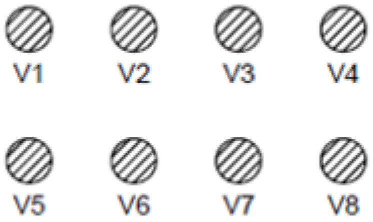
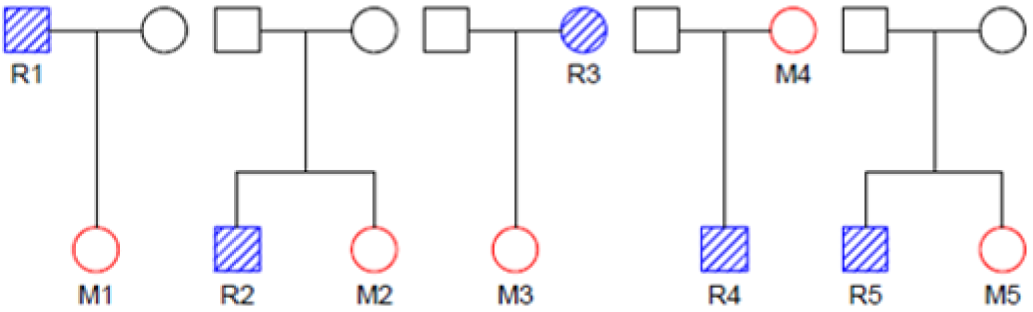
+ **dvir**

Workshop Alcalá de Henares 2026

Disaster victim identification





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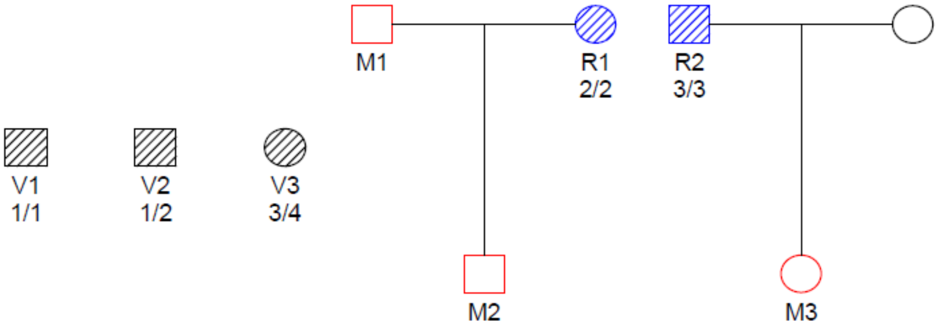
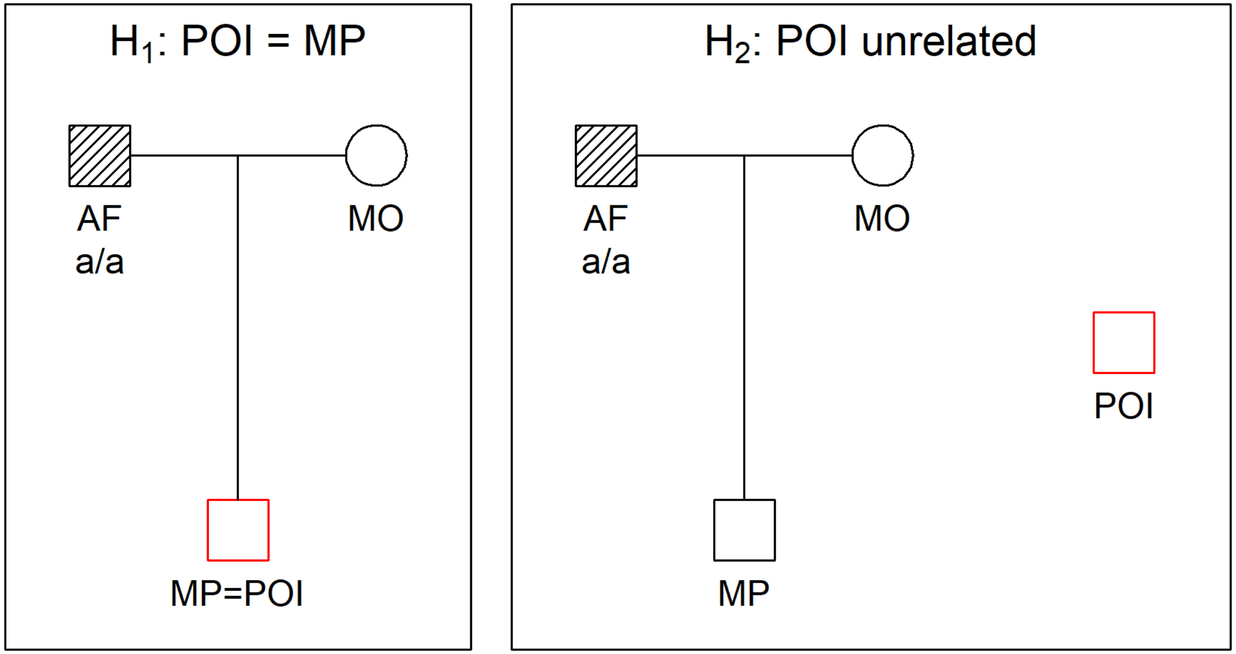
Disaster Victim Identification (DVI)

- DVI
  - Match list of unidentified persons against a list of missing persons
  - Special case:
    - Missing Person Identification
- Cases
  - Missing grandchildren of Argentina
  - World Trade Center attack
  - Spitsbergen civil aircraft disaster
  - Balkan conflicts
  - Drowned immigrants
  - Thailand tsunami
- Methods and software
  - Exclusion and inclusion power
  - Treat *each* victim (PM approach) or *each* family (AM approach) at a time
  - Joint approach. GLR
    - library(dvir)
  - DIVIANA (Magnus)

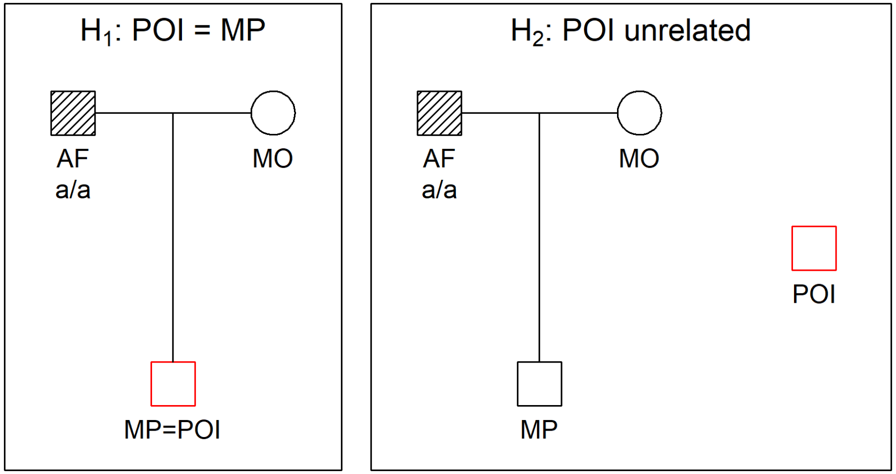


First: Missing Person Identification



- Special case of DVI:
  - ✓ Only one *missing person* (MP) in each reference family
  - ✓ Possibly many reference families and many *persons of interest* (POIs)
  - ✓ Each case treated independently

Exclusion power



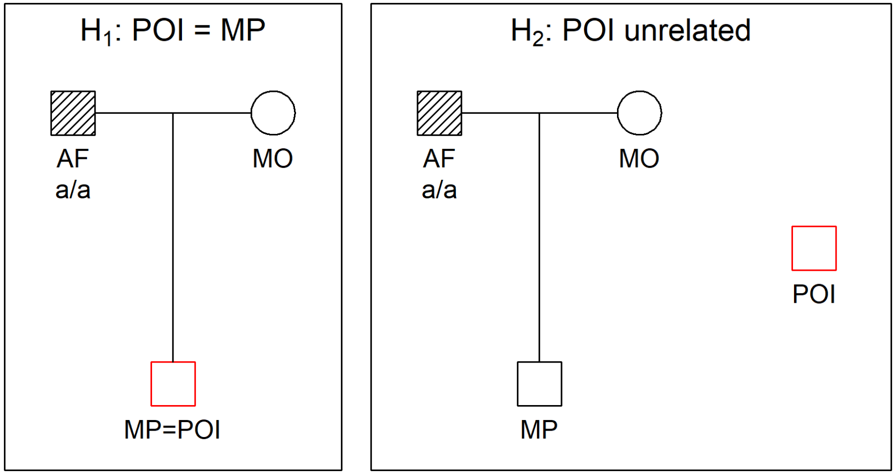
- Sufficient data to *exclude* an unrelated POI?
- **Exclusion power**

$$EP = P(\text{data incompat. with ped} \mid POI \text{ unrelated})$$

- Can be computed exactly
  (Egeland, Pinto, Vigeland, 2014).

In forrel:
> exclusionPower()
> missingPersonEP()

Inclusion power

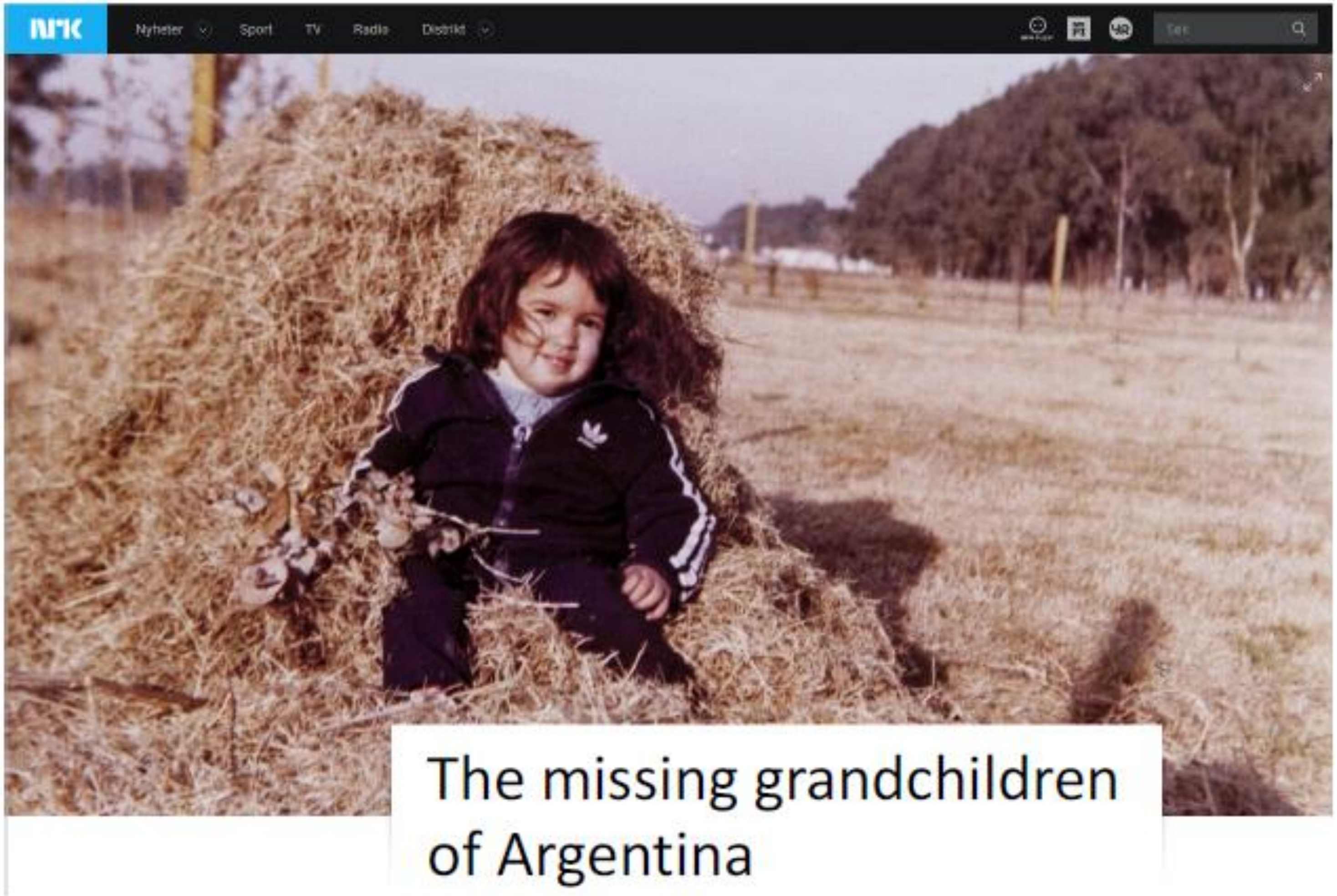


- Sufficient data to give a positive match if POI = MP?
- **Inclusion power** (or *exceedance probability*):

$$\boxed{IP_{10000} = P(LR > 10000 \mid POI = MP)}$$

- Can be computed by simulation!
  - Unconditional → average for all pedigrees of this type
  - Conditional → probability for this particular case

In forrel:
> missingPersonIP()



The missing grandchildren of Argentina

Argentina 1976 – 1983: Dirty War

- Military dictatorship
- *War* against guerrillas

- Opponents killed or disappeared

- *About 500 children abducted*
    - – kidnapped with their parents or born in captivity
    - – parents killed
    - – raised by police or military families

History

- 1977*: Grandmothers of Plaza de Mayo*
  - weekly marches ever since
  - https://www.abuelas.org.ar
- 1983: Mary-Claire King, US geneticist
  - Collaboration with the Grandmothers
  - HLA typing + blood groups
  - First grandchild recovered using genetics
- 1987: National Genetic Data Bank (BNDG)
- 2007: Argentine Forensic Anthropology Team
- July 2025: In total 140 reunifications by BNDG:

BNDG

BANCO NACIONAL DE DATOS GENÉTICOS

Argentina identifies 140th ‘stolen grandchild’ nearly five decades on

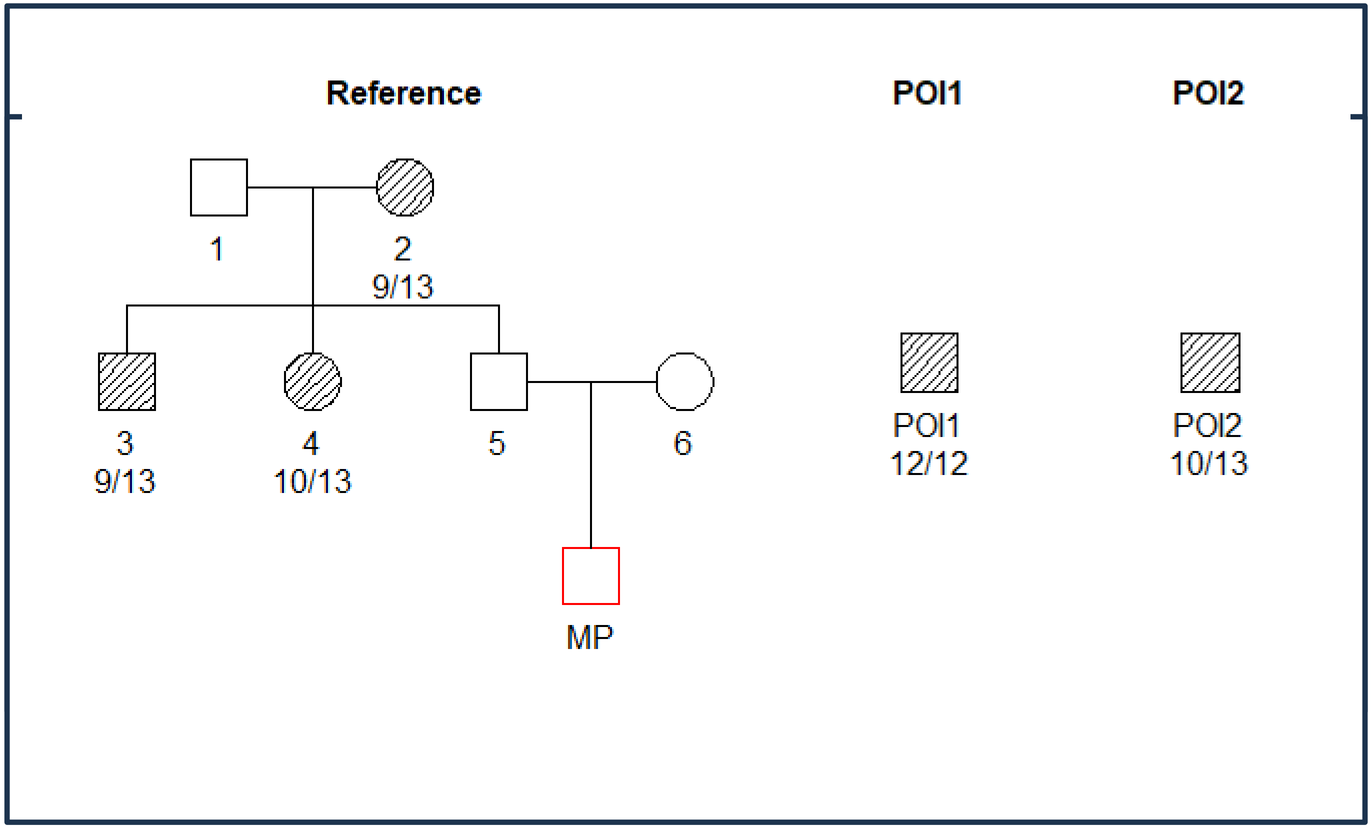
AMERICAS

A 48-year-old man born in a secret detention centre under Argentina’s 1976–1983 military dictatorship has become the 140th person to recover his true identity through DNA testing. Rights group Grandmothers of Plaza de Mayo spent decades tracing babies taken from political prisoners and raised under false identities.

Issued on: 08/07/2025 - 00:07 Modified: 08/07/2025 - 08:52 | 3 min

By: FRANCE 24 / FRANCE 24

Exclusion and inclusion



- POI1 = 12/12 is excluded if mutations are ignored since the alleles of his father are among 9/10/13
- POI2 is
  - ✓ not excluded
  - ✓ included if LR > 10000

Power analysis

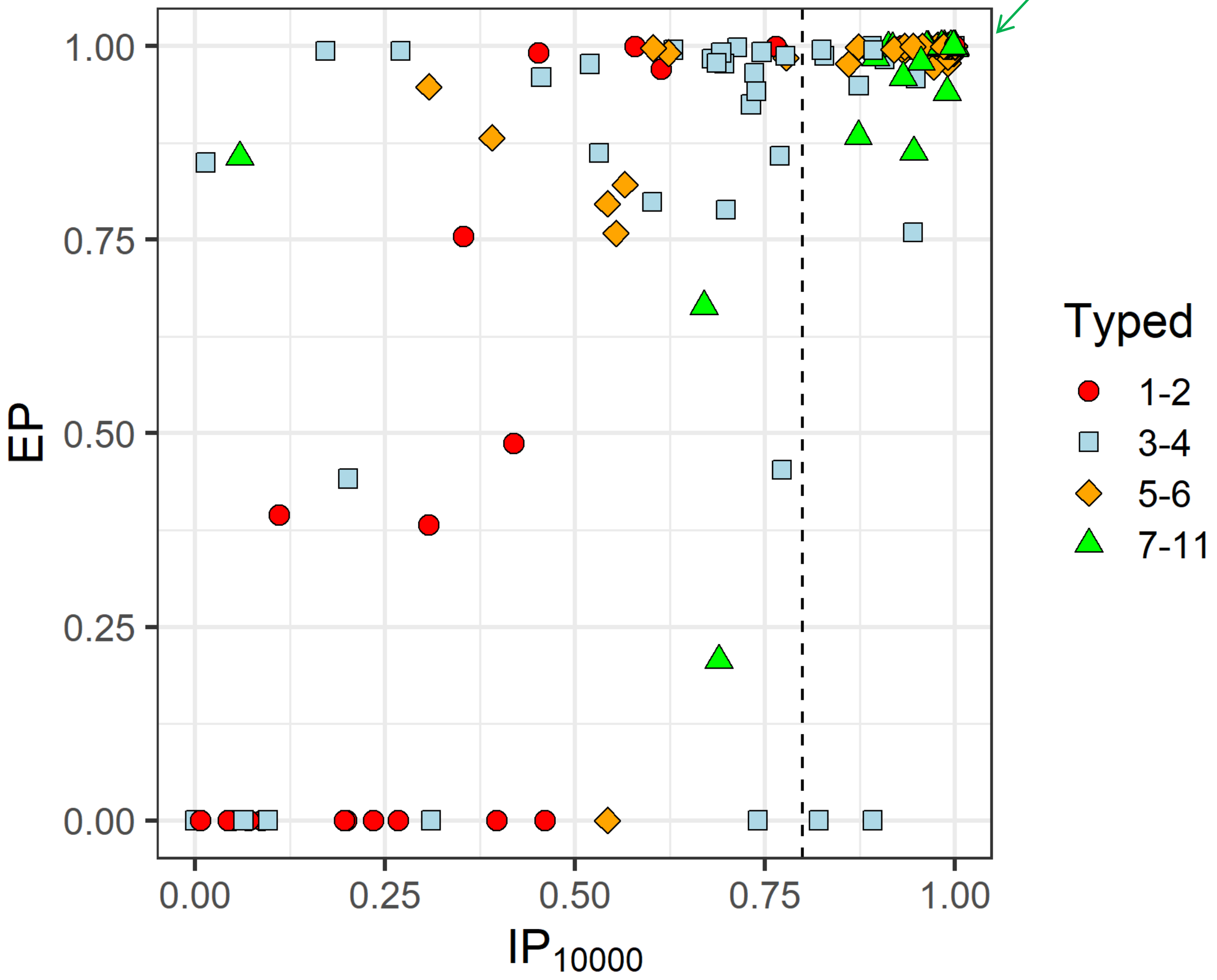
- Power evaluation of ~200 families in the BNDG database
  - most of them unsolved

Typed	Families	Parent(s) typed	2^{nd} degree only
1	11	5	5
2	20	5	15
3	29	7	20
4	41	6	33
5	29	7	14
6	26	5	14
7	14	0	8
8	14	0	9
9	5	0	3
10+	7	0	5
Total	**196**	**35**	**126**

Missing	Total	mtDNA	Y
Male	27	27	25
Female	17	17	-
Unknown	152	142	108
Total	**196**	**186**	**133**

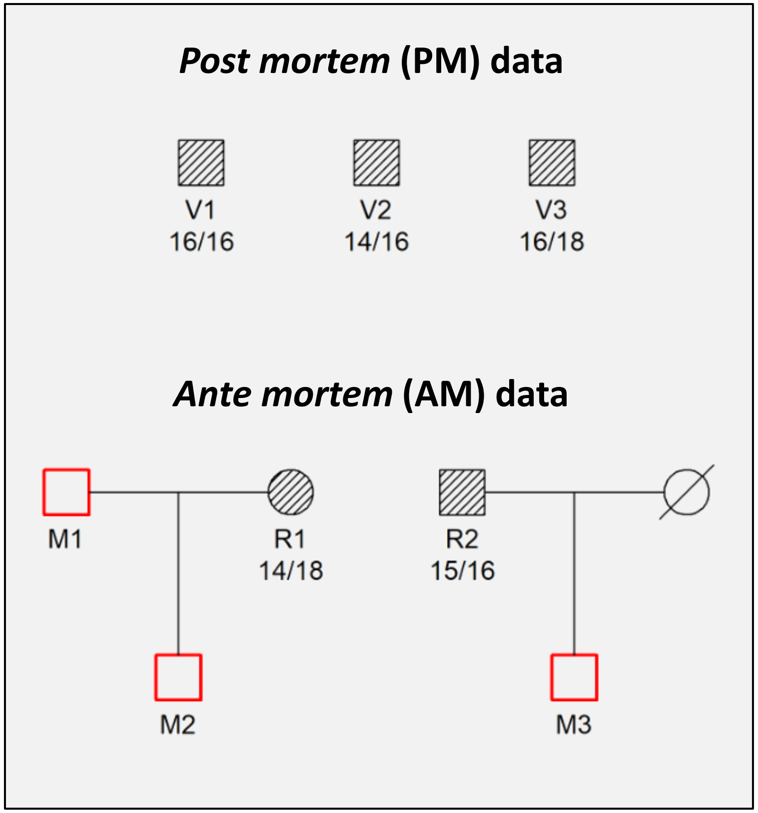
- For each family: Compute IP_{10000} and EP

Results



Excellent power

Disaster victim identification (DVI)



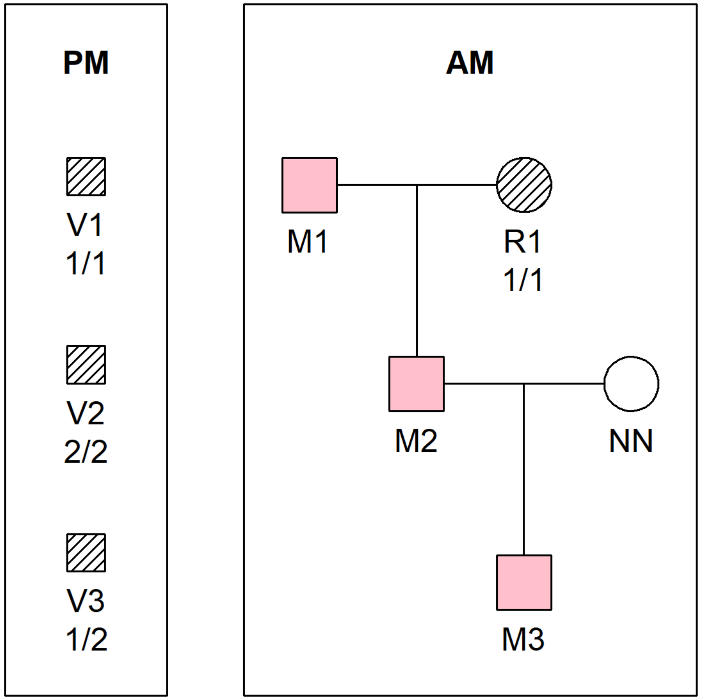
Initial steps

- ➢ Merge identical samples
- ➢ Direct matching
- ➢ Remove non-identifiable
- ➢ Exclude

➢ Pairwise LR. H_1: Vi = Mj vs. H_2: unrelated

$$\begin{array}{c|ccc} & M1 & M2 & M3 \\ \hline V1 & 1 & 0 & 0.39 \\ V2 & 1 & 16142 & 0 \\ V3 & 1 & 0 & 6266 \end{array}$$

Challenge: Sometimes pairwise fails

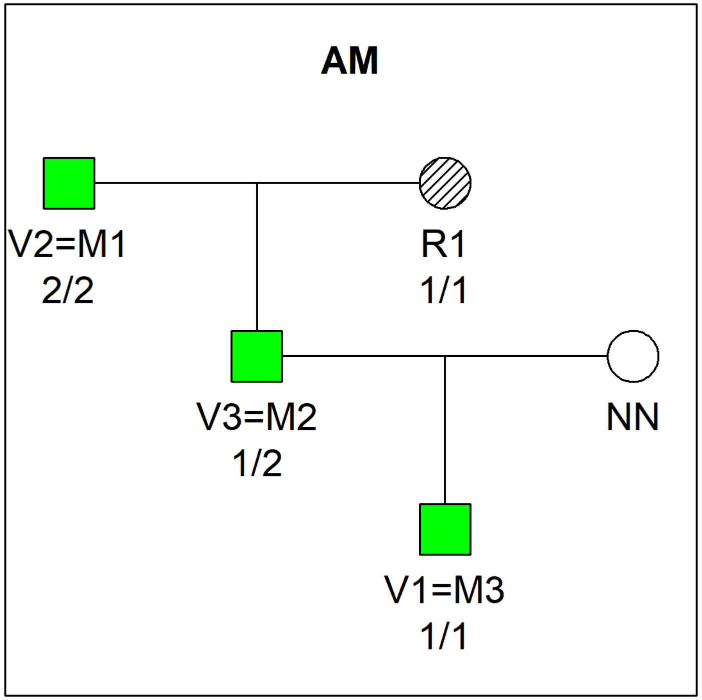


```
    M1  M2   M3
V1   1  20 10.5
V2   1   0  0.5
V3   1  10  5.5
```

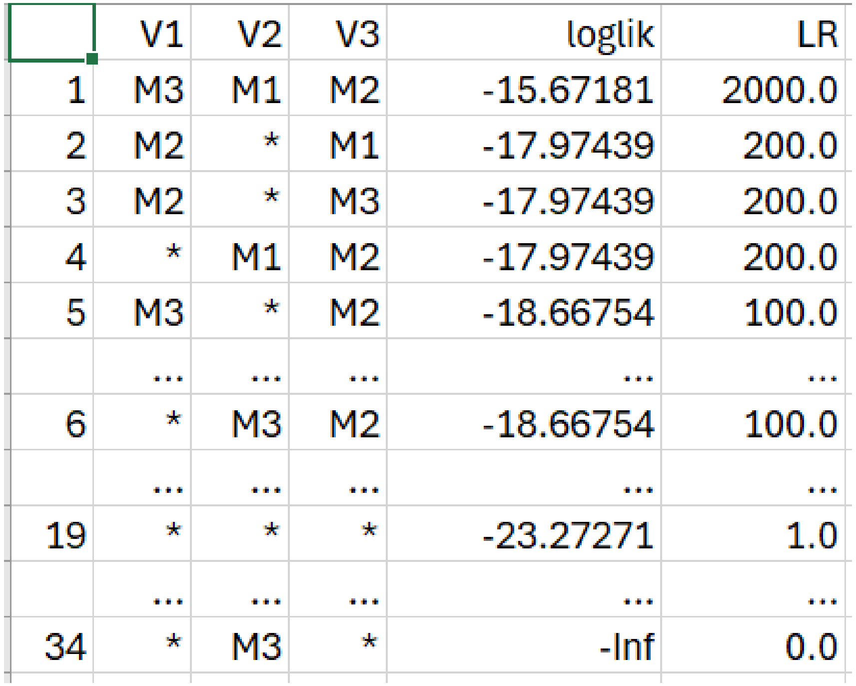
Pairwise LRs indicate V1 = M2, but

- **V1 = M2 is impossible if V2 is among the missing**

Joint solution



Joint likelihoods, sorted



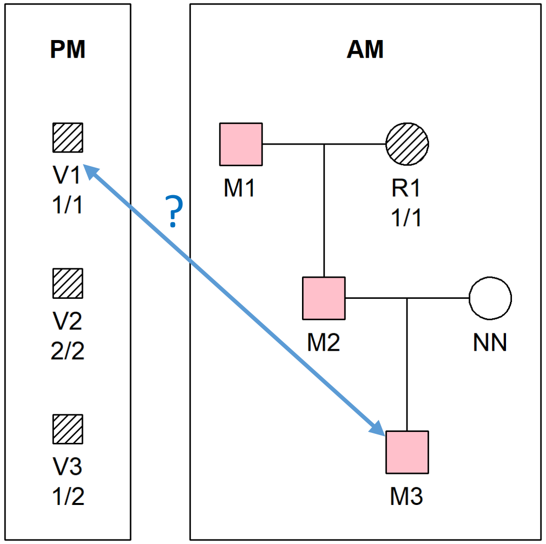
	V1	V2	V3	loglik	LR
1	M3	M1	M2	-15.67181	2000.0
2	M2	*	M1	-17.97439	200.0
3	M2	*	M3	-17.97439	200.0
4	*	M1	M2	-17.97439	200.0
5	M3	*	M2	-18.66754	100.0
	...	...	...	...	...
6	*	M3	M2	-18.66754	100.0
	...	...	...	...	...
19	*	*	*	-23.27271	1.0
	...	...	...	...	...
34	*	M3	*	-Inf	0.0

- Two problems:
  - ✓ LR uses V1 = ‘*’, V2 = ‘*’, V3 = ‘*’ as comparison
  - ✓ How do we test e.g. H_1: V1 = M3 vs. H_2: V1 = ‘*’?

A tool for interpreting joint results:

Generalised likelihood ratio (GLR)

$$\mathrm{GLR} = \frac{\max_{i \in H_1} L_i}{\max_{j \in H_2} L_j}$$



	V1	V2	V3	loglik	LR
1	M3	M1	M2	-15.67181	2000.0
2	M2	*	M1	-17.97439	200.0
3	M2	*	M3	-17.97439	200.0
4	*	M1	M2	-17.97439	200.0
5	M3	*	M2	-18.66754	100.0
	...	...	...	...	...
6	*	M3	M2	-18.66754	100.0
	...	...	...	...	...
19	*	*	*	-23.27271	1.0
	...	...	...	...	...
34	*	M3	*	-Inf	0.0

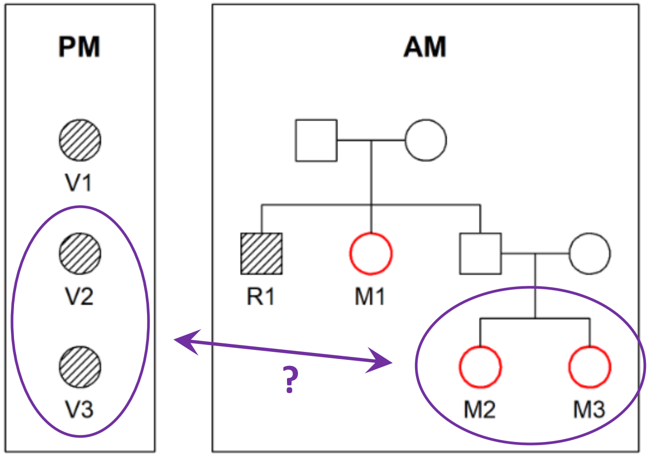
$$\mathrm{GLR} = \frac{LR_1}{LR_2} = \frac{2000}{200} = 10$$

Interpretation of $GLR = x$

$$\text{GLR} = \frac{\max_{i \in H_1} L_i}{\max_{j \in H_2} L_j}$$

The best explanation of the data given H1
is $\boldsymbol{x}$ times more likely
than the best explanation given H2

Symmetric matches



Question 2:

{V1, V2} = {M2, M3} ?

Joint likelihoods

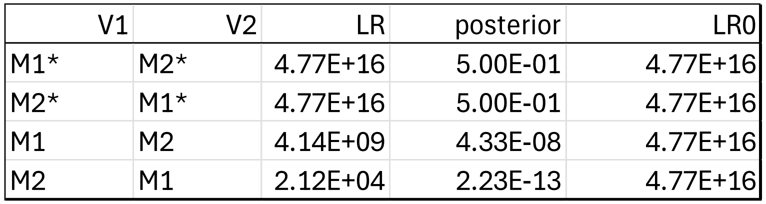
	V1	V2	V3	loglik	
1	M1	M2	M3	-257.7	✓
2	M1	M3	M2	-257.7	✓
3	*	M2	M3	-268.9	✓
4	*	M3	M2	-268.9	✓
5	M2	M1	M3	-272.6	✗
6	M3	M1	M2	-272.6	✗
7	M1	*	M2	-276.5	✗
8	M1	*	M3	-276.5	✗
9	M2	M3	M1	-276.6	✗
⋮					
32	*	*	*	-286.0	✗
33	*	M1	*	-286.5	✗
34	*	*	M1	-292.2	✗

$$\mathrm{GLR} = \frac{L_1}{L_5} = 2.9 \times 10^6$$

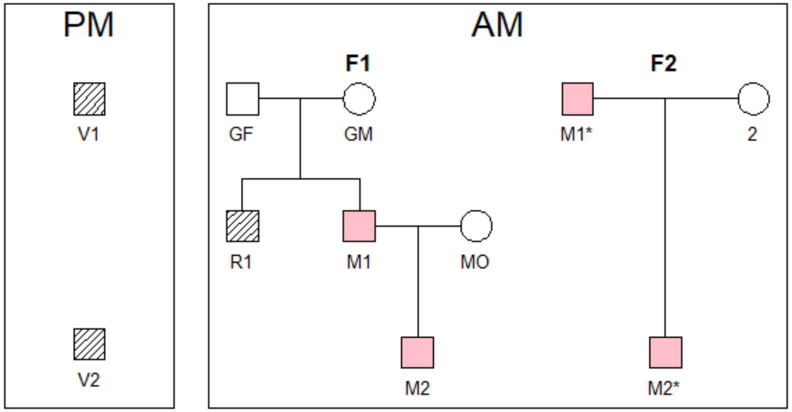
Strong evidence

Potential problem: Related victims

- Assume V1 and V2 are related, e.g. father son, but not related to R1
- Then {V1, V2} may be wrongly identified as {M1, M2} if family F2 is not included



V1	V2	LR	posterior	LR0
M1*	M2*	4.77E+16	5.00E-01	4.77E+16
M2*	M1*	4.77E+16	5.00E-01	4.77E+16
M1	M2	4.14E+09	4.33E-08	4.77E+16
M2	M1	2.12E+04	2.23E-13	4.77E+16

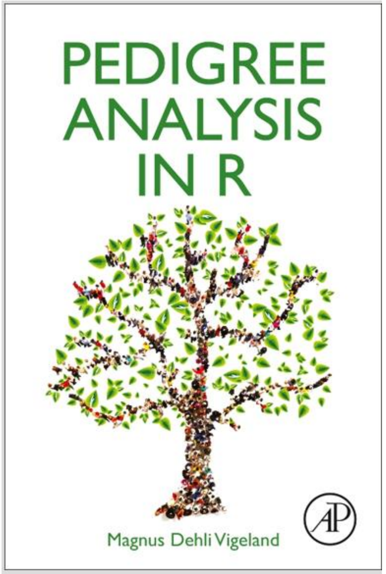


- Column LR0: Genotypes of references removed before calculation: need not include F2

Discussion

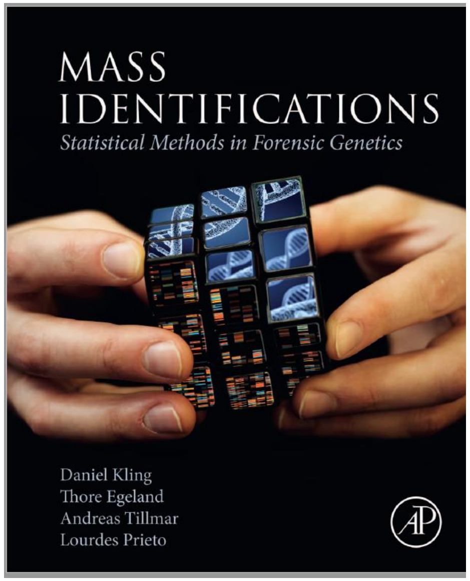
- What should be reported?
  - LR, GLR, and, or posterior?
  - Thresholds?
  - Verbal scales?

Biased selection of references



PEDIGREE ANALYSIS IN R

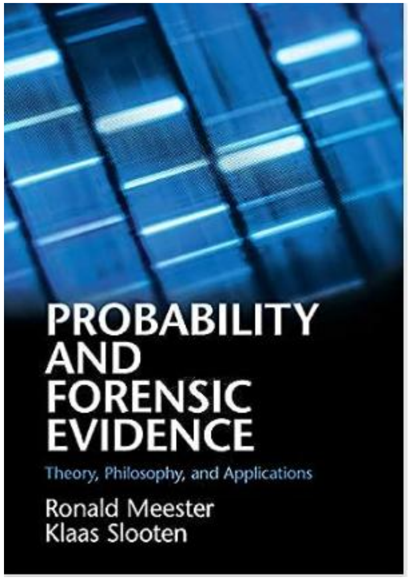
Magnus Dehli Vigeland



MASS IDENTIFICATIONS

Statistical Methods in Forensic Genetics

Daniel Kling
Thore Egeland
Andreas Tillmar
Lourdes Prieto



PROBABILITY AND FORENSIC EVIDENCE

Theory, Philosophy, and Applications

Ronald Meester
Klaas Slooten

Kinship cases with partially specified hypotheses

Thore Egeland [a b], Magnus Dehli Vigeland [a]

Forensic Science International: Genetics

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