How a simple graph improves people' understanding of informed consents and their decision-making in a medical screening setting

Imke Hrycyk, Nicolas Sanchez-Fuenzalida, Esteban Hurtado, Rut Correia & Gorka Navarrete

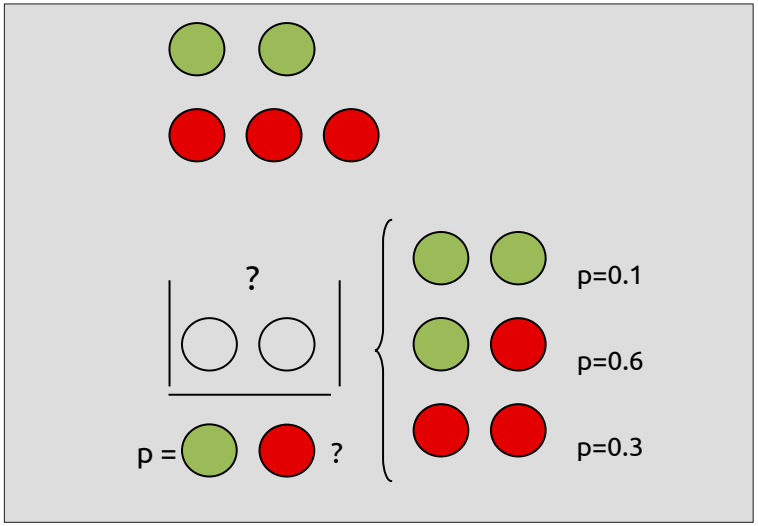
CSCN
CENTRO DE NEUROCIENCIA SOCIAL Y COGNITIVA
ESCUELA DE PSICOLOGÍA · UAI

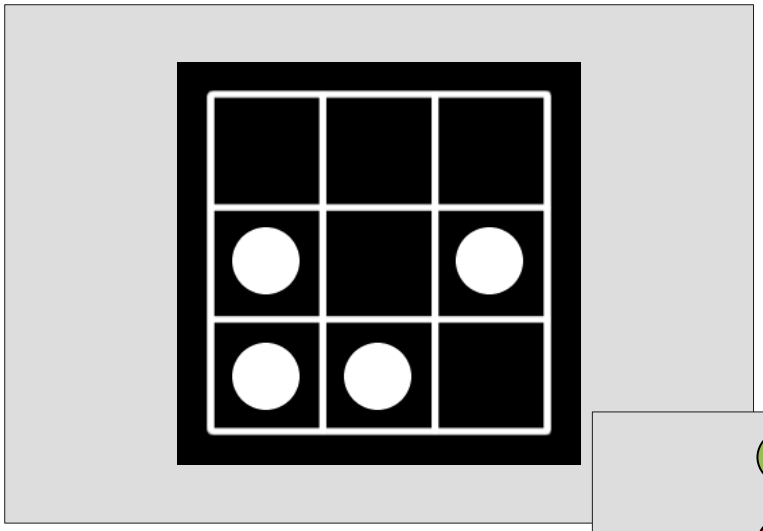
Gorka Navarrete
www.cscn.uai.cl
gorka.navarrete@uai.cl
@gorkang

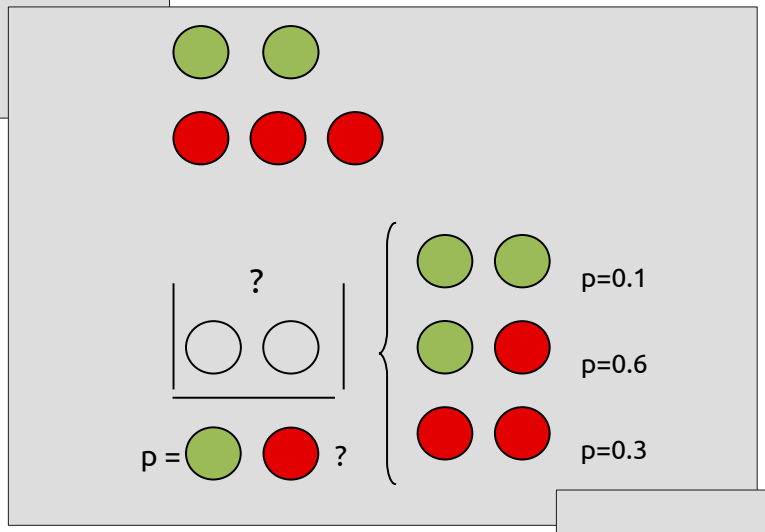
(2015-2016) Fodecyt Regular 1150824. Communication and interpretation of diagnostic tests: behavioral and physiological variables of Bayesian reasoning

(2017-2019) Fondecyt Regular 1171035. Towards a more integrated model of Bayesian reasoning: calculation, understanding and decision making in medical contexts

"Just a darn minute! — Yesterday
you said that X equals **two**!"


?
p =
?
p=0.1
p=0.6
p=0.3

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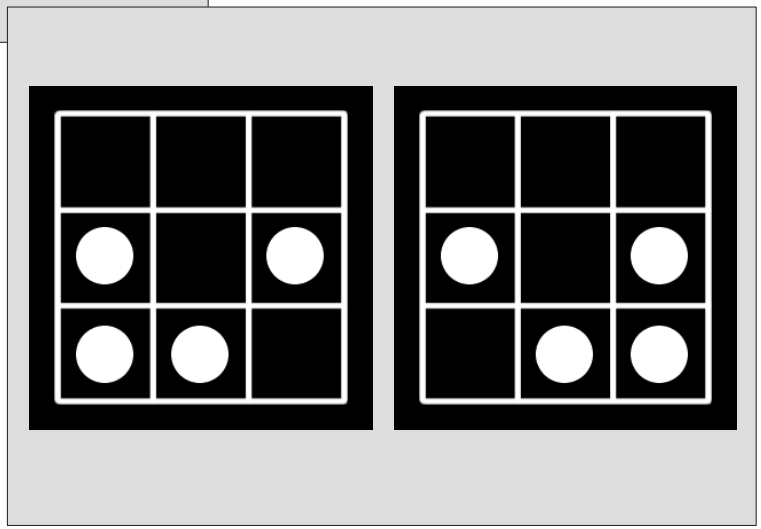
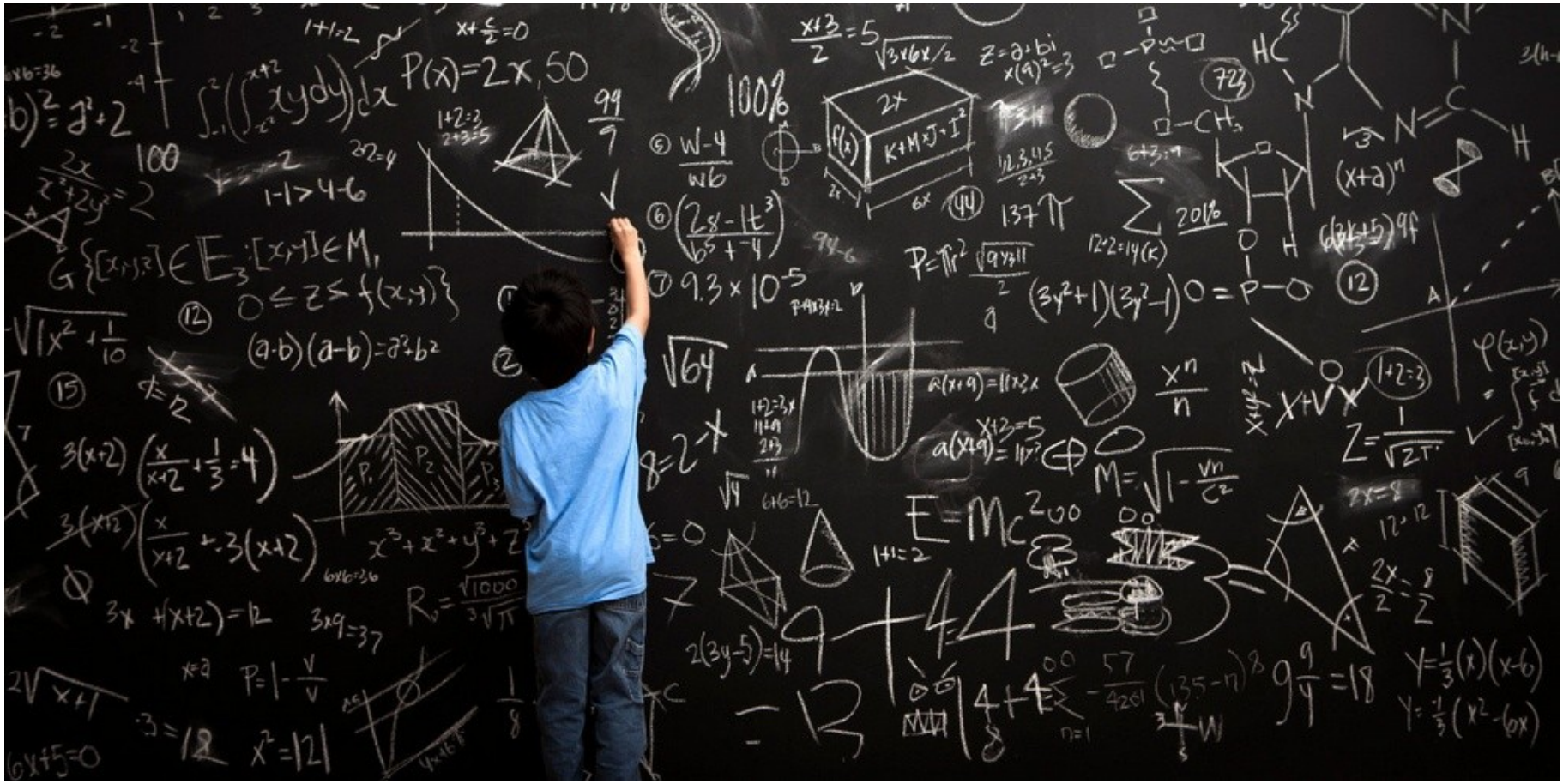
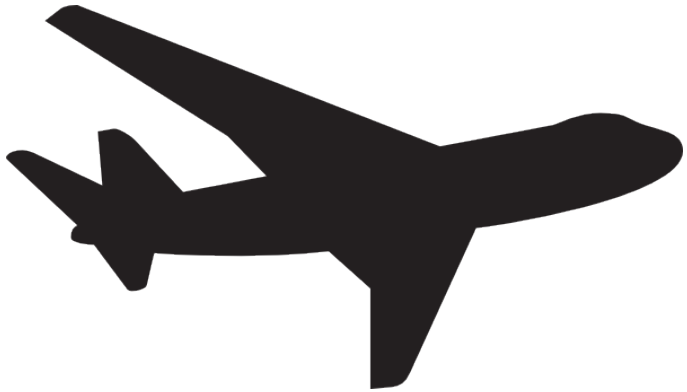


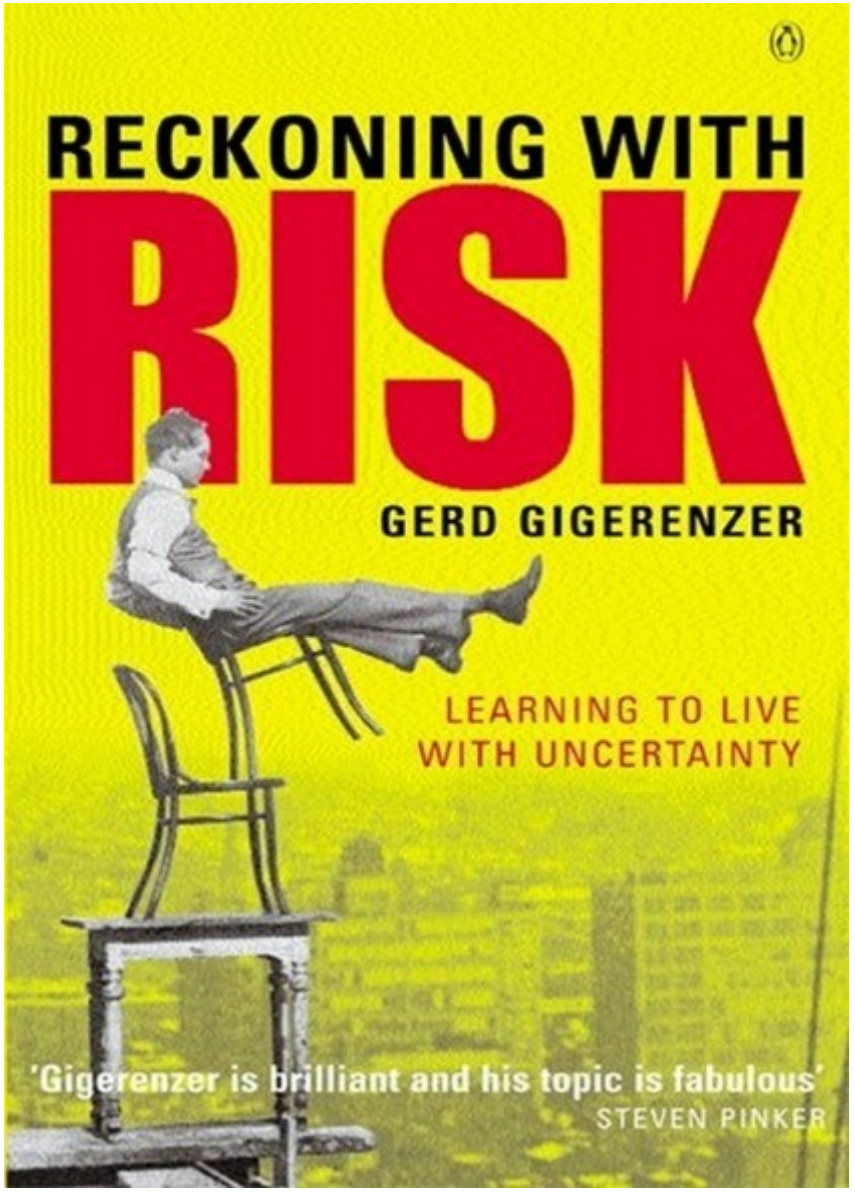
High complexity

Low confidence (<50%)

High accuracy rate (**>80%**)





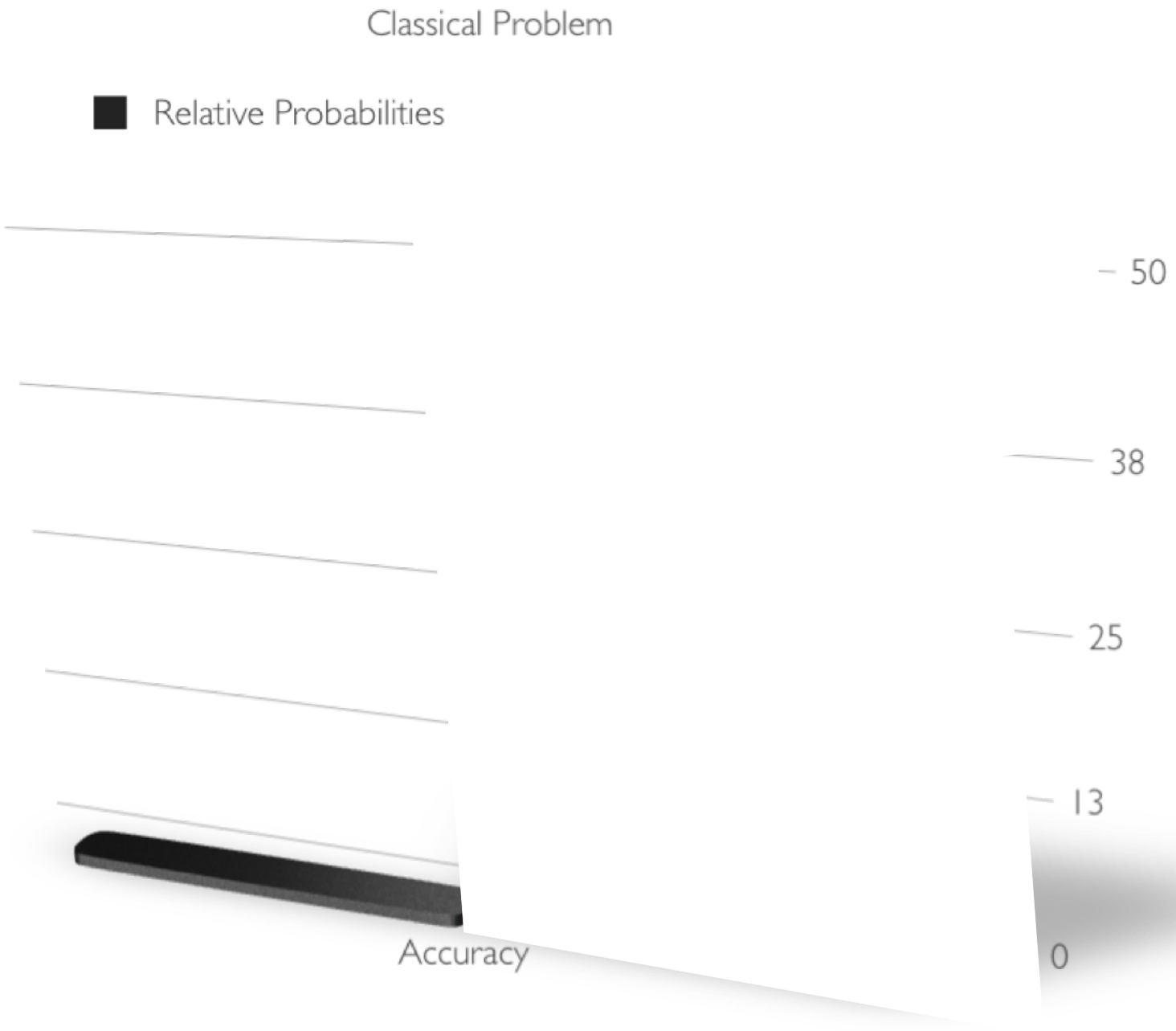

RECKONING WITH
RISK
GERD GIGERENZER
LEARNING TO LIVE
WITH UNCERTAINTY
'Gigerenzer is brilliant and his topic is fabulous'
STEVEN PINKER

The probability of breast cancer is 1% for women aged forty who participate in routine screening.

If a woman has breast cancer, the probability is 80% that she will get a positive mammogram.

If a woman does not have breast cancer, the probability is 9.6% that she will also get a positive mammogram.

A woman in this age group has a positive mammogram in a routine screening. **What is the probability that she actually has breast cancer? ____ %**

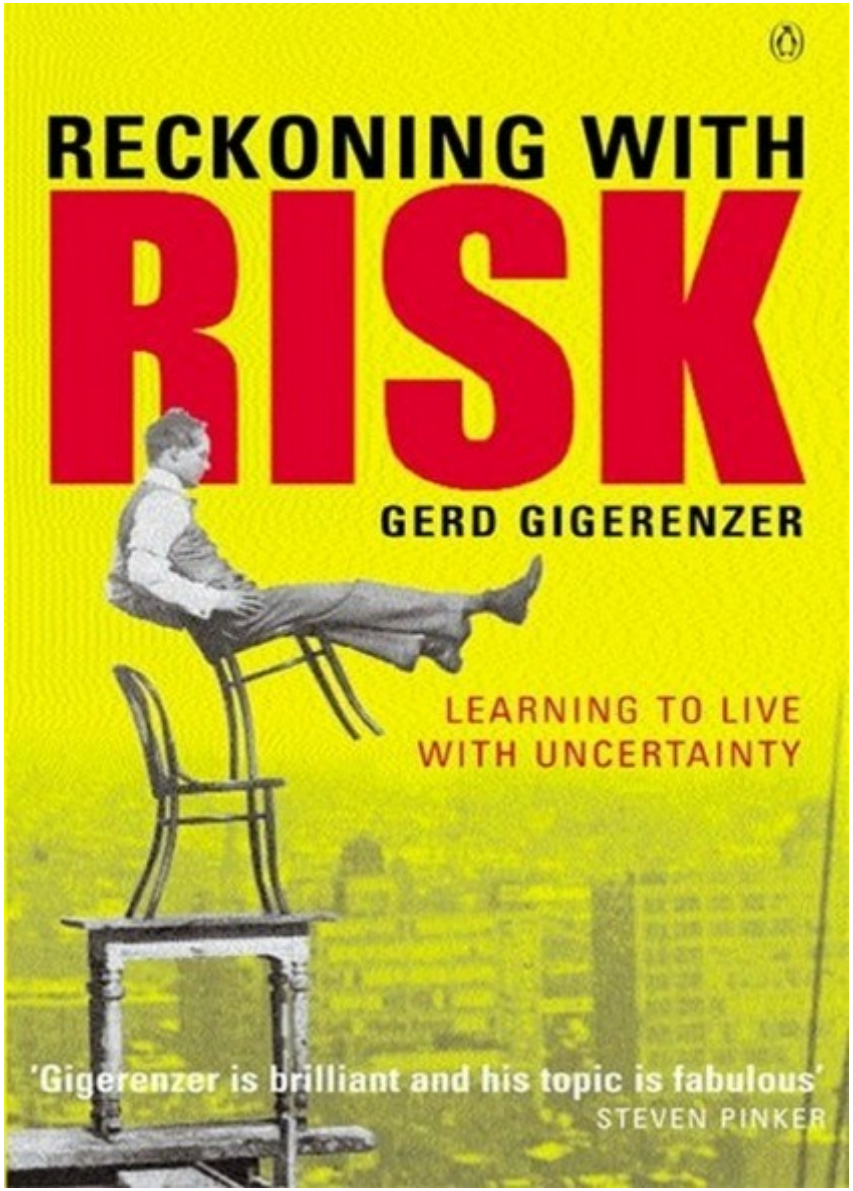


But see McDowell, M., & Jacobs, P. (2017). Meta-Analysis of the Effect of Natural Frequencies on Bayesian Reasoning. Psychological Bulletin, 58(6), 441–451

High complexity

High confidence (>80%)

Low accuracy rate (**~5%**)


RECKONING WITH
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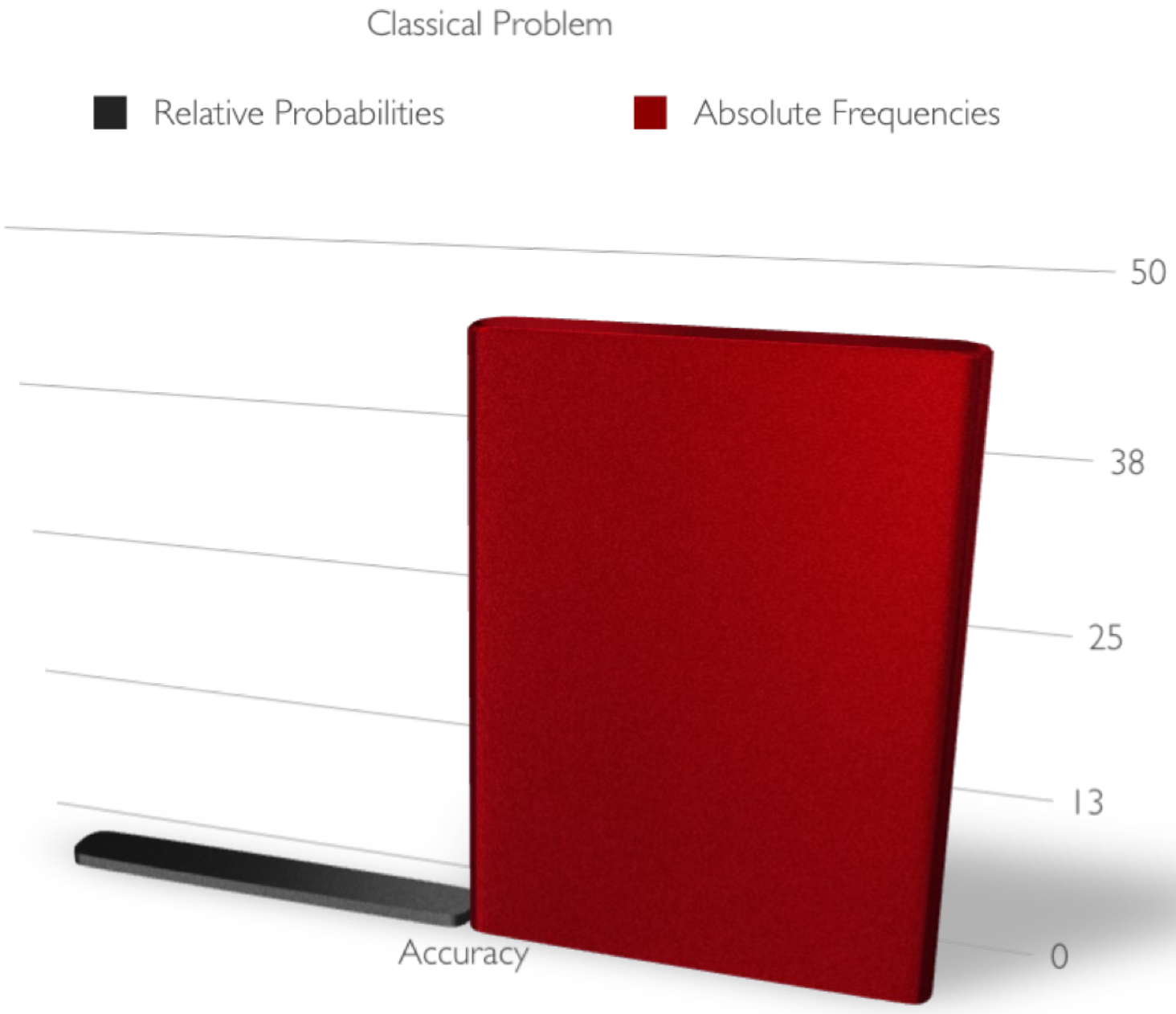
WITH UNCERTAINTY
'Gigerenzer is brilliant and his topic is fabulous'
STEVEN PINKER

10 out of every 1,000 women at age forty who participate in routine screening have breast cancer.

8 of every 10 women with breast cancer will get a positive mammography.

95 out of every 990 women without breast cancer will also get a positive mammography.

Here is a new representative sample of women at age forty who got a positive mammography in routine screening. **How many of these women do you expect to actually have breast cancer?** ____out of____



But see McDowell, M., & Jacobs, P. (2017). Meta-Analysis of the Effect of Natural Frequencies on Bayesian Reasoning. Psychological Bulletin, 58(6), 441–451

$$\mathrm{p}(H|D) = \frac{\mathrm{p}(D|H)\,\mathrm{p}(H)}{\mathrm{p}(D)}$$

Base Rate Neglect

Unicorn Test

Hit rate: 100% (sensitivity)
False positives: 0,1% (1 - specificity)

Massive screening

Type 2 diabetes

Population A

Population B

Massive screening

Type 2 diabetes

Population A

Population A

Hit rate
100%

False positives
0,1%

Prevalence
1 out of 1000

p(Disease|+)?

<25% 25-49% 50% 51-75% >75%

Population A

Hit rate
100%

False positives
0,1%

Prevalence
1 out of 1000

p(Disease|+)?

<25% | 25-49% | 50% | 51-75% | >75%

1 out of 1000

Hit rate **100%**

1 out of 1000

False positives

0,1%

PPV = 50%

Hit rate **100%**

1 out of 1000

False positives
0,1%

$$p(H|D) = \frac{p(H).\,p(D|H)}{p(H).\,p(D|H) + p(\bar{H}).\,p(D|\bar{H})}$$

PPV = 50%

Hit rate **100%**

1 out of 1000

False positives
0,1%

$$p(H|D) = \frac{p(H) \cdot p(D|H)}{p(H) \cdot p(D|H) + p(\bar{H}) \cdot p(D|\bar{H})}$$

PPV = 50%

Hit rate **100%**

1 out of 1000

False positives
0,1%

$$p(H|D) = \frac{0.1\% \cdot 100\%}{0.1\% \cdot 100\% + 99.9\% \cdot 0.1\%}$$

PPV = 50%

Hit rate **100%**

1 out of 1000

False positives
0,1%

$$\frac{\text{TRUE +}}{\text{TRUE +} \; + \; \text{FALSE +}} = \frac{\square}{\square + \square}$$

Massive screening

Type 2 diabetes

Population B

Population B

Hit rate
100%

False positives
0,1%

Prevalence
500 out of 1000

p(Disease|+)?

<25% 25-49% 50% 51-75% >75%

Population B

Hit rate
100%

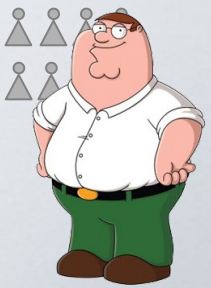
False positives
0,1%

Prevalence
500 out of 1000

p(Disease|+)?

<25% 25-49% 50% 51-75% >75% **(99,8%)**

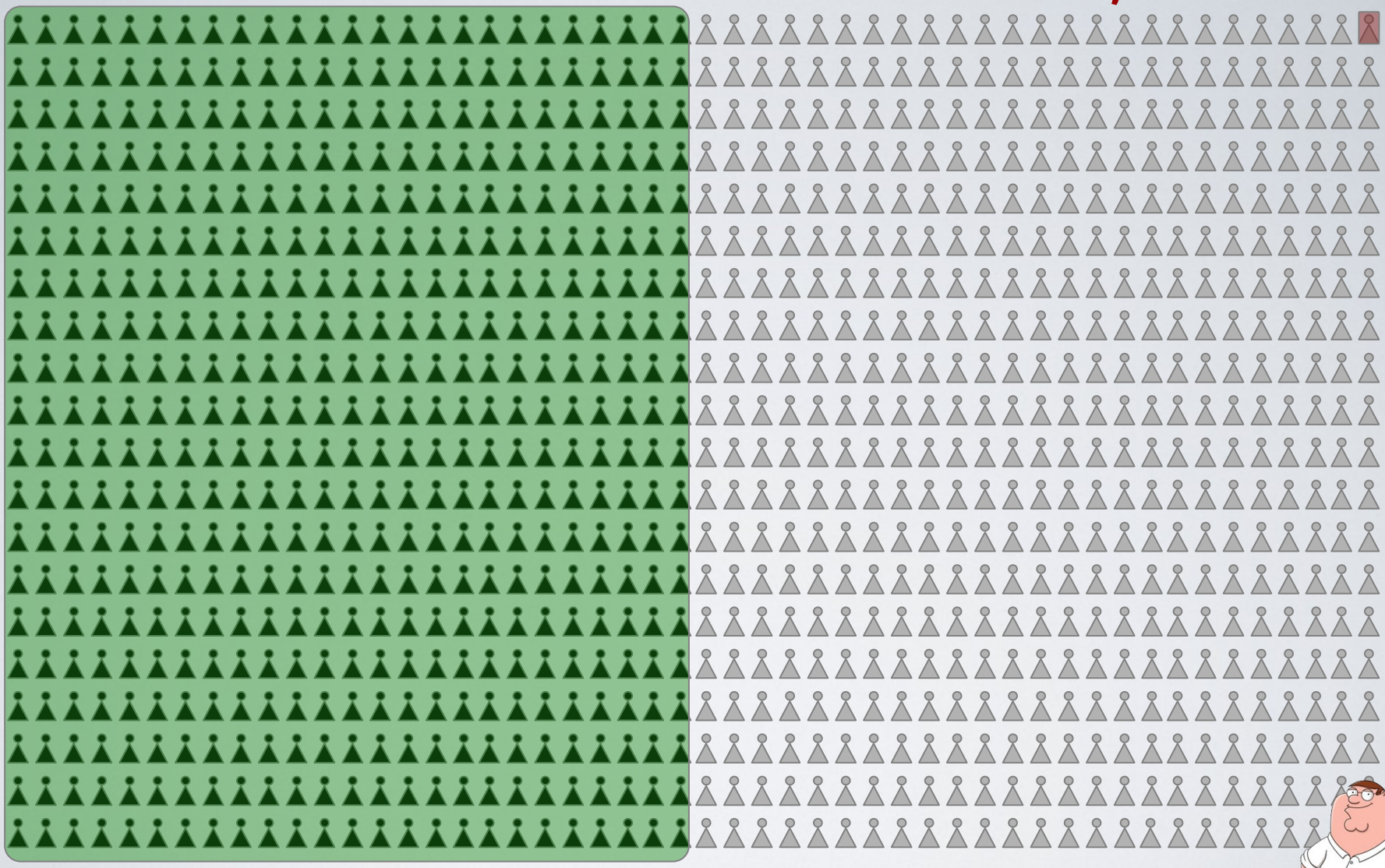
500 out of 1000

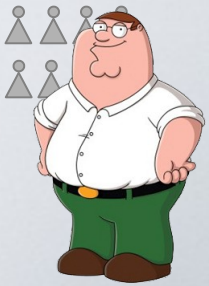


Hit rate **100%**

500 out of 1000

False positives **0,1%**





PPV = 99.8%

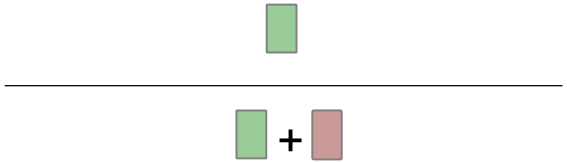
Hit rate **100%**

500 out of 1000

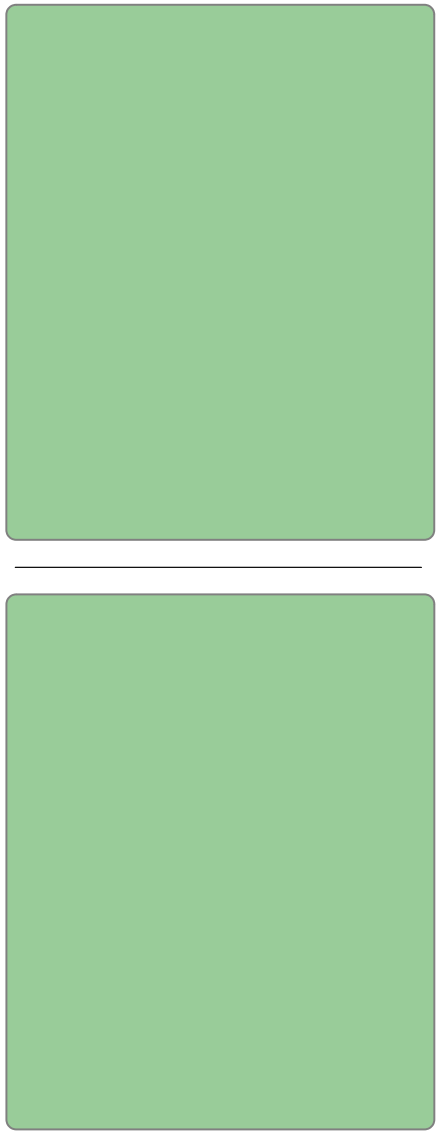
False positives
0,1%

$$\frac{\text{TRUE +}}{\text{TRUE +} \; + \; \text{FALSE +}} = \frac{\square}{\square} + \square$$

Population A



Population B



Epidemiology 101:

Screening tests , PPV and NPV

Screening tests are to discard healthy people:

- NPV very high
- PPV, … it depends, but who cares?

$$\text{PPV} = \frac{\text{TRUE } +}{\text{TRUE } + \; + \; \text{FALSE } +} \qquad \text{NPV} = \frac{\text{TRUE } -}{\text{TRUE } - \; + \; \text{FALSE } -}$$

We focus on **PPV**:

- Relevance for the individual
- Massive cost of False Positives
  - (e.g. 4 Billion US$/year Breast cancer)
- Important for the decision:

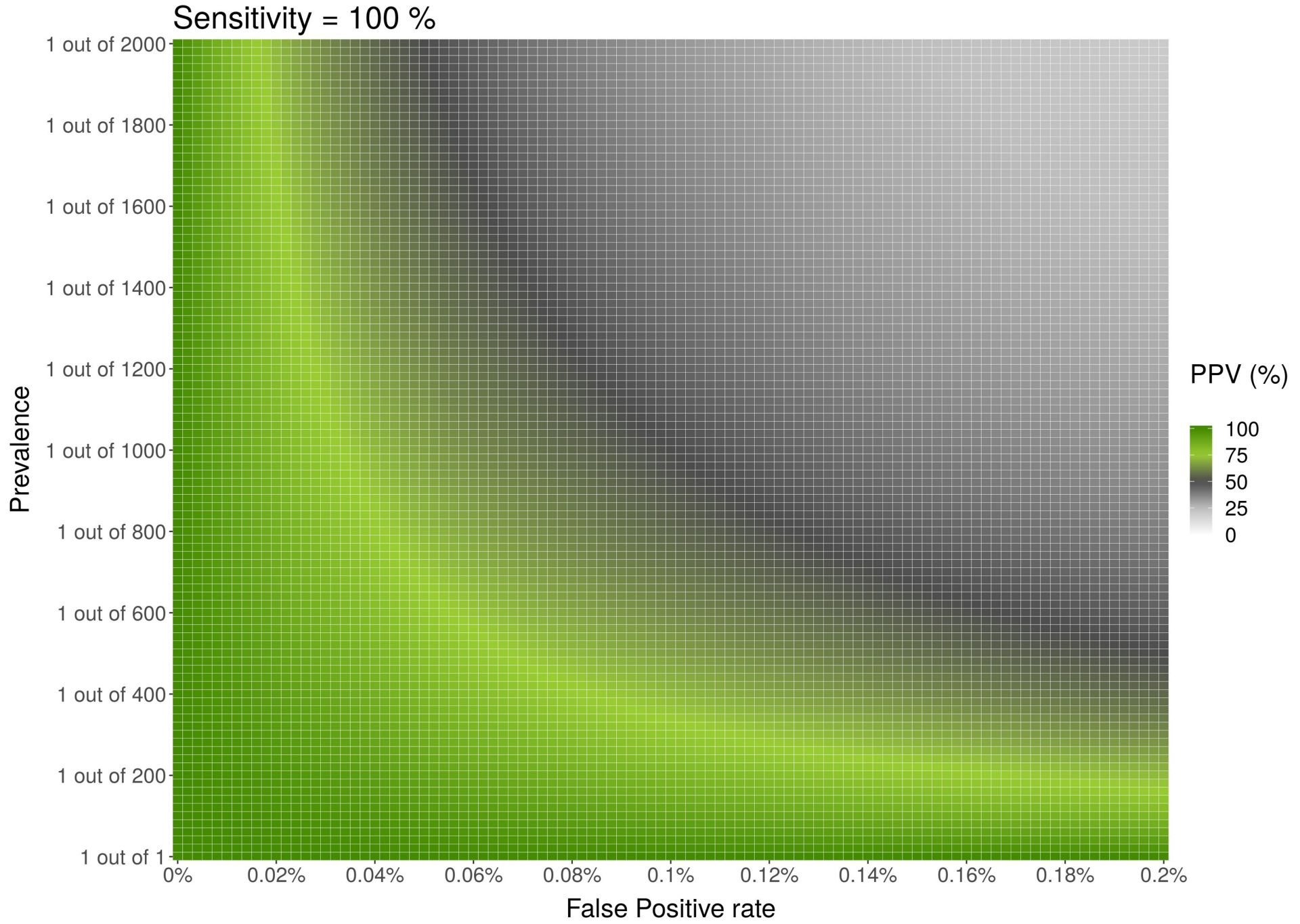
screening test? → + → diagnostic test?

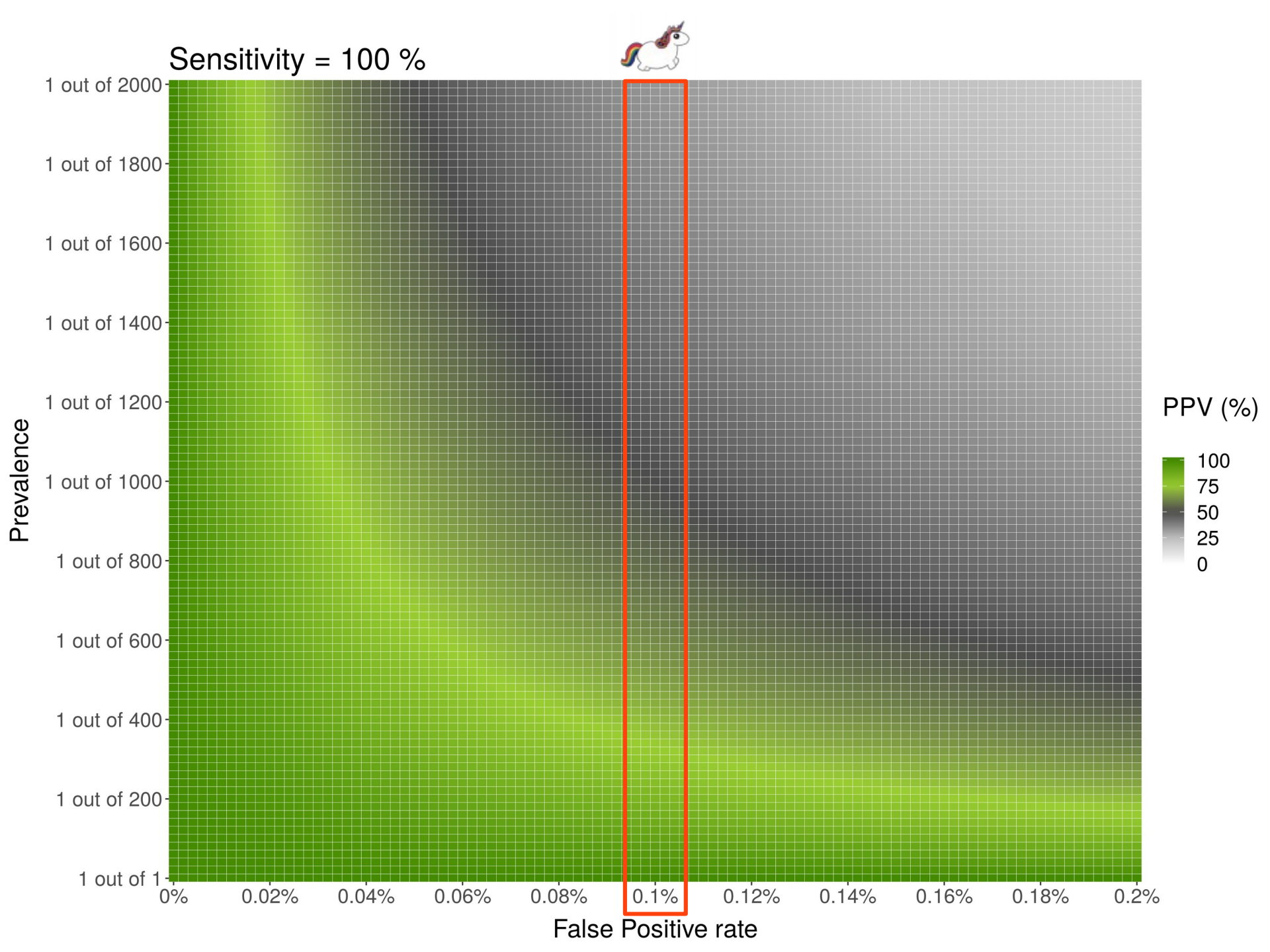
$$\text{PPV} = \frac{\text{TRUE +}}{\text{TRUE +} + \text{FALSE +}}$$

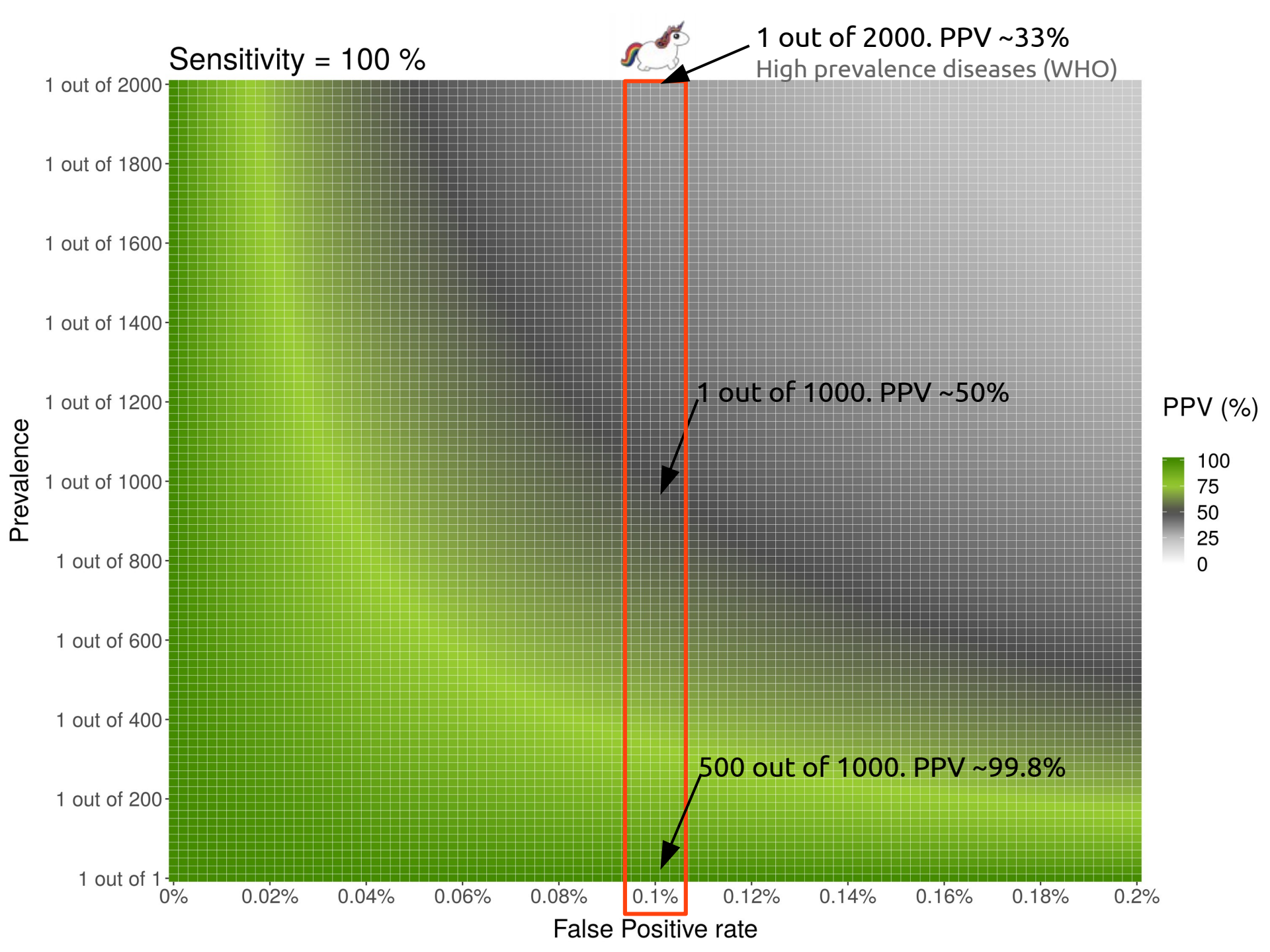
Unicorn Test

In the real world

Hit rate: 100% (sensitivity)
False positives: 0,1% (1 - specificity)

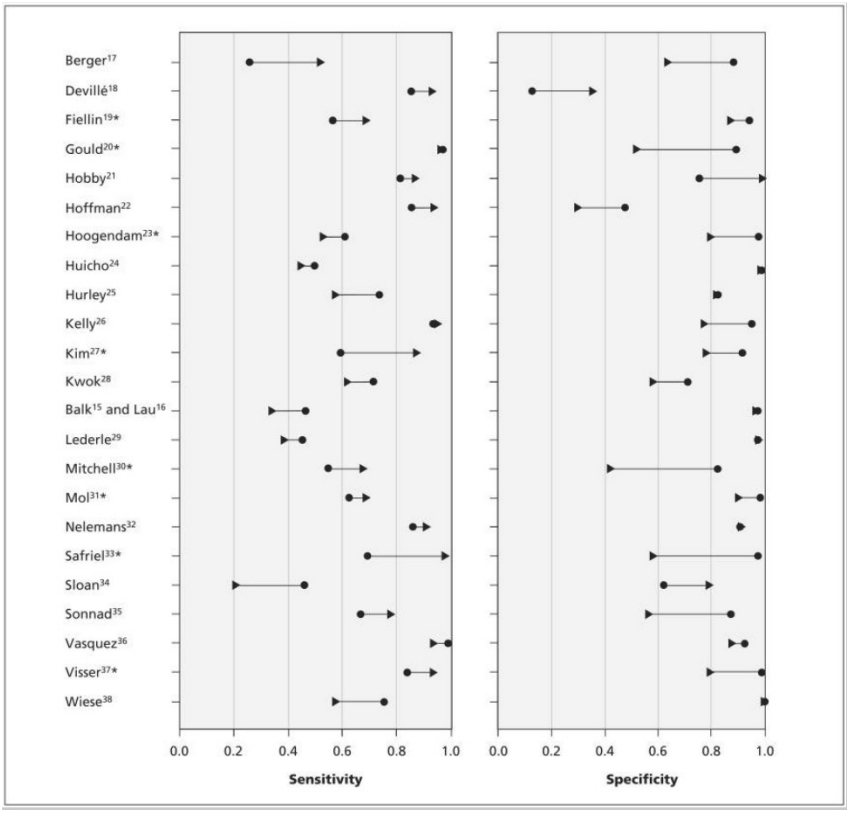



Sensitivity = 100 %
1 out of 2000
1 out of 1800
1 out of 1600
1 out of 1400
1 out of 1200
1 out of 1000
1 out of 800
1 out of 600
1 out of 400
1 out of 200
1 out of 1
Prevalence
0%
0.02%
0.04%
0.06%
0.08%
0.1%
0.12%
0.14%
0.16%
0.18%
0.2%
False Positive rate
PPV (%)
100
75
50
25
0


Sensitivity = 100 %
1 out of 2000. PPV ~33%
High prevalence diseases (WHO)
1 out of 1000. PPV ~50%
500 out of 1000. PPV ~99.8%
Prevalence
1 out of 2000
1 out of 1800
1 out of 1600
1 out of 1400
1 out of 1200
1 out of 1000
1 out of 800
1 out of 600
1 out of 400
1 out of 200
1 out of 1
0%
0.02%
0.04%
0.06%
0.08%
0.1%
0.12%
0.14%
0.16%
0.18%
0.2%
False Positive rate
PPV (%)
100
75
50
25
0

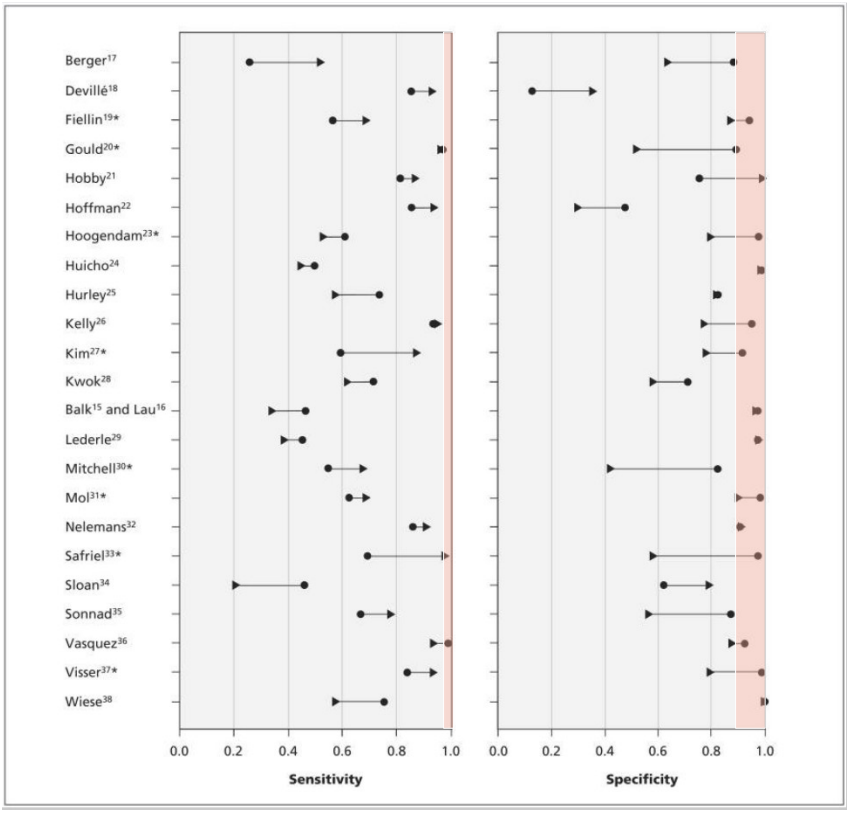
Real world screening tests

In real world diseases



43 meta-analysis; 416 studies: Leeflang, M. M. G., Rutjes, A. W. S., Reitsma, J. B., Hooft, L., & Bossuyt, P. M. M. (2013). Variation of a test's sensitivity and specificity with disease prevalence. Cmaj, 185(11), 537–544. http://doi.org/10.1503/cmaj.121286

Sensitivity: 100%
False positives: 0 - 10% (1 - specificity)



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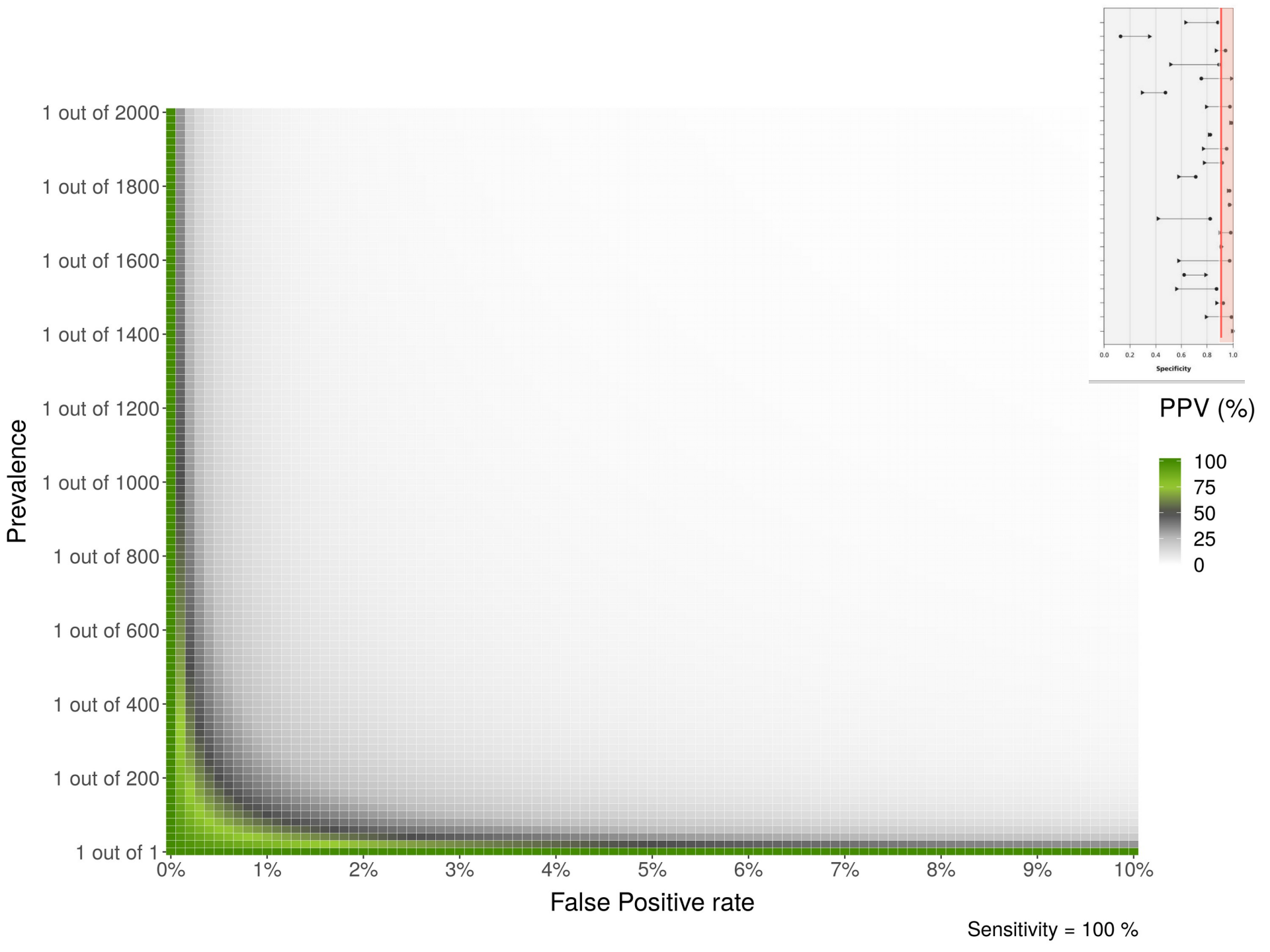
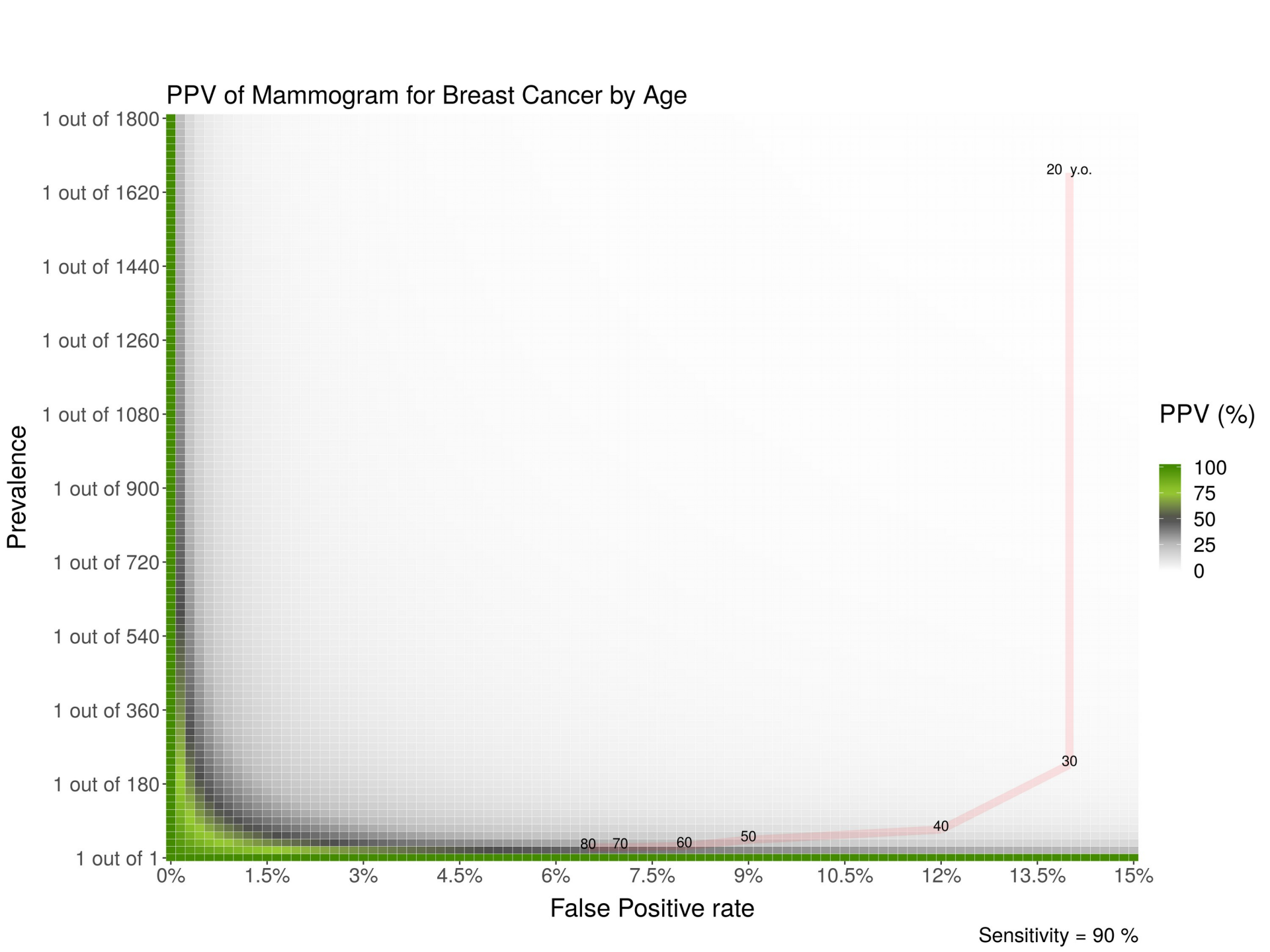
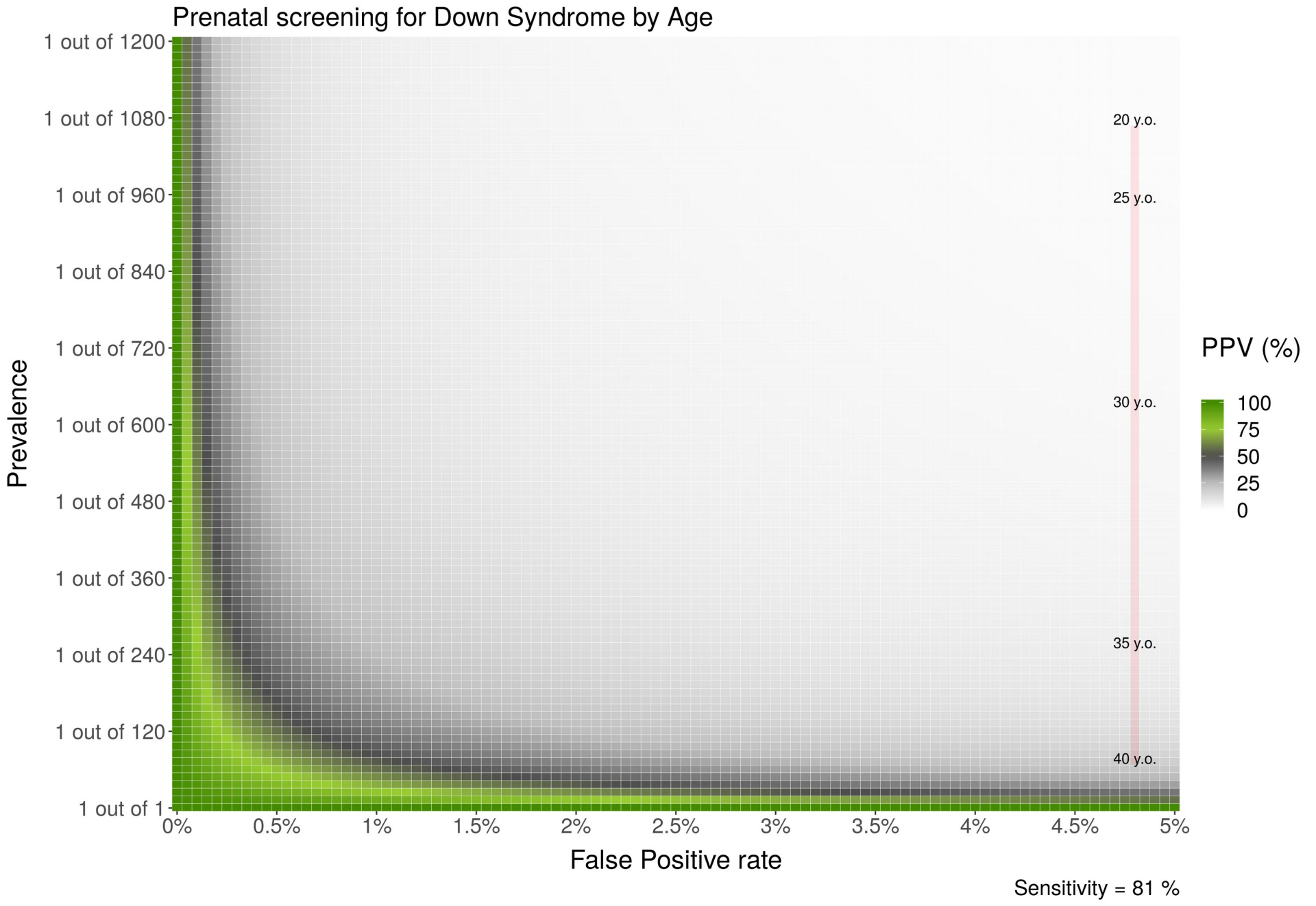
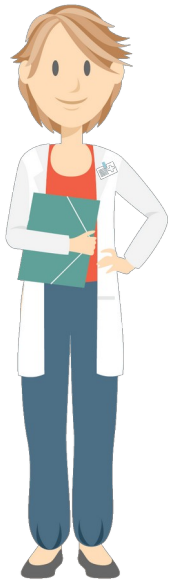

1 out of 2000
1 out of 1800
1 out of 1600
1 out of 1400
1 out of 1200
1 out of 1000
1 out of 800
1 out of 600
1 out of 400
1 out of 200
1 out of 1
Prevalence
0%
1%
2%
3%
4%
5%
6%
7%
8%
9%
10%
False Positive rate
0.0
0.2
0.4
0.6
0.8
1.0
Specificity
PPV (%)
100
75
50
25
0
Sensitivity = 100 %


PPV of Mammogram for Breast Cancer by Age
Prevalence
1 out of 1800
1 out of 1620
1 out of 1440
1 out of 1260
1 out of 1080
1 out of 900
1 out of 720
1 out of 540
1 out of 360
1 out of 180
1 out of 1
0%
1.5%
3%
4.5%
6%
7.5%
9%
10.5%
12%
13.5%
15%
False Positive rate
20 y.o.
30
40
50
60
70
80
PPV (%)
100
75
50
25
0
Sensitivity = 90 %

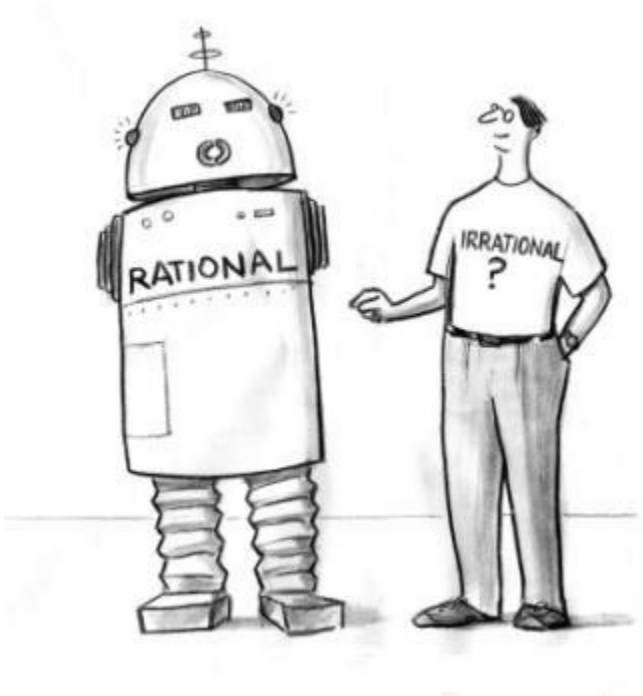

Prenatal screening for Down Syndrome by Age
1 out of 1200
1 out of 1080
1 out of 960
1 out of 840
1 out of 720
1 out of 600
1 out of 480
1 out of 360
1 out of 240
1 out of 120
1 out of 1
Prevalence
0%
0.5%
1%
1.5%
2%
2.5%
3%
3.5%
4%
4.5%
5%
False Positive rate
20 y.o.
25 y.o.
30 y.o.
35 y.o.
40 y.o.
PPV (%)
100
75
50
25
0
Sensitivity = 81 %

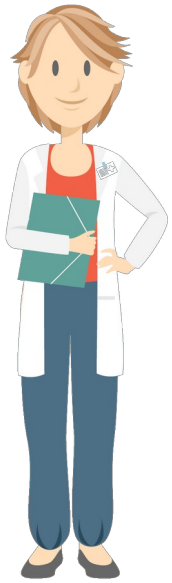
Physicians

Probabilities	4 to 21% accuracy
Nat. Frequencies	29 to 67% accuracy

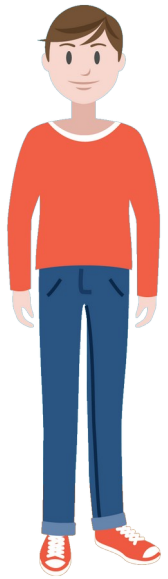


Hoffrage, U., & Gigerenzer, G. (1998). Using Natural Frequencies to Improve Diagnostic Inferences. *Academic Medicine*, *73*(5), 538–540


RATIONAL
IRRATIONAL
?

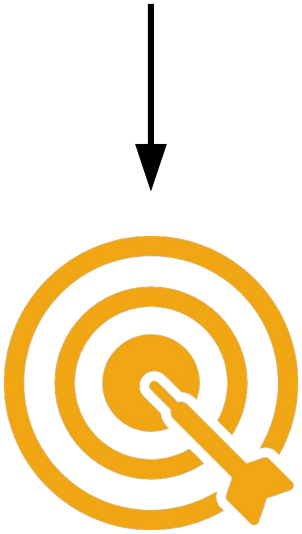


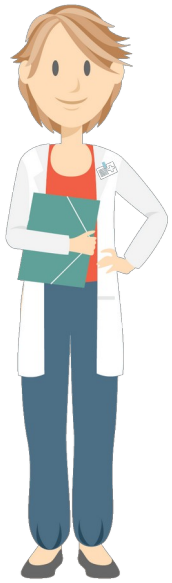

I
CERTAINTY

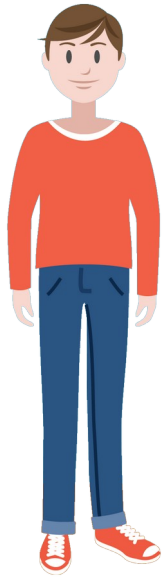


Hit rate **100%**

False positives
0,1%

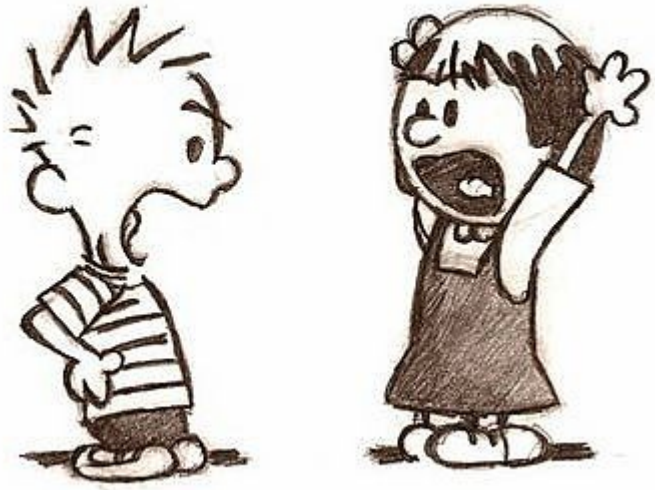






Consent forms

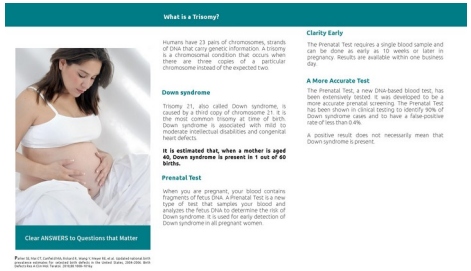
Shared decision making



Information about the test and the medical condition

What's the meaning of a **+** result?

Would you go through this **screening test**?



What is a Trisomy?

Humans have 23 pairs of chromosomes, strands of DNA that carry genetic information. A trisomy is a chromosomal condition that occurs when there are three copies of a particular chromosome instead of the expected two.

Down syndrome

Trisomy 21, also called Down syndrome, is caused by a third copy of chromosome 21. It is the most common trisomy at time of birth. Down syndrome is associated with mild to moderate intellectual disabilities and congenital heart defects.

It is estimated that, when a mother is aged 40, Down syndrome is present in 1 out of 60 births.

Prenatal Test

When you are pregnant, your blood contains fragments of fetus DNA. A Prenatal Test is a new type of test that samples your blood and analyzes the fetus DNA to determine the risk of Down syndrome. It is used for early detection of Down syndrome in all pregnant women.

Clarity Early

The Prenatal Test requires a single blood sample and can be done as early as 10 weeks or later in pregnancy. Results are available within one business day.

A More Accurate Test

The Prenatal Test, a new DNA-based blood test, has been extensively tested. It was developed to be a more accurate prenatal screening. The Prenatal Test has been shown in clinical testing to identify 90% of Down syndrome cases and to have a false-positive rate of less than 0.4%.

A positive result does not necessarily mean that Down syndrome is present.

Clear ANSWERS to Questions that Matter

Result is

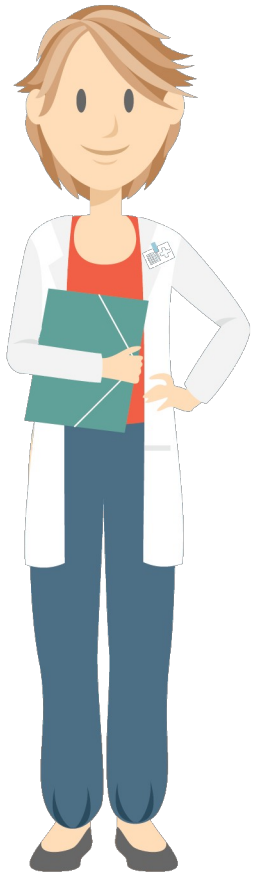
+

Would you go through a **Follow up test** with 1% chance of a procedure-related miscarriage?

Result is

−

CLINICIAN

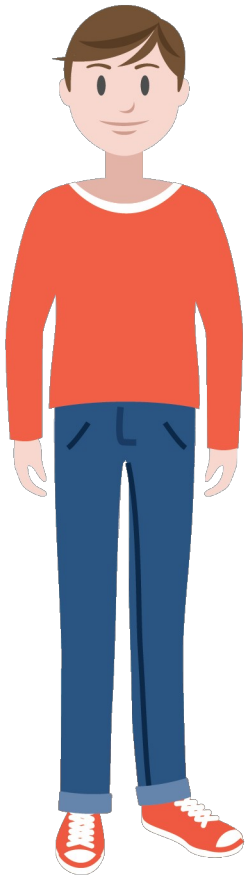


SHARED DECISION MAKING

Information & Recommendations

Values & Preferences

PATIENT



How people deal with Consent Forms?

Service, and in exchange for service, all users of this site agree to immediately assign their first-born child to NameDrop, Inc. If the user does not yet have children, this

Obar, J. A. (2016). The Biggest Lie on the Internet: Ignoring the Privacy Policies and Terms of Service Policies of Social Networking Services. SSRN Electronic Journal, 15(2), 67–82. http://doi.org/10.2139/ssrn.2757465

Service, and in exchange for service, all users of this site agree to immediately assign their first-born child to NameDrop, Inc. If the user does not yet have children, this

1.7%

complained about the Child clause

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Consent forms

Prenatal screening examples

A) Not enough information

B) Too much information

C) Consequences

A) Not enough information

B) Too much information

C) Consequences


TOSHIBA
20111010.094517.H.U.C.:20111010.094517.H.... F
HOSP UNIV DE CANARIA... Semana 20
10/10/2011
09:50:00 AM
0
5
10
2DG
79
DR
60
6C1
15.0
19 fps
497
IP6
HDD:89% Free
CINE REVIEW
ABC

X

Prevalence

90%

Hit rate
(sensitivity)

1%

False positives
(1 – specificity)

Positive
Predictive
Value
(PPV)

X

Prevalence

90%

Hit rate
(sensitivity)

1%

False positives
(1 – specificity)

Positive
Predictive
Value
(PPV)

$$p(\text{Down syndrome}|+) = \frac{x \times 90\%}{(x \times 90\%) + ((1-x) \times 1\%)} = \frac{x}{x+y} = \sim[0..100]\%$$

A) Not enough information

B) Too much information

C) Consequences

Harmony™
PRENATAL TEST

An advance in non-invasive fetal trisomy testing

Specialized Diagnostics

Integrated GENETICS
LabCorp Specialty Testing Group

What is a Trisomy?

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TRISOMY 21

Trisomy 21 is due to an extra chromosome 21 and is the most common trisomy at the time of birth. Trisomy 21, also called Down syndrome, is associated with mild to moderate intellectual disabilities and may also lead to digestive disease and congenital heart defects. It is estimated that trisomy 21 is present in 1 out of every 800 births in Canada.[1]

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[2]Ontario Ministry of Health and Long-Term Care
[3]U.S. National Library of Medicine
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	Harmony
Cost*	$795.00

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	Harmony
Cost*	$795.00

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* The information provided about sensitivity and specificity are probably an overestimation…

$$p\left(Trisomy\ 21 \mid +test\right) =$$

$$(A)\ \frac{1\ out\ of\ 800\ \times\ 99\%}{\left(1\ out\ of\ 800 \times 99\%\right) + \left(799\ out\ of\ 800 \times 0.1\%\right)} =$$

$$(B)\ \frac{0.123}{0.123 + 0.0998} = 0.55$$

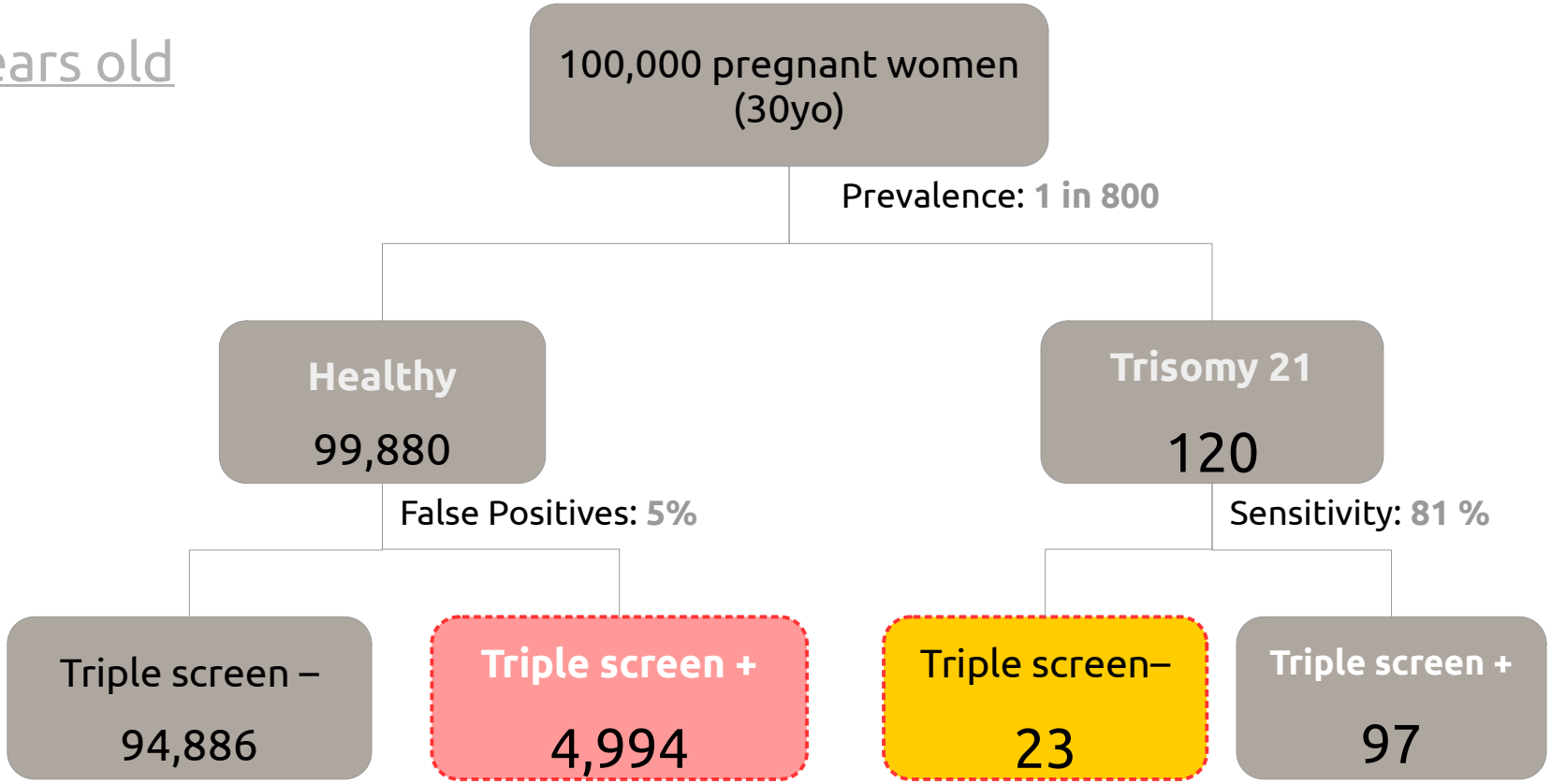
What's the meaning of a + result?

A) Not enough information

B) Too much information

C) Consequences

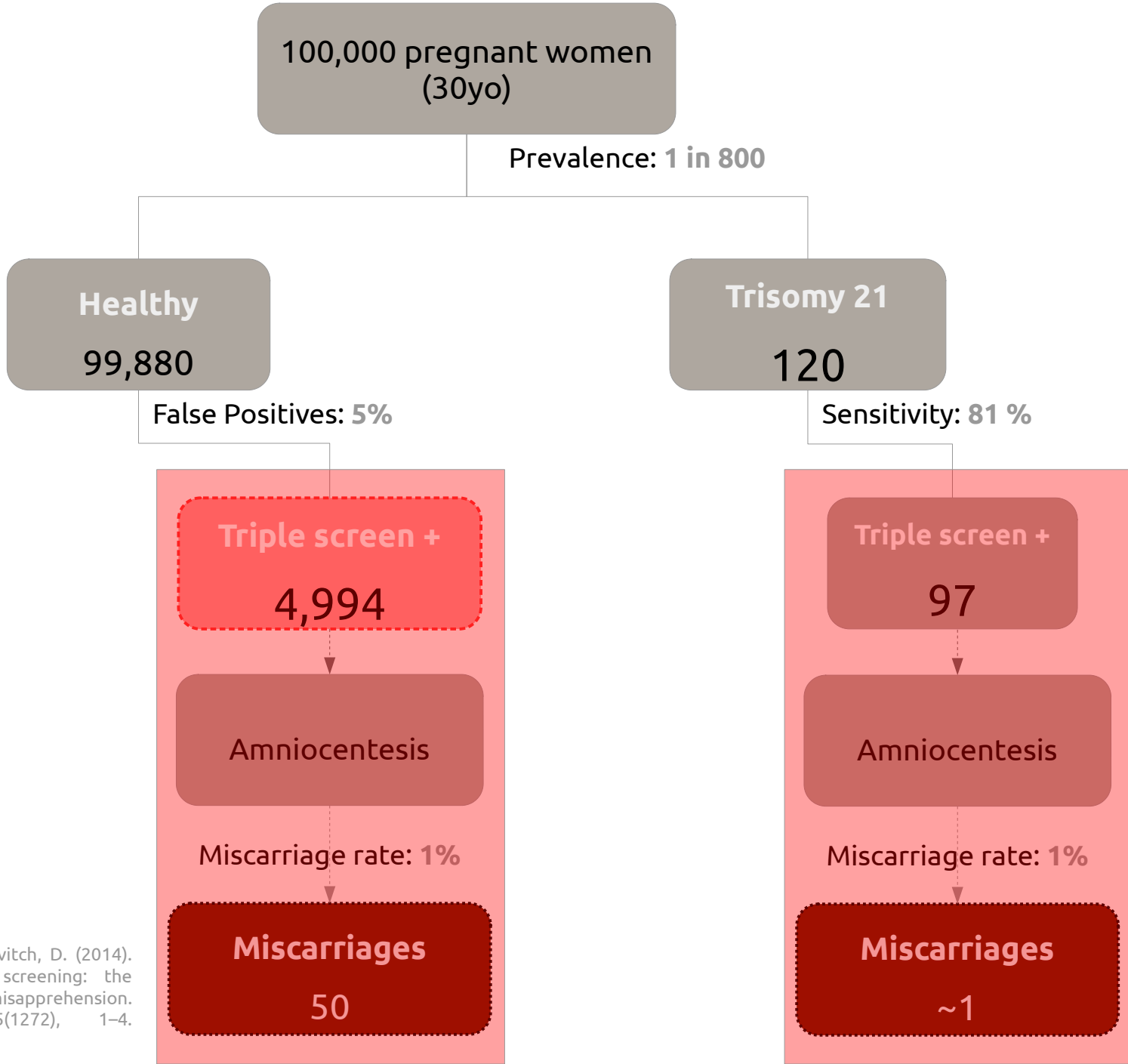
30 years old



PPV (21): ~1.60%
PPV (18): ~0.48%
PPV (13): ~0.32%

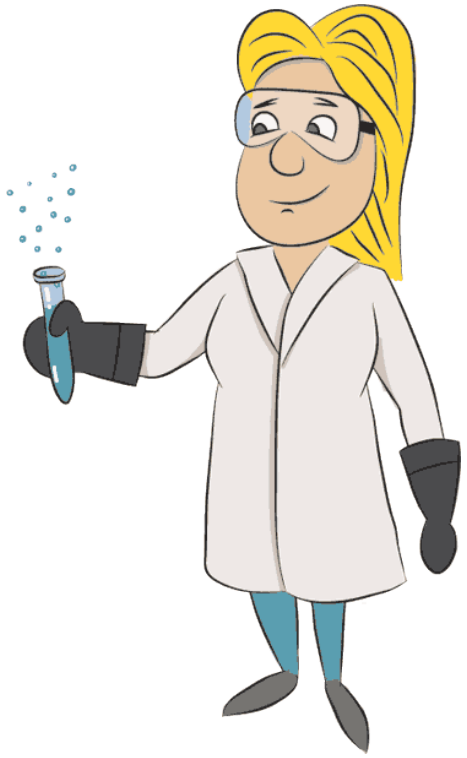
Navarrete, G., Correia, R., & Froimovitch, D. (2014). Communicating risk in prenatal screening: the consequences of Bayesian misapprehension. Frontiers in Psychology, 5(1272), 1–4. doi:10.3389/fpsyg.2014.01272

30 years old



Navarrete, G., Correia, R., & Froimovitch, D. (2014). Communicating risk in prenatal screening: the consequences of Bayesian misapprehension. Frontiers in Psychology, 5(1272), 1–4. doi:10.3389/fpsyg.2014.01272

OLD RESEARCH!



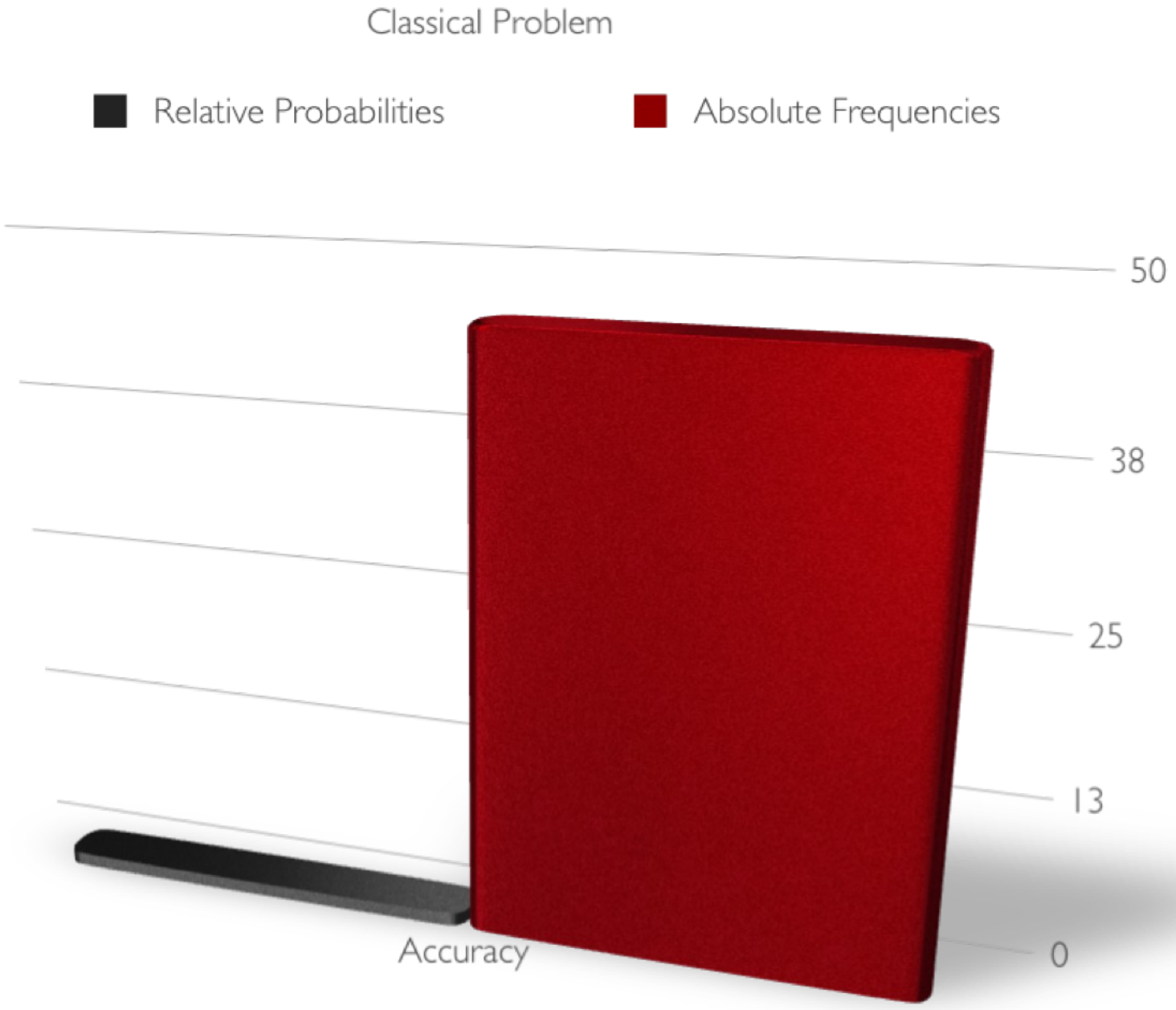
Cognitive mechanisms behind the comprehension of Bayesian reasoning problems

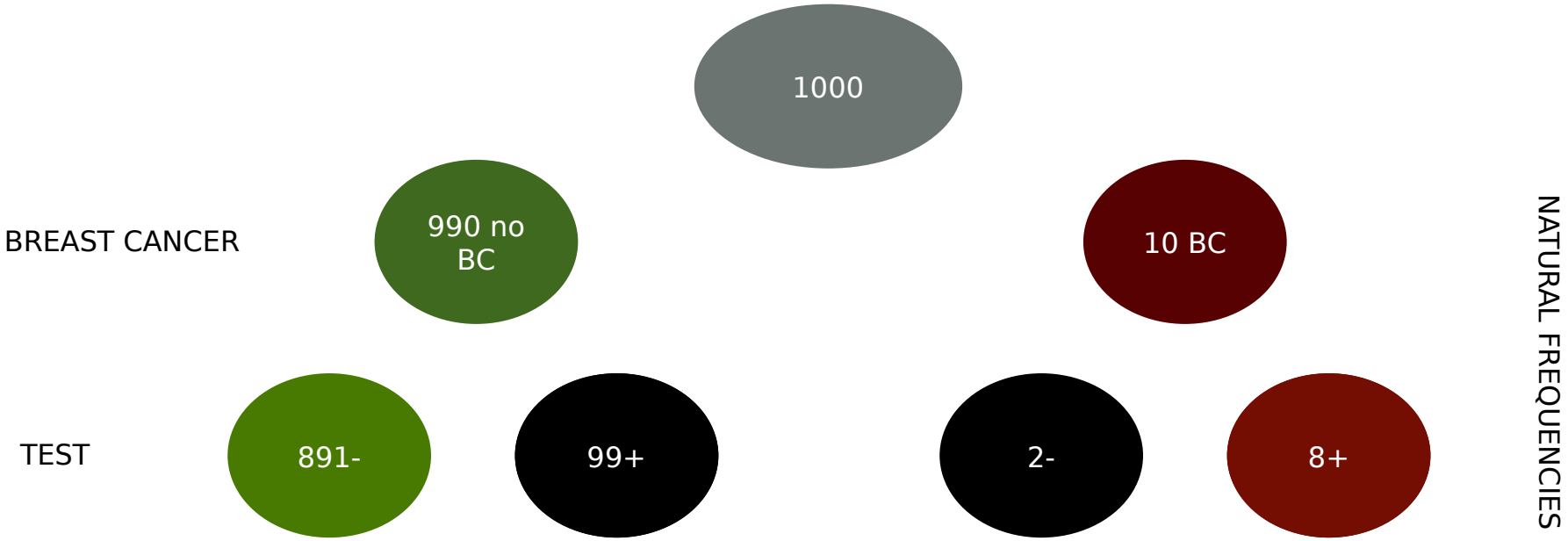
Arithmetic complexity

Individual differences

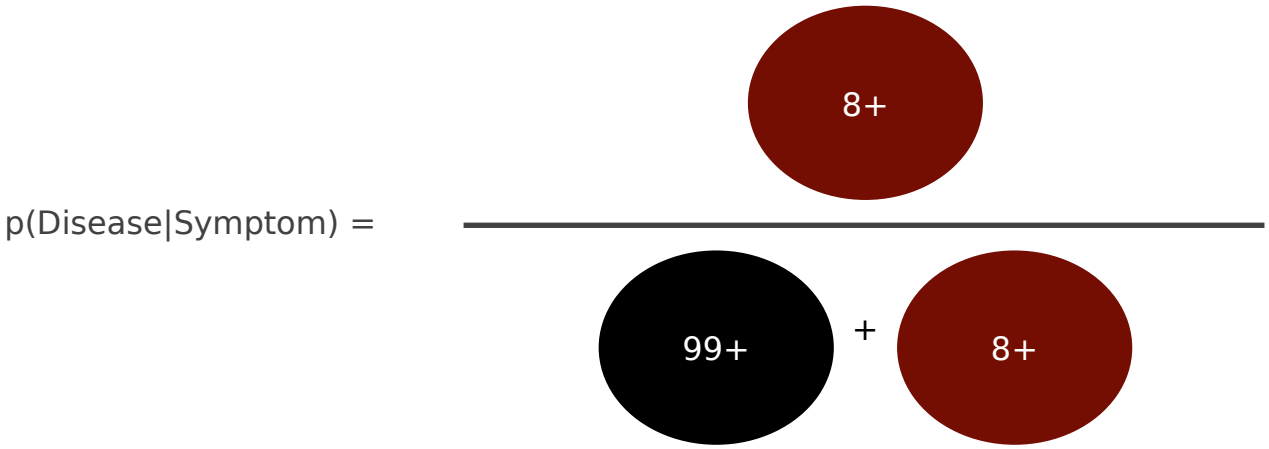
Reference class

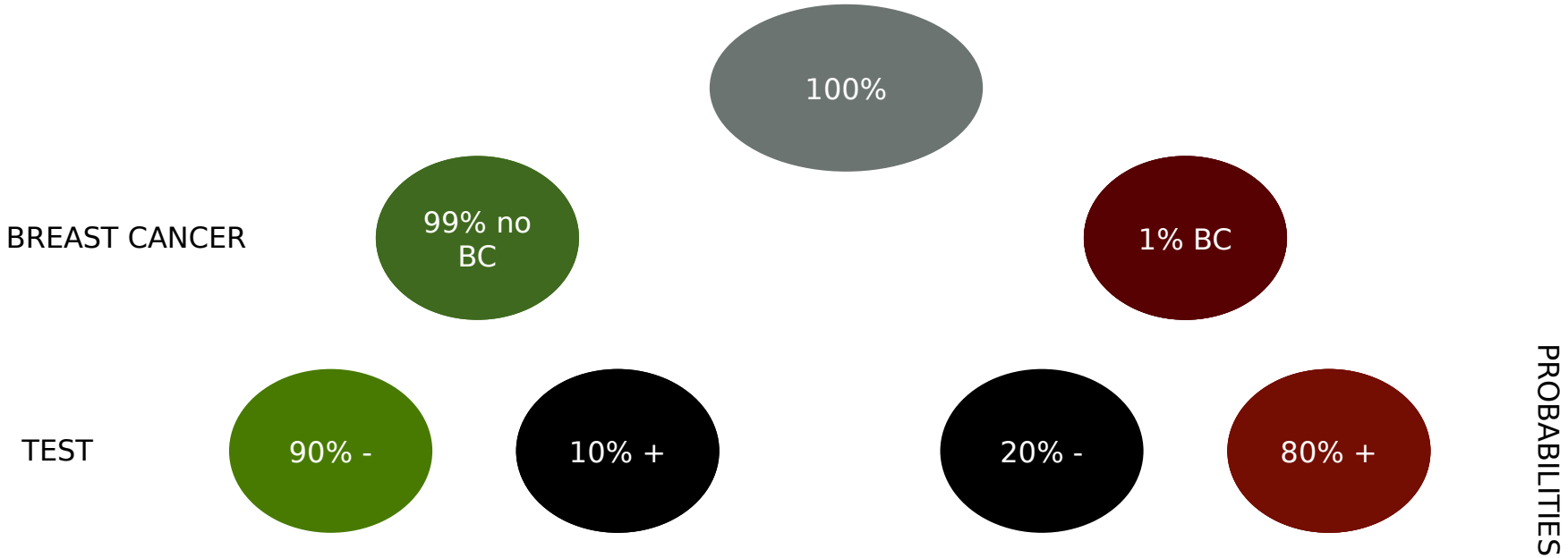
Arithmetic complexity


Classical Problem
Relative Probabilities
Absolute Frequencies
50
38
25
13
0
Accuracy

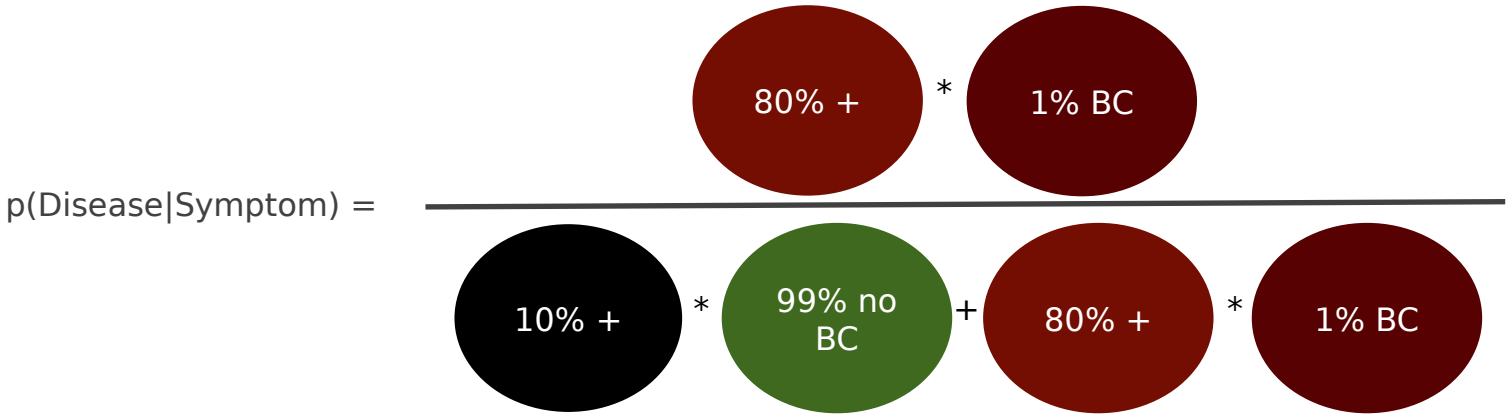


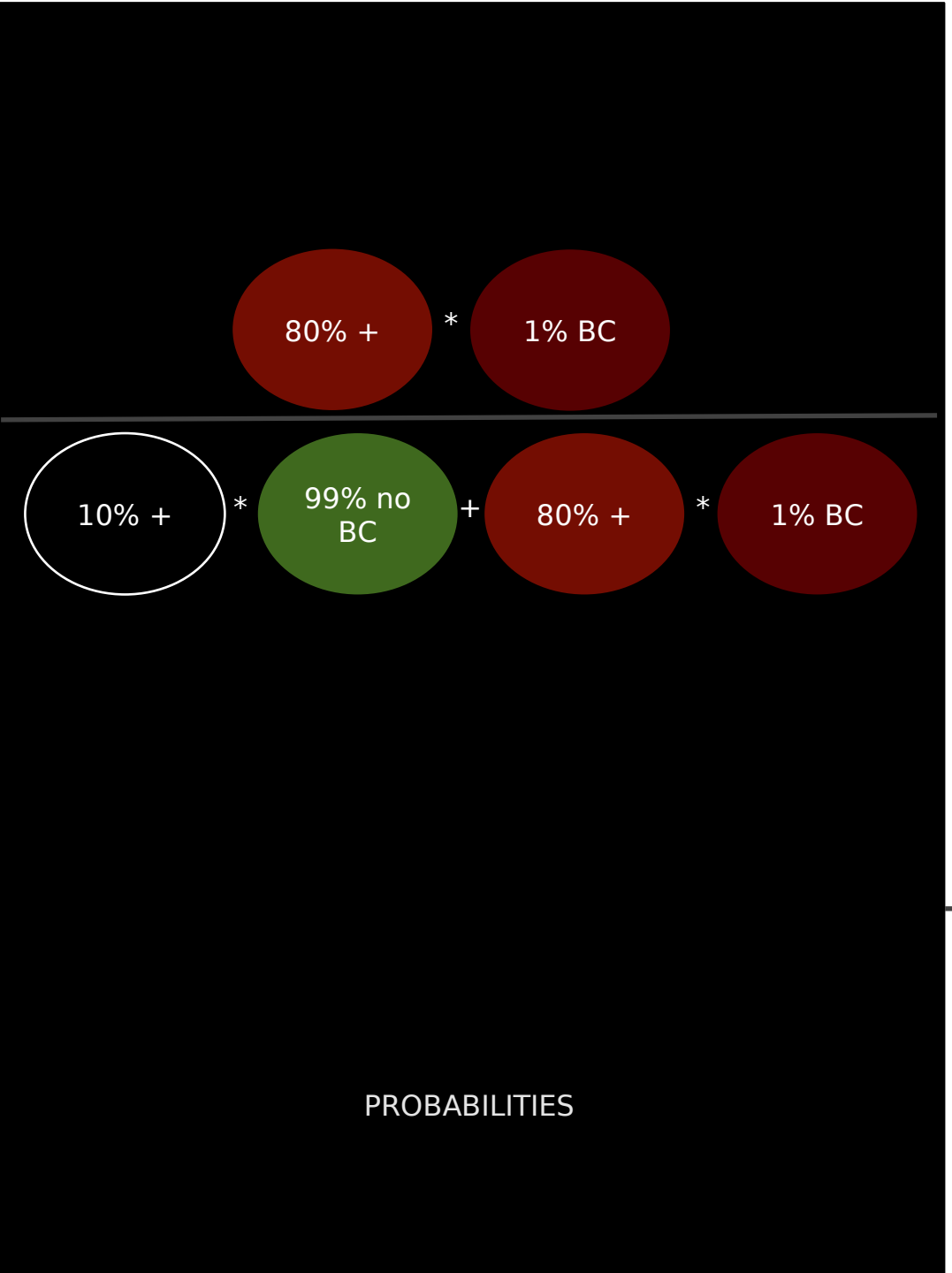
Take, for example, a sample of women who have positive mammograms. How many of these women actually have breast cancer?



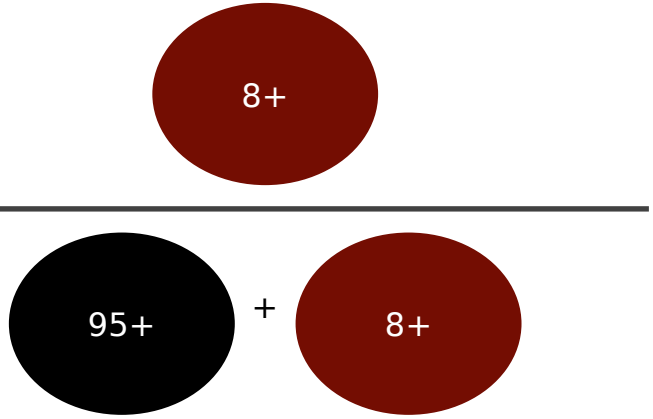


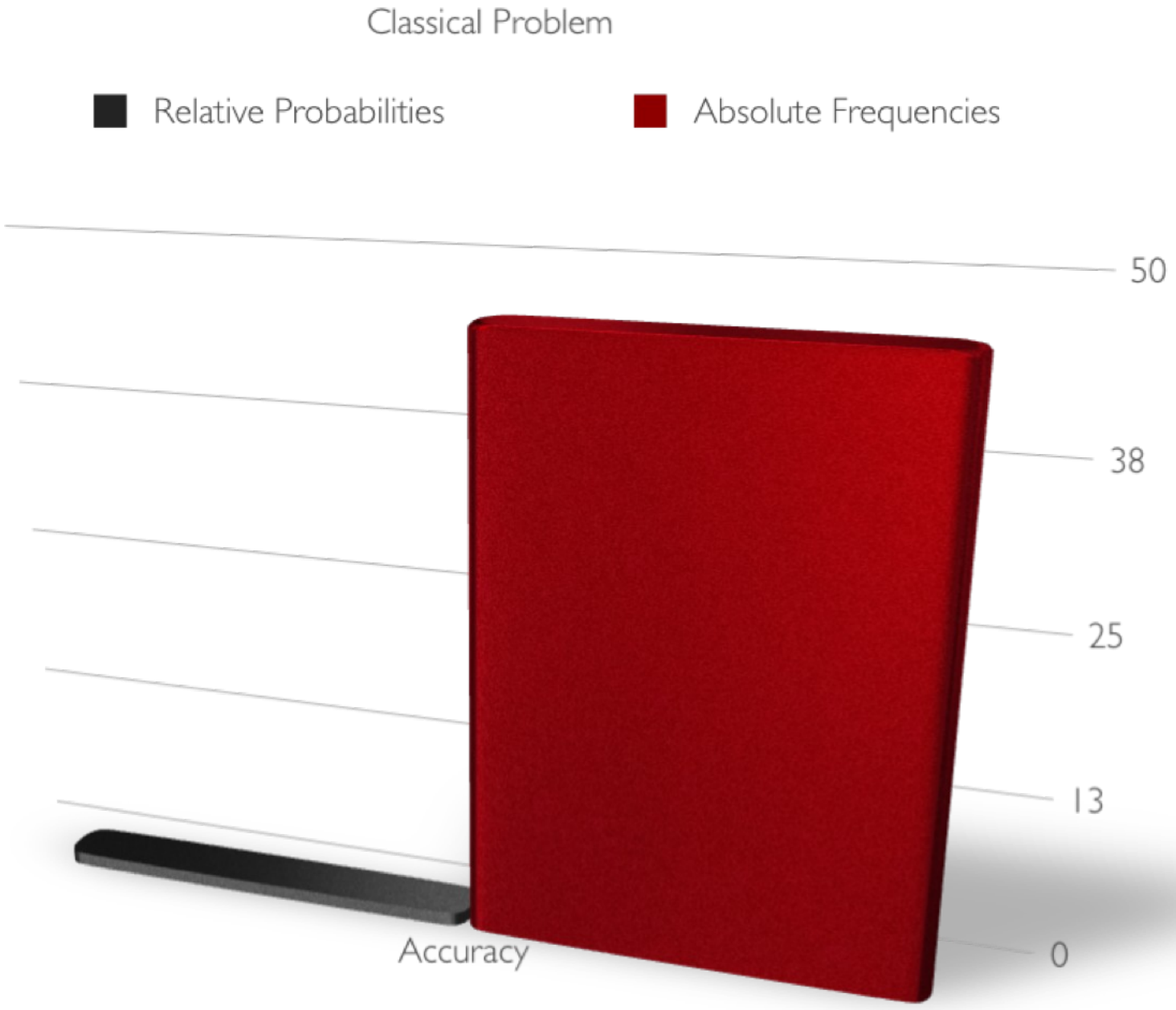
Take, for example, a sample of women who have positive mammograms. What is the probability that she actually has breast cancer?

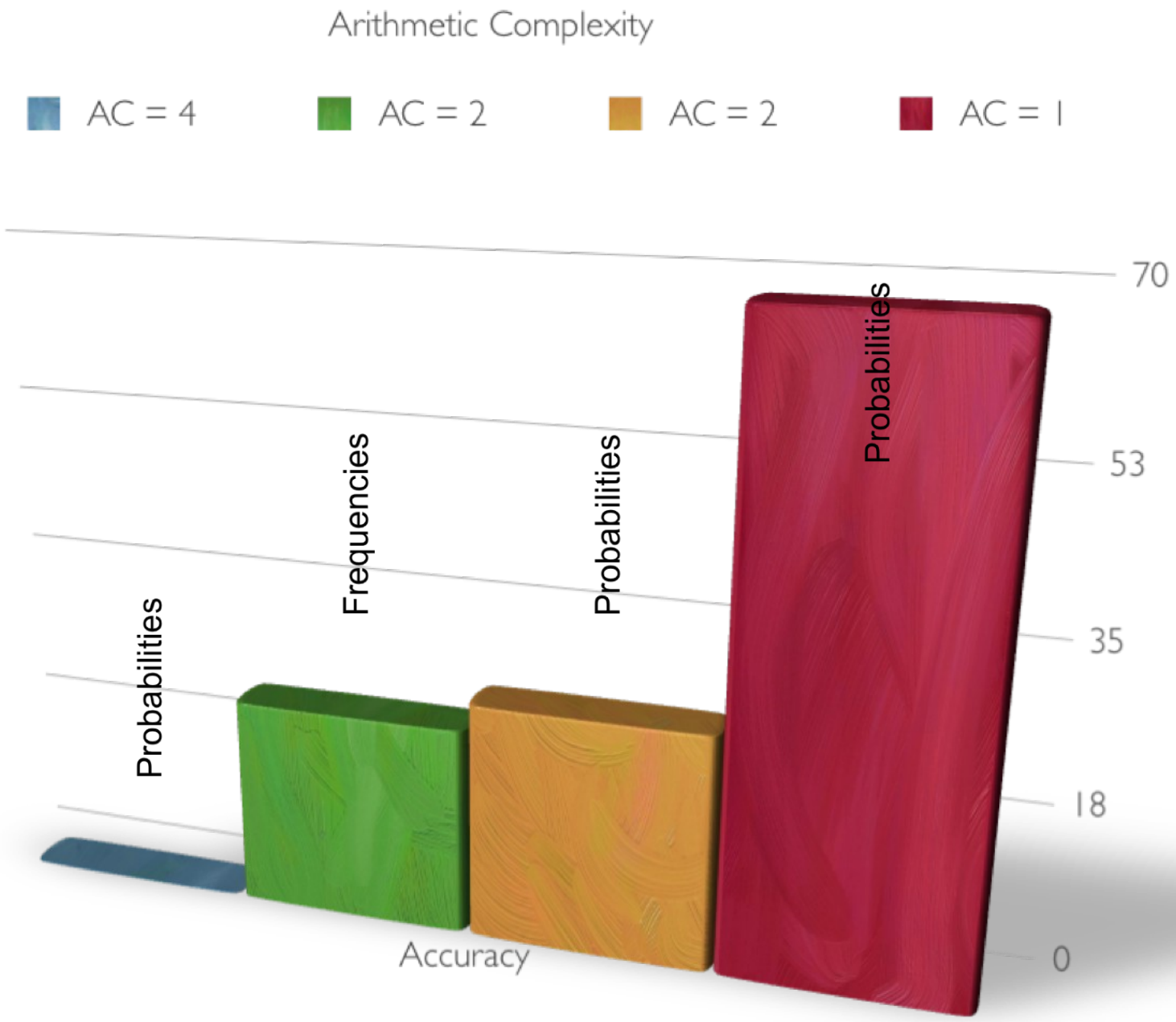




NATURAL FREQUENCIES

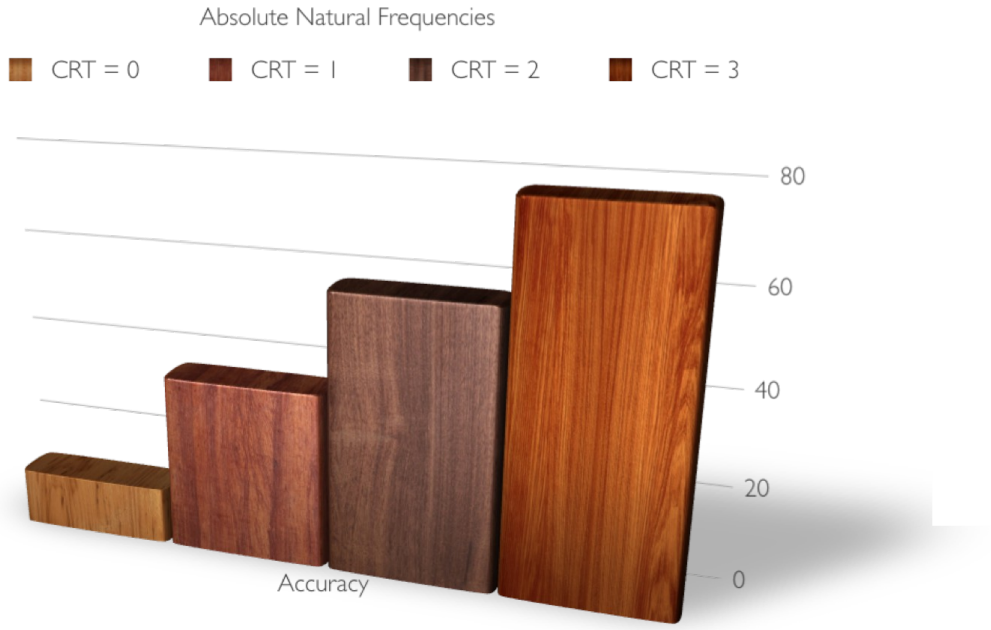


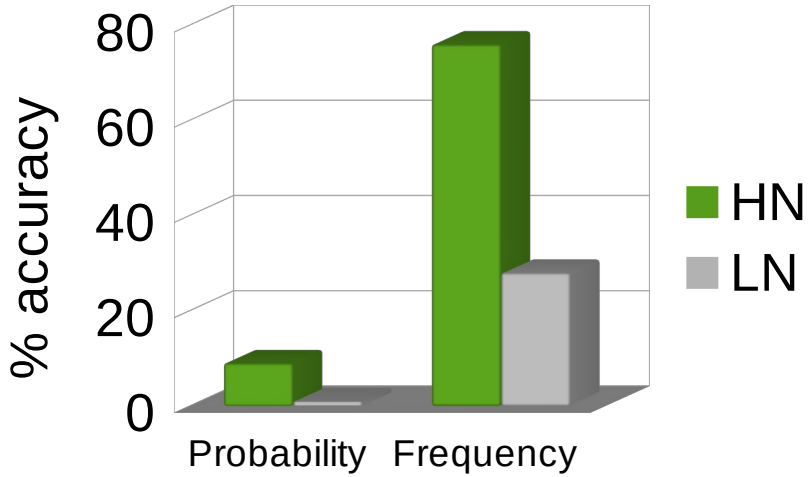

Classical Problem
Relative Probabilities
Absolute Frequencies
50
38
25
13
0
Accuracy

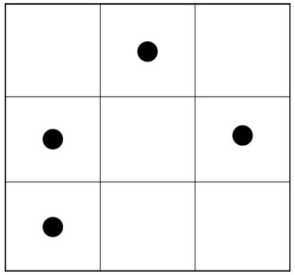

Arithmetic Complexity
AC = 4
AC = 2
AC = 2
AC = 1
70
53
35
18
0
Probabilities
Frequencies
Probabilities
Probabilities
Accuracy

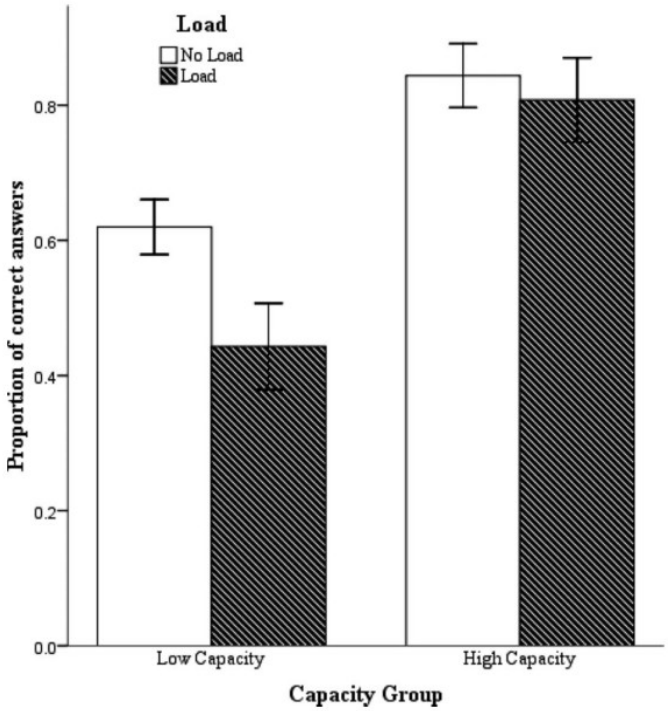
Individual differences

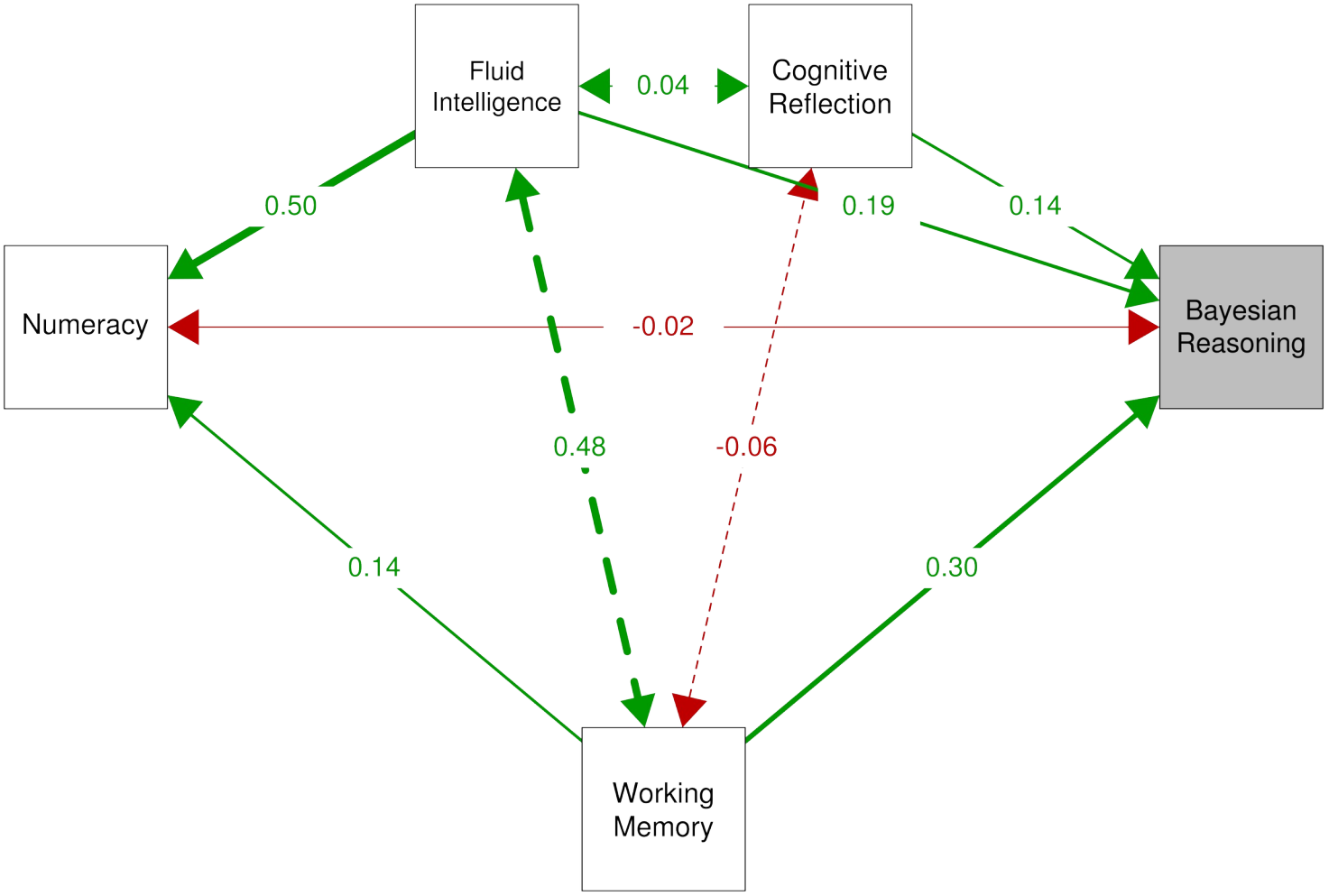
Cognitive Reflection, Numeracy, WM


Absolute Natural Frequencies
CRT = 0
CRT = 1
CRT = 2
CRT = 3
80
60
40
20
0
Accuracy


% accuracy
80
60
40
20
0
Probability
Frequency
HN
LN




Load
No Load
Load
Proportion of correct answers
0.0
0.2
0.4
0.6
0.8
Low Capacity
High Capacity
Capacity Group


Fluid Intelligence
Cognitive Reflection
Numeracy
Bayesian Reasoning
Working Memory
0.04
0.50
0.19
0.14
-0.02
0.48
-0.06
0.14
0.30

Cognitive mechanisms behind the comprehension of Bayesian reasoning problems

Improve medical risks communication

Presentation format

University students

Presentation format x Response type

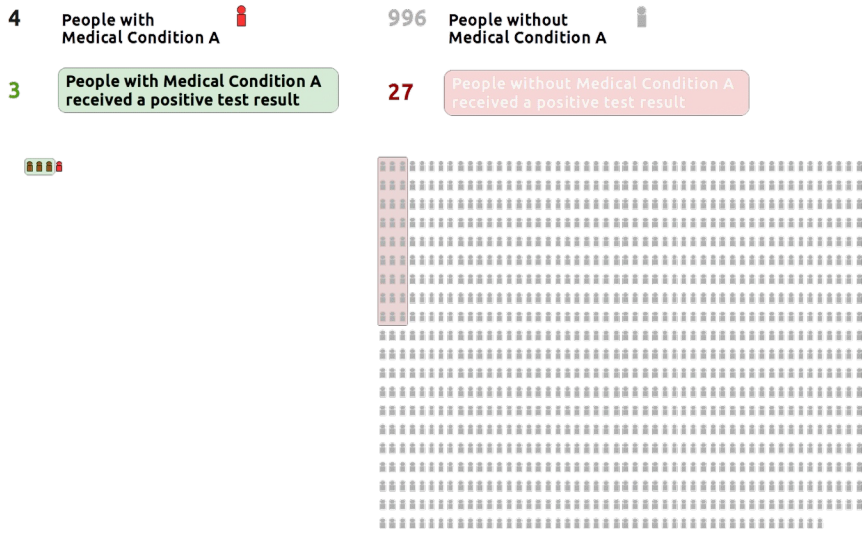
Vulnerable population

Presentation format

University students

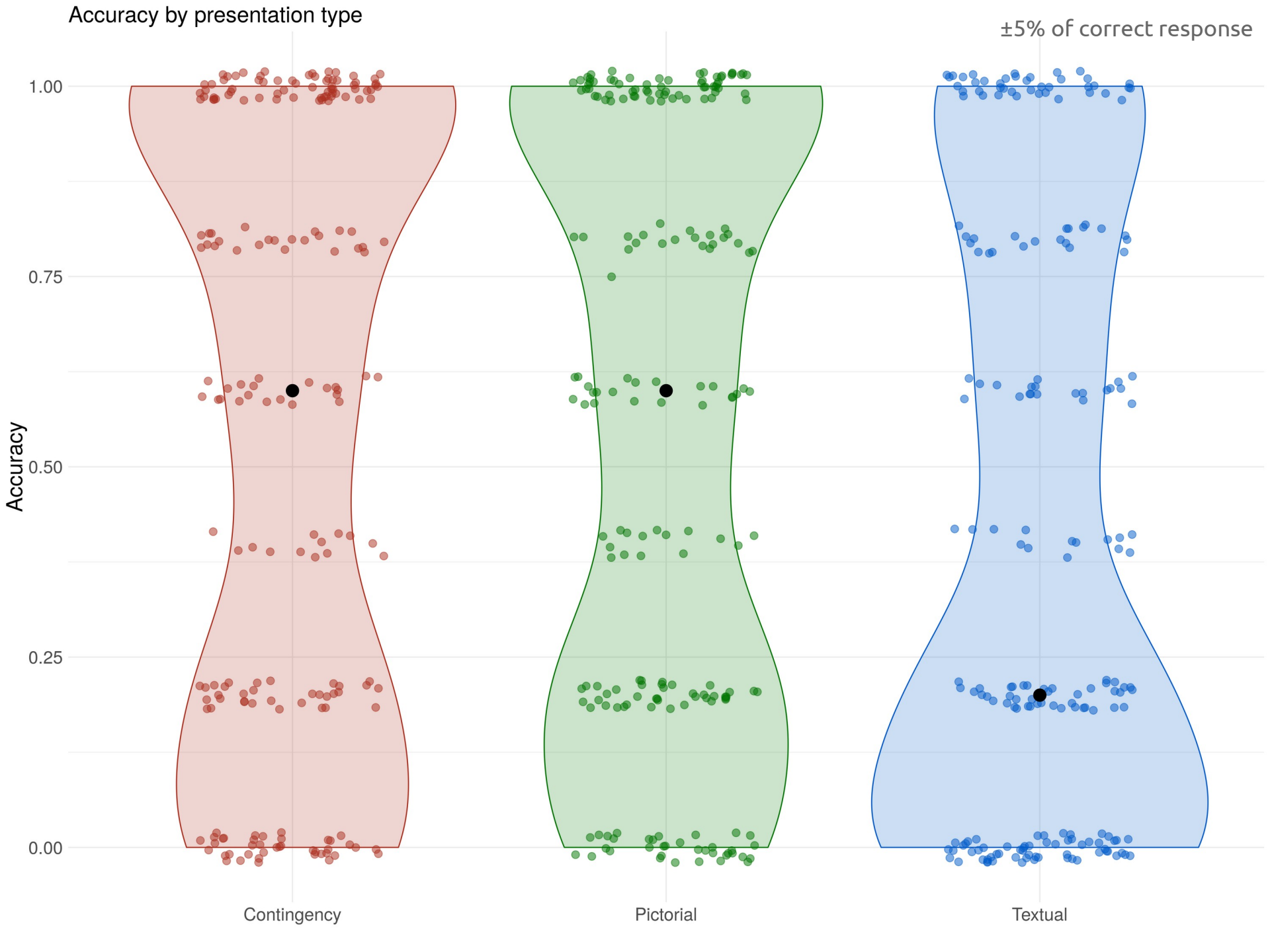
Imagine that a group of 1000 people have participated in a medical screening to detect disease A.
The following information is available about the screening.

4 in every 1000 people actually have the disease A.
3 in every 4 person with the disease A has received a positive screening test result.
27 in every 996 people without the disease A have also received a positive screening test result.



	Received positive screening test result	Received negative screening test result	1000 people
With Disease A	3	1	4
Without Disease A	27	969	996

Of the people who have received a positive screening test result, how many would do you expect to have the disease A? _____ out of _____


Accuracy by presentation type
±5% of correct response
Accuracy
1.00
0.75
0.50
0.25
0.00
Contingency
Pictorial
Textual

Presentation format x Response type

Vulnerable population

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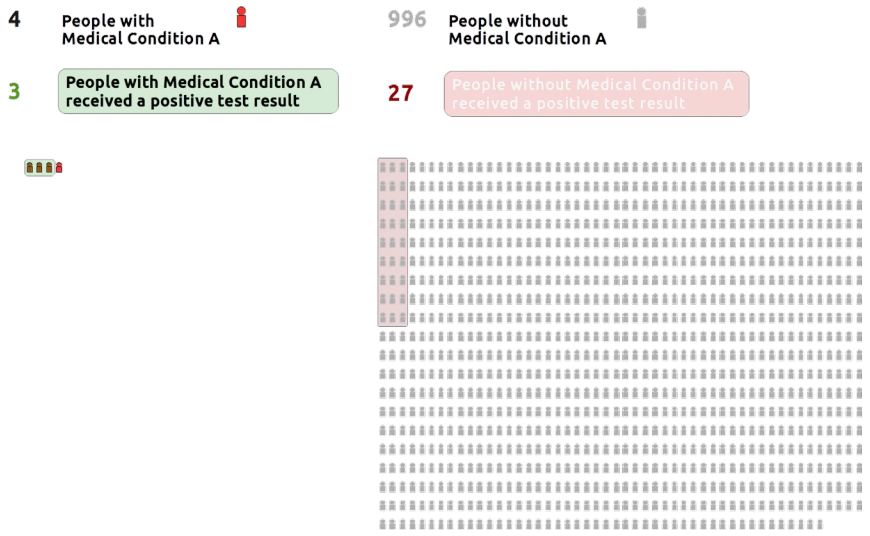
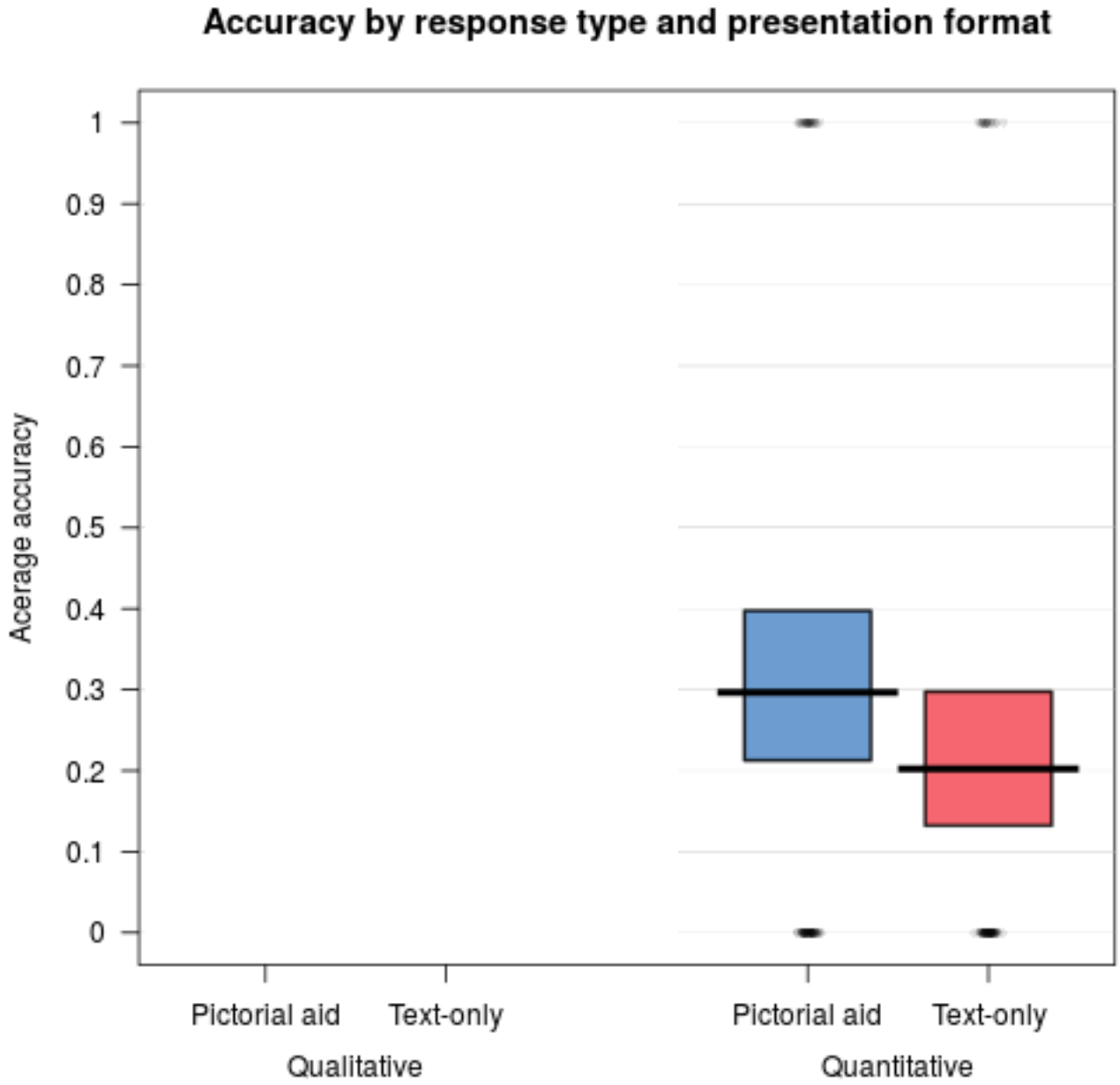


Of the people who have received a positive screening test result, how many would do you expect to have the disease A?

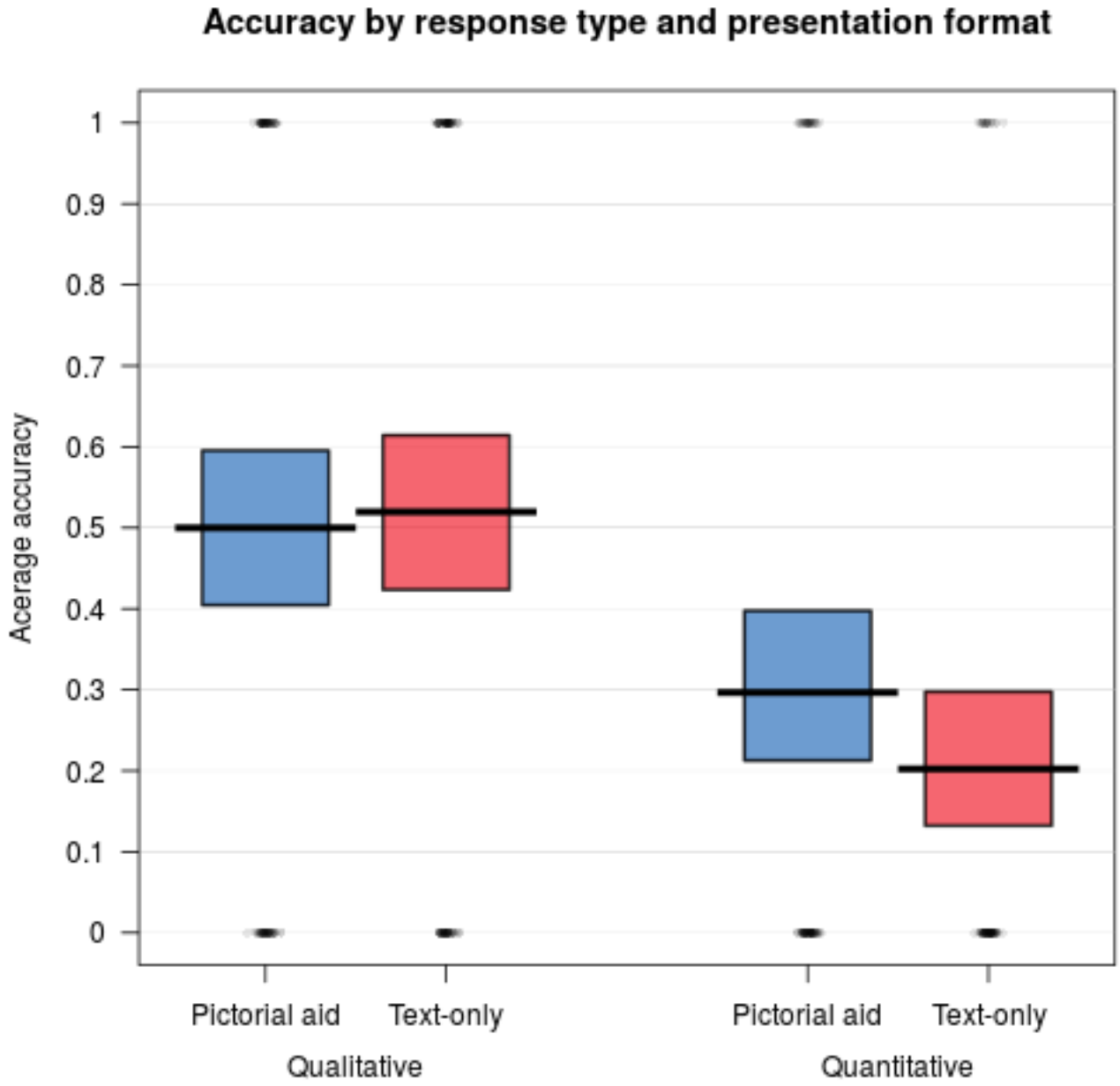
_____ out of _____

Very few (0-20%) Few (21-40%) Half (41-60%) Quite (61-80%) Many (81-100%)

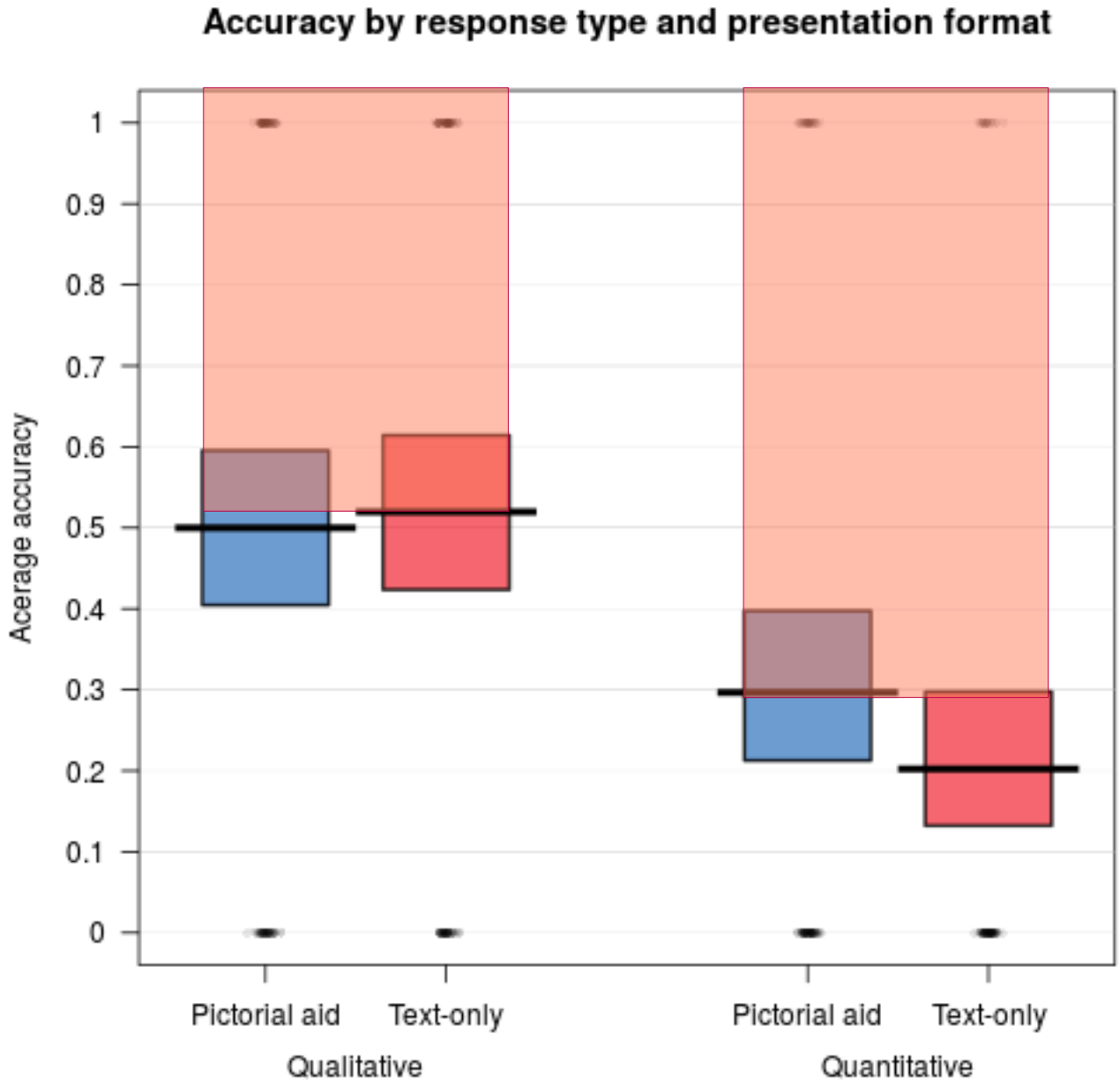
±10% of correct response



±10% of correct response



±10% of correct response



New research

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~5-10% correct responses

~50% correct responses

_____ out of _____

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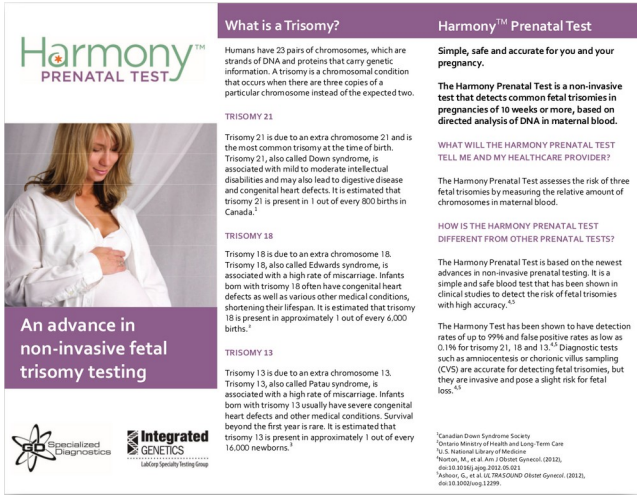
~5-10% correct responses



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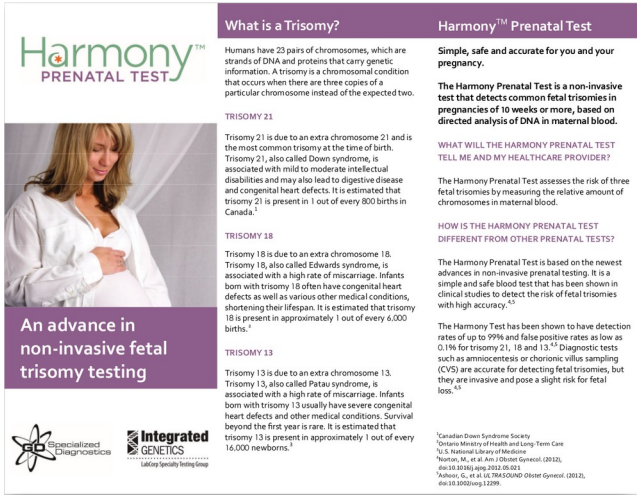

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HOW IS THE HARMONY PRENATAL TEST DIFFERENT FROM OTHER PRENATAL TESTS?

The Harmony Prenatal Test is based on the newest advances in non-invasive prenatal testing. It is a simple and safe blood test that has been shown in clinical studies to detect the risk of fetal trisomies with high accuracy.[4,5]

The Harmony Test has been shown to have detection rates of up to 99% and false positive rates as low as 0.1% for trisomy 21, 18 and 13.[4,5] Diagnostic tests such as amniocentesis or chorionic villus sampling (CVS) are accurate for detecting fetal trisomies, but they are invasive and pose a slight risk for fetal loss.[4,5]

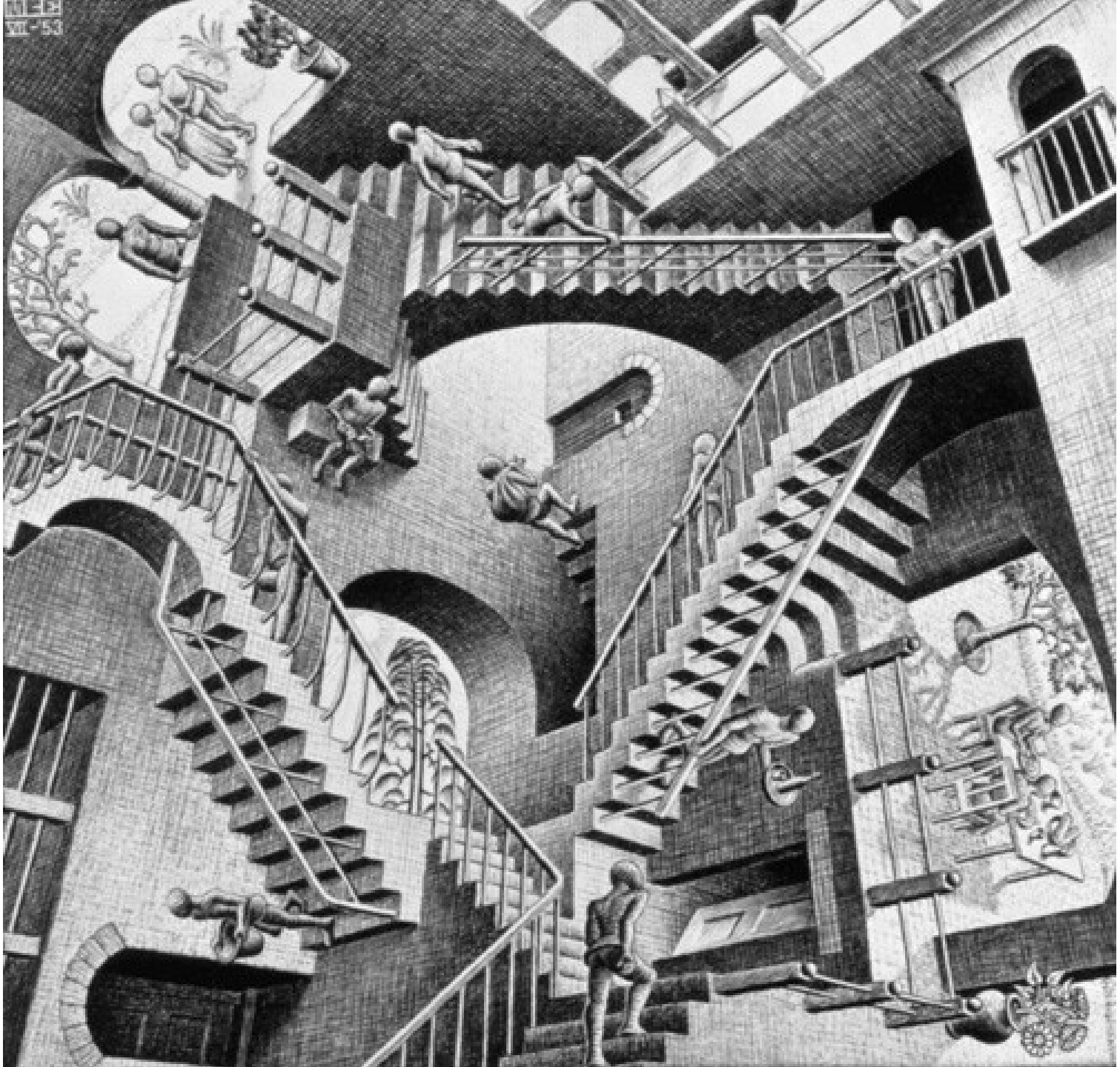
[1]Canadian Down Syndrome Society
[2]Ontario Ministry of Health and Long-Term Care
[3]U.S. National Library of Medicine
[4]Norton, M., et al. Am J Obstet Gynecol. (2012), doi:10.1016/j.ajog.2012.05.023
[5]Ashoor, G., et al. ULTRASOUND Obstet Gynecol. (2012), doi:10.1002/uog.12299.

$$p\left(Trisomy\ 21 \mid +test\right) =$$

$$(A)\ \frac{1\ out\ of\ 800\ \times\ 99\%}{\left(1\ out\ of\ 800 \times 99\%\right) + \left(799\ out\ of\ 800 \times 0.1\%\right)} =$$

$$(B)\ \frac{0.123}{0.123 + 0.0998} = 0.55$$

What's the meaning of a + result?



New paradigm

Ask questions people know how to answer

What is your age?

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$$(A)\ \frac{1\ out\ of\ 800\ \times\ 99\%}{\left(1\ out\ of\ 800 \times 99\%\right) + \left(799\ out\ of\ 800 \times 0.1\%\right)} =$$

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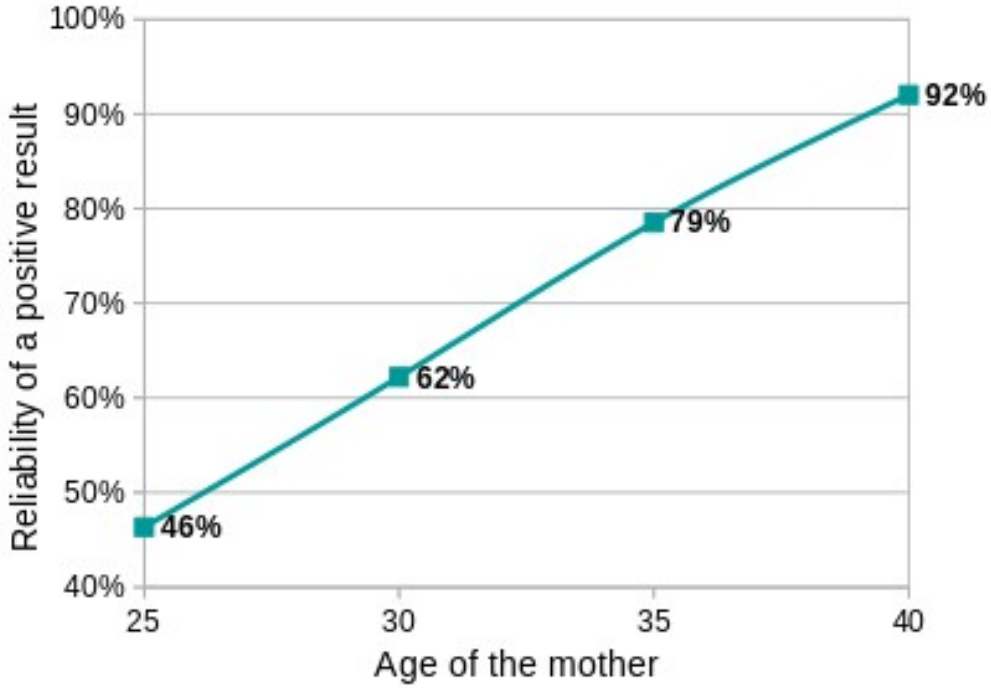
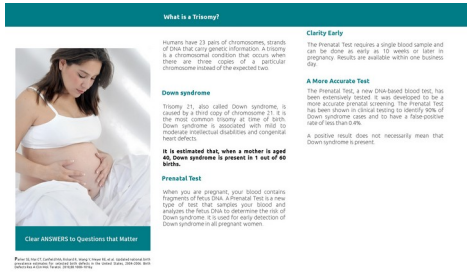
Ask questions people know how to answer



Reliability of a positive test result depending on the mother's age.

Navarrete, G., Correia, R., Sirota, M., Juanchich, M., & Huepe, D. (2015). Doctor, what does my positive test mean? From Bayesian textbook tasks to personalized risk communication. Frontiers in Psychology, 6(1327), 1–6. doi:10.3389/fpsyg.2015.01327

Would you recommend this **screening test**?



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It is estimated that, when a mother is aged 40, Down syndrome is present in 1 out of 40 births.

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When you are pregnant, your blood contains fragments of fetus DNA. A Prenatal Test is a new type of test that samples your blood and analyzes the fetus DNA to determine the risk of Down syndrome. It is used for early detection of Down syndrome in all pregnant women.

Clarity Early

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A positive result does not necessarily mean that Down syndrome is present.

Clear ANSWERS to Questions that Matter

Palmer SE, Knox CT, Canfield MA, Krivchenia K, Wang Y, Hoyer PE, et al. Updated national birth prevalence estimates for selected birth defects in the United States, 2004-2006. Birth defects research Clinical and molecular teratology. 2010;88:1008-1016.

YES / NO

→

Imagine the result is

+

→

Would you recommend a **Follow up test** with 1% chance of a procedure-related miscarriage?

YES / NO

Do people know the information they need?

Can we improve calculation/comprehension?

Can we improve decisions?

Do people know what they need?

All vs Missing information

All information

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$$\frac{0.9}{0.9+0.236}=79\%$$

Parker SE, Mai CT, Canfield MA, Rickard R, Wang Y, Meyer RE, et al. Updated national birth prevalence estimates for selected birth defects in the United States, 2004–2006. Birth Defects Res A Clin Mol Teratol. 2010;88:1008–1016y.

Missing information

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$$\frac{x}{x+y}=\sim[0..100]\%$$

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Did the brochure include enough information
to solve the problem?

YES!

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NO

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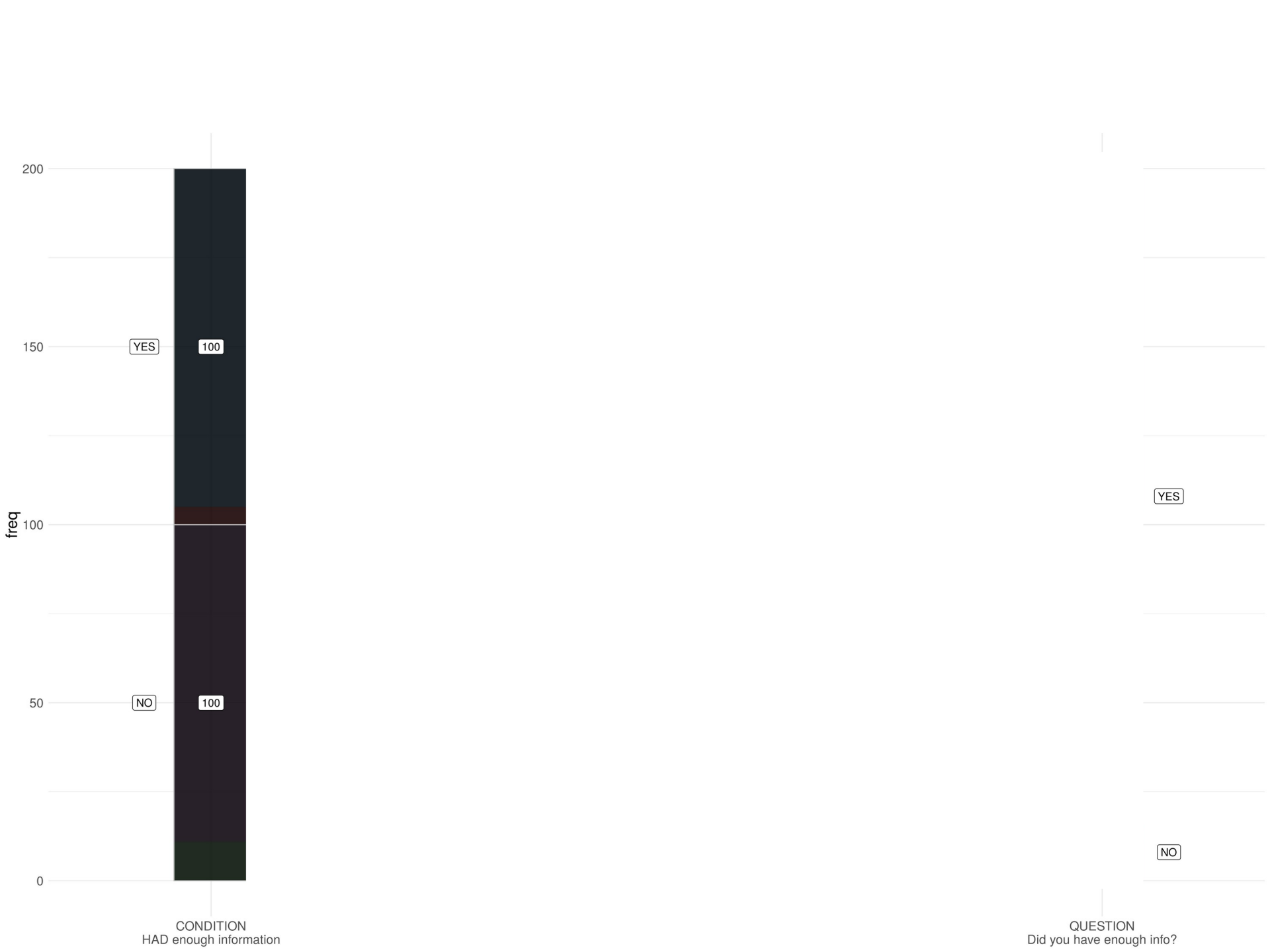
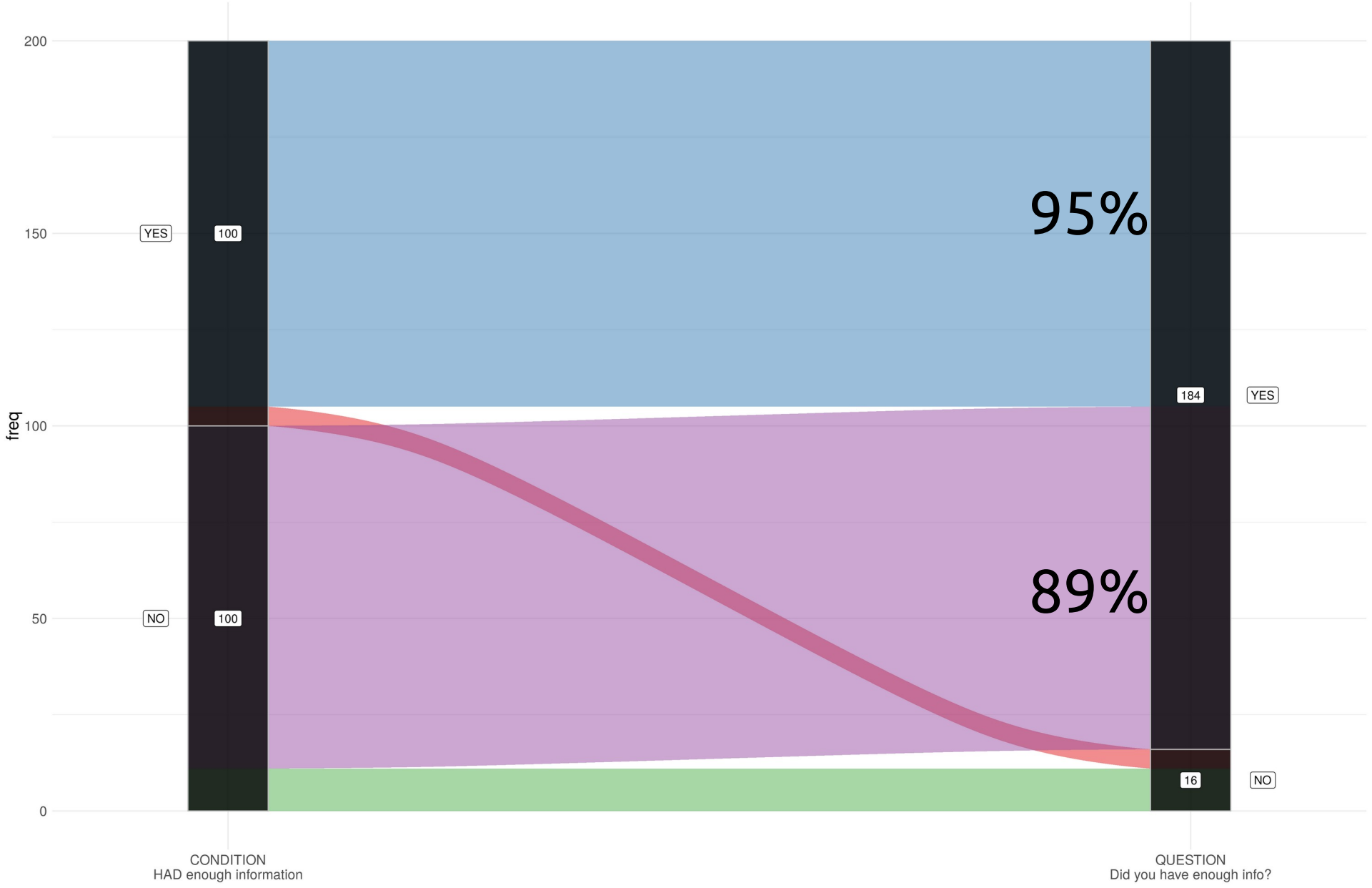

200
150
100
50
0
freq
YES
NO
100
100
YES
NO
CONDITION
HAD enough information
QUESTION
Did you have enough info?

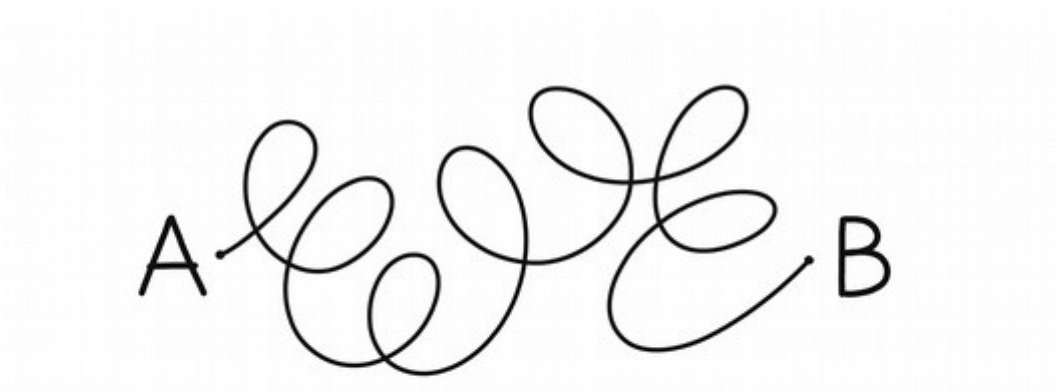
89% of those without Enough info said YES



Can we improve calculation/comprehension?

OLD vs NEW paradigm

OLD paradigm



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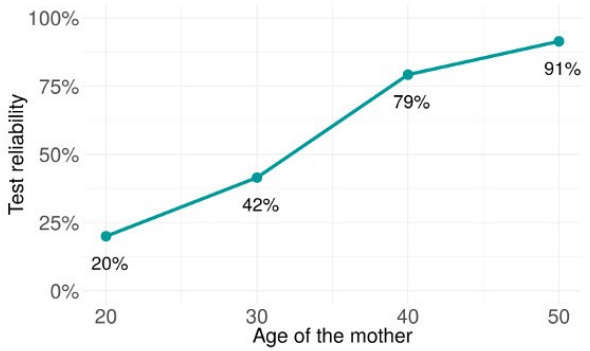

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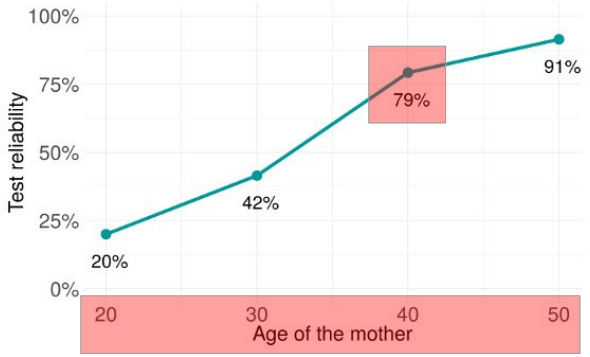

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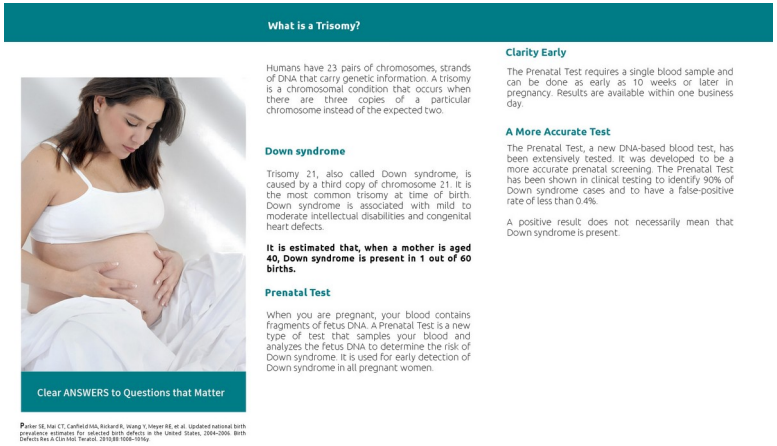
OLD vs NEW



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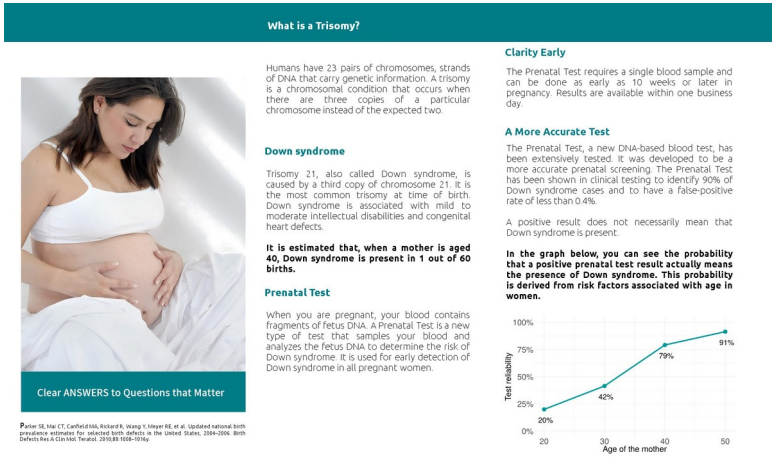

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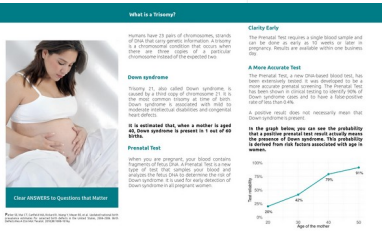
Positive Predictive Value (PPV)

Estimate the probability that a **positive result** in the Prenatal screening test **means** that her child has **Down Syndrome**



brochure

OLD

NEW

0

50

100

PPV_screening

brochure

NEW

OLD

Good vs bad test

40 years old
Prevalence 1 out of 60
PPV~75%

Good test

20 years old
Prevalence 1 out of 900
PPV~25%

Bad test

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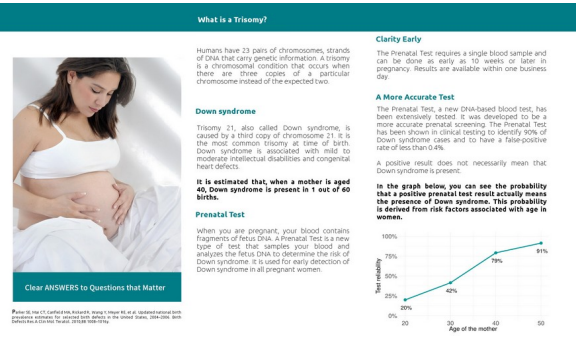

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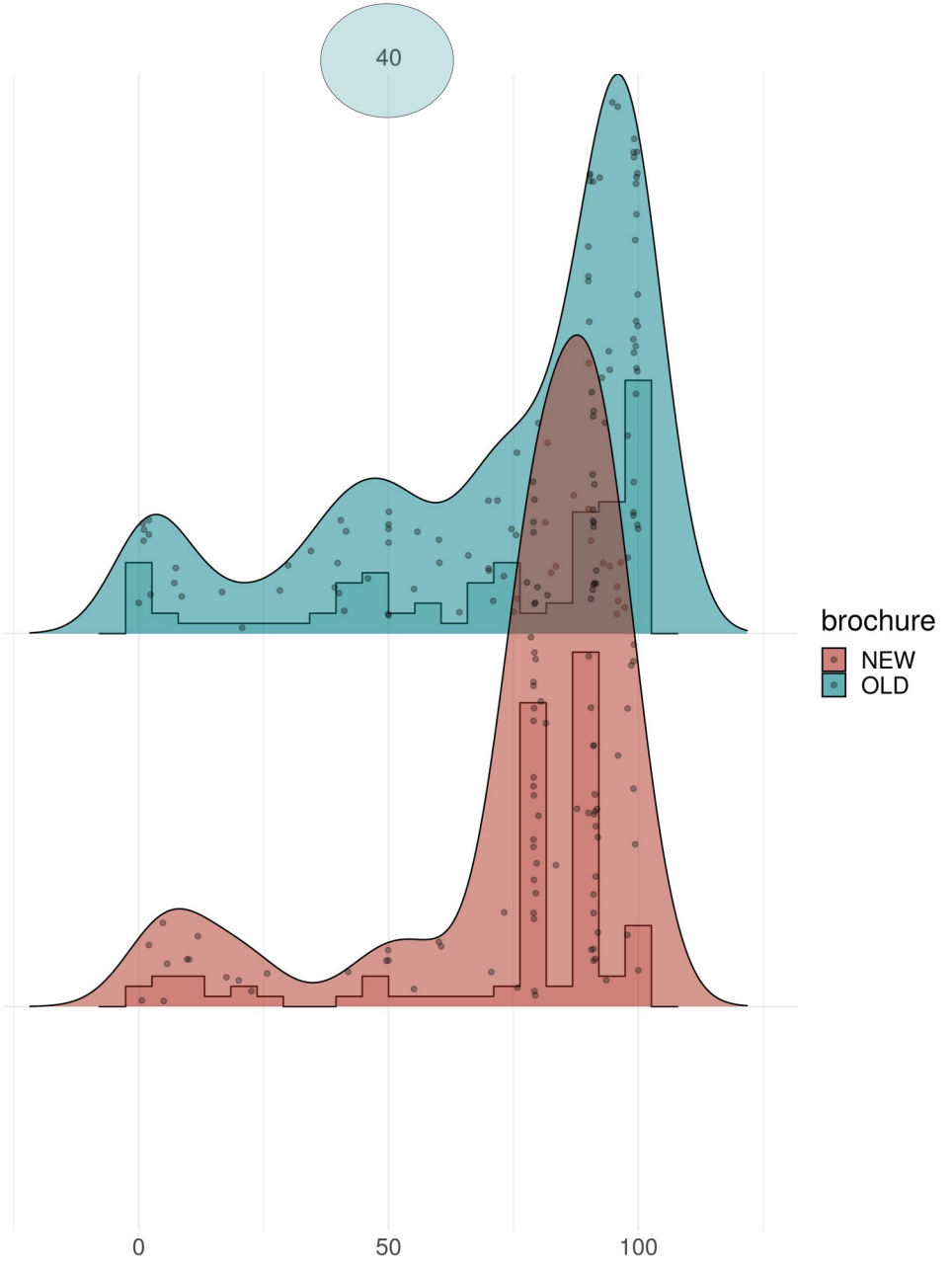

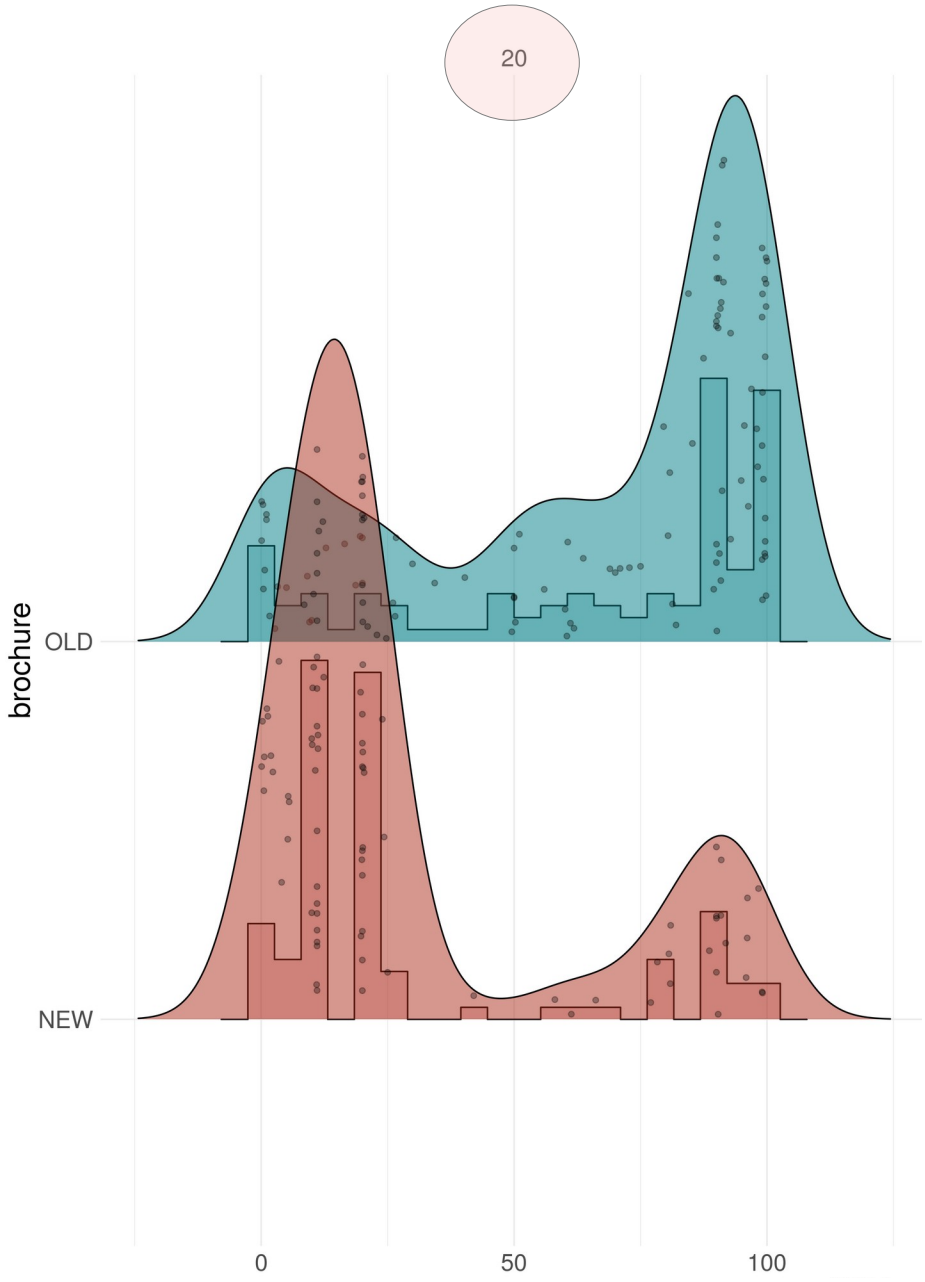

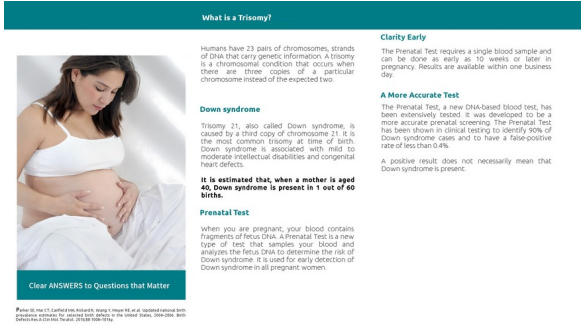

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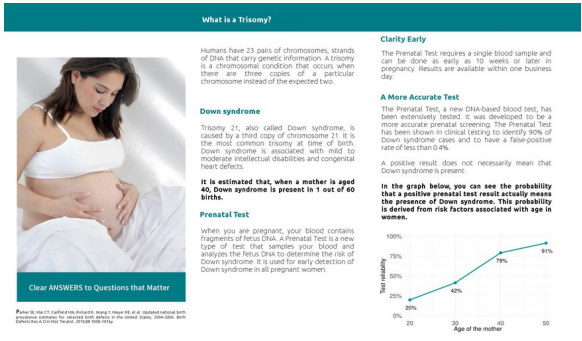
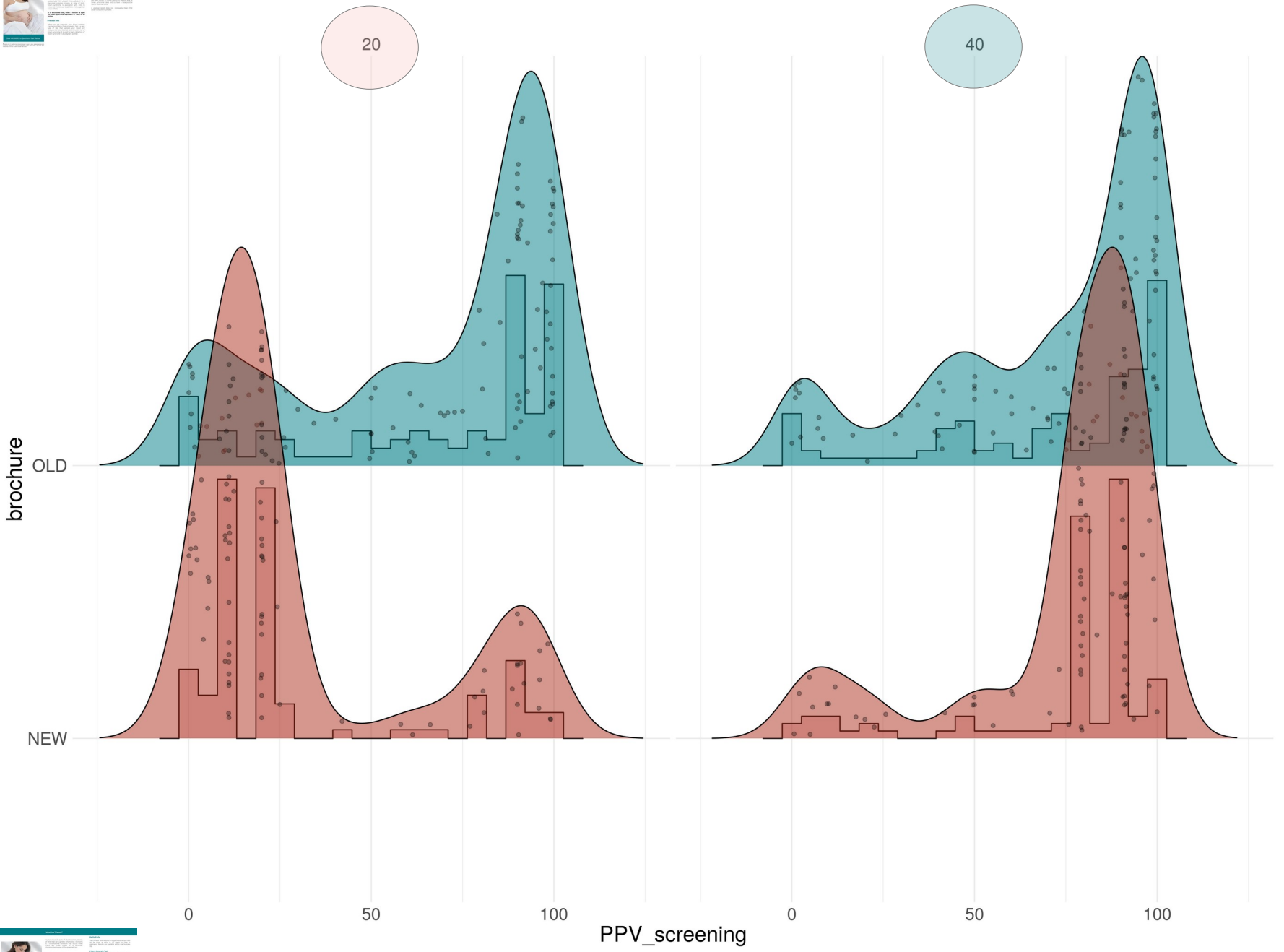
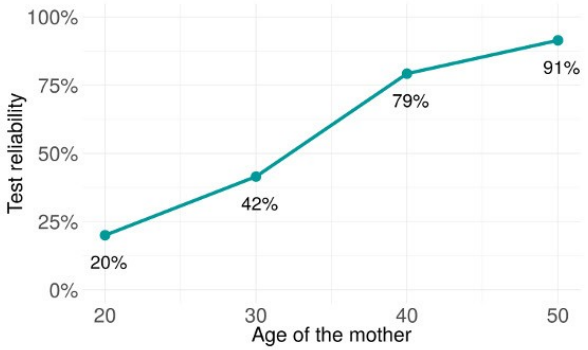
Bad test




20
40
brochure
OLD
NEW
0
50
100
PPV_screening
brochure
NEW
OLD

16%
average absolute error



40%
average absolute error

$$p(\text{Down syndrome}|+)=$$

$$\frac{1\,out\,of\,60\times 90\%}{(1\,out\,of\,60\times 90\%)+(59\,out\,of\,60\times 0.4\%)}=$$

$$\frac{0.9}{0.9+0.236}=79\,\%$$

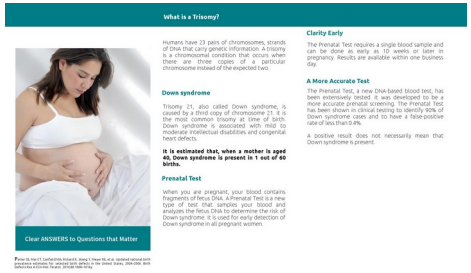
Can we improve decisions?

OLD vs NEW paradigm

Screening test

Follow-up test

Would you recommend this **screening test**?



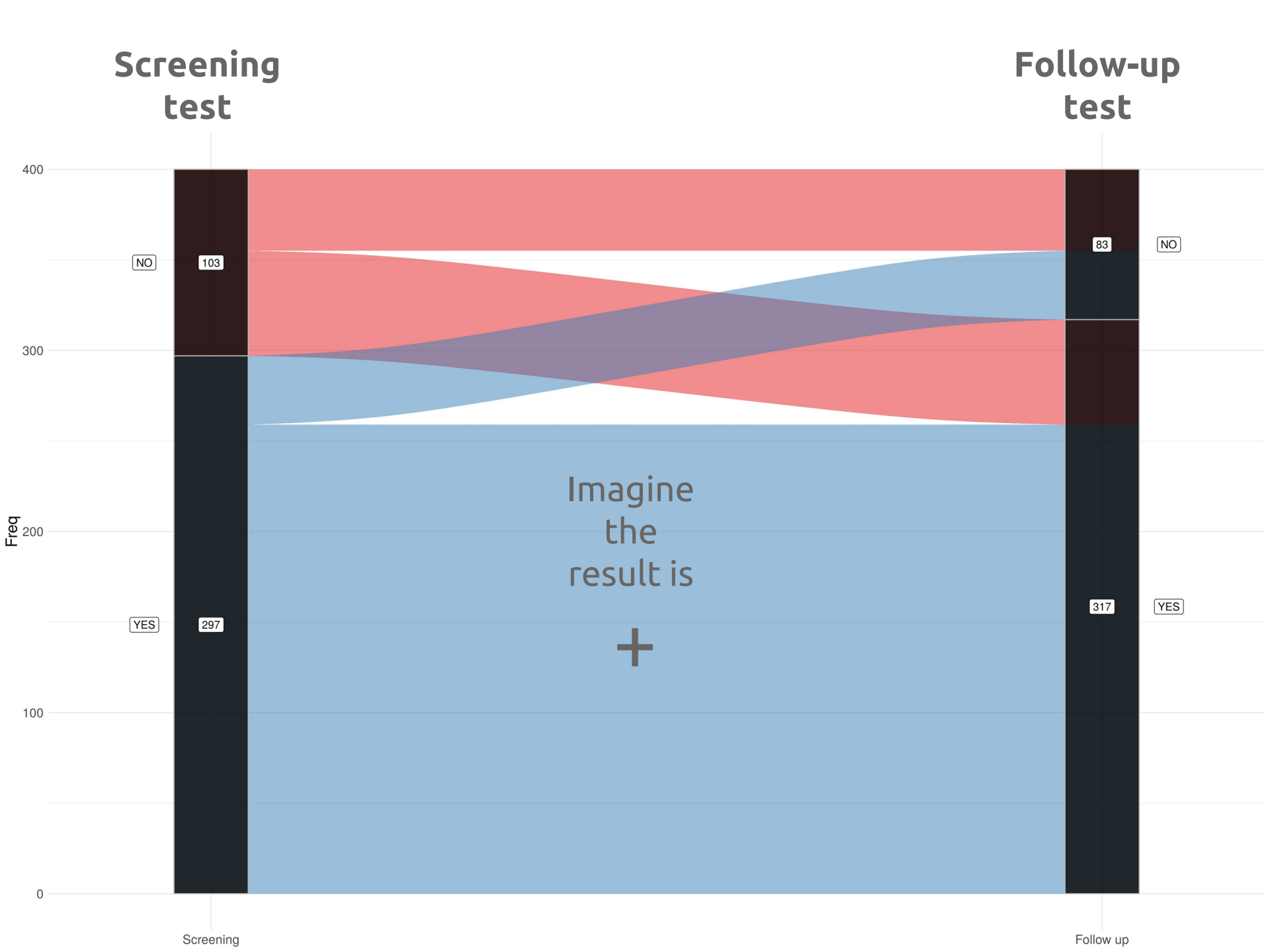
YES / NO

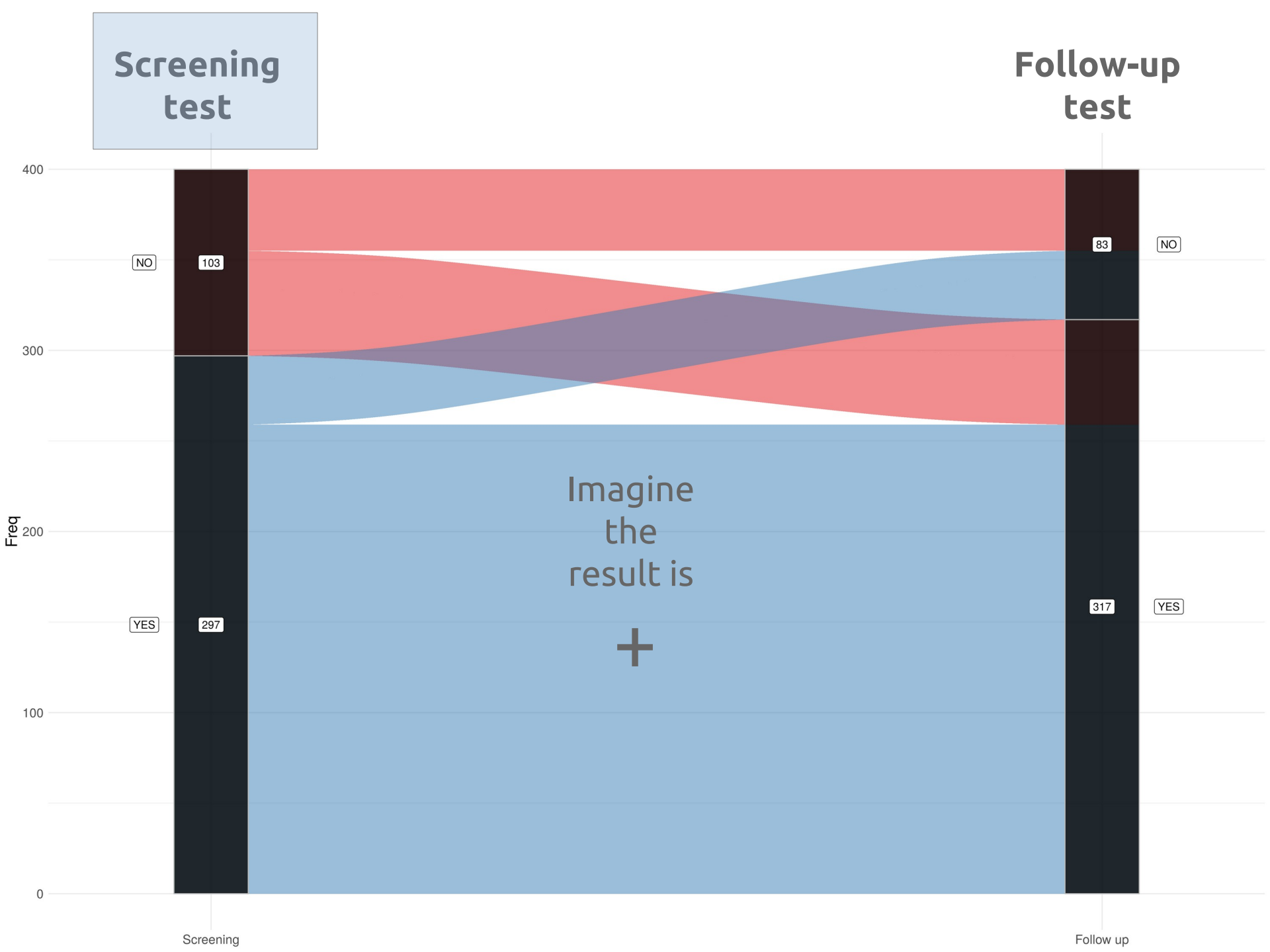
Imagine the result is

+

Would you recommend a **Follow up test** with 1% chance of a procedure-related miscarriage?

YES / NO


Screening test
Follow-up test
400
300
200
100
0
Freq
NO
YES
103
297
83
317
NO
YES
Imagine the result is
+
Screening
Follow up


Screening test
Follow-up test
400
300
200
100
0
Freq
NO
YES
103
297
83
317
NO
YES
Imagine the result is
+
Screening
Follow up

20 years old
Prevalence 1 out of 900
PPV~25%

Bad test

Bad test

Vs

Good test

40 years old
Prevalence 1 out of 60
PPV~75%

Good test

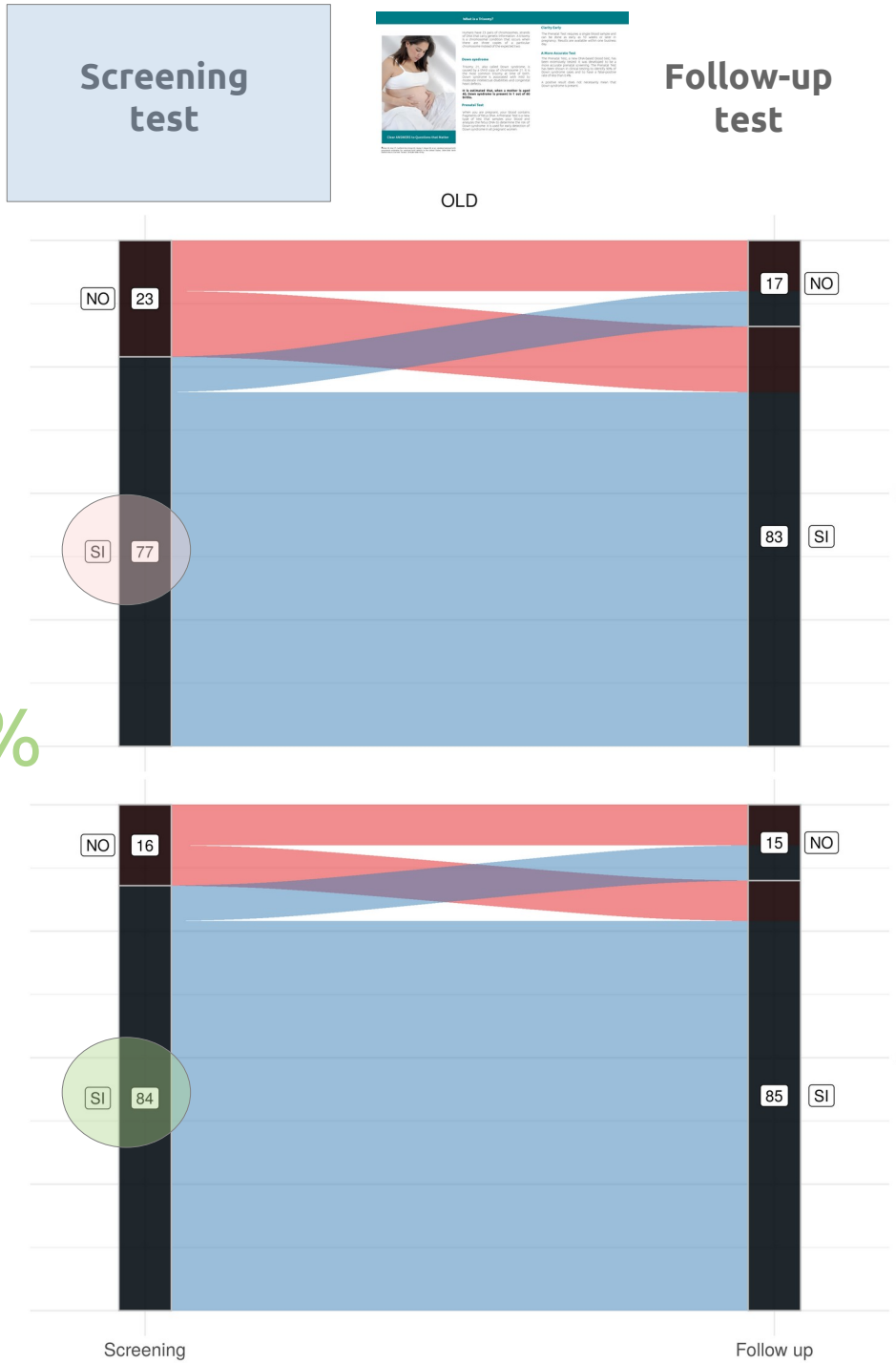
20 years old
Prevalence 1 out of 900
PPV~25%

Bad test

77% vs 84%

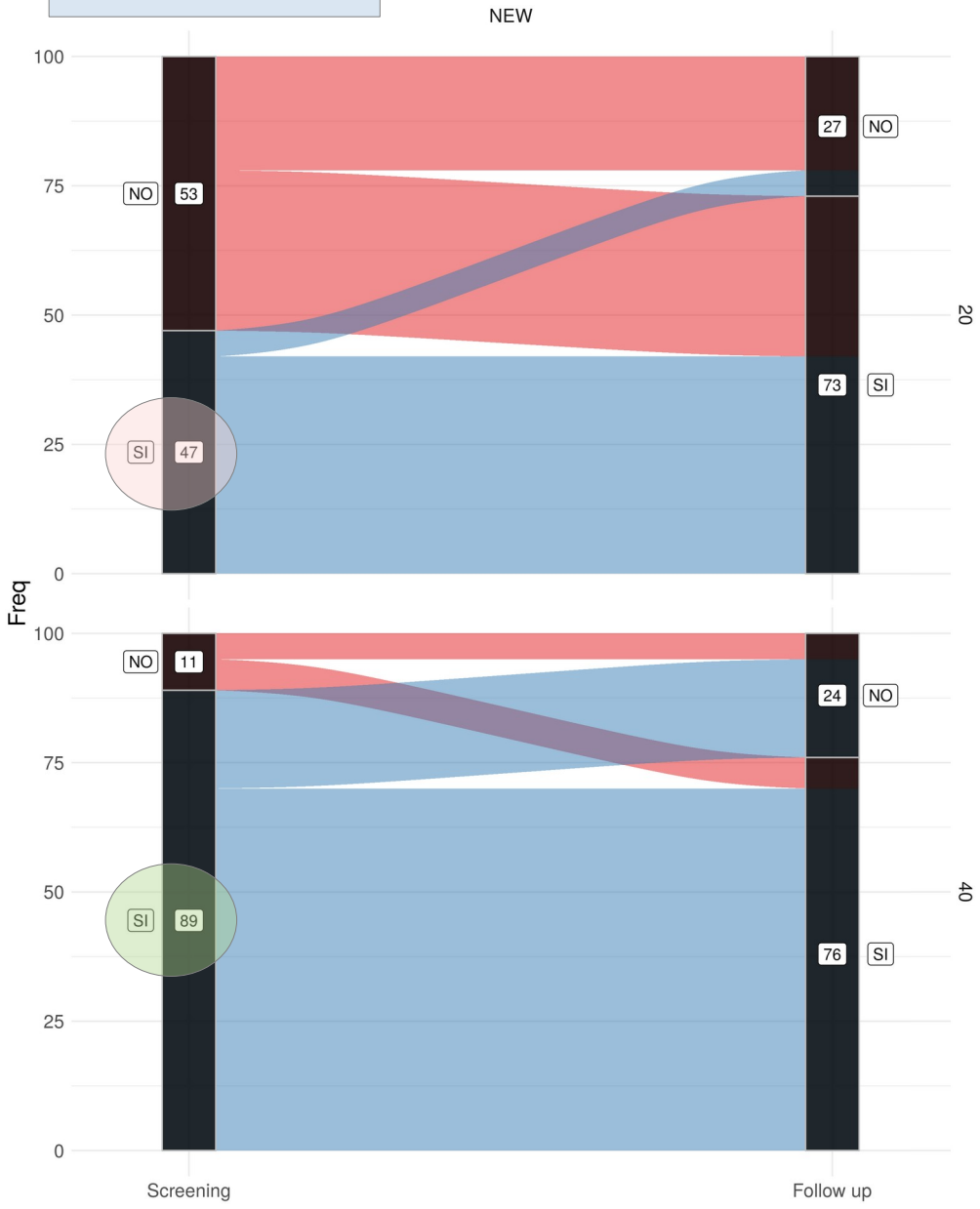
40 years old
Prevalence 1 out of 60
PPV~75%

Good test



Screening test

Follow-up test



20 years old
Prevalence 1 out of 900
PPV~25%

Bad test

47% vs 89%

40 years old
Prevalence 1 out of 60
PPV~75%

Good test

Screening test

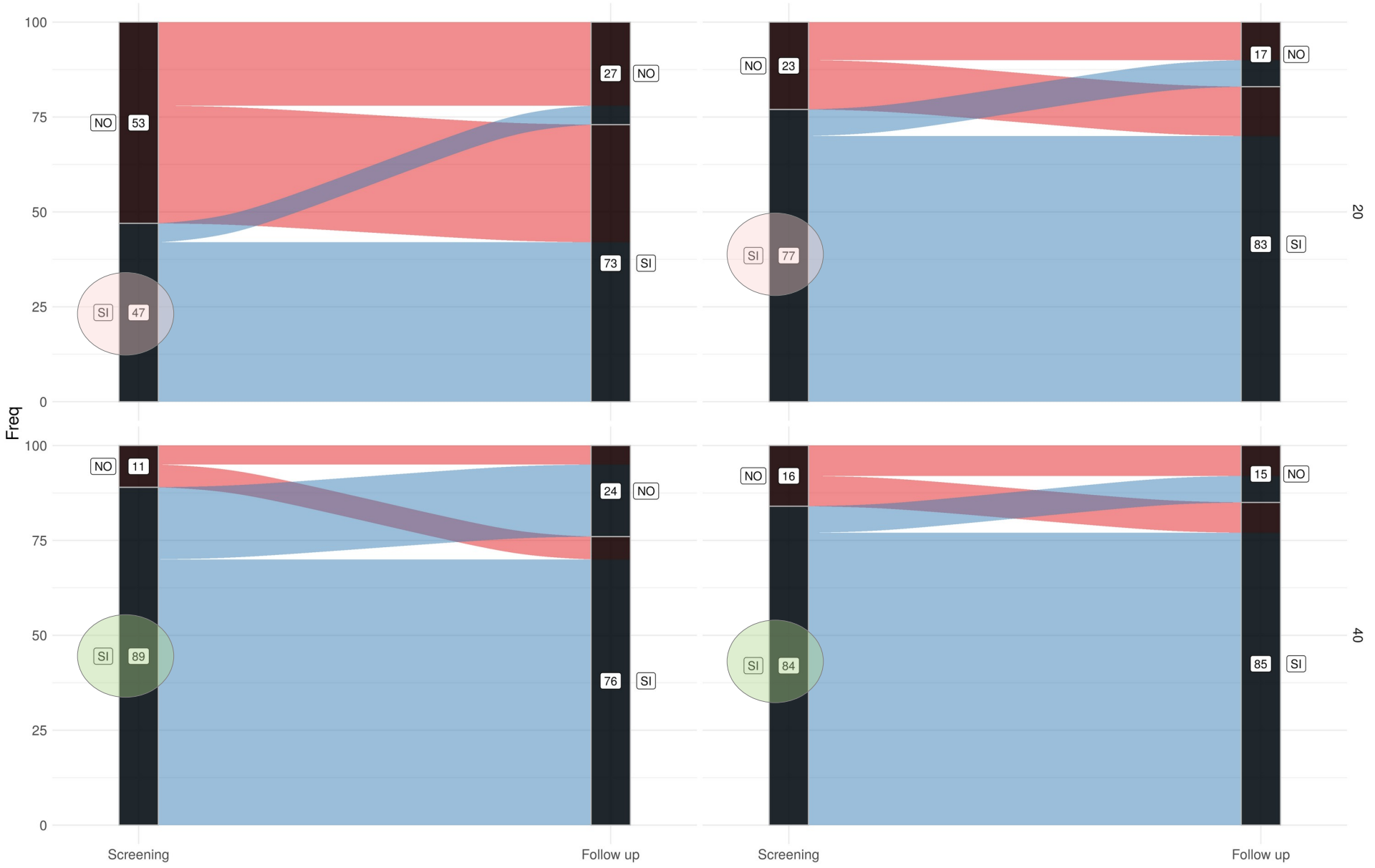
Follow-up test

NEW

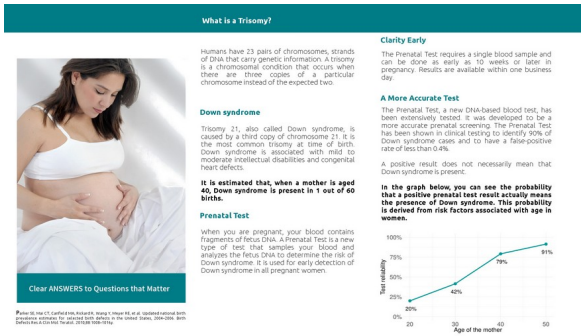
Screening test

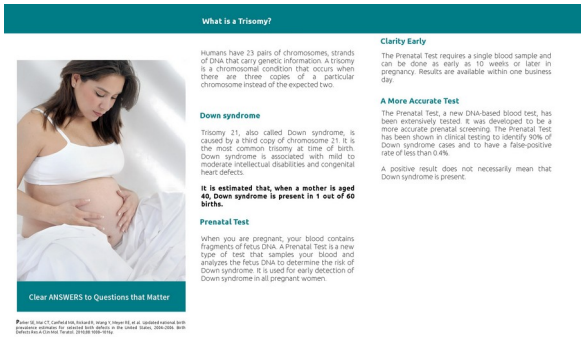
Follow-up test

OLD



Would you recommend
this **screening test**?





47%

Bad test

77%

89%

Good test

84%

Screening test

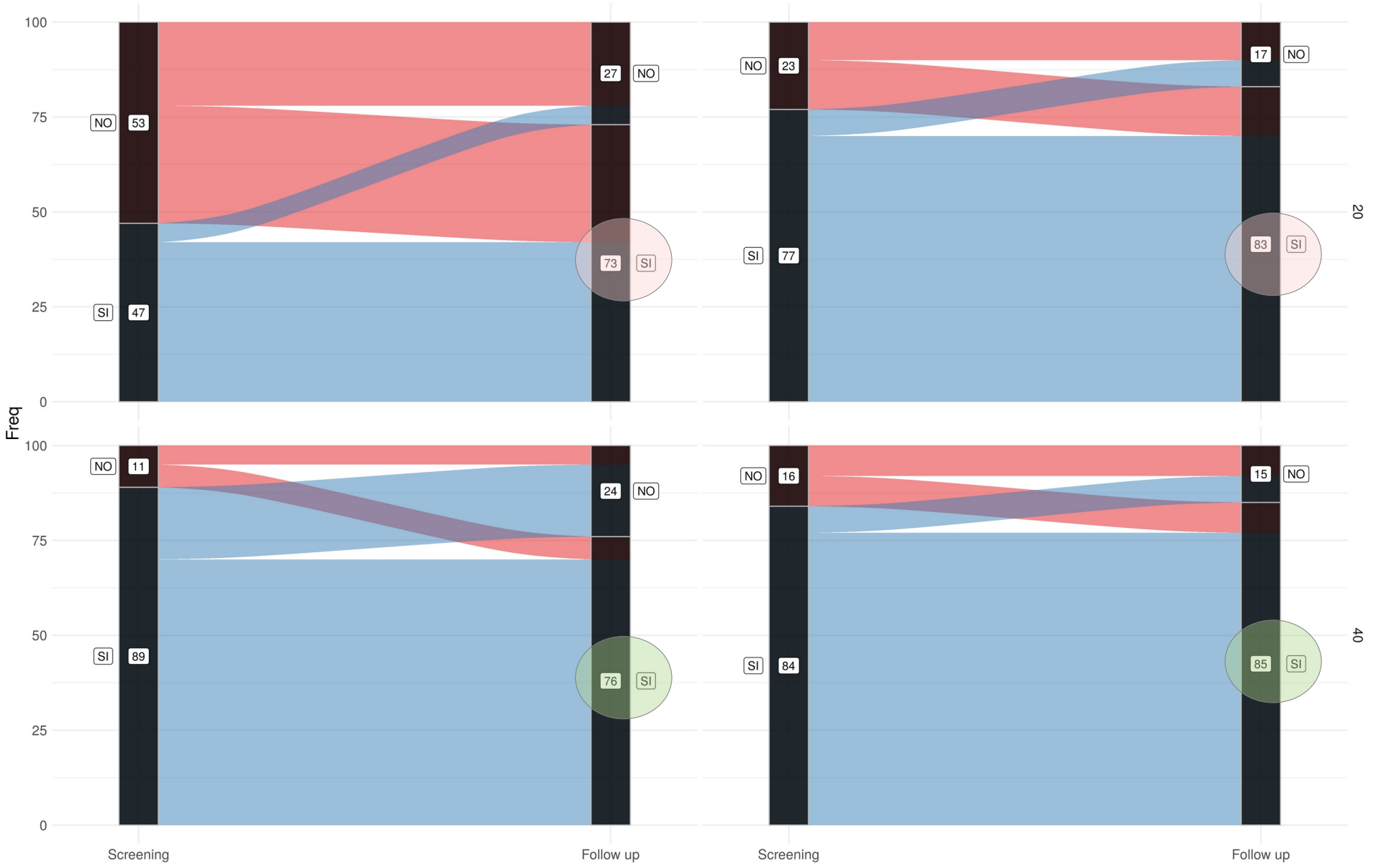
Follow-up test

NEW

Screening test

Follow-up test

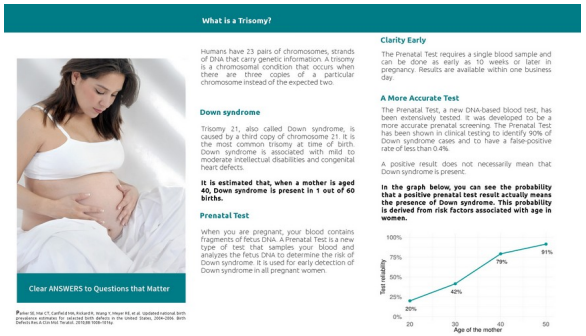
OLD

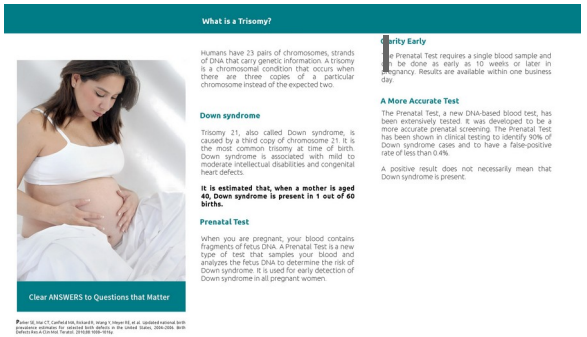


Imagine the result is

+

Would you recommend a **Follow up test** with 1% chance of a procedure-related miscarriage?





73%

Bad test

83%

76%

Good test

85%

Overview of results

Do people know the information they need?

Can we improve calculation/comprehension?

Can we improve decisions?

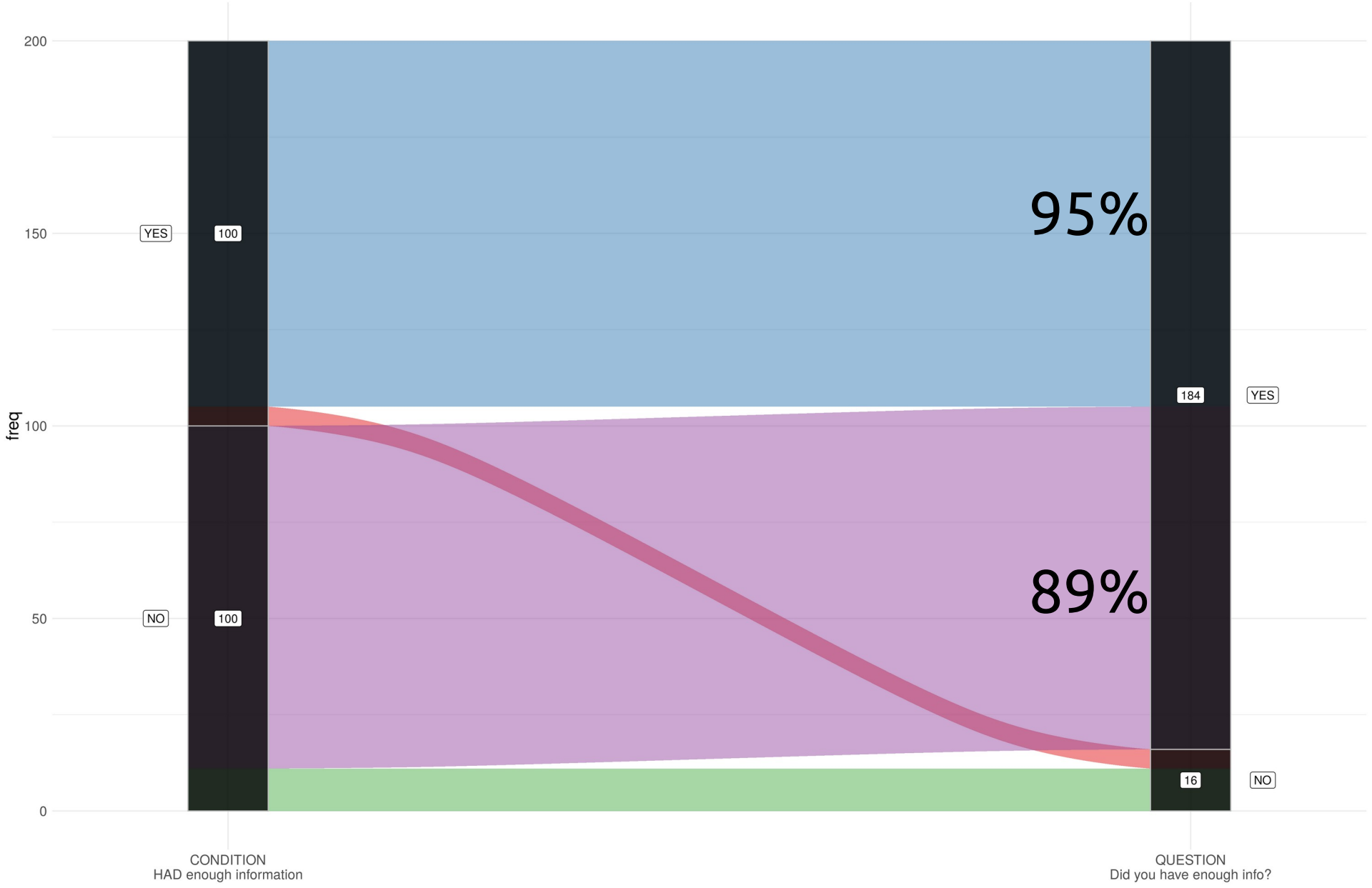
Overview of results

Do people know the information they need?

Can we improve calculation/comprehension?

Can we improve decisions?

NO


200
150
100
50
0
freq
YES
NO
100
100
95%
89%
184
16
YES
NO
CONDITION
HAD enough information
QUESTION
Did you have enough info?

Overview of results

Do people know the information they need?

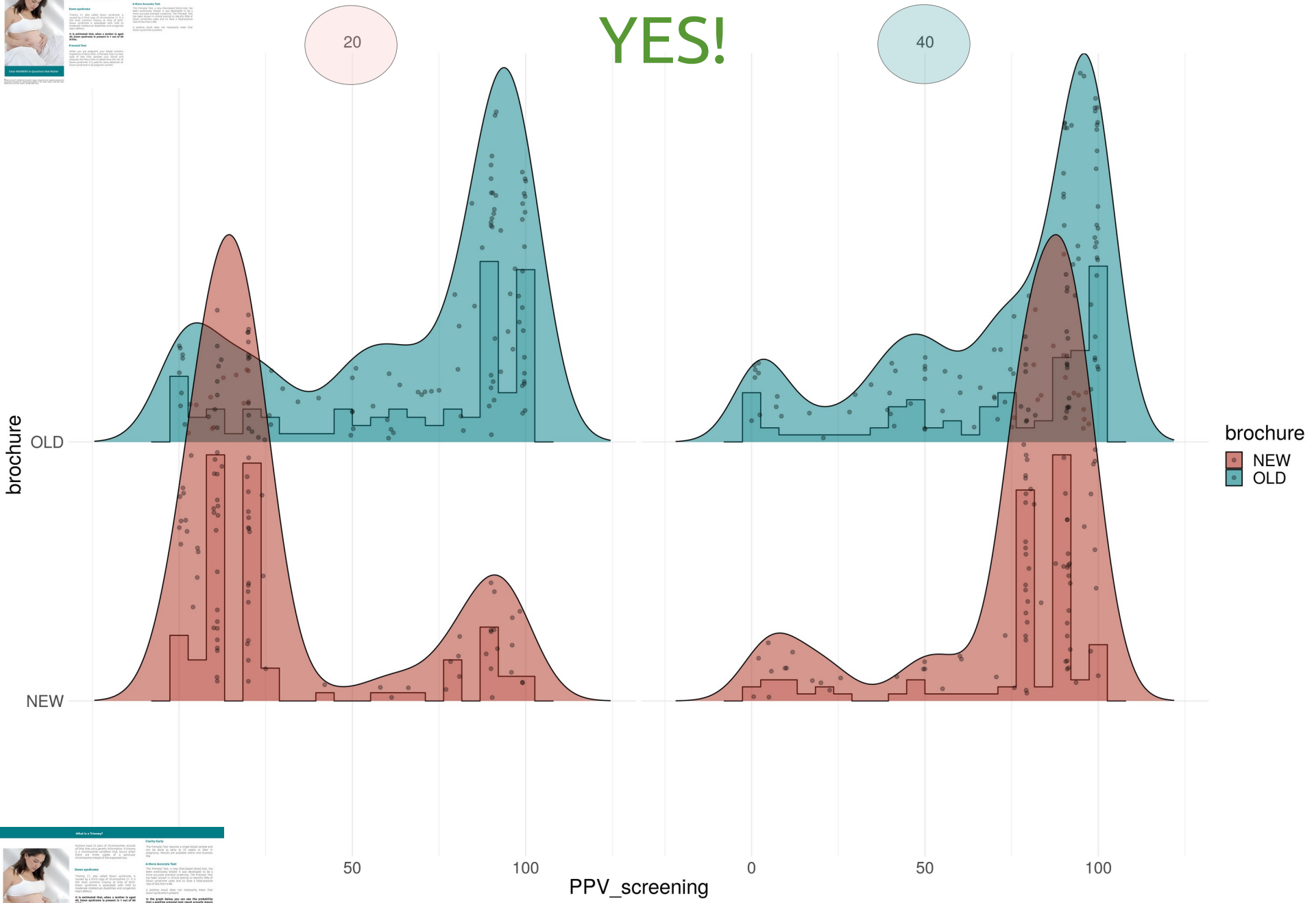
Can we improve calculation/comprehension?

Can we improve decisions?


What is a Trisomy?
Clarity Early
Down syndrome
A More Accurate Test
Prenatal Test
Clear ANSWERS to Questions that Matter

YES!


What is a Trisomy?
Clarity Early
Down syndrome
A More Accurate Test
Prenatal Test
Clear ANSWERS to Questions that Matter

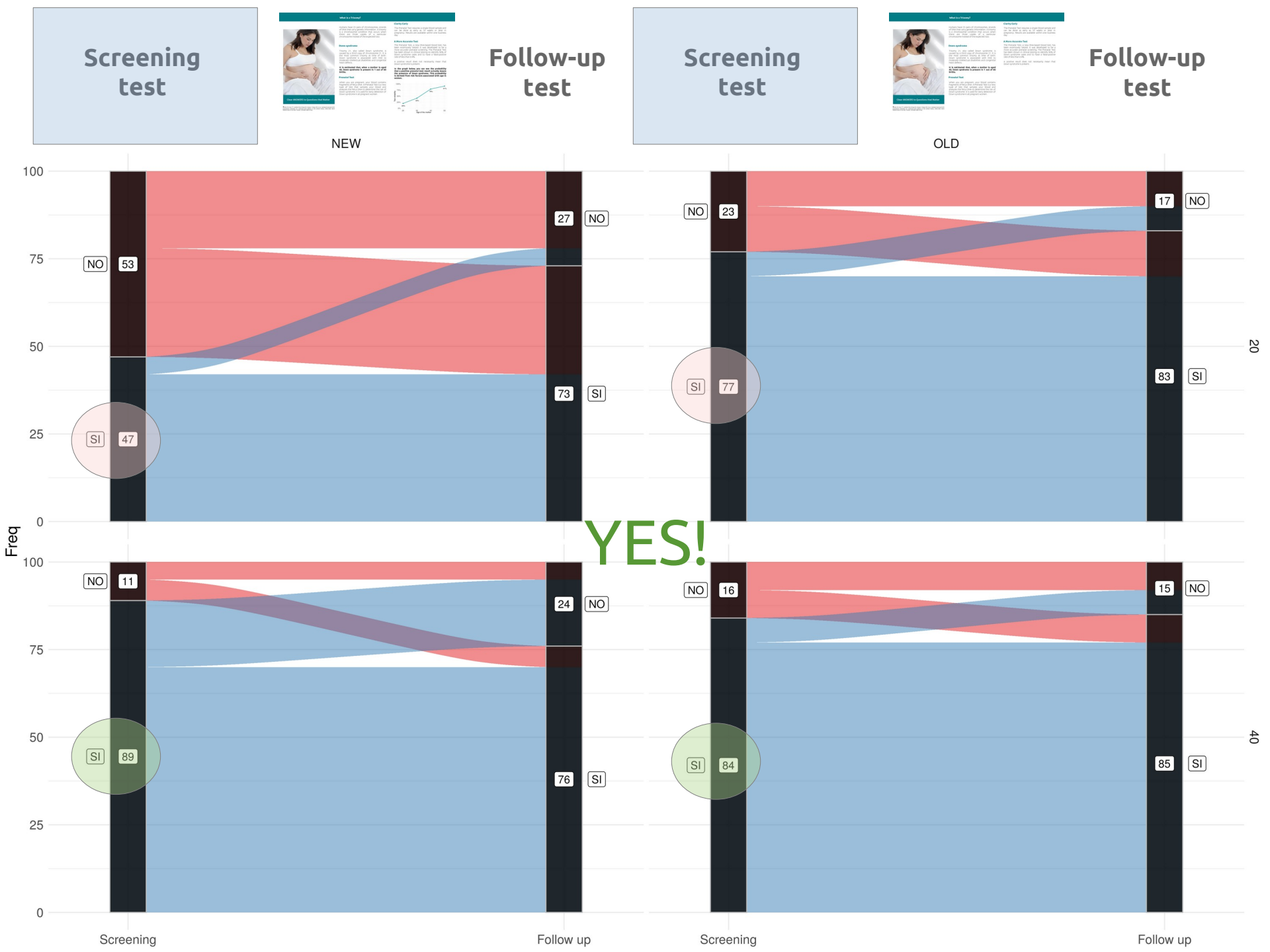

20
40
brochure
OLD
NEW
0
50
100
PPV_screening
brochure
NEW
OLD

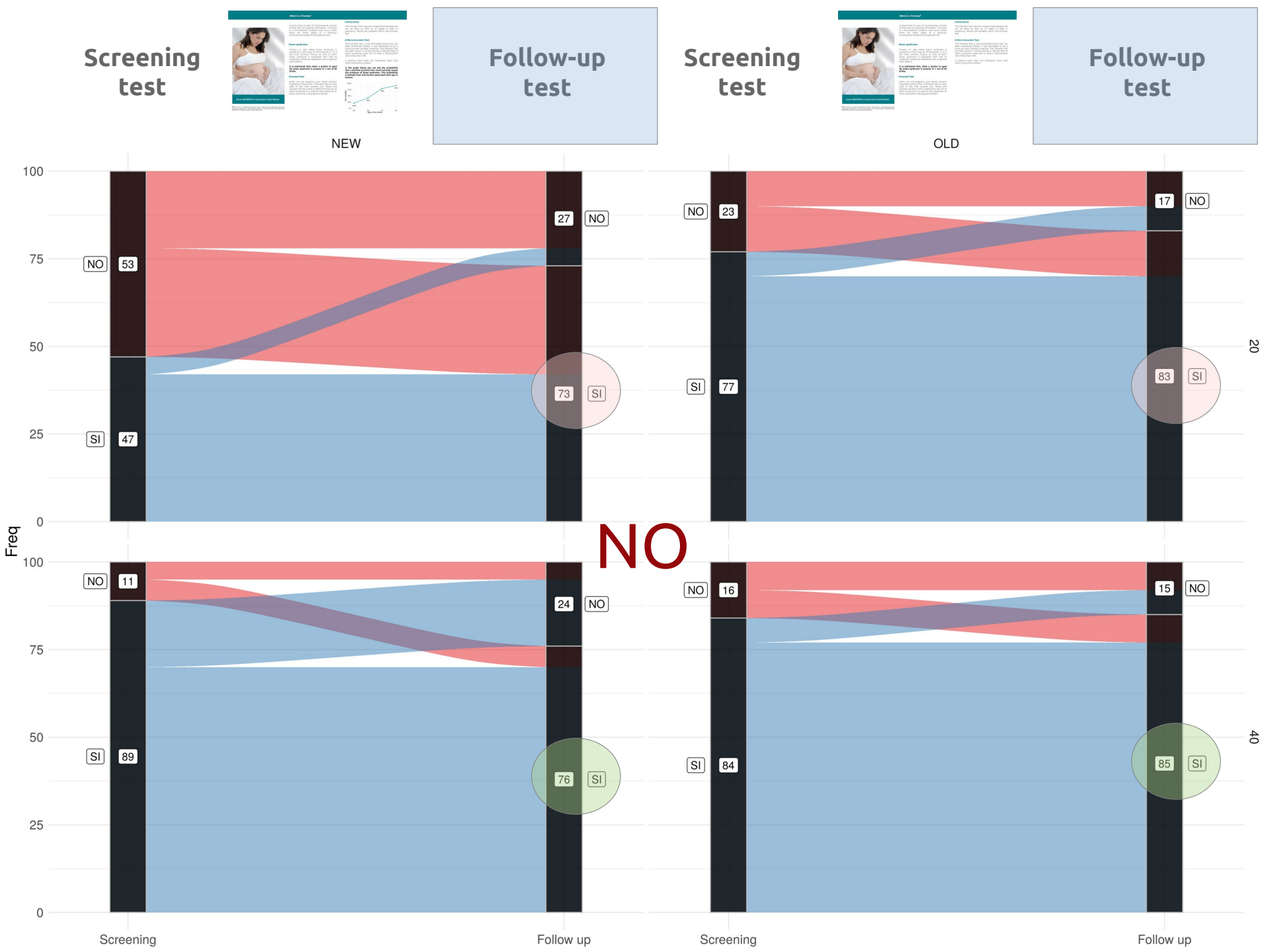
Overview of results

Do people know the information they need?

Can we improve calculation/comprehension?

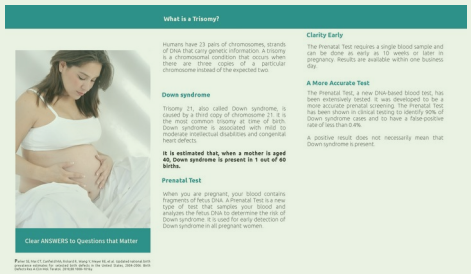
Can we improve decisions?


Screening test
Follow-up test
NEW
Screening test
Follow-up test
OLD
100
75
50
25
0
Freq
NO
53
SI
47
27
NO
73
SI
NO
23
SI
77
17
NO
83
SI
20
YES!
NO
11
SI
89
24
NO
76
SI
NO
16
SI
84
15
NO
85
SI
40
Screening
Follow up
Screening
Follow up


Screening test
Follow-up test
NEW
Screening test
Follow-up test
OLD
NO
Freq
100
75
50
25
0
NO 53
SI 47
27 NO
73 SI
NO 23
SI 77
17 NO
83 SI
20
NO 11
SI 89
24 NO
76 SI
NO 16
SI 84
15 NO
85 SI
40
Screening
Follow up
Screening
Follow up

Screening test

Would you recommend this **screening test**?



YES / NO

→ Imagine the result is +

Follow-up test

Would you recommend a **Follow up test** with 1% chance of a procedure-related miscarriage?

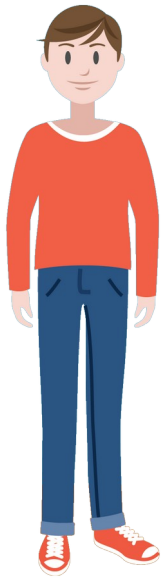
YES / NO

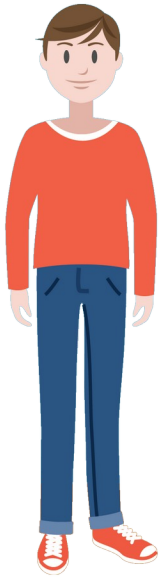
Take home message

We can do better! And it matters…

We can do better! And it matters…

Patients

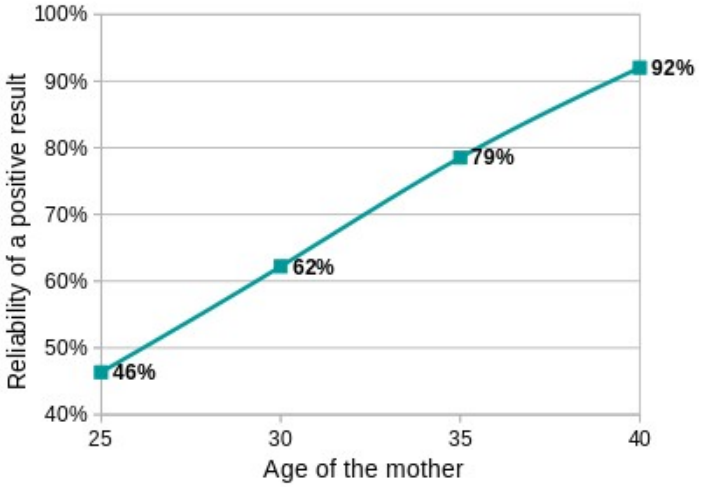




$$p\left(Trisomy\ 21 \mid +test\right) =$$

$$(A)\ \frac{1\ out\ of\ 800\ \times\ 99\%}{\left(1\ out\ of\ 800 \times 99\%\right) + \left(799\ out\ of\ 800 \times 0.1\%\right)} =$$

$$(B)\ \frac{0.123}{0.123 + 0.0998} = 0.55$$



Reliability of a positive test result depending on the mother's age.

Would you go through this **screening test**?

GOOD test

Result is +

Would you go through a **Follow up test** with 1% chance of a procedure-related miscarriage?

Result is −

BAD test

We can do better! And it matters…

Many **false positives** in low prevalence conditions / populations

This leads to:

- unnecessary tests ($$$)
- overdiagnosis (loss of health)
- miracles!

We can do better! And it matters…

When people understand: they may avoid entering the tunnel!

less bad tests → less false positives

This would lead to:

- **less** unnecessary tests
- **less** overdiagnosis
- **less** miracles

We can do better! And it matters…

This is only the first step, but we must be careful

Next steps…

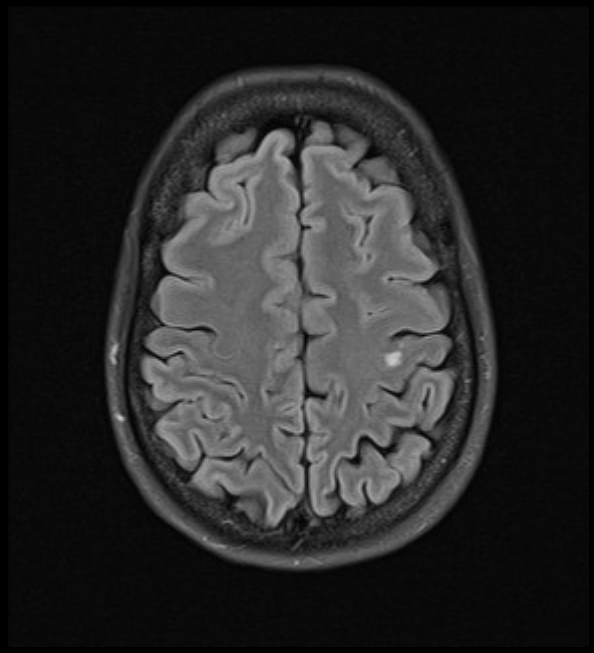
Registered report extending results to different risk levels: 1% vs 10%

Next steps…

Help the ones helping

Screening versus Diagnostic tests

Gender



Next steps…

Help the ones helping

Screening versus Diagnostic tests

Gender

$$p\left(Trisomy\ 21 \mid +test\right) =$$

$$(A)\ \frac{1\ out\ of\ 800\ \times\ 99\%}{\left(1\ out\ of\ 800 \times 99\%\right) + \left(799\ out\ of\ 800 \times 0.1\%\right)} =$$

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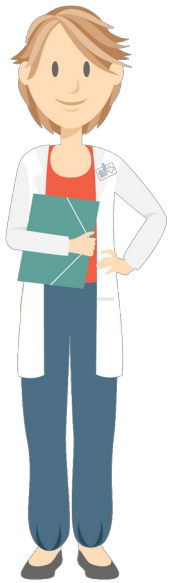
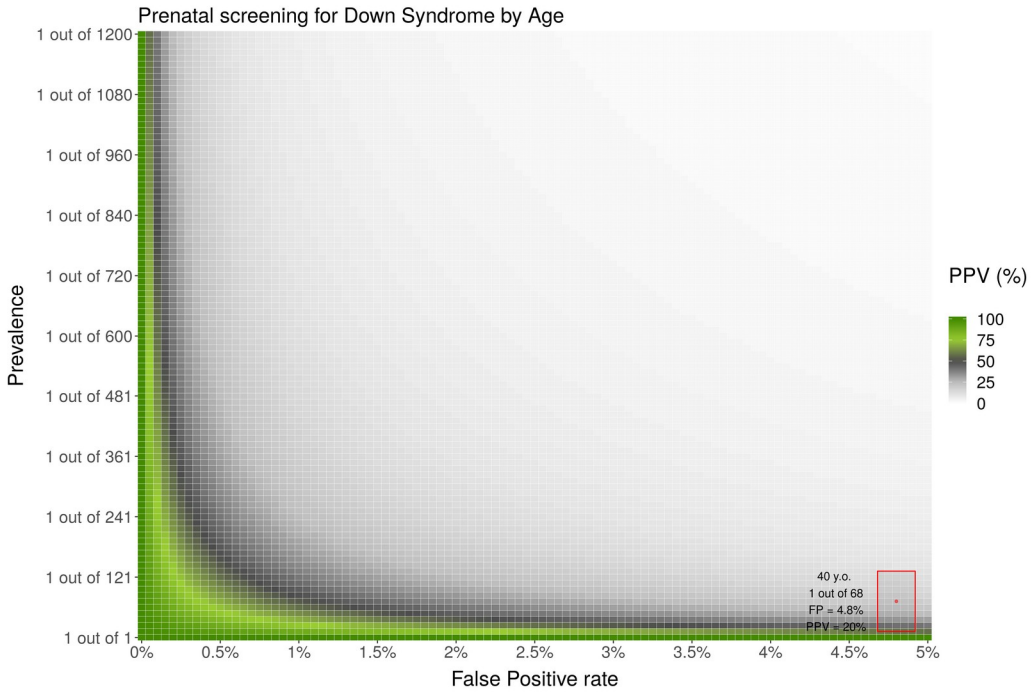
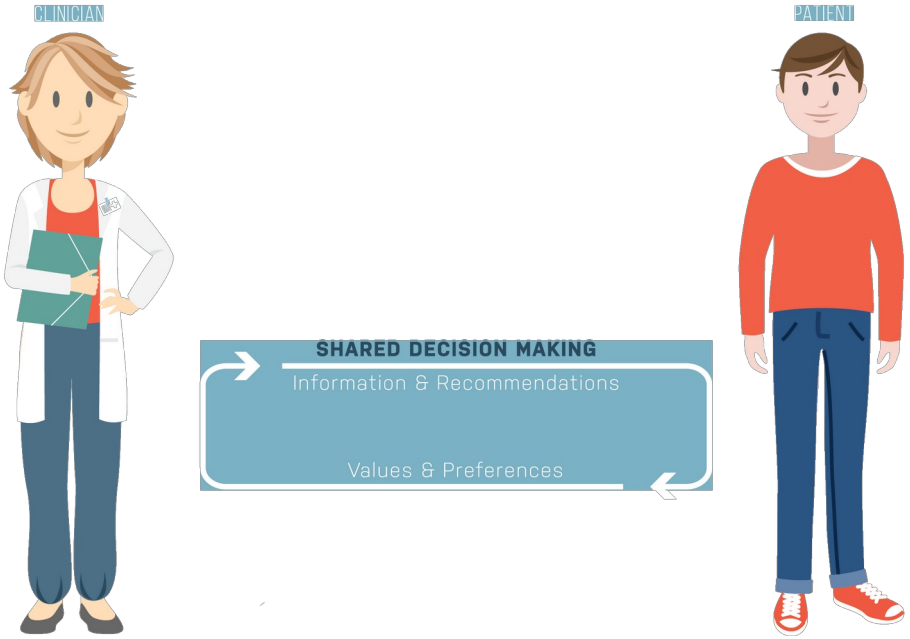
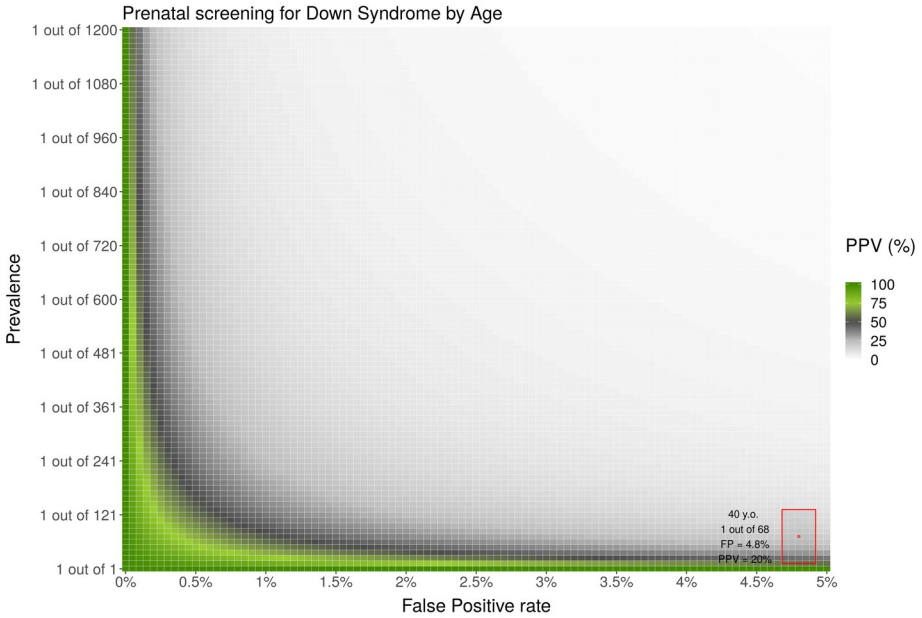
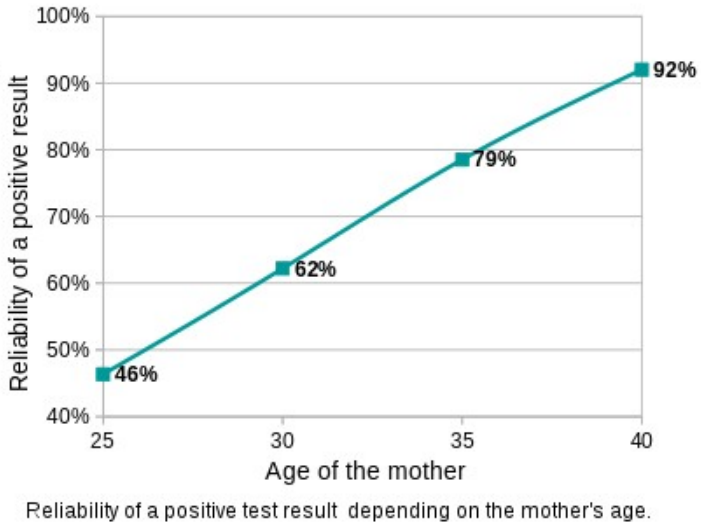










Reliability of a positive test result depending on the mother's age.

Next steps…

Help the ones helping

Screening versus Diagnostic tests

Gender

Screening tests

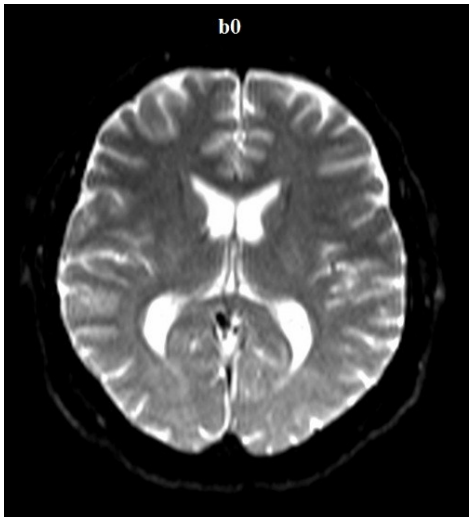
NPV very high

PPV, … it depends

Diagnostic tests

NPV, … it depends

PPV, very high



Next steps…

Help the ones helping

Screening versus Diagnostic tests

Gender

Thomas Bayes Portrait: https://enkeling.nl/2013/04/07/thomas-bayes-portrait/

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CENTRO DE NEUROCIENCIA SOCIAL Y COGNITIVA
ESCUELA DE PSICOLOGÍA · UAI

Gorka Navarrete
www.cscn.uai.cl
gorka.navarrete@uai.cl
@gorkang

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(2015-2016) Fodecyt Regular 1150824. Communication and interpretation of diagnostic tests: behavioral and physiological variables of Bayesian reasoning

(2017-2019) Fondecyt Regular 1171035. Towards a more integrated model of Bayesian reasoning: calculation, understanding and decision making in medical contexts

16% average absolute error

40% average absolute error