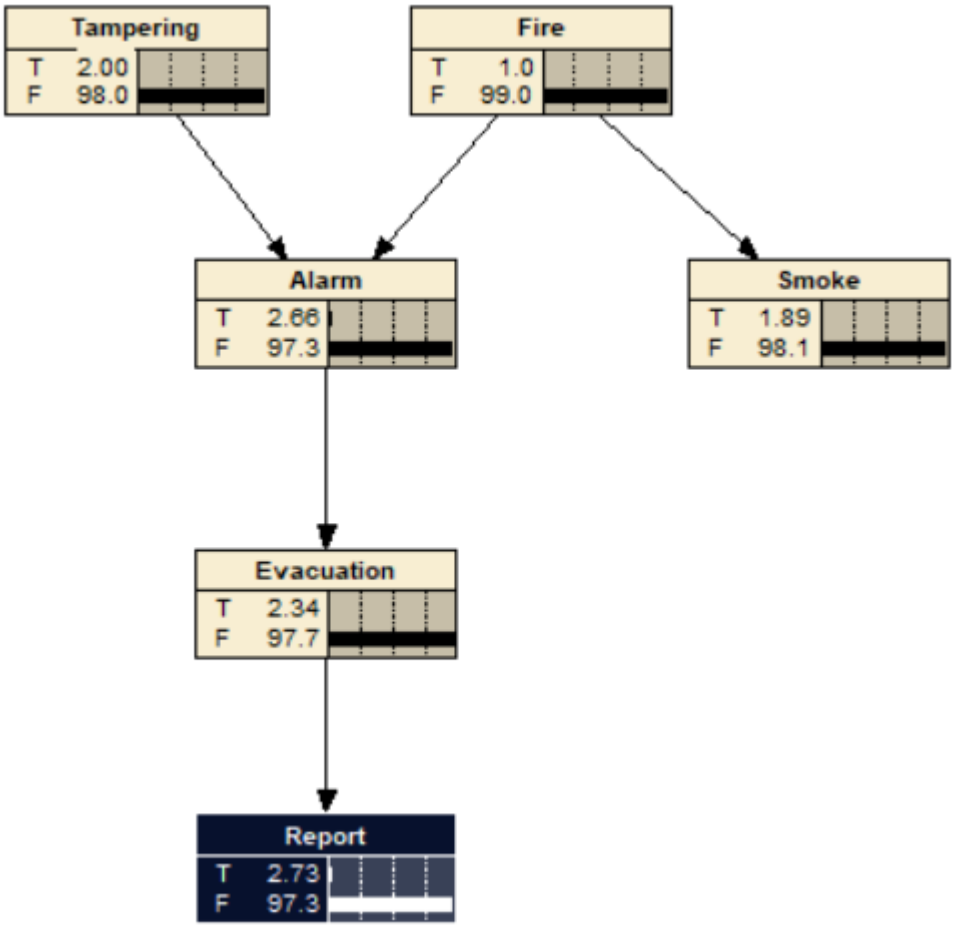
probability notated by $P(X_i|Parents(X_i))$ to quantify the direct influence of its parent(s) on it. The network structure shows that tampering and fire directly affect the probability of alarm to sound whereas the probability of evacuation and report to happen depends solely on alarm. Given the conditional probability table of smoke for each conditioning case of fire, smoke was able to be added into the structure with a link from fire indicating direct causal relationship. Hence, fire directly affect smoke and this concept applies for all the newly added nodes with alarm affecting evacuation and indirectly affecting report, a continuation from evacuation affecting report. Given their conditional probability table for each conditioning case of their parent, they were able to be added to the structure with a link from their parent.

(b)



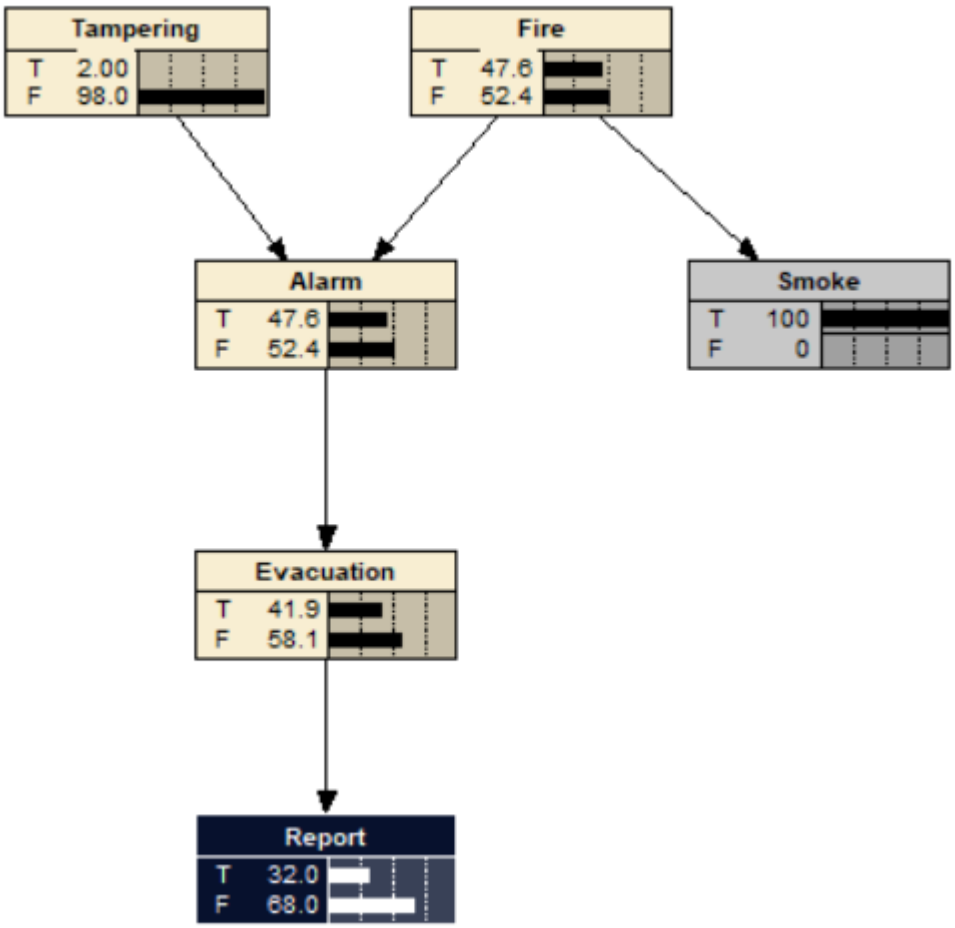
(i)

P(Tampering = T) = 0.02



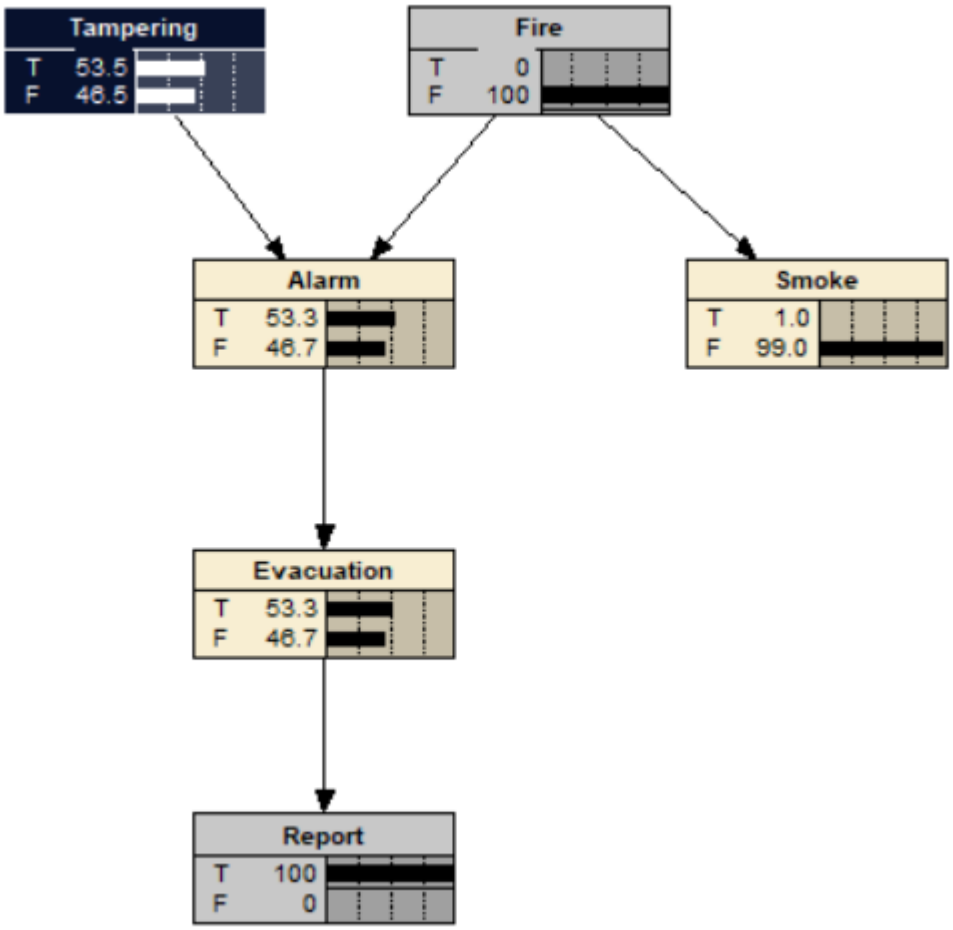
(ii)

P(Report = T) = 0.0273



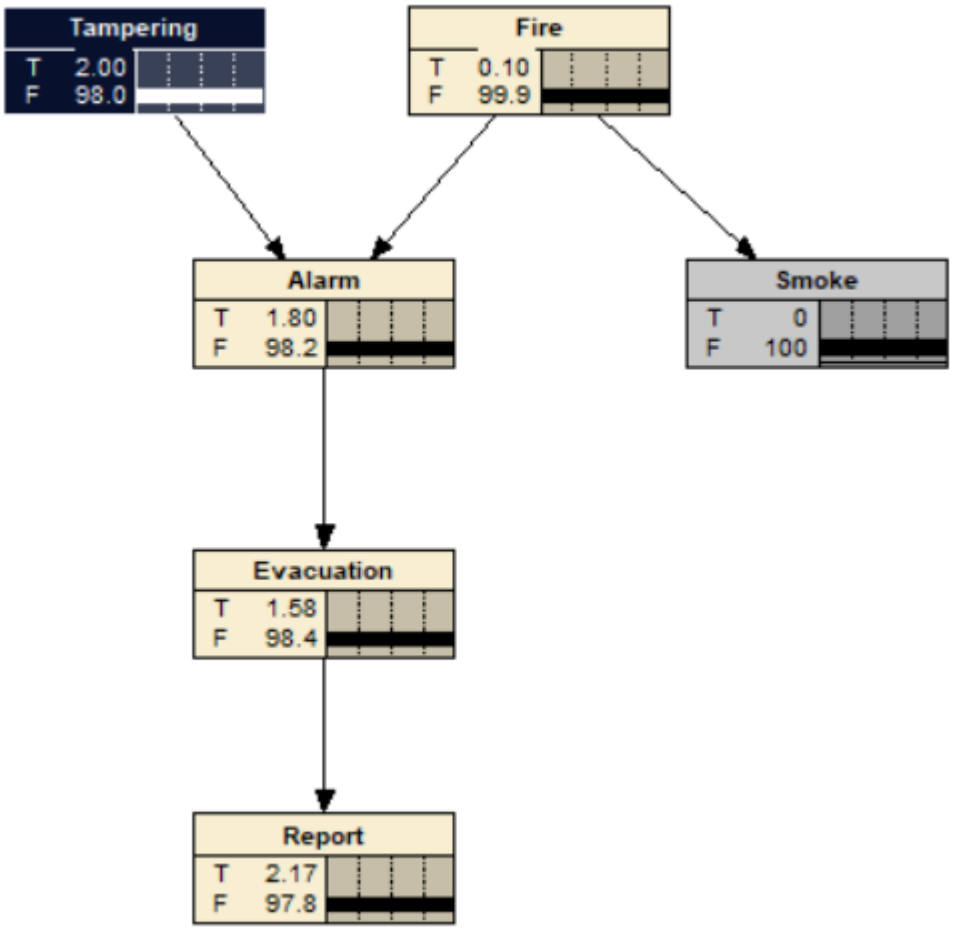
(iii)

P(Report = T | Smoke = T) = 0.32



(iv)

P(Tampering = T | Fire = F, Report = T) = 0.535

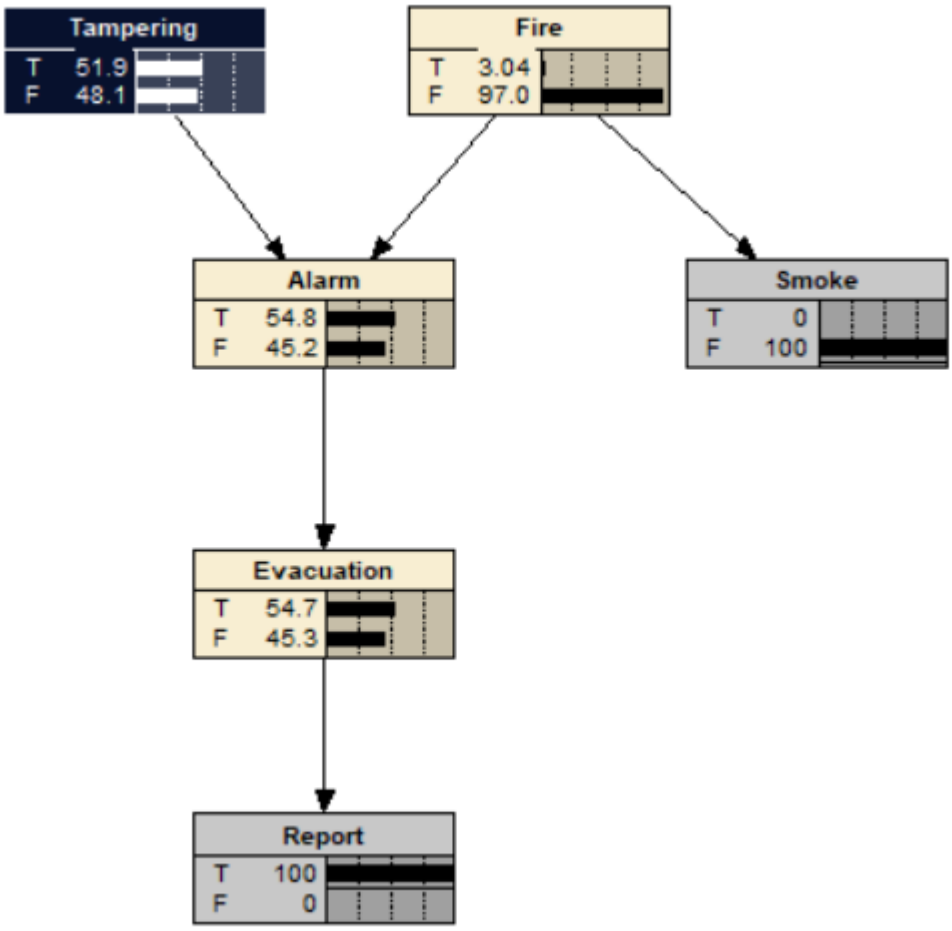


(v)

P(Tampering = T | Smoke = F) = P(Tampering = T) = 0.02

What conditional independence property could help you here?

Tampering ⫫ Smoke, given no observation on alarm and the absence of a link between tampering and smoke.

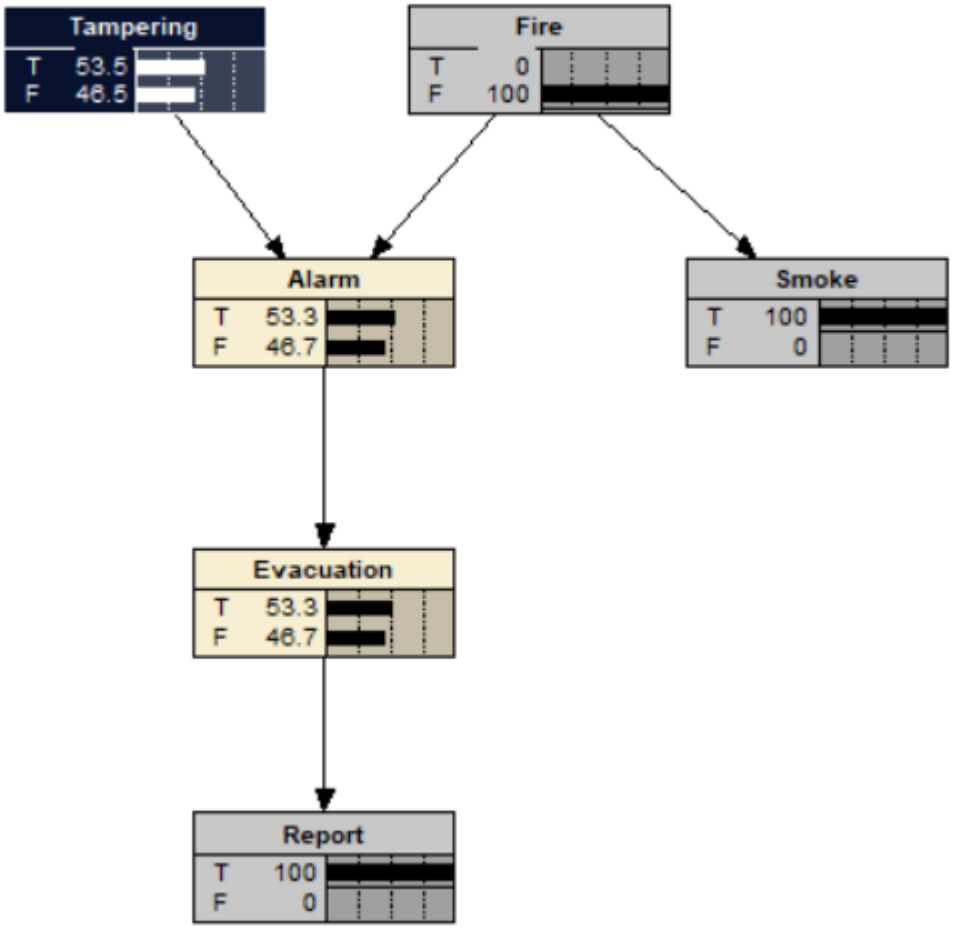


(vi)

P(Tampering = T | Smoke = F, Report = T) = 0.519

Given that the news report was observed, why does observing the absence of smoke affect your belief of whether or not your smoke alarm was tampered with?

Let Z = {Smoke, Report}. Given no observation on Fire, Alarm - Fire - Smoke is an active triplet which renders a path from Alarm to Smoke[I]. Tampering and Smoke is d-connected as Report – the descendant of the collider node Alarm – is a member of Z which consists of observed nodes. This is possible by backward sampling from the descendant to the ancestor. It creates an active triplet Tampering - Alarm - Fire which connects with the path from I. Hence, observing the absence of Smoke affects the conditional probability table of Fire which then affects the probability that the smoke detector has been tampered with.



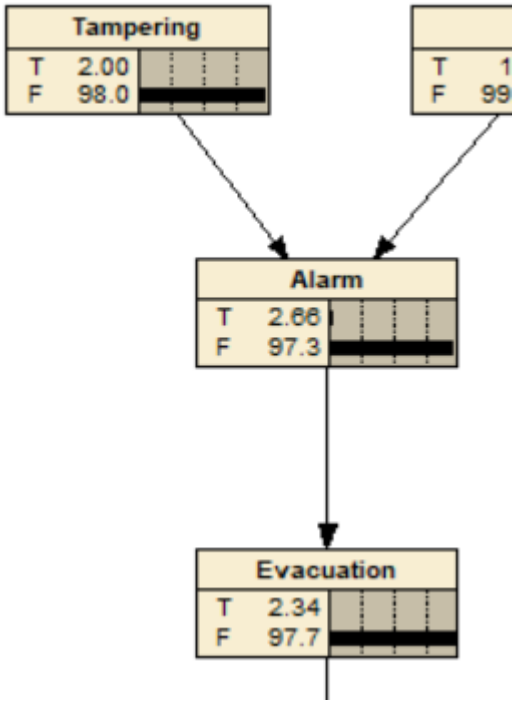
(vii)

P(Tampering = T | Fire = F, Report = T, Smoke = T) = 0.535

How does observing whether or not there is smoke affect your belief of whether or not your smoke detector has been tampered with? Why?

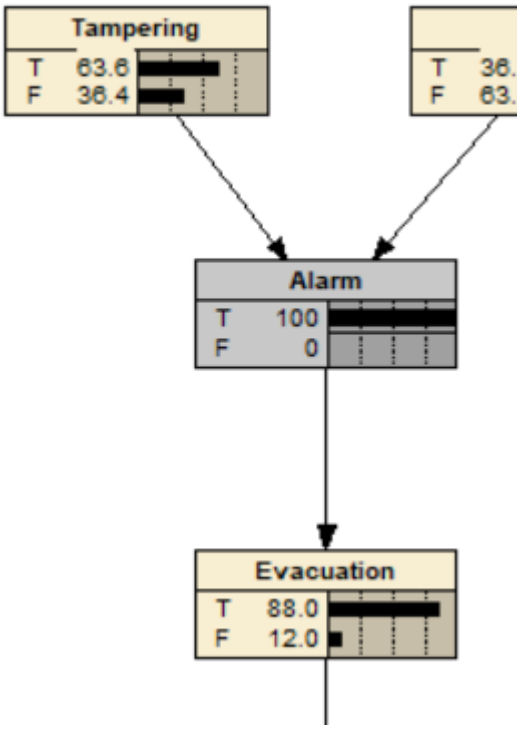
Let Z = {Fire, Report, Smoke}. Tampering and Fire is d-connected as Report – the collider between Tampering and Fire – is a member of Z which consists of observed nodes. It creates an active triplet between Tampering - Fire - Alarm which renders a path. However, Fire is also a member of Z. Observing Fire creates an inactive triplet between Alarm - Fire - Smoke which d-separates Tampering and Smoke. So, observing whether or not there is smoke does not affect the probability that the smoke detector has been tampered with.

(c)



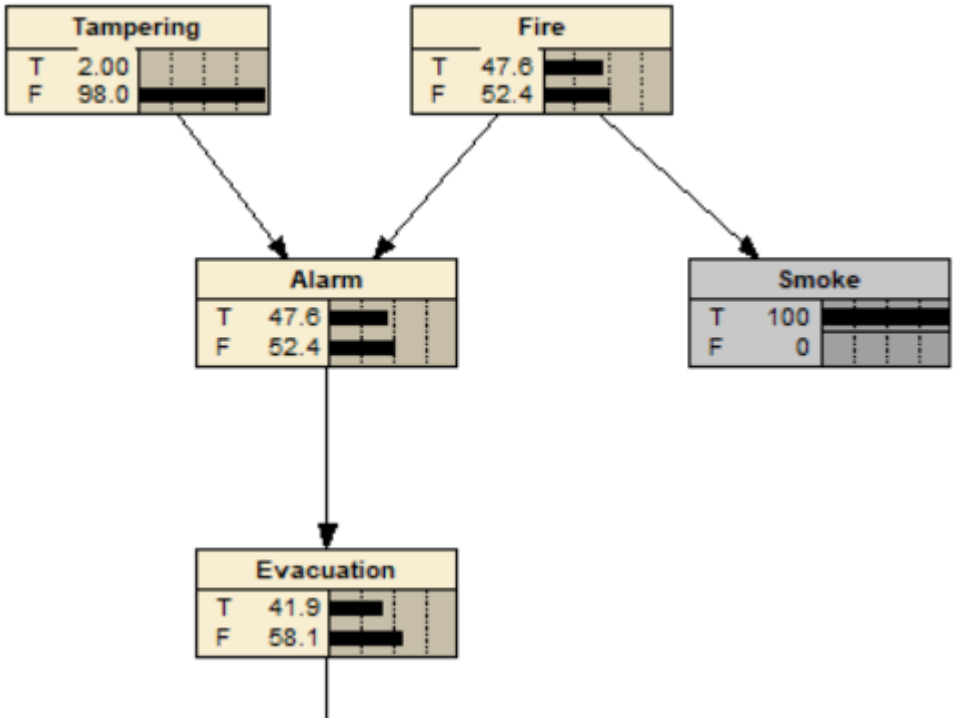
Tampering ⫫ Evacuation

False. None of the nodes between Tampering and Evacuation are colliders. None of the nodes are observed, hence, Tampering - Alarm - Evacuation is an active triplet which d-connects Tampering and Evacuation.



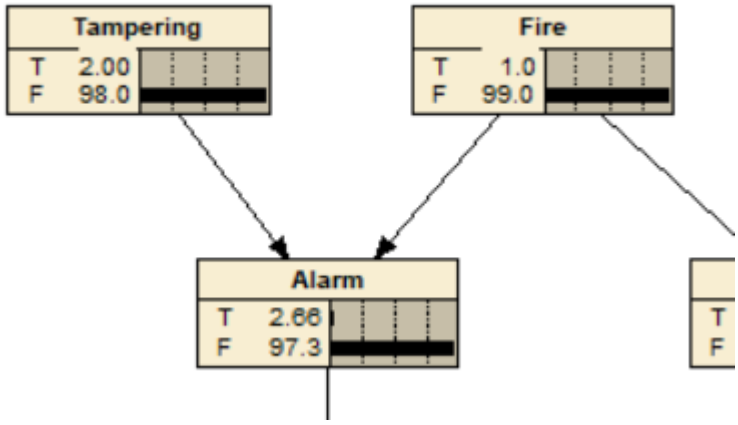
Tampering ⫫ Evacuation | Alarm

True. Let Z = {Alarm}. None of the nodes between Tampering and Evacuation are colliders. However, the Alarm node in between their path is a member of Z which consists of observed nodes. It creates an inactive triplet between Tampering - Alarm - Evacuation which d-separates Tampering and Evacuation.



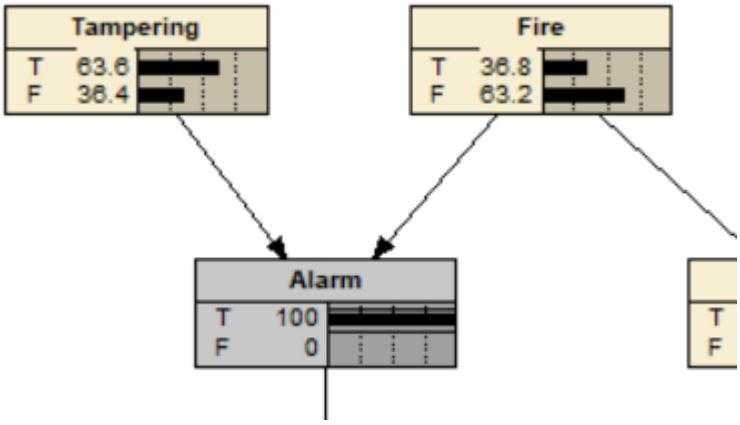
Tampering ⫫ Evacuation | Smoke

False. Given no observation on the collider (Alarm) or the descendants of the collider (Evacuation and Report)[I], Tampering - Alarm - Fire is an inactive triplet which d-separates Tampering and Smoke. Smoke is not a direct cause of Evacuation since it does not affect Tampering which eliminates the direct causal relationship between them. Hence, Tampering - Alarm - Evacuation is an active triplet (from I) which d-connects Tampering and Evacuation.



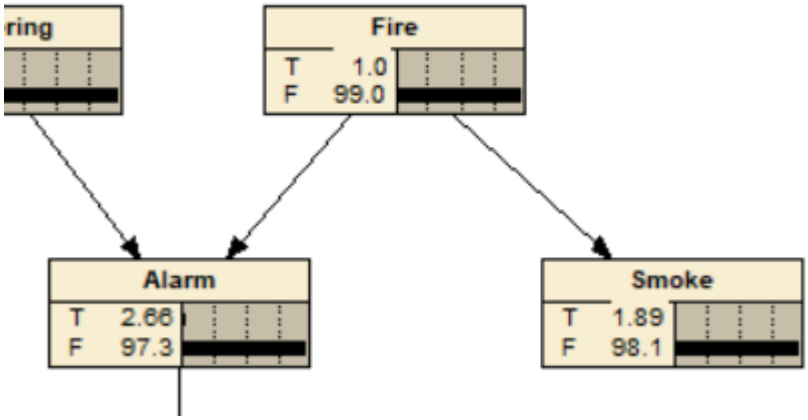
Tampering ⫫ Fire

True. None of the nodes are observed. Given no observation on the collider node Alarm, Tampering - Alarm - Fire is an inactive triplet which d-separates Tampering and Fire. There is also no other path from Tampering to Fire without having to traverse through Alarm.



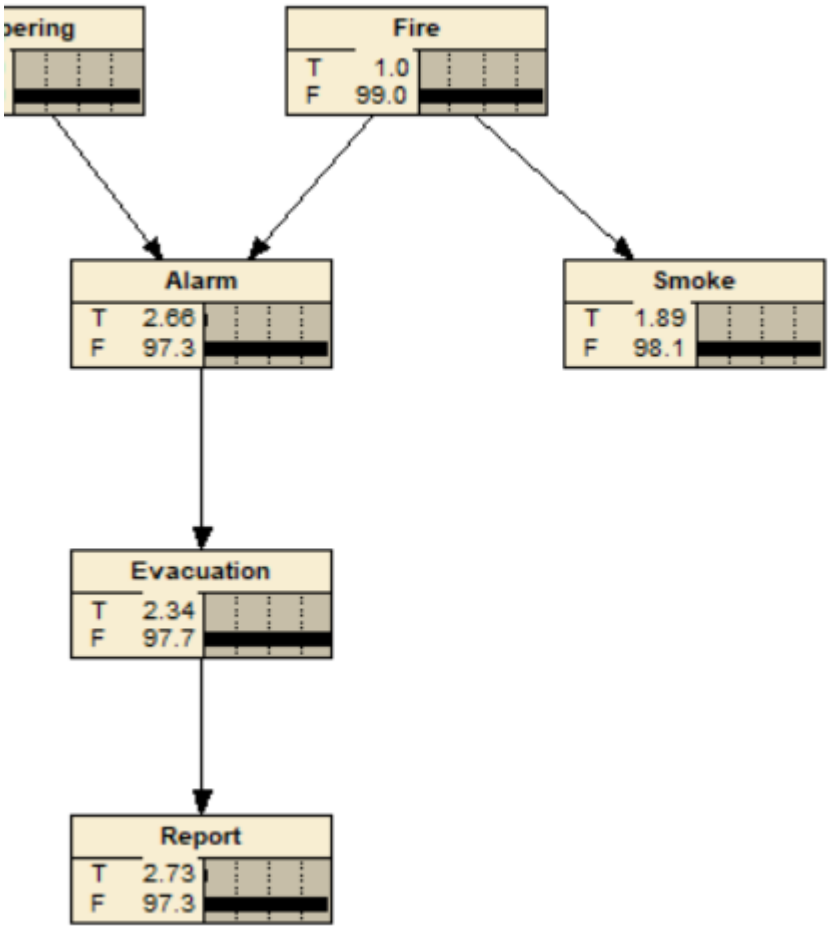
Tampering ⫫ Fire | Alarm

False. Let Z = {Alarm}. Tampering and Fire is d-connected as Alarm – the collider between Tampering and Fire – is a member of Z which consists of observed nodes. It creates an active triplet between Tampering - Alarm - Fire which renders a path.



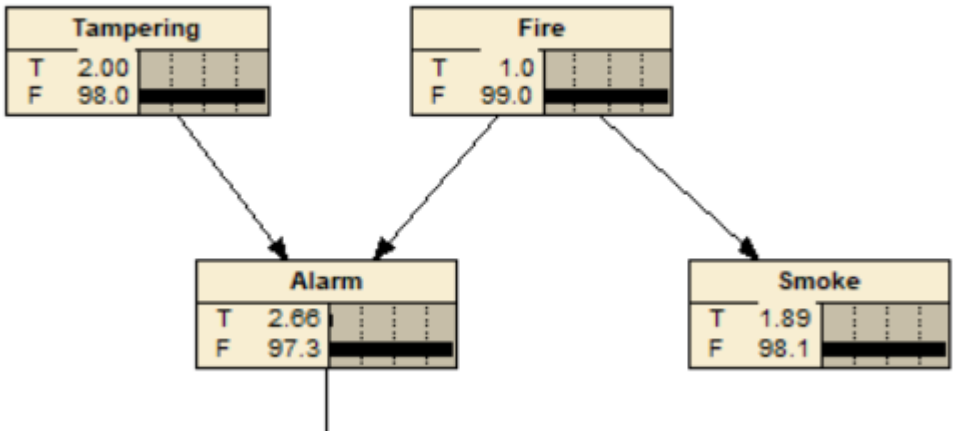
Alarm ⫫ Smoke

False. None of the nodes between Alarm and Smoke are colliders. None of the nodes are observed, hence, Alarm - Fire - Smoke is an active triplet which d-connects Alarm and Smoke.



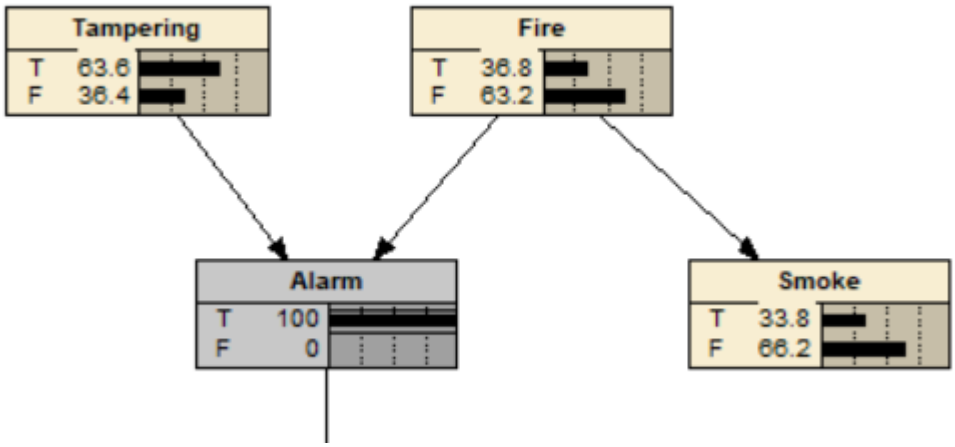
Smoke ⫫ Report

False. Given no observation on Evacuation, Alarm - Evacuation - Report is an active triplet which renders a path[I]. None of the nodes between Alarm and Smoke are colliders. None of the nodes are observed, hence, Report and Smoke is d-connected. It creates an active triplet between Alarm - Fire - Smoke which connects with the path from I.



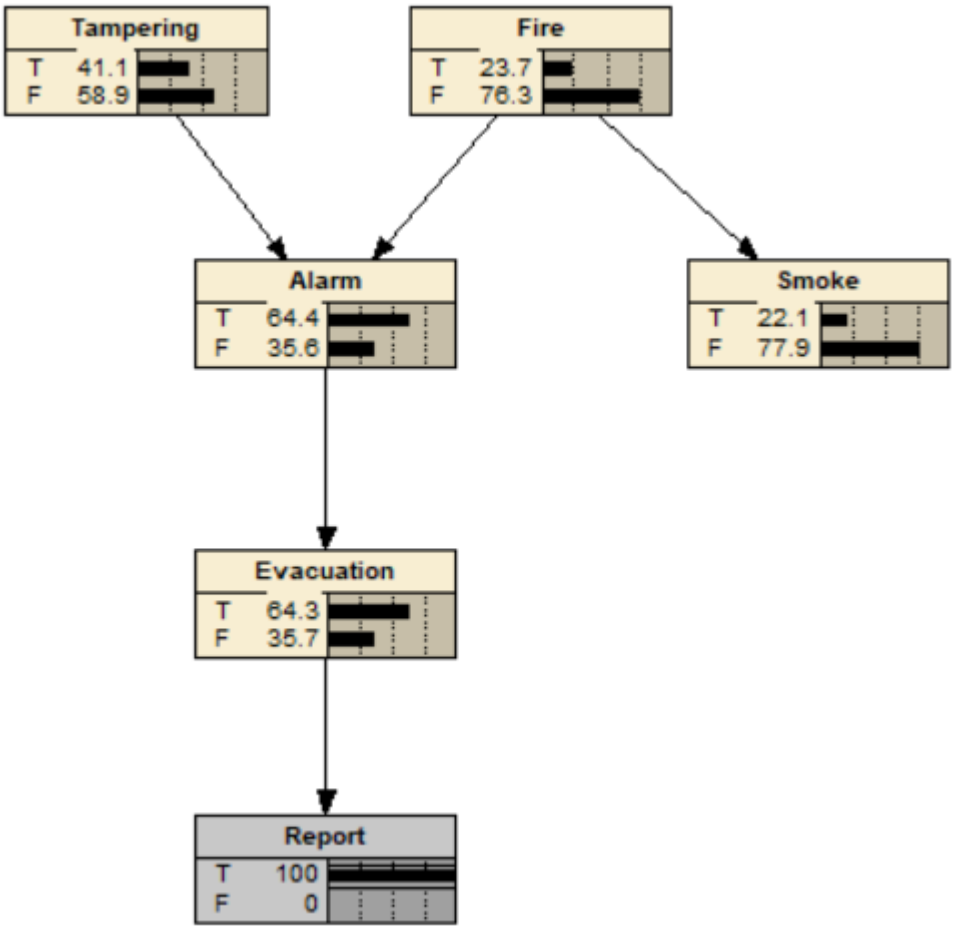
Smoke ⫫ Tampering

True. Given no observation on Fire, Alarm - Fire - Smoke is an active triplet which renders a path[I]. Also given no observation on Alarm, Tampering - Fire - Smoke is an inactive triplet which d-separates Tampering and Fire. There is also no other path from Tampering to Fire without having to traverse through Alarm, hence, Tampering and Smoke is d-separated despite connecting path with I.



Smoke ⫫ Tampering | Alarm

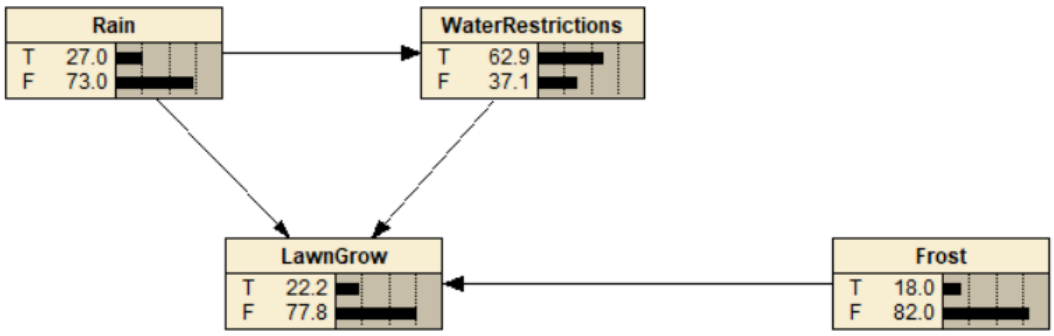
False. Let Z = {Alarm}. Given no observation on Fire, Alarm - Fire - Smoke is an active triplet which d-connects Alarm and Smoke[I]. Tampering and Fire is d-connected as Alarm – the collider between Tampering and Fire – is a member of Z which consists of observed nodes. It creates an active triplet between Tampering - Alarm - Fire which connects with the path from I.



Smoke ⫫ Tampering | Report

False. Let Z = {Report}. Given no observation on Fire, Alarm - Fire - Smoke is an active triplet which d-connects Alarm and Smoke[I]. Tampering and Fire is d-connected as Alarm – the descendant of the collider node Alarm – is a member of Z which consists of observed nodes. This is possible by backward sampling from the descendant to the ancestor. It creates an active triplet Tampering - Alarm - Fire which connects with the path from I.

2(a)



The Bayesian network is a directed graph in which each node represents a random variable X. An arrow from node X to Y indicates X as the parent of Y. Each node has a conditional probability notated by $P(X_i|Parents(X_i))$ to quantify the direct influence of its parent(s) on it. The network structure shows that rain and water restrictions directly affect the probability of lawn grow as well as frost. Given the conditional probability table of water restrictions for each conditioning case of rain, water restrictions was able to be added into the structure with a link from rain indicating direct causal relationship. Hence, rain directly affect water restrictions and this concept applies for all the newly added nodes with rain affecting lawn grow, water restrictions affecting lawn grow and frost affecting lawn grow. Given their conditional probability table for each conditioning case of their parent, they were able to be added to the structure with a link from their parent.

(b)

WaterRestrictions ⫫ Frost

The current value assignments to LawnGrow did not cause either of its conditioning case (T and F) to have the probability of 1.0 which otherwise would render it observed. That said, WaterRestrictions and Frost is d-separated because LawnGrow – the collider between WaterRestrictions and Frost – is not observed. It creates an inactive triplet between WaterRestrictions - LawnGrow - Frost which renders no path. There is also no other path from WaterRestrictions to Frost without having to traverse through LawnGrow.

Rain ⫫ Frost

The current value assignments to LawnGrow did not cause either of its conditioning case (T and F) to have the probability of 1.0 which otherwise would render it observed. That said, Rain and Frost is d-separated because LawnGrow – the collider between Rain and Frost – is not observed. It creates an inactive triplet between Rain - LawnGrow - Frost which renders no path. There is also no other path from Rain to Frost without having to traverse through LawnGrow.

(c)

Rain

T	F
27	73

“the area has been in drought for the previous 12 months”

Considering the above statement and the fact that rainfall decreases during severe drought (University of Southern Queensland, 2017), the probability for rain to fall has been decided to be 0.27 with reference to [1].

Frost

T	F
18	82

“there is a small chance that the area could experience another frost before the weather warms up”

Considering the above statement, the probability of frost to happen has been decided to be small and made smaller to emphasize the condition as stated that “the area has been in drought for the previous 12 months”. Values made with reference to [2].

WaterRestrictions

Rain	T	F
T	22	78
F	78	22

“if there is no rain, the authorities could increase the level of water restrictions”

Considering the above statement, the use of “could” introduces leniency in the possibility of water restriction despite the lack of rain. Thus, the probability of water restriction taken into action during dry period was made (0.78) more than a chance but also borderline less than top 20%. Water restriction during rainy period was kept reasonable (0.22) considering the condition as stated that “the area has been in drought for the previous 12 months”. Surely, safety measures are taken against the condition.

LawnGrow

Rain	WaterRestrictions	Frost	T	F
T	T	T	10	90
T	T	F	27	73
T	F	T	20	80
T	F	F	80	20
F	T	T	0	100
F	T	F	5	95
F	F	T	10	90
F	F	F	27	73

“If there is no rain before summer, it will be very hard to get the new lawn to grow”

“if there is no rain, the authorities could increase the level of water restrictions, meaning that Ron will be unable to water his lawn at all”

Considering the above statements, the opposite where water source is available may increase the chance for the lawn to grow.

$P(LawnGrow = T|Rain = T)$ *or* $P(LawnGrow = T|WaterRestrictions = F)$

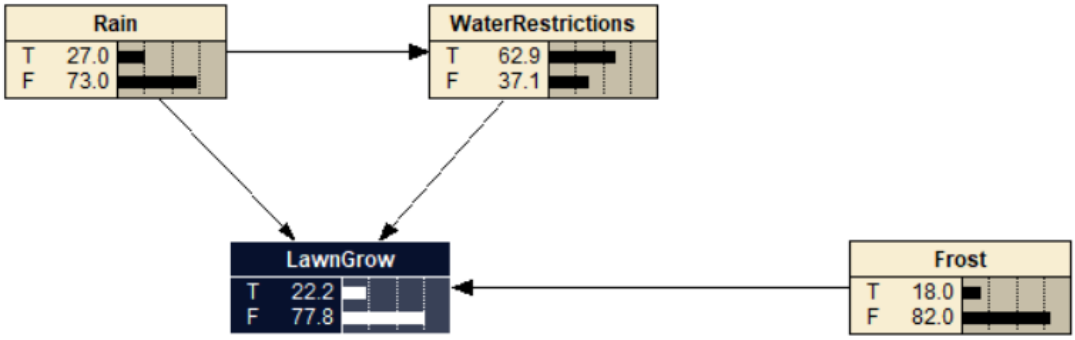
Referencing [1] and the marginal probability for rain to fall, the probability of lawn to grow was made 0.27 whenever water source is available which points to the conditioning cases $\boldsymbol{Rain = T}$ **or** $\boldsymbol{Water\ Restrictions = F}$. Thus, the probability of conditioning cases $\boldsymbol{Rain = F}$ **or** $\boldsymbol{Water\ Restrictions = T}$ has been made very small (0.1) to indicate “very hard” rather than impossible. There is a 0.8 probability for the lawn to grow if both water sources are available to illustrate the desperation for and importance of water in the question.

“there is a small chance that the area could experience another frost before the weather warms up, which also could damage the new lawn”

Considering the above statement, there is a small chance for the lawn to grow even while faced with frost from the use of “could”. The probability of lawn to grow during the frost period was kept reasonable (0.20) but lower than the probability of lawn to grow with water sources available. Values made with reference to [2].

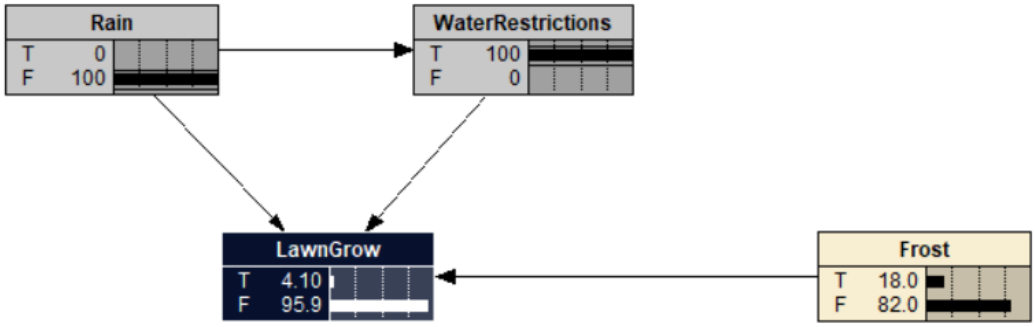
Furthermore, the probability of $Rain = F$ **and** $Water\ Restrictions = F$ is 0 to indicate the impossibility when there are no water source at all and $Frost = T$[I]. A low 0.05 was decided for the conditioning case $Rain = F$ **and** $Water\ Restrictions = T$ and $Frost = F$ just to show the different chances from I.

(d)



(i)

P(LawnGrow = T) = 0.222

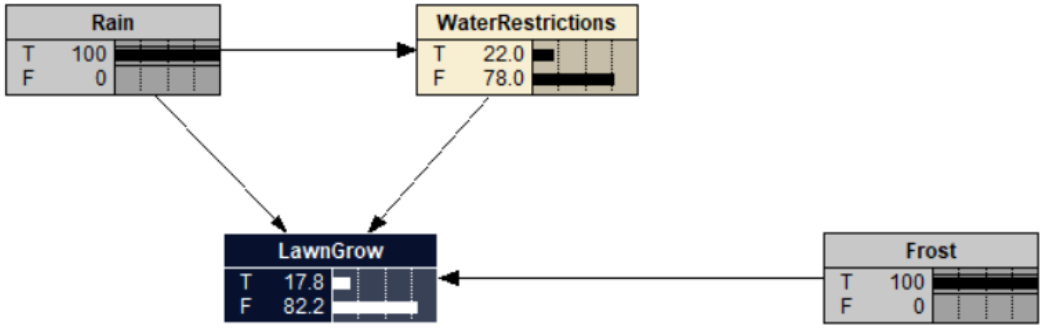


(ii)

P(LawnGrow = T | Rain = F, WaterRestrictions = T) = 0.041

Explain your results compared to item 1.

Let Z = {Rain, WaterRestrictions}. As there exist a link from both Rain and WaterRestrictions to LawnGrow, it indicates direct causal relationship. Rain and WaterRestrictions directly affect LawnGrow. Observing both Rain and WaterRestrictions affects the conditional probability distribution of LawnGrow, hence, the change in values compared to item 1.



(iii)

P(LawnGrow = T | Rain = T, Frost = T) = 0.178

Explain your results compared to item 1.

Let Z = {Rain, Frost}. As there exist a link from both Rain and Frost to LawnGrow, it indicates direct causal relationship. Rain and Frost directly affect LawnGrow. Observing both Rain and Frost affects the conditional probability distribution of LawnGrow, hence, the change in values compared to item 1.

3(a) Income -> Rent_charged

Instantiating Property_area – the collider between Income and Housing_prices – creates an active triplet between Income - Property_area - Housing_prices which renders a path[I]. Then, **instantiating** Tenant – the collider between Housing_prices and Rent_charged – creates an active triplet between Housing_prices and Rent_charged which renders a path[II]. Housing_prices must be **uninstantiated** to connect path I and II. Now, evidence can be propagated along the path and the value of Rent_charged can be determined by diagnostic reasoning from Tenant.

(b) Happiness -> Property_area

No nodes should be **instantiated** whereas Tenant must be **uninstantiated** to create an active triplet between Housing_prices - Tenant - Happiness which renders a path[I]. Then, Housing_prices must be **uninstantiated** to create an active triplet between Property_area - Housing_prices - Tenant which connects with the path from I. Now, evidence can be propagated along the path and the value of Property_area can be determined by causal reasoning from Housing_prices.

(c)

Income -> Rent_charged

Previously, Property_area and Tenant were **instantiated**. Now, no nodes should be instantiated whereas Property_area and Tenant must be **uninstantiated** to create an active triplet between Income - Property_area - Tenant and Property_area - Tenant - Rent_charged respectively which renders a connected path. Evidence can then be propagated along the path and the value of Rent_charged can be determined by diagnostic reasoning from Tenant.

Happiness -> Property_area

Previously, no nodes were **instantiated**, and the stand remained after the arc addition from Property_area to Tenant. Except that evidence propagation along the path traverse lesser node, from previously Happiness - Tenant - Housing_prices - Property_area to now Happiness - Tenant - Housing_prices. Now, Tenant must be **uninstantiated** to create an active triplet between Property_area - Tenant - Happiness which renders a path and as before, the value of Property_area can be determined by diagnostic reasoning from Tenant.

References

[1]University of Southern Queensland. (2017). *Will It Rain?* Queensland: University of Southern Queensland.

[2]Madadgar, S., AghaKouchak, A., Farahmand, A., & Davis, S. J. (2017). Probabilistic estimates of drought impacts on agricultural production. *AGU Publications*.