



# CAT: The Causal Attribution Tool

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- SM: CAT Demo – walk through main features & how it integrates with ABNMS DB
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# CAT

To try out CAT see <http://causalattribution.org:3000/>.

To read more about CAT (the Explainer) see [http://causalattribution.org:3000/what\\_is\\_cat](http://causalattribution.org:3000/what_is_cat)

KK



# CAT Introduction

BN tools are quite familiar by now; they've been around for decades.

They have been used for a great variety of tasks:

- Assessing evidence (Fenton, et al., 2016)
- Argument Analysis (Nyberg, et al., 2022)
- Modeling & Prediction (Marcot & Penman, 2019; Arora, et al., 2019))
- Explanation
- Hypothetical Reasoning (Glymour & Danks, 2007)



Which of these involve causal reasoning?

KK



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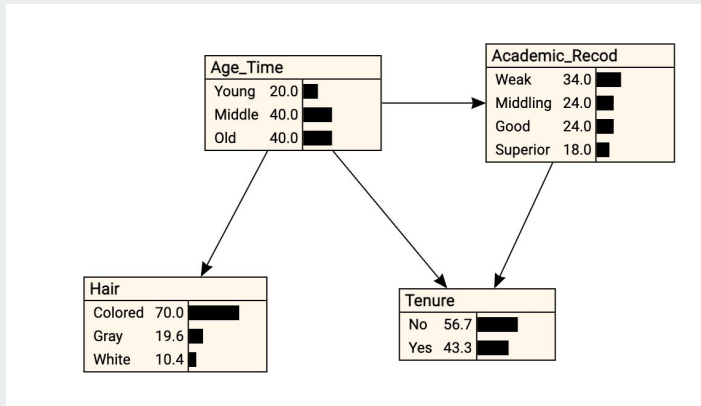


Which of these involve causal reasoning? Marked in green.

KK



## CAT Introduction



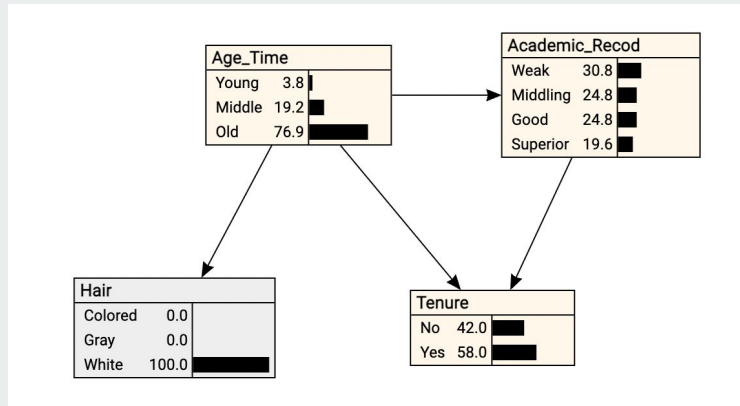
With this model we can reason probabilistically about all kinds of things. E.g., what's the average age of tenured academics?

This is a causal BN, but can't answer causal questions (using ordinary BN tools).

KK



## CAT Introduction



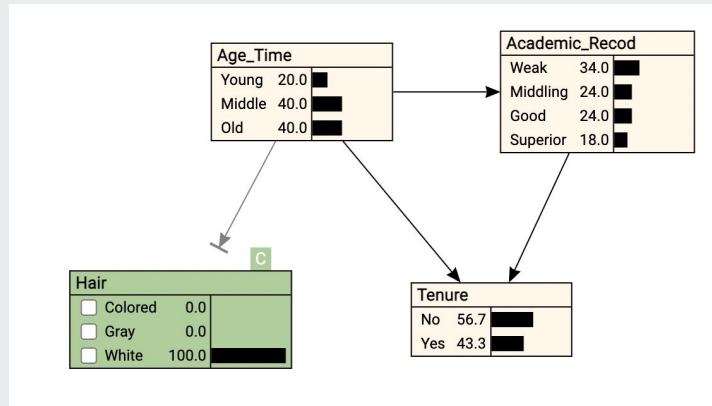
This BN can answer: What's the probability of tenure given white hair?

What we can't ask, and get a sensible answer for, is: How will bleaching my hair white affect my chances of getting tenure? (without special hacks)

KK



## CAT Introduction



This is the causal model that answers that question.

You can get it by:

- Hacking a BN (but has to be done just right!!)
- Using CAT (simples)



KK



## CBNs v BNs

Importantly, CAT can give you the verdict on causal attribution questions:

- Did A cause B?
- How much did A contribute to B? More than C?

According to a variety of causal criteria.



Caveat Emptor: CAT requires its models to be **causal**. With non-causal networks you will get nonsensical results.

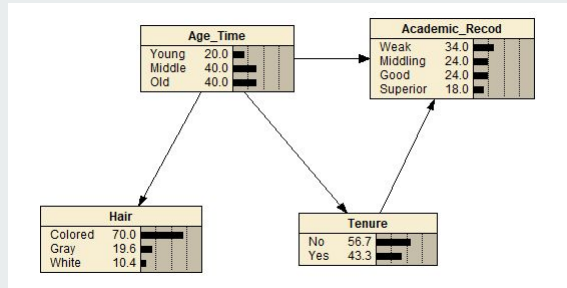
Sourcing, and validating, a causal BN (e.g., machine learning, expert elicitation) is an issue that must precede use of CAT.

KK



## CBNs v BNs

It's critical that you establish the model for CAT is *causal*. Otherwise, CAT's answers will be nonsensical. E.g.,



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# Causal Criteria

Association v Causation

How can we distinguish these?

Scientific verdict usually depends on randomized experiments



Prescientific verdict comes down to observations versus personal interventions. See the psychology of causal reasoning.

KK

# Causal Criteria

## Association v Causation

How can we distinguish these?

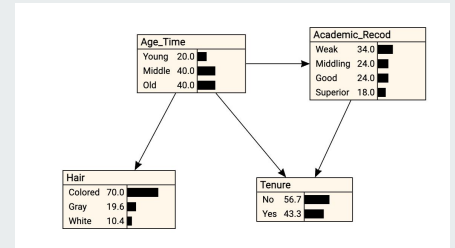
Scientific verdict usu depends on randomized experiments

With CBNs we can do other things:

Eyeball

- Does Tenure cause Age?
- Does Age cause Tenure?

Apply formal criteria



KK



## Causal Criteria

David Lewis's Counterfactual Criterion (Lewis, 1973):

*If A and B are distinct events that actually occur, then A caused B if and only if, were A not to have occurred, B would not have occurred.*



KK



## Causal Criteria

David Lewis's Counterfactual Criterion (Lewis, 1973):

*If A and B are distinct events that actually occur, then A caused B if and only if, were A not to have occurred, B would not have occurred.*

The underlying intuition is close to universal: any cause makes a difference to its effect.



KK



## Causal Criteria

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The underlying intuition is close to universal: any cause makes a difference to its effect.

One problem is how to formalize this intuition. CAT provides a platform for doing so, in many different ways.



KK



# Causal Criteria

Three formal Causal Criteria are implemented already in CAT:

- Fraction of Attributable Risk
- Cheng's Causal Power Theory
- Wiggle Theories & Causal Information Theory





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## ABNMS BN Repository Compatibility

CAT is compatible with the ABNMS BN repository

There are two options:

- Integrated on the same server (buttons allow moving between BN repo and CAT)
- Allow imports from the ABNMS BN repository and vice versa



How CAT will integrate into ABNMS

Uploading CBNs

Loading ABNMS BNs

# CAT Demo

CAT: Causal Attribution Tool

https://causalattribution.org

## Causal Attribution Tool (beta)

stevenm

### What is CAT?

CAT (the Causal Attribution Tool) is a tool for exploring different causal scenarios incorporating uncertainties and allowing you to entertain and test different hypotheses about what is causing what in these scenarios. CAT will also allow you to compare alternative ideas about the nature of causal attribution itself, that is, distinct criteria for judging causal attribution can (and will) be implemented - although we have implemented our own preferred criterion first, naturally, along with a couple of popular alternatives.

[Read more...](#)

### My Causal BNs

#### Chest Clinic

This Bayes net is also known as "Asia", and is an example which is popular for introducing Bayes nets. It is from Lauritzen & Spiegelhalter (1988).

[Delete](#) [Open](#)

### Public Library of Causal BNs

#### Load a Causal BN

Drag and Drop [Or browse: Upload...](#)

CAT can accept any files supported by GeNIe (including Netica and HUGIN files)

#### Tenure

The Tenure network is a very simple BN that illustrates the basic concepts of CAT. This causal model induces a positive correlation between having White Hair and getting Tenure: the common cause of Age/Time sets up such a probabilistic dependency.

[Open](#)



#### Coronary Risk

A modified version of the model developed by Assessment Technologies, Inc. Estimates the 10 year likelihood of developing coronary artery disease (CAD), as a function of accepted coronary disease risk factors. Modified to remove non-causal factor. Original model at noreys.com.

[Open](#)

#### Chest Clinic

This Bayes net is also known as "Asia", and is an example



# CAT Demo

The screenshot displays the Causal Attribution Tool (beta) website in a browser window. The page title is "Causal Attribution Tool (beta)" and the user is logged in as "stevnm". The website layout includes a navigation bar, a main content area with several sections, and a file upload dialog box.

**What is CAT?**  
CAT (the Causal Attribution Tool) is a tool for exploring different causal scenarios incorporating uncertainties and allowing you to entertain and test different hypotheses about what is causing what in those scenarios. CAT will also allow you to compare alternative ideas about the nature of causal attribution itself: that is, distinct criteria for judging causal attribution can (and will) be implemented – although we have implemented our own preferred criterion first, naturally, along with a couple of popular alternatives.  
[Read more...](#)

**Load a Causal BN**  
Drag and Drop  
CAT can accept any files supported by GoMe (including Netica and HUGIN files)  
[+ COPY](#)

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- Chest Clinic**  
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[Delete](#) [Open](#)

**Public Library of Causal BNs**

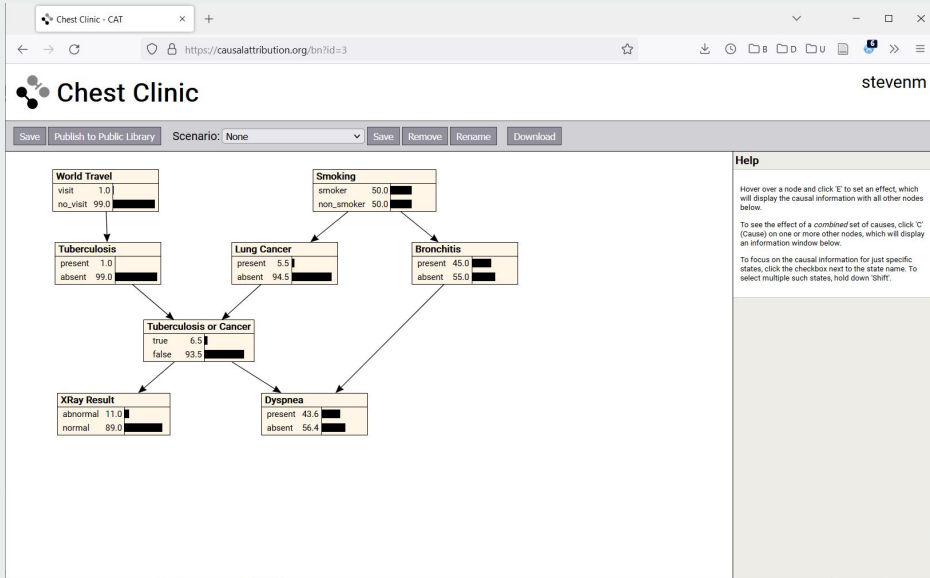
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The Tenure network is a very simple BN that illustrates the basic concepts of CAT. This causal model induces a positive correlation between having White Hair and getting Tenure: the common cause of Age/Time sets up such a probabilistic dependency.  
[Open](#)

**Chest Clinic**  
This Bayes net is also known as 'Asia', and is an example

The file upload dialog box shows a file named "Chest Clinic.dne" being selected for upload.



# CAT Demo



Using CAT for BN updating/reasoning  
Using CAT for causal reasoning  
Hypothetical interventions

# CAT Demo

The screenshot displays the Chest Clinic CAT interface. The browser address bar shows <https://causalattribution.org/bn?id=3>. The interface includes a navigation bar with 'Save', 'Publish to Public Library', 'Scenario: None', 'Save', 'Remove', 'Rename', and 'Download' buttons. The main area contains a causal network diagram with the following nodes and their states:

- World Travel**: visit (1.0), no\_visit (99.0)
- Smoking**: smoker (47.6), non\_smoker (52.4)
- Tuberculosis**: present (1.0), absent (99.0)
- Lung Cancer**: present (0.0), absent (100.0)
- Bronchitis**: present (44.3), absent (55.7)
- Tuberculosis or Cancer**: true (1.0), false (99.0)
- XRay Result**: abnormal (6.0), normal (94.0)
- Dyspnea**: present (41.4), absent (58.6)

The diagram shows causal relationships: World Travel and Smoking influence Tuberculosis and Lung Cancer. Tuberculosis and Lung Cancer influence Tuberculosis or Cancer. Tuberculosis or Cancer and Bronchitis influence XRay Result and Dyspnea. A 'Help' panel on the right provides instructions on how to interact with the nodes.

Using CAT for BN updating/reasoning  
Using CAT for causal reasoning  
Hypothetical interventions

# CAT Demo

The screenshot displays the 'Chest Clinic - CAT' web application interface. The browser address bar shows the URL <https://causalattribution.org/bn?id=3>. The application header includes the 'Chest Clinic' logo and the user name 'stevenm'. Below the header, there are navigation buttons: 'Save', 'Publish to Public Library', 'Scenario: None', 'Save', 'Remove', 'Rename', and 'Download'. The main content area features a causal network diagram with the following nodes and their states:

- World Travel**: visit (1.0), no\_visit (99.0)
- Smoking**: smoker (90.9), non\_smoker (9.1)
- Tuberculosis**: present (1.0), absent (99.0)
- Lung Cancer**: present (100.0), absent (0.0)
- Bronchitis**: present (57.9), absent (42.7)
- Tuberculosis or Cancer**: true (100.0), false (0.0)
- XRay Result**: abnormal (98.0), normal (2.0)
- Dyspnea**: present (81.5), absent (18.5)

The diagram shows causal relationships: World Travel and Smoking influence Tuberculosis and Lung Cancer. Tuberculosis and Lung Cancer influence Tuberculosis or Cancer. Tuberculosis or Cancer influences XRay Result and Dyspnea. Smoking also influences Bronchitis, which in turn influences Dyspnea. A 'Help' sidebar on the right provides instructions on how to interact with the nodes.



Using CAT for BN updating/reasoning  
Using CAT for causal reasoning  
Hypothetical interventions

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- World Travel**: visit (1.0), no\_visit (99.0)
- Tuberculosis**: present (1.0), absent (99.0)
- Smoking**: smoker (50.0), non\_smoker (50.0)
- Lung Cancer**: present (100.0), absent (0.0) - highlighted in green
- Bronchitis**: present (45.0), absent (55.0)
- Tuberculosis or Cancer**: true (100.0), false (0.0)
- XRay Result**: abnormal (98.0), normal (2.0)
- Dyspnea**: present (79.0), absent (21.0)

Arrows indicate causal relationships: World Travel and Tuberculosis point to Tuberculosis or Cancer; Smoking and Lung Cancer point to Tuberculosis or Cancer; Tuberculosis or Cancer points to XRay Result; Tuberculosis or Cancer and Bronchitis point to Dyspnea. A mouse cursor is hovering over the 'Lung Cancer' node, with an 'E' icon indicating an intervention.

The right sidebar contains a 'Help' section with the following text:

Hover over a node and click 'E' to set an effect, which will display the causal information with all other nodes below.

To see the effect of a combined set of causes, click 'C' (Cause) on one or more other nodes, which will display an information window below.

To focus on the causal information for just specific states, click the checkbox next to the state name. To select multiple such states, hold down Shift.

Using CAT for BN updating/reasoning  
Using CAT for causal reasoning  
Hypothetical interventions



# CAT Demo

The screenshot shows the 'Chest Clinic - CAT' web application interface. The browser address bar displays 'https://causalattribution.org/bn?id=3'. The application title is 'Chest Clinic' and the user is 'stevenson'. The interface includes a navigation bar with 'Save', 'Publish to Public Library', 'Scenario: None', 'Save', 'Remove', 'Rename', and 'Download' buttons.

The main area displays a causal network diagram with the following nodes and their states:

- World Travel**: visit (1.0), no\_visit (99.0) [0%]
- Tuberculosis**: present (1.0), absent (99.0) [0%]
- Smoking**: smoker (50.0), non\_smoker (50.0) [4%]
- Lung Cancer**: present (5.5), absent (94.5) [10.7%]
- Bronchitis**: present (45.0), absent (55.0) [22.3%]
- Tuberculosis or Cancer**: true (6.5), false (93.5) [10.2%]
- XRay Result**: abnormal (11.0), normal (89.0) [0%]
- Dyspnea**: present (43.6), absent (56.4) [100%]

The diagram shows causal relationships: World Travel and Tuberculosis cause Tuberculosis or Cancer. Smoking and Tuberculosis cause Lung Cancer. Smoking and Bronchitis cause Lung Cancer. Tuberculosis or Cancer and Bronchitis cause Dyspnea. XRay Result is also shown as a node.

**Help**

Hover over a node and click 'E' to set an effect, which will display the causal information with all other nodes below.

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**Causal Information Table**

Variable	MI	CI	%
Dyspnea	0.9882	1	100
Bronchitis	0.3615	0.3527	35.3
Tuberculosis or Cancer	0.0296	0.1092	10.9
Lung Cancer	0.0254	0.1071	10.7
Tuberculosis	0.004	0.1	10
Smoking	0.0404	0.0404	4
World Travel	0	0.0001	0
XRay Result	0.0152	0	0

Logos for the University of Queensland and a network diagram are visible in the bottom right corner.

CAT measures

- Mutual Information
- Cheng's Causal Power
- FAR
- CI



# CAT Demo

The screenshot shows the 'Chest Clinic - CAT' web application interface. The main area displays a causal network diagram with nodes for World Travel, Tuberculosis, Lung Cancer, Bronchitis, Tuberculosis or Cancer, XRay Result, and Dyspnea. Each node includes a bar chart showing the distribution of its states. The 'Measures' sidebar on the right provides statistical data for the selected effect, Dyspnea.

**Measures**

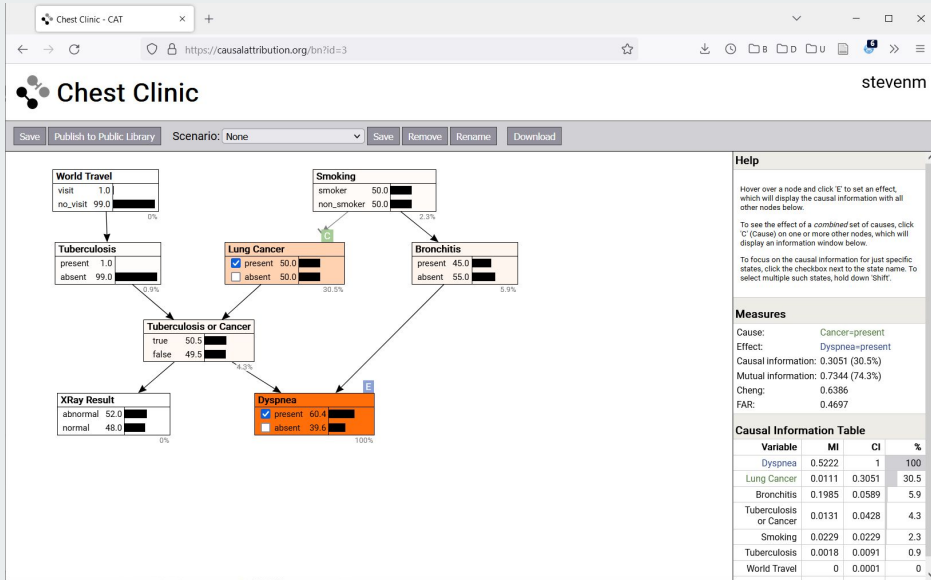
Cause: Cancer  
 Effect: Dyspnea  
 Causal Information: 0.1071 (10.7%)  
 Mutual Information: 0.0254 (2.6%)  
 Cheng: -  
 FAR: -

**Causal Information Table**

Variable	MI	CI	%
Dyspnea	0.9882	1	100
Bronchitis	0.3615	0.1624	16.2
Tuberculosis or Cancer	0.0296	0.1092	10.9
Lung Cancer	0.0254	0.1071	10.7
Smoking	0.0404	0.0404	4
Tuberculosis	0.004	0.0303	3
World Travel	0	0.0001	0

CAT measures  
 Mutual Information  
 Cheng's Causal Power  
 FAR  
 CI

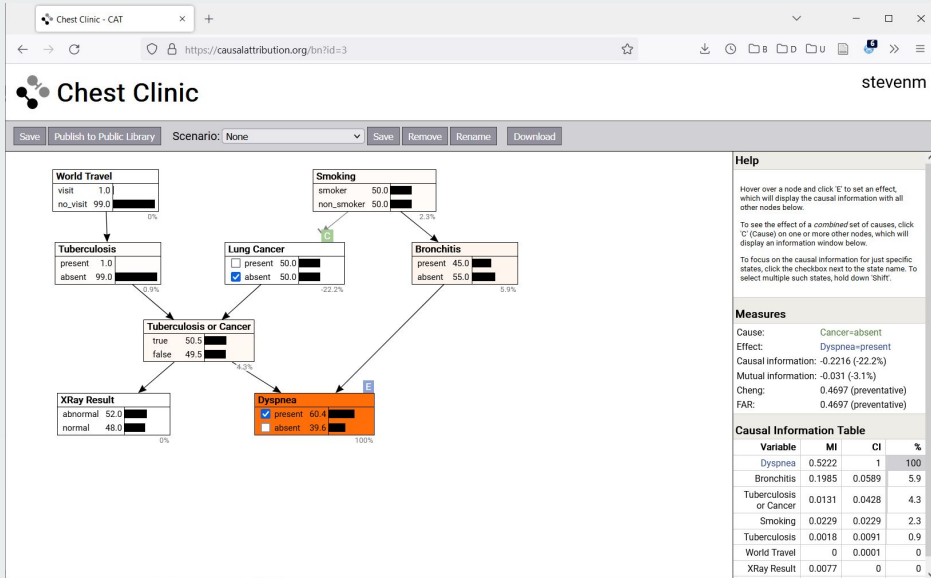
# CAT Demo



CAT measures  
 Mutual Information  
 Cheng's Causal Power  
 FAR  
 CI



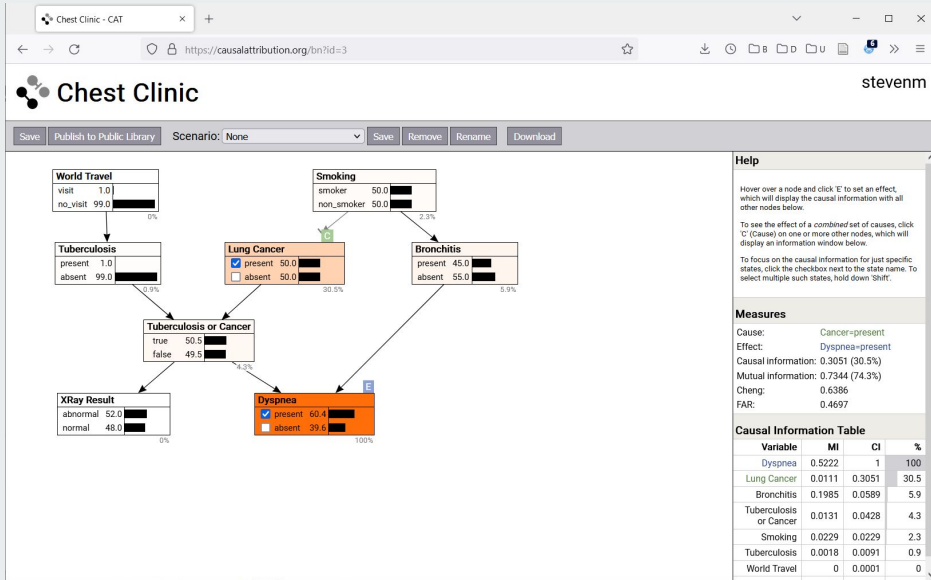
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CAT measures  
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# CAT Demo



CAT measures  
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# CAT Demo

The screenshot shows the Chest Clinic - CAT web application interface. The main area displays a causal network diagram with nodes for World Travel, Tuberculosis, Lung Cancer, Bronchitis, Tuberculosis or Cancer, XRay Result, and Dyspnea. Each node shows its state and associated probabilities. The XRay Result node is highlighted with a red box. The right sidebar contains a Help section, Measures section, and a Causal Information Table.

**Measures**

Cause: Cancer-present  
 Effect: Dyspnea-present  
 Causal Information: 0.026 (2.6%)  
 Mutual Information: 0.2818 (29.9%)  
 Cheng: 0.5965  
 FAR: 0.393

**Causal Information Table**

Variable	MI	CI	%
Dyspnea	0.4113	1	100
Bronchitis	0.0583	0.0477	4.8
Lung Cancer	0.0326	0.026	2.6
Tuberculosis or Cancer	0.0464	0.0072	0.7
Smoking	0.022	0.0011	0.1
Tuberculosis	0.0024	0.0001	0
World Travel	0	0	0

CAT measures  
 Mutual Information  
 Cheng's Causal Power  
 FAR  
 CI

# CAT Demo

The screenshot shows the Chest Clinic - CAT web application interface. The main area displays a causal network diagram with nodes for World Travel, Tuberculosis, Lung Cancer, Bronchitis, XRay Result, and Dyspnea. Each node has a table of states and their probabilities. For example, the 'Dyspnea' node is highlighted with a red box, showing a probability of 0% for the 'absent' state. A 'Warning' message is displayed in a red-bordered box, stating: "You are conditioning on evidence downstream of both cause and effect. This will bias the estimates of causal effect (as a selection bias)." Below the warning is a 'Measures' section with the following values: Cause: Cancer=present, Effect: Bronchitis=present, Causal information: -0.1562 (-15.6%), Mutual information: -0.2519 (-38.8%), Cheng: 0.4042 (preventative), FAR: 0.4042 (preventative). At the bottom right, there is a 'Causal Information Table' with the following data:

Variable	MI	CI	%
Bronchitis	0.2185	0.2293	22.9
Tuberculosis or Cancer	0.0063	0.0309	3.1
Smoking	0.0032	0.0235	2.3

CAT measures  
Mutual Information  
Cheng's Causal Power  
FAR  
CI

# CAT Demo

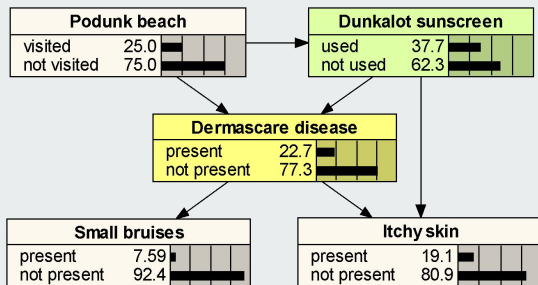
```
86 }
87     return null;
88 }
89 },
90 mi: {
91     active: true,
92     calculate(nets, roles, selectedStates, opts = {}) {
93         opts.jointCause = opts.jointCause || null;
94         let net = nets.originalNet;
95         let causes = roles && roles.cause && roles.cause.length && roles.cause;
96         let effect = roles && roles.effect && roles.effect.length && roles.effect[0];
97         if (causes && effect) {
98             let cause = causes.length == 1 ? causes[0] : opts.jointCause;
99             let table = net.mi(net.node(effect), {
100                 targetStates: selectedStates[effect],
101                 otherStates: {[cause]: selectedStates[cause]},
102             });
103             let table2 = net.mi(net.node(effect));
104             let value = table.find(row => row[0] == cause)[1];
105             let effectValue = table2.find(row => row[0] == effect)[1];
106             let percent = value/effectValue;
107             return (value, percent, _effectValue: effectValue, title: 'Mutual information');
108         }
109         return null;
110     }
111 },
112 /* Modifications:\n- Arc cutting\n- n-ary cause nodes are treated as binary with respect to "focus" states\n- Paths through other parents are left as they are */
113 cheng: {
114     active: true,
115     calculate(nets, roles, selectedStates, opts = {}) {
116         console.log('CHENG');
117         let net = nets.interventionNet;
118         let causes = roles && roles.cause && roles.cause.length && roles.cause;
119         let effect = roles && roles.effect && roles.effect.length && roles.effect[0];
120     }
121 }
```



How to add new measures via GIT Hub  
See <https://github.com/voracity/CAT>

## Dermscare model

EPN: Adding observations



Dermscare disease had two suspected causes: visiting polluted Podunk beach, or using contaminated Dunkalot sunscreen. The disease has two possible early symptoms: small bruises, and itchy skin.

Researchers built this model based on the available hospital statistics. How much is the sunscreen to blame?



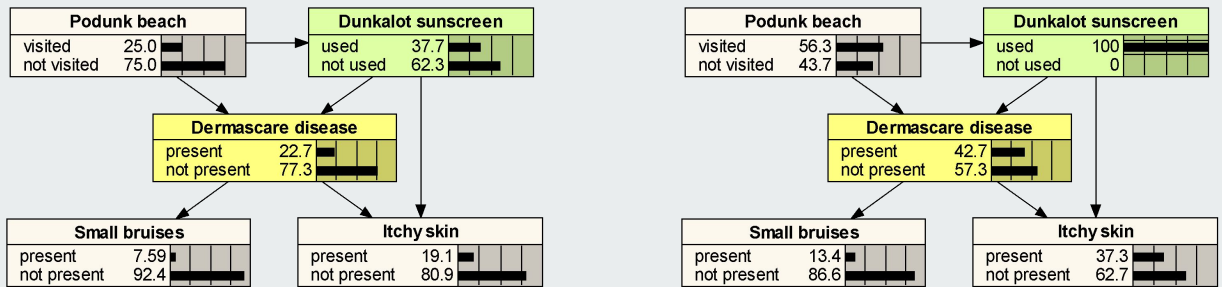
We've been talking about measuring the causal power of one variable over another by simulating an intervention on the putative cause. This is structurally distinct from just entering an observation about the cause. But now I want to make a few remarks about doing both at once: intervening on the cause where we have observed some other variables.

This fictitious example concerns a skin disease called Dermscare. Dermscare disease had two suspected causes: visiting polluted Podunk beach, or using contaminated Dunkalot sunscreen. The disease has two possible early symptoms: small bruises, and itchy skin. Researchers built this model based on the available hospital statistics. How much is the sunscreen to blame?



## No intervention or observation

EPN: Adding observations



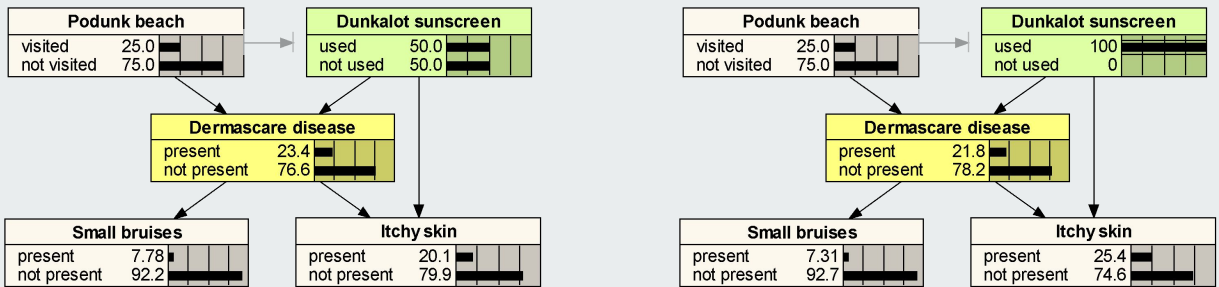
Dependence between sunscreen and disease:  
both causal (direct) and noncausal (via beach).



As we've already seen, the problem with just observing the people who used sunscreen is that the change in probability for them having the disease may be partly due to noncausal paths. Here, using sunscreen makes it more likely that the person visited the beach, which might be contributing to the dramatic increase in the probability of the disease.

## Intervening on the cause of interest

EPN: Adding observations



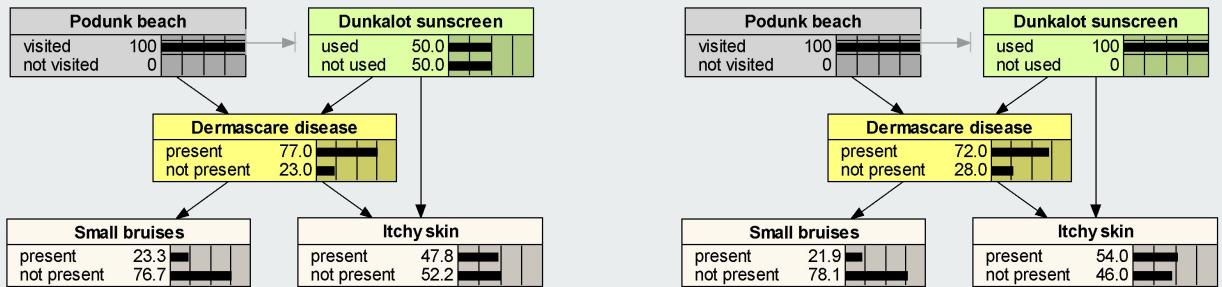
Dependence between sunscreen and disease:  
only causal (direct).



When we use CAT to simulate an intervention on sunscreen, such as the randomisation shown here, we can break such noncausal paths, which guarantees that the remaining dependence is entirely due to the causal paths. Notice that using sunscreen has a slightly protective effect against the disease; the dramatic increase we saw previously was entirely due to visiting the beach.

## ...and observing another cause

EPN: Adding observations



Dependence between sunscreen and disease:  
only causal (direct),  
observable among people who visited the beach.

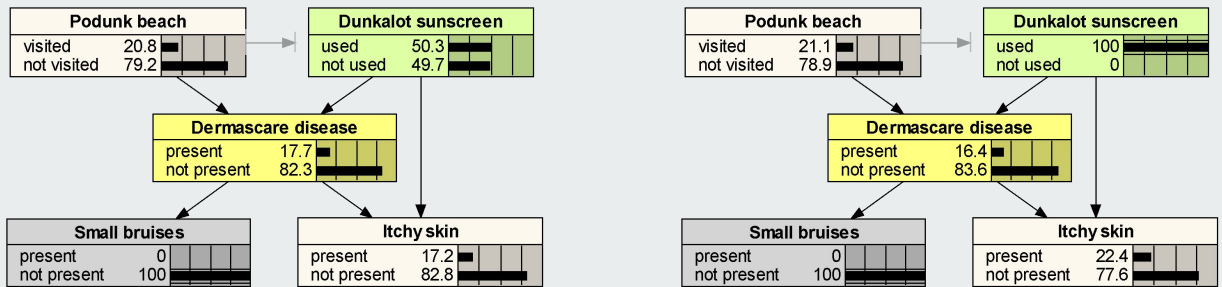


But what if we have also observed that someone has visited the beach? Now, the first mistake one might make in interpreting the result would be to think that the dependence here is the causal power of sunscreen in general. This is equivalent to selection bias: if we want to know the causal power for the population in general, but we have selected (usually inadvertently) a disproportionate number of people who went to the beach, then the results may differ and a naive extrapolation would be misleading.

However, this is a perfectly legitimate measurement provided that it is interpreted correctly: it's the causal power of sunscreen on the disease that is observable among people who visited the beach.

## ...and observing an effect

EPN: Adding observations



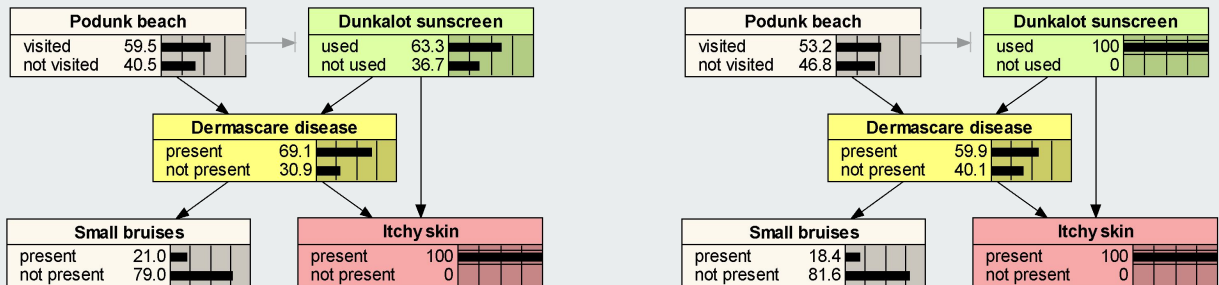
Dependence between sunscreen and disease:  
 only causal (direct),  
 observable among people who don't have bruises.



Similarly, we can measure the causal power given the observation that someone has no bruises. A more subtle mistake in interpretation is to say that this is the causal power sunscreen really has (or had) in this subset of the population. But you're not seeing what sunscreen might have done to these people if it resulted in them not having bruises. You're only seeing the causal influence that is observable given that they ended up without bruises.

## ...and observing a common effect

EPN: Adding observations



Dependence between sunscreen and disease:  
 both causal (direct) and noncausal (via itchy skin),  
 observable among people who have itchy skin.



But even if you interpret the measurement properly, there is a more serious quantitative problem if you observe a common effect, i.e., a descendant of both the cause and the effect variable of interest. Here, the observation actually creates a noncausal path that the intervention on sunscreen doesn't prevent. Specifically, either sunscreen or the disease could cause itchy skin. When we apply sunscreen, we have partly explained the itchy skin observation, so it becomes weaker evidence for the disease, and the probability of the disease drops. Consequently, any measurement of the dependence between sunscreen and disease will be partly due to the noncausal component.

We will add a verbal and visual warning to this tool (e.g., colouring the variable red) if you have added an observation that created a noncausal connection of this kind. This will help prevent users from misinterpreting the result, and might persuade them not to add the observation after all.



## References

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