

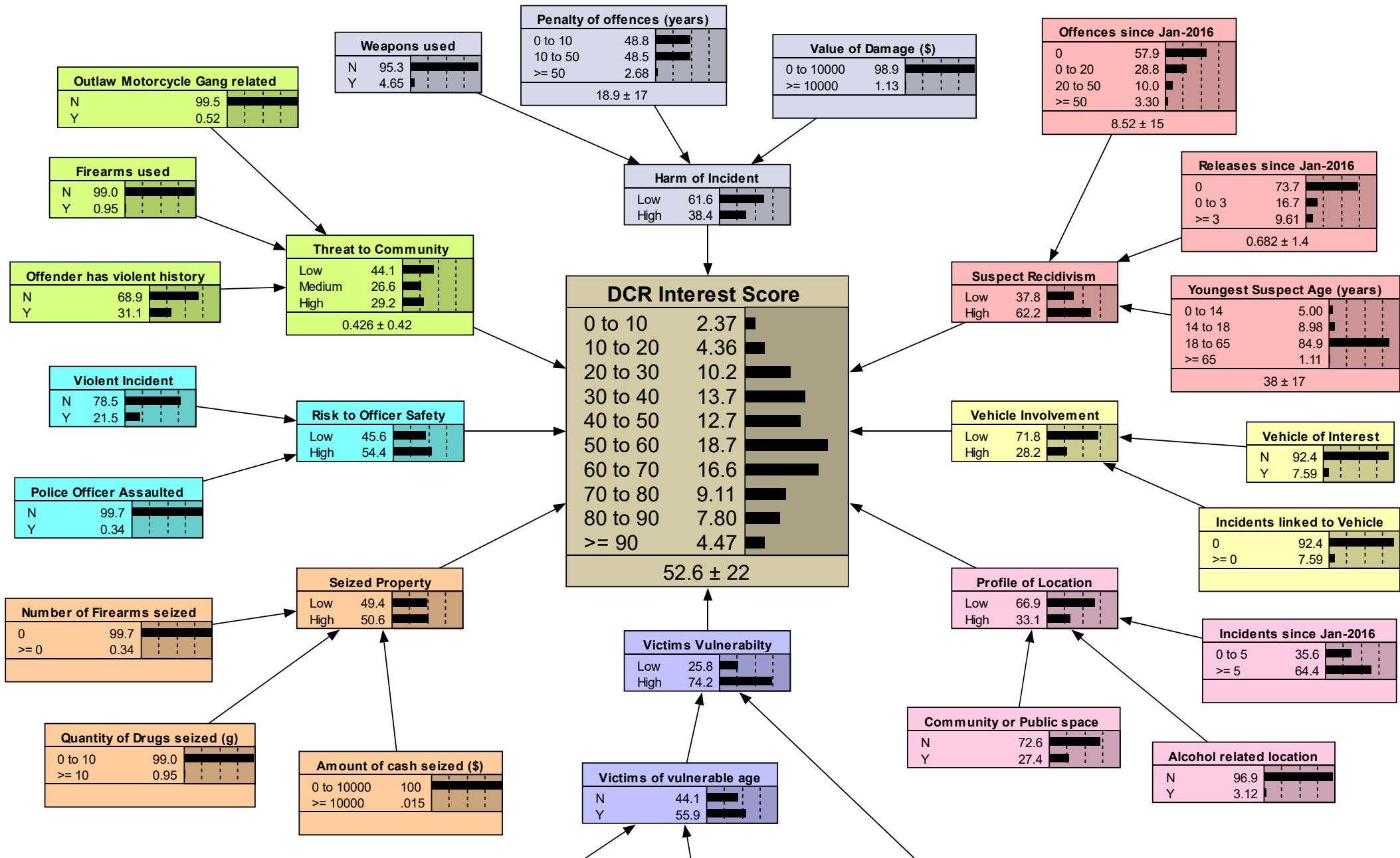


Using Bayesian Networks to Identify Significant Crime Events

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¹Curtin University

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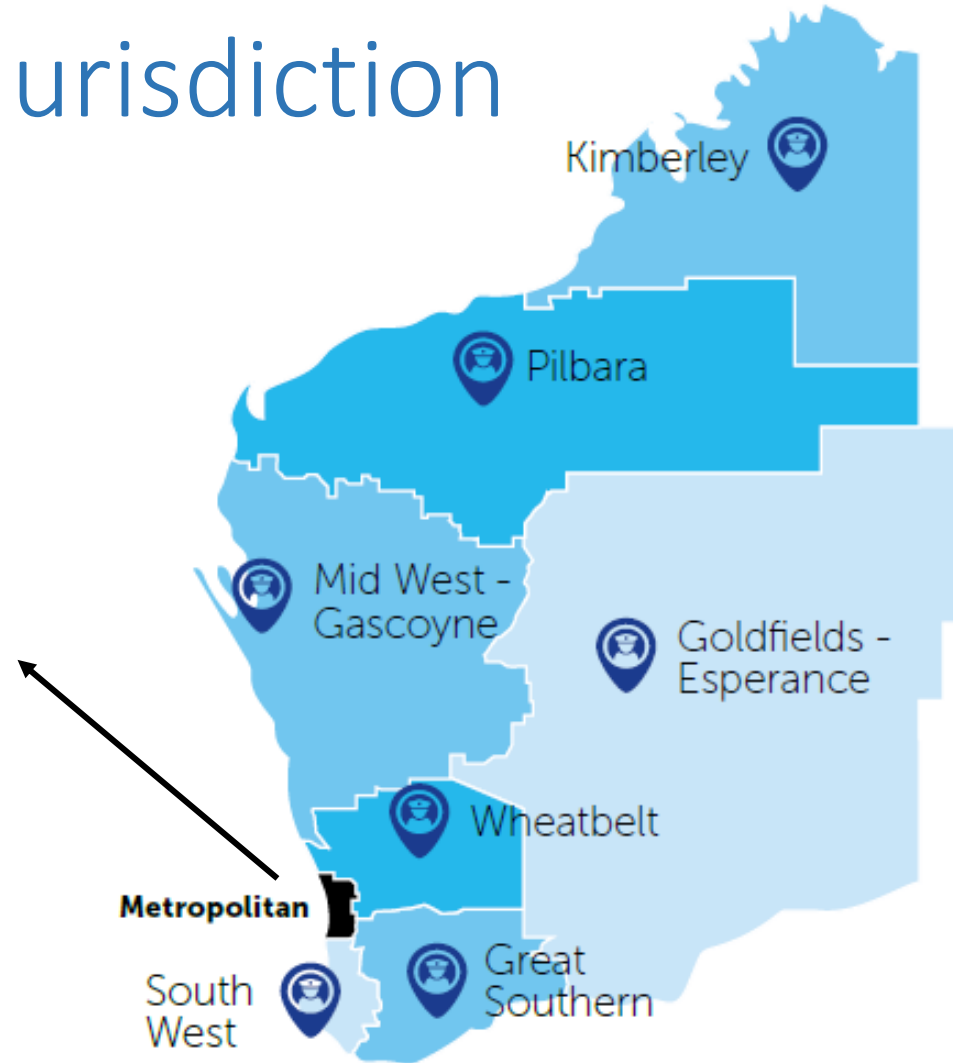
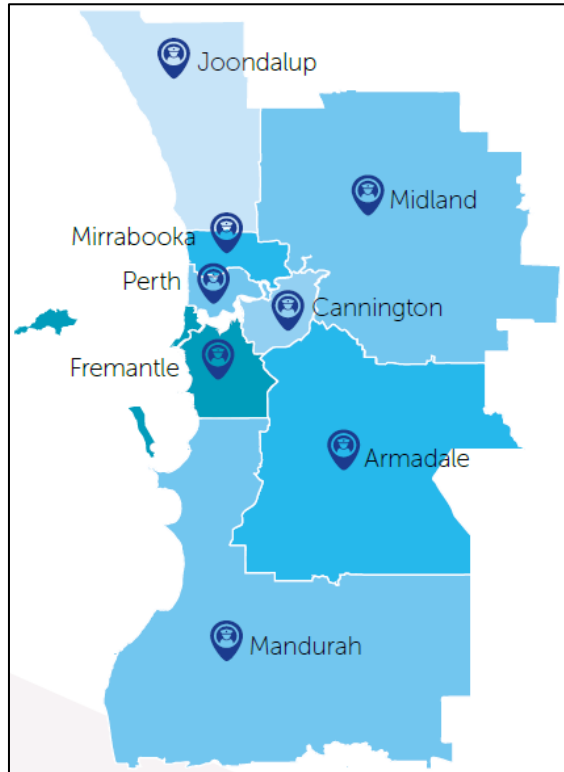




Outline

- The Daily Crime Review (DCR)
- Modelling incidence “significance”
- Bayesian Network model
- Classification results
- Going forwards
- Questions and responses

WA Police Jurisdiction



≈ 2.6M km²

15 districts

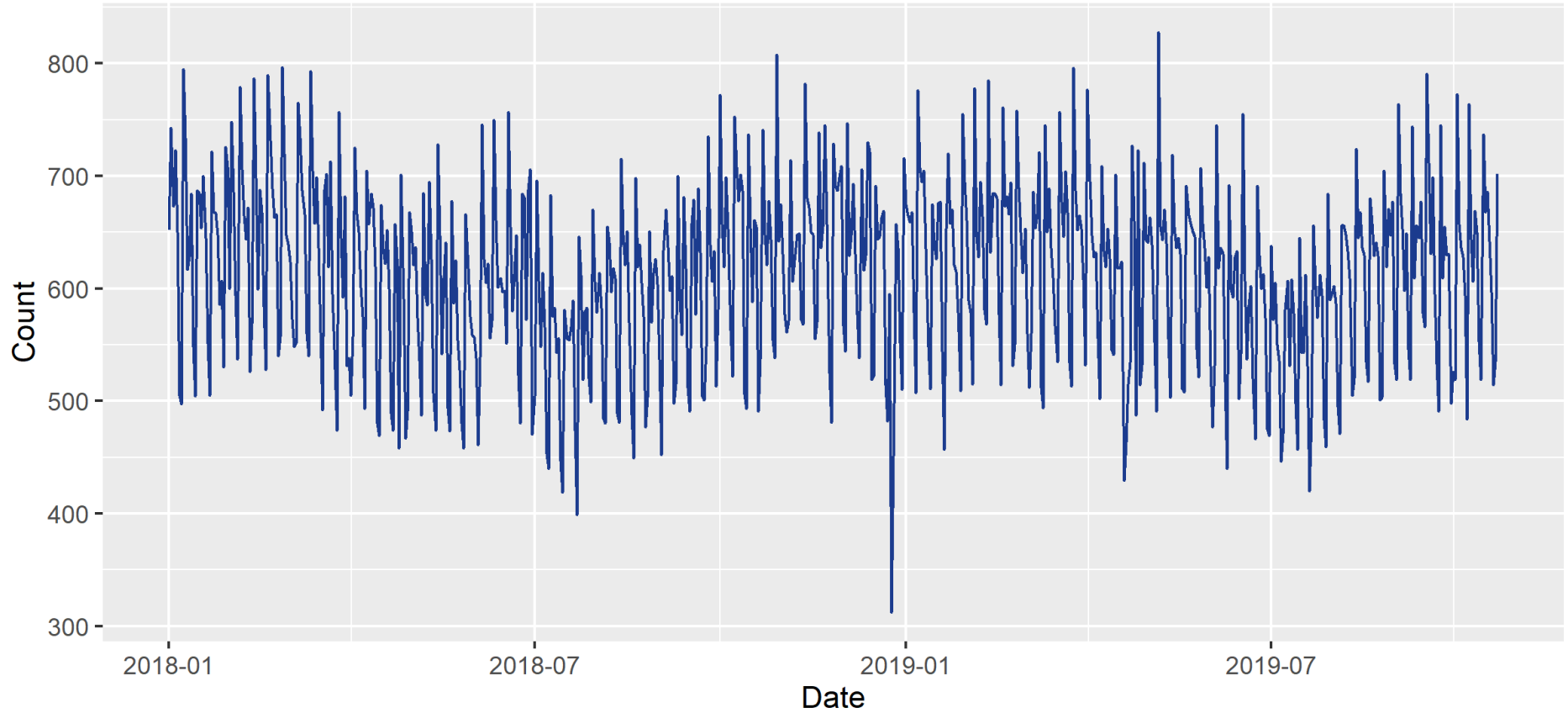
≈ 2.6M people

3932 officers FTE

Source: WA Police Force Annual Report 2020



Total incidents recorded per day



Source: WA Police Force Annual Report 2020



Daily Crime Review

 06:00 – 06:15

Last 24h
≈ 700
incident
reports




Staff Officer




Commissioner




Deputy Commissioner




GOVERNMENT OF
WESTERN AUSTRALIA



Minister for Police



Attorney General



Chief Magistrate

⋮



What makes an incident significant enough to include in the Daily Crime Review?

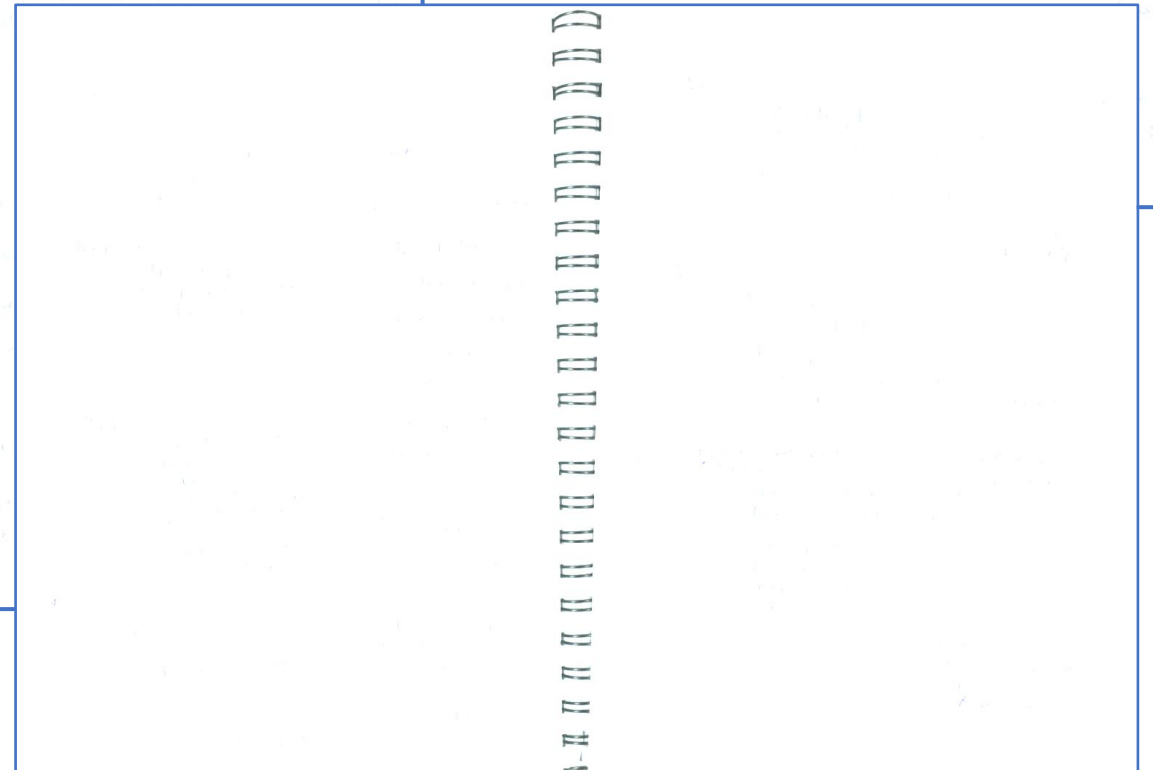
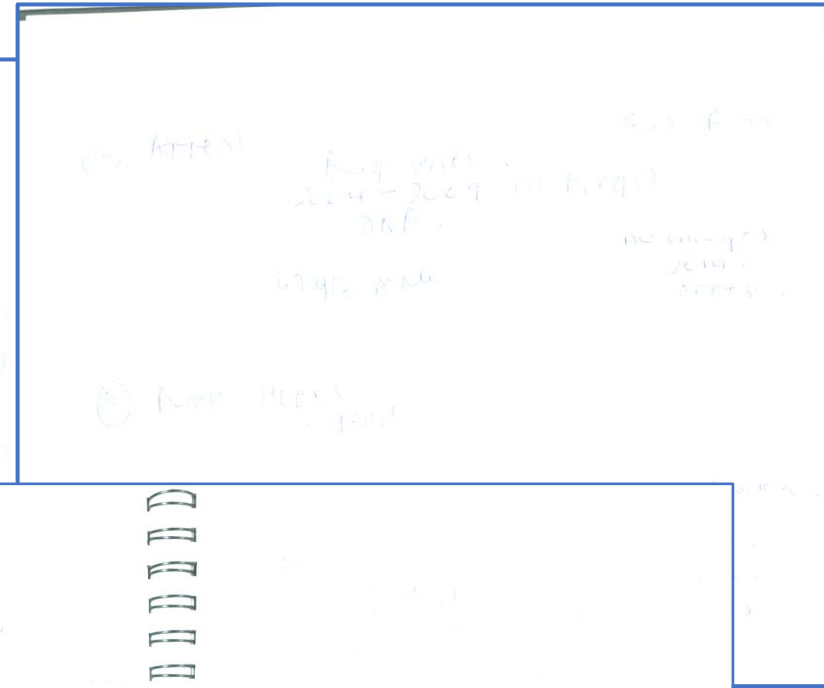
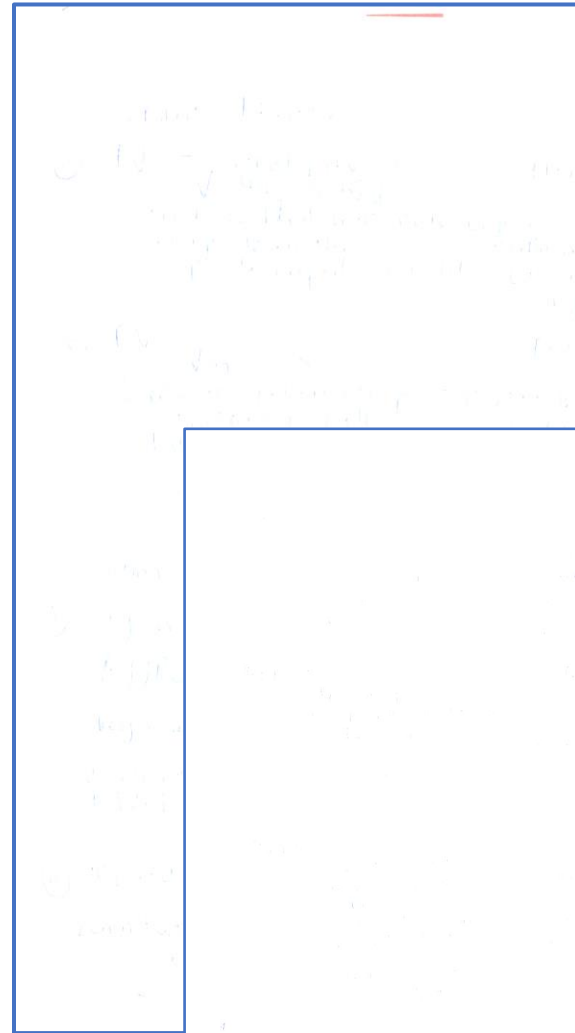
Daily Crime Review

 06:00 – 06:15

Last 24h
≈ 700
incident
reports



60 minutes
≈ 15 incidents



Elicit Expert Police Knowledge

- Un/structured interviews (12h)
- Group workshops (3h)
- Observation of experts' routines (4h)
- Posing hypothetical scenarios (3h)

TYPE OF INCIDENTS

SERIOUS OFFENCES

BURGLARIES - F/ARMS - # VALUE

BURGLARIES - N^o in a short space of time

FRAUD/STERINGS - # VALUE

LINKED INCIDENTS

ORGANISED CRIME - DENYS-WEIGHT GAINCE

DATE/TIME OF OFFENCE

VICTIMS

VULNERABLE - OVER 60 / 80yo + Under /

INJURIES SUSTAINED

REPEAT FV

SEX ASSAULT / CHILD ABUSE

ETHNICITY

SUSPECTS

ARE THEY ON BAIL - BAIL CONDS

PREVIOUS VOLUME CRIME HISTORY

PREVIOUS FV HISTORY

IS SUSP. IN CUSTODY

USE OF WEAPONS F/ARM/KNIFE

SUSPICIOUS APPROACH

OVER 50 CONVICTIONS - WEIGHTING TO INC. VOL CRIME / LAST OFFENCE / REINTEGRATION

- VIOLENT HISTORY

- AGGRAVATED VIOLENCE

MULTIPLE LINKED INCIDENTS

LCU - LINKED CRIME.

AGE OF SUSPECT

Age	Gender
0	M
0	F
Y	M
Y	F

Factors

Offender instead of suspect.

Suspect is an additional category

Offender - Restraining orders

" breaded.

- Family violence incidents. (# of)

- Warnings - Mental Health, recidivist FIV, Prohib drug, violence + anti police, weapons.

Incident Significance Weightings.

see my FV regression model.

Elicit Expert Police Knowledge

1. Risk to Officer Safety
2. Threat to Community
3. Victims' Vulnerability
4. Harm of Incident
5. Suspect Recidivism
6. Seized Property
7. Profile of Location
8. Vehicles of Interest

TYPE OF INCIDENTS

SERIOUS OFFENCES

BURGLARIES - F/ARMS - # VALUE

BURGLARIES - N' in a short space of time

STERINGS - # VALUE

LINKED INCIDENTS

ORGANISED CRIME - DENYS-WEIGHT GANDE

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AGE OF SUSPECT

Age	Gender
0	M
0	F
Y	M
Y	F

Factors

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Elicit Expert Police Knowledge

- Risk to Officer Safety
- Threat to Community
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- Harm of Incident
- Suspect Recidivism
- Seized Property
- Profile of Location
- Vehicles of Interest

Subjective Beliefs

Handwritten notes on a whiteboard:

TYPE OF INCIDENTS
SERIOUS OFFENCES
 BURGLARIES - # VALU...
 BURGLARIES - N° IN...
 STERINGS - # VALU...
 LINKED INCIDENTS
 ORGANISED CRIME
 DELIVERY OF OFFENCE

AGE OF SUSPECT

VICTIMS
 VULNERABLE - OVER 60 / 80yo + Under 1
 INSURIES SUSTAINED
 REPEAT FV
 SEX ASSAULT / CHILD ABUSE
 ETHNICITY

	Age	Gender
ARE THEY ON BAIL - BAIL CONDS	0	M
PREVIOUS VOLUME CRIME HISTORY	0	F
PREVIOUS FV HISTORY	Y	M
IS SUSP. IN CUSTODY	Y	F

SUSPECTS
 USE OF WEAPONS
 SUSPICIOUS APPROACH
 OVER 50 CONVICTIONS - WEIGHTING TO INC. VOL CRIME / LAST OFFENCE / REARRESTATION
 - VIOLENT HISTORY
 - AGGRAVATED VIOLENCE

MULTIPLE LINKED INCIDENTS
 LCU - LINKED CRIME
 AGE OF SUSPECT

Handwritten notes on a sticky note:

Factors
 Offender instead of suspect.
 Suspect is an additional category

Offender - Restraining orders
 " breaded"
 - Family violence incidents. (# of)
 - Warnings - Mental Health, recidivist FV, Prohib drug, violence + anti police, weapons.

Incident Significance Weightings.
 see my FV regression model.

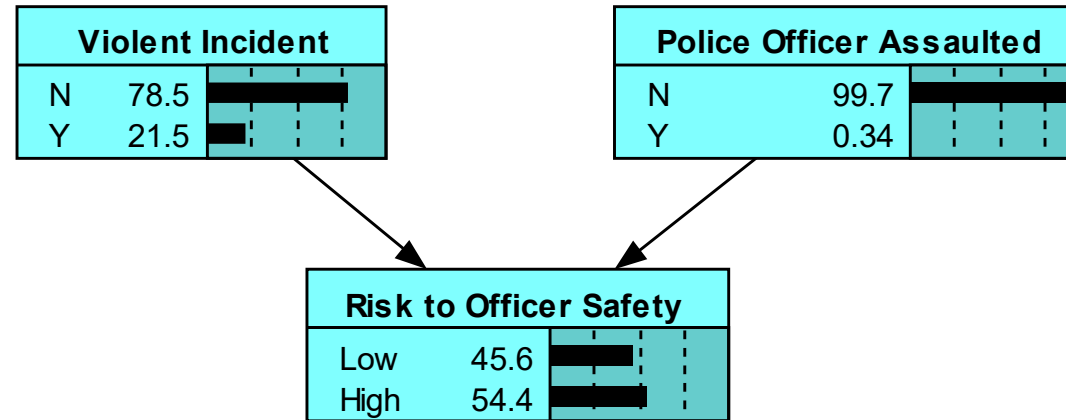
Bayesian (Belief) Networks

- A node for each **random variable** of interest.
- Directed edges connecting variables with **causal relationships**.
- **Conditional Probability Tables** (CPTs) describing **parent** → **child** dependencies and conditional *in*dependencies.
- Total state of system, as described by the **joint probability distribution** of all variables, can be factorised as:

$$P(A_1, \dots, A_n) = \prod_{i=1}^n P(A_i \mid \text{Parents}(A_i))$$



Example: Risk to Officer Safety



Violent Incident	
No	0.785
Yes	0.215

Police Officer Assaulted	Violent Incident	Risk to Officer Safety	
		Low	High
No	No	0.5	0.5
No	Yes	0.3	0.7
Yes	No	0	1
Yes	Yes	0	1

Police Officer Assaulted	
No	0.997
Yes	0.0034

Model

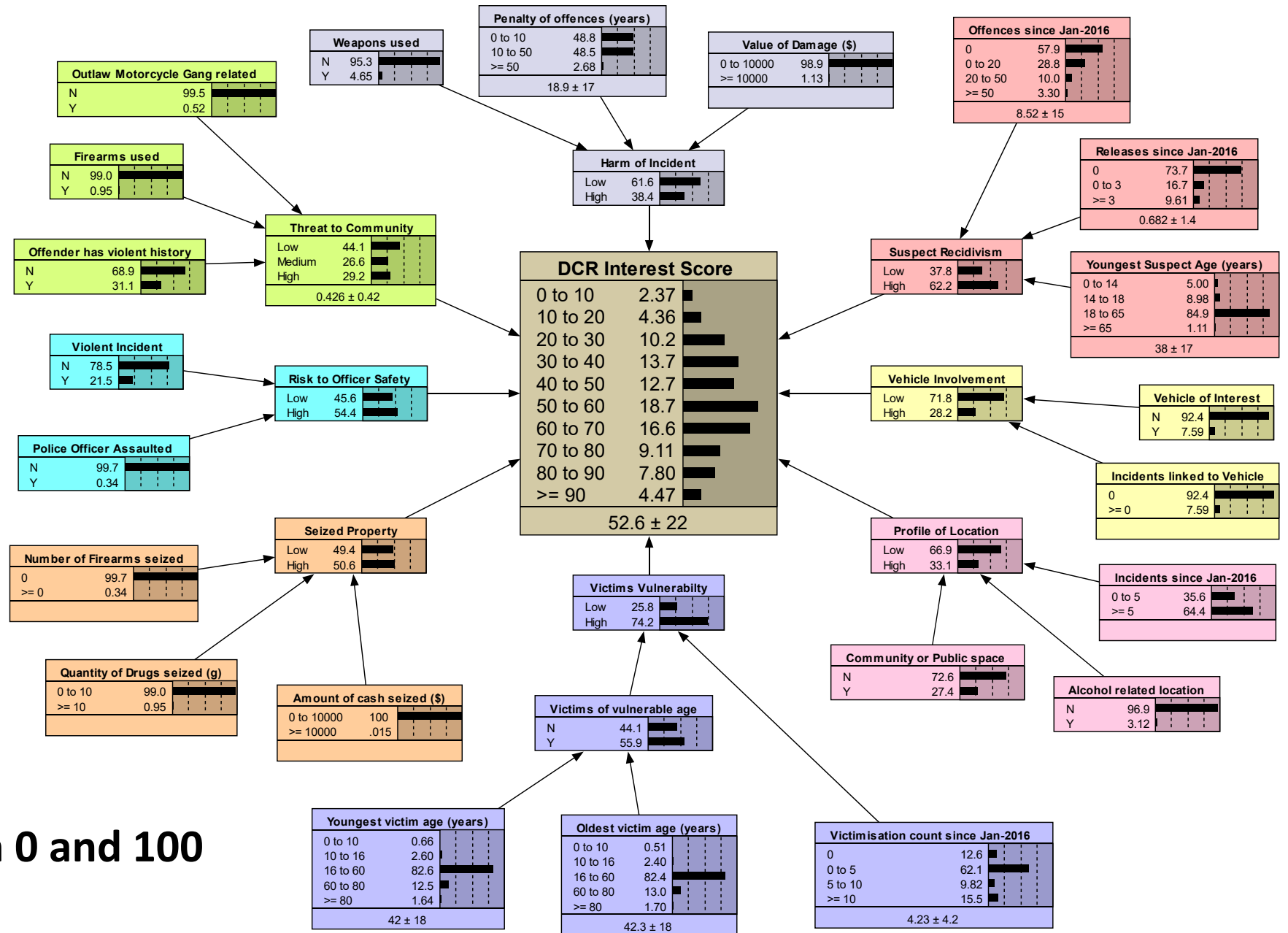
22 input variables

10 latent nodes

Max. of 3 states

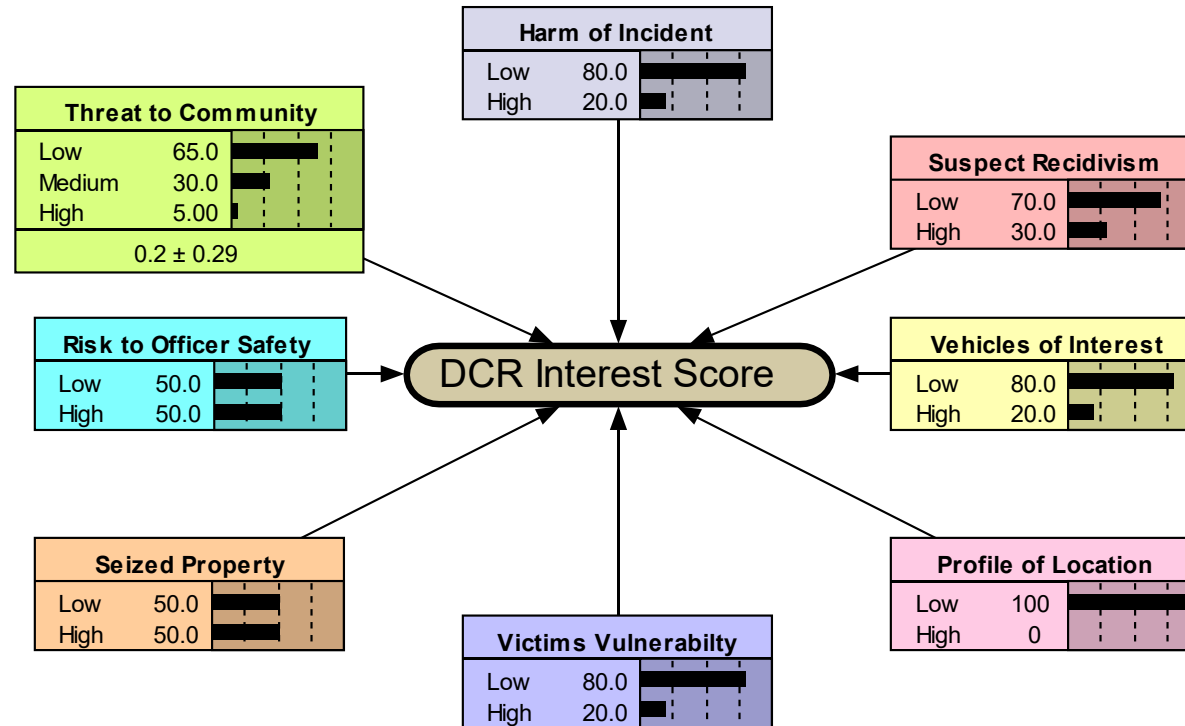
Max. of 3 parents

Zero shared parents



Interest Score between 0 and 100

Daily Crime Review Interest Score



$$\text{Score} = 100 \times ($$

$$30\% \times \text{Risk to Officer Safety} +$$

$$30\% \times \text{Threat to Community} +$$

$$16\% \times \text{Victims' Vulnerability} +$$

$$7\% \times \text{Harm of Incident} +$$

$$7\% \times \text{Suspect Recidivism} +$$

$$5\% \times \text{Seized Property} +$$

$$2.5\% \times \text{Profile of Location} +$$

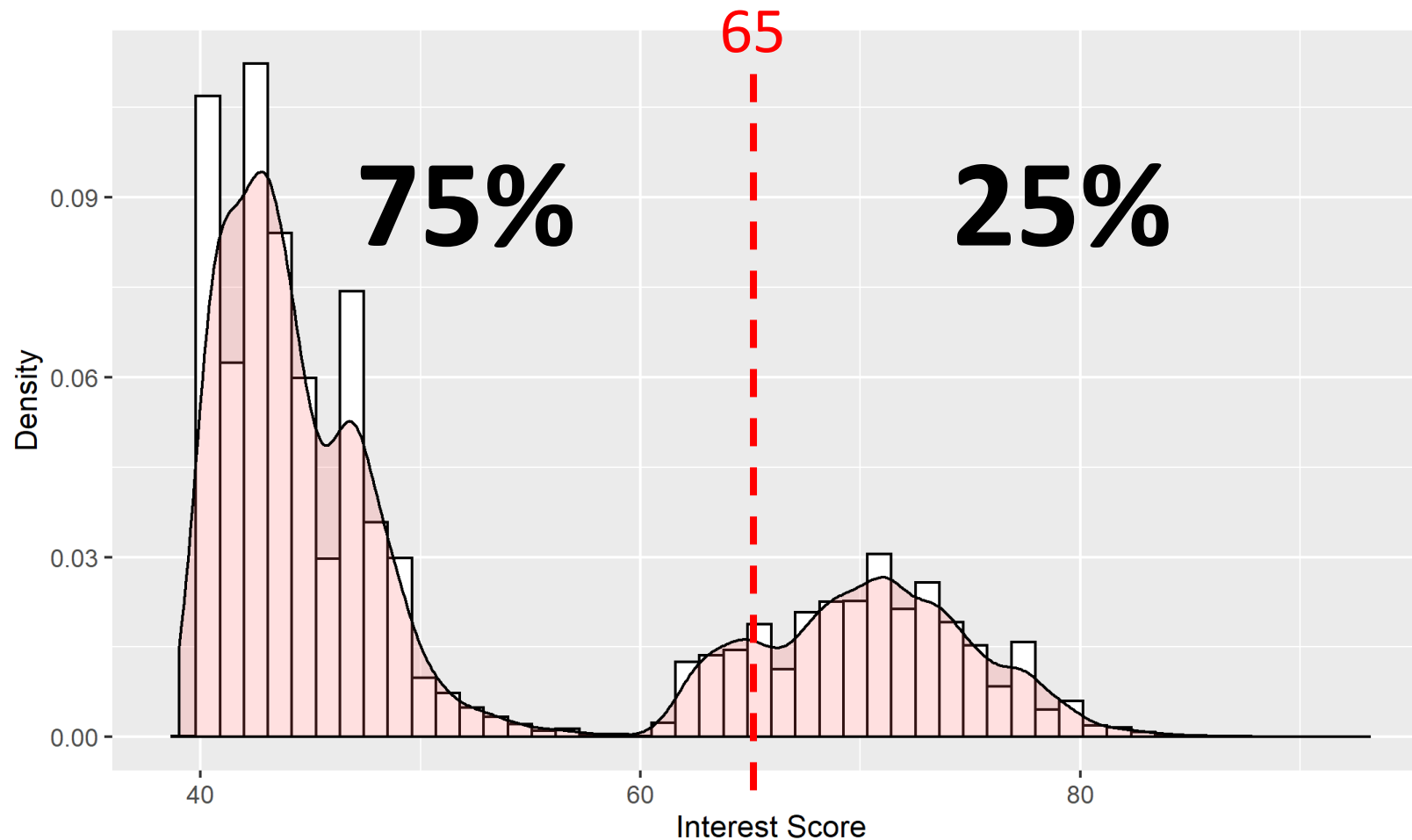
$$2.5\% \times \text{Vehicles of Interest})$$



Incident Management System Data

- 403,693 incident reports from 1-Jan-2018
- 32 variables
- Suspect/Victim histories from 1-Jan-2016
- Daily Crime Reviews from 2 to 22-Oct-2019

Distribution of Interest Scores



2 distinct clusters

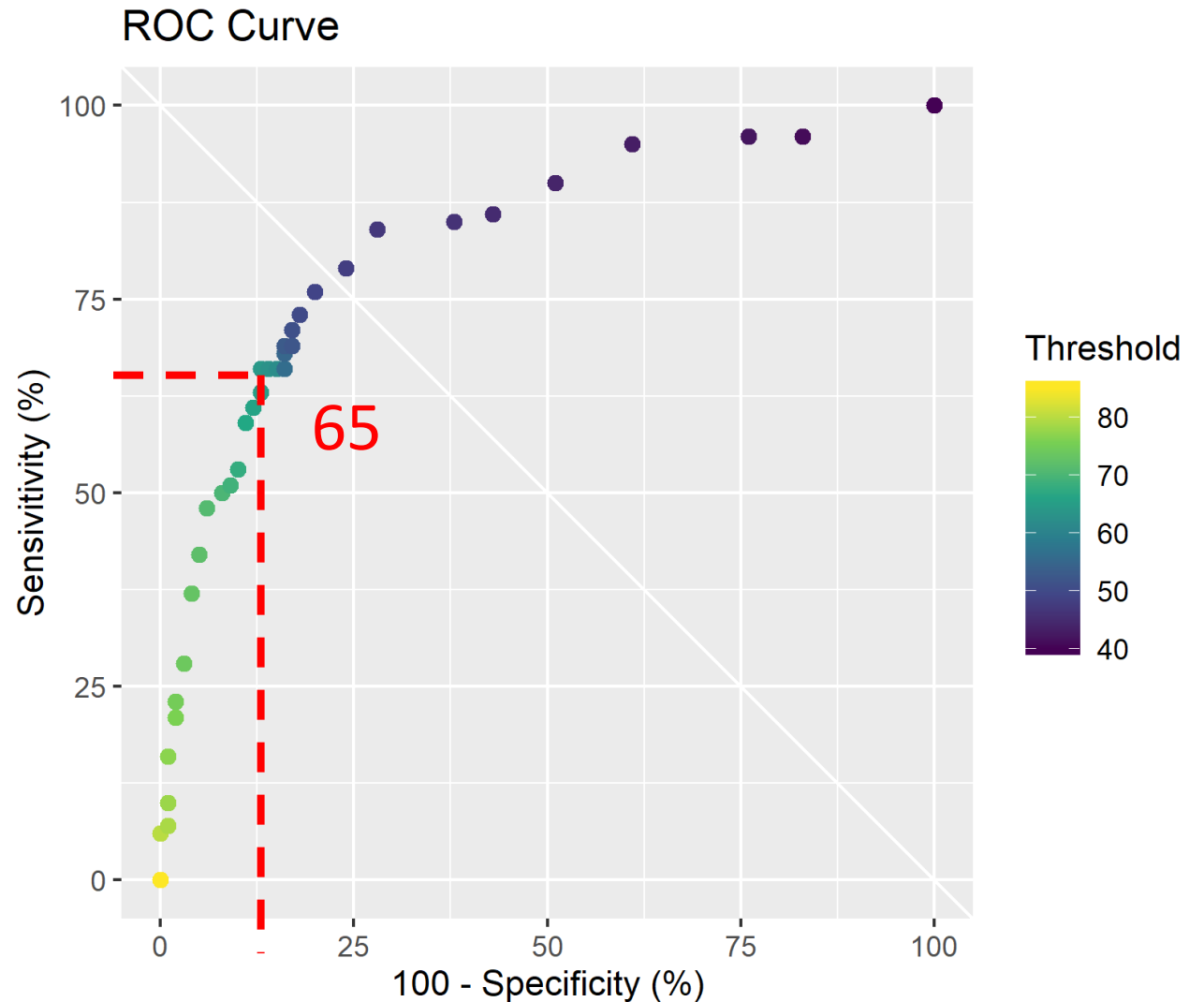
Zero scores below 40

Decision threshold at 65

Screening tool

Assessing the Model

- Known classification for 13,228 incident reports between 2 and 22 October 2019.
- Compare predicted classification with known classification.
- Plot *True Positive Rate vs False Positive Rate* for different thresholds (ROC)
- AUC = **0.83**





Analysis of False Negatives

- Identified the following patterns in incidents **missed** by the network but considered interesting by the human expert:
 - Incidents **linked** to several other co-occurring incidents
 - **Family violence** cases
 - Drug and **methamphetamine** seizures
- Introducing new data on these variables may improve performance of network.
- Analysis needed on *false positives* to find exclusion criteria.

Conclusions

- **Bayesian Networks** can be used to model the deliberations of a human officer in judging relative significance of crime incidents.
- Constructing a network is an inherently **subjective exercise** in deciding its structure and composition, e.g., estimating CPTs.
- This first model has sufficient accuracy to serve as a **screening tool**.
- Refinements may come from relaxing constraints, incorporating new variables such as **linked incidents** or dropping others.
- Plenty of follow-on work available.