# Statistics for the terrified

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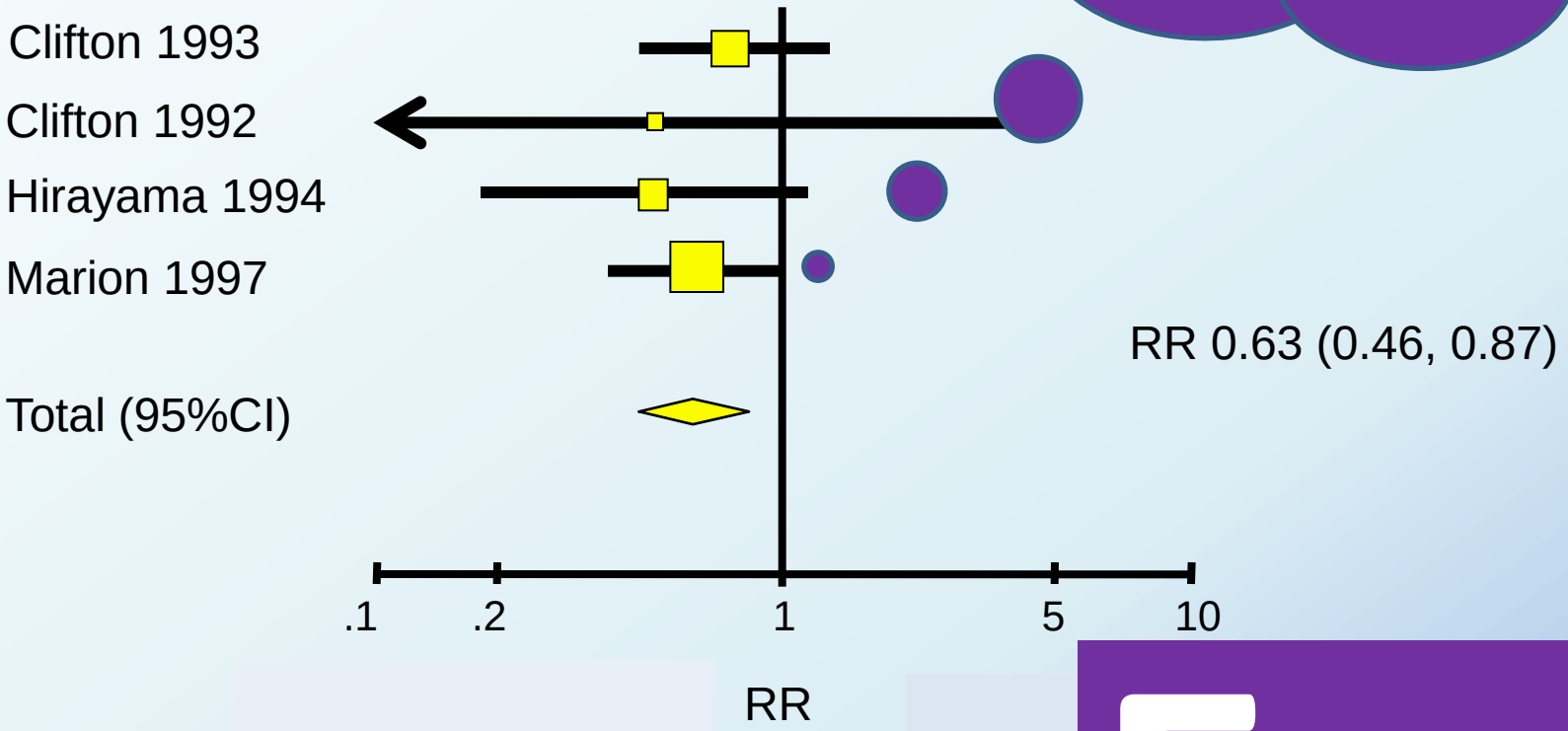
# Post-prand


End

# Hypothermia vs. control

*In severe head injury*
*Mortality or incapacity (n=158)*

- 1 minute to discuss with your neighbour
- Then write down what you think this graphic tells you




End

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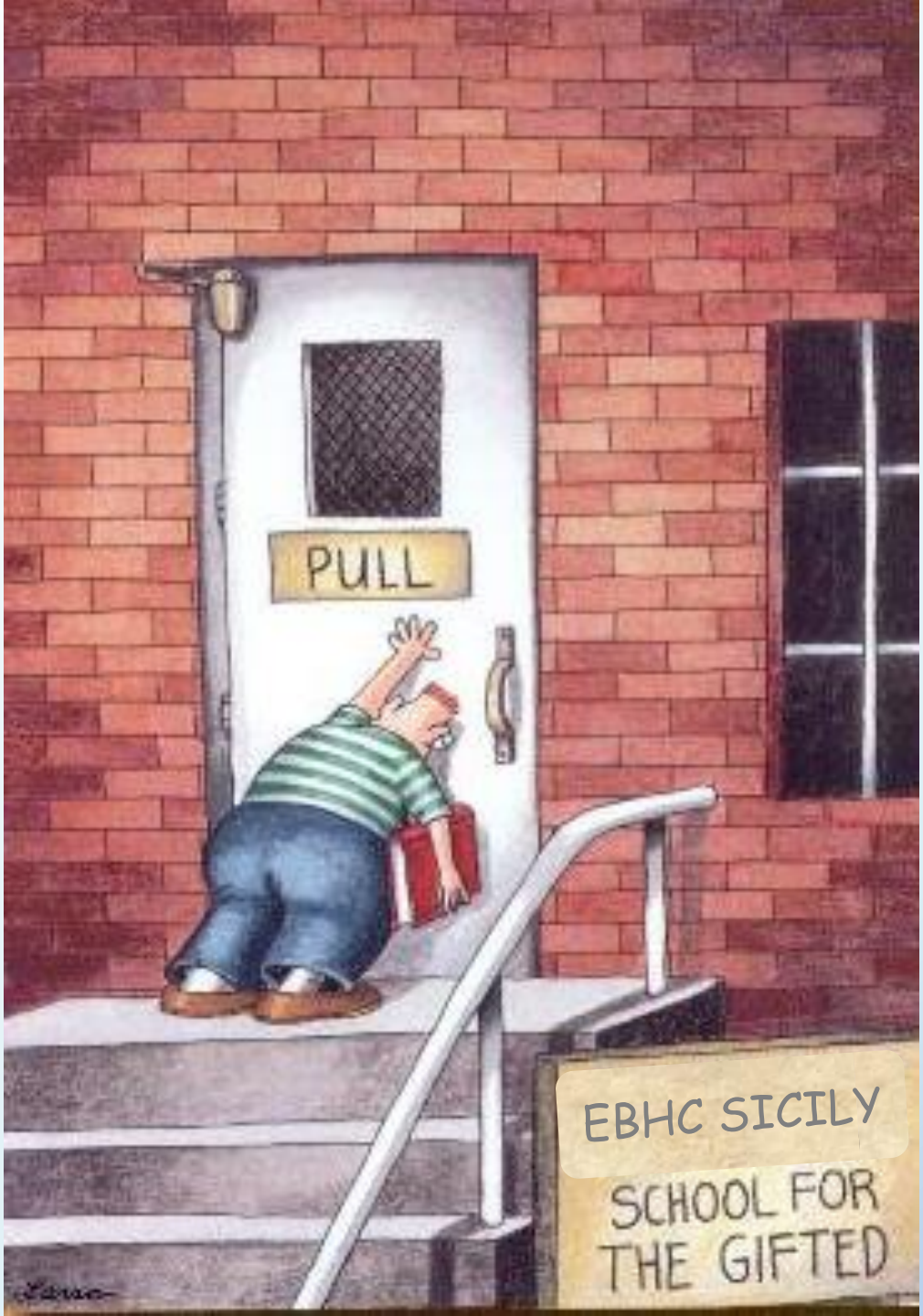
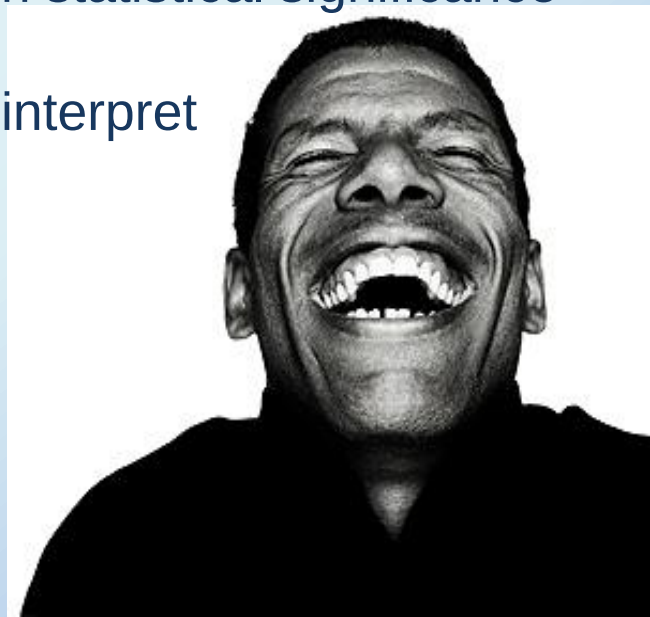


# Learning objectives

- By the end of this session you will
  - Know how measures of effect are reported
  - Be able to interpret p-values
  - Be able to interpret confidence intervals
  - Be able to calculate relative risks (RR, OR)
  - Be able to explain the difference between statistical significance clinical significance
  - Like to use blobbograms and be able to interpret then with ease
- Have have fun!



# Statistics without fear

# Before we start, let's remind ourselves

What are the important things to think about when we are using research evidence to help inform your decisions?

# Validity for an intervention study?


- Randomised controlled trial

End

# Validity for an RCT – Getting similar groups and keeping them similar

- Randomized
- Concealment of allocation
- Similar baseline characteristics
- Blinding
- Treating groups the same
- Minimal losses to follow up
- Intention to treat analysis

# Appraisal of any study must consider

**There are two sorts of error**

- ***Validity***
  - Can the results be trusted? ← ***Systematic error (Bias)***
- ***Results***
  - **What are the results**
  - **How are they (or can they be) expressed**
  - **Could they have occurred by chance** ← ***Random error***
- ***Relevance***
  - Do these results apply to the local context or to me or to my patient?

# Warning!

Everything I say from now onwards assumes that the results being considered come from an *unbiased* study!

*(assumes **NO** systematic errors)*

# How are results summarised?

- Most useful studies compare at least two alternatives.
- How can the results of such comparisons be expressed?

# Well-conducted RCT (no bias)

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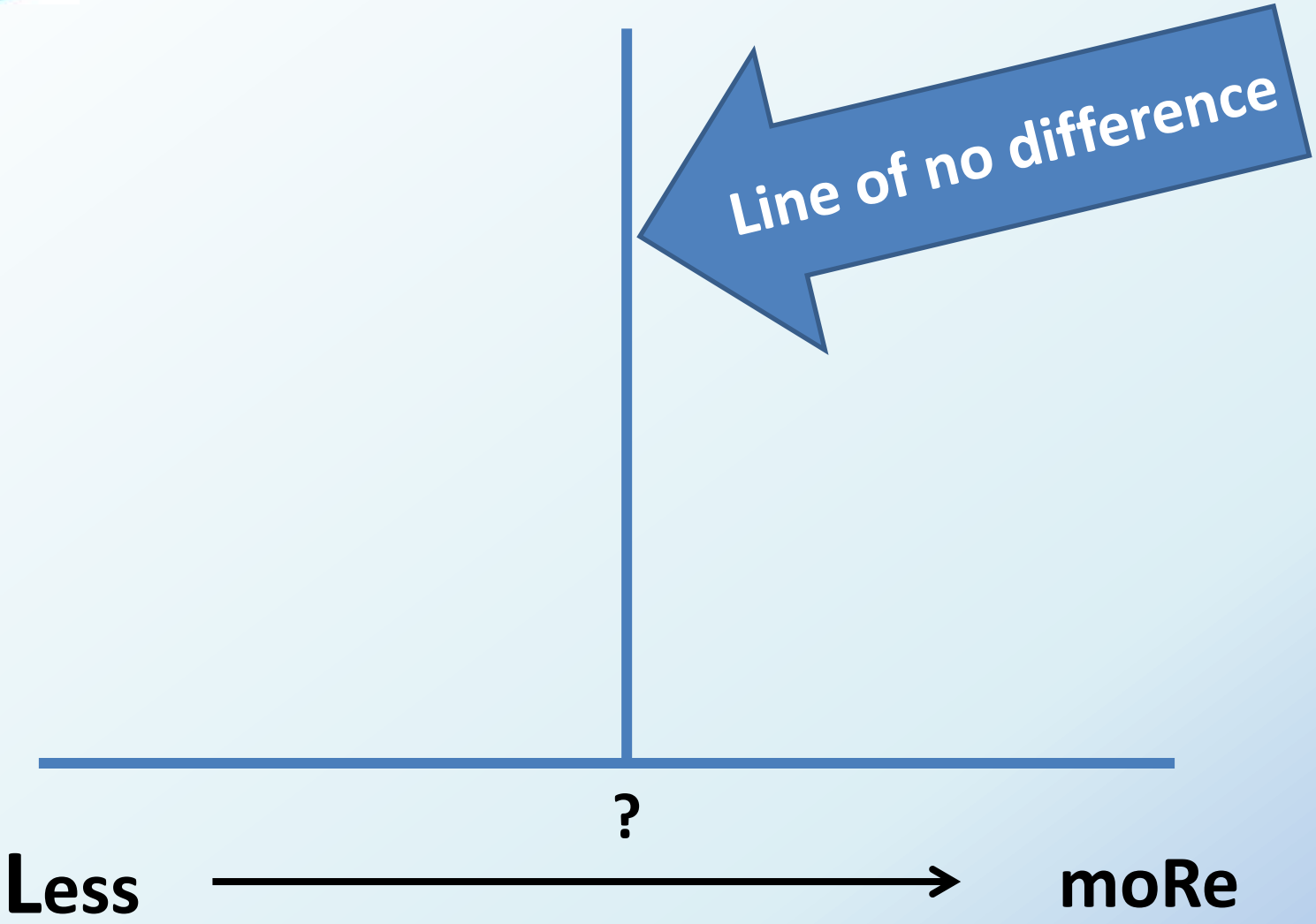
# *Expressing results: What did the study show?*

- Patients with backache:
  - 10 randomised to receive Potters
  - 10 randomised to receive placebo
- After 3 months:
  - 2 get better on Potters
  - 1 get better on placebo
- **Summarise this result to your neighbour in at least three different ways**

# Summarise

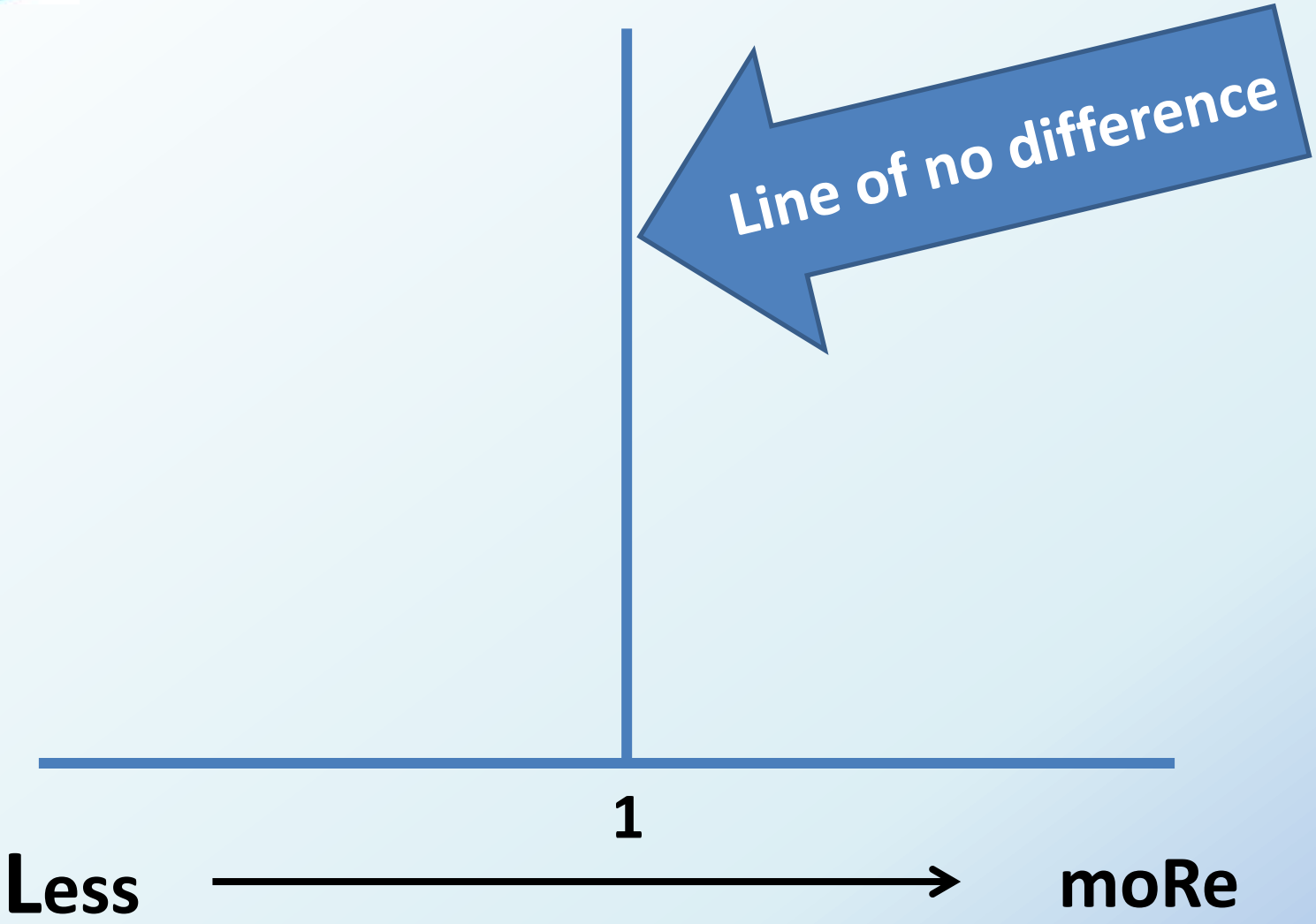
- 2 out of 10 (20%) better on Potters
- 1 out of 10 (10%) better on placebo

- **Twice as likely to get better on Potters**
- **An extra 10% of people get better on Potters**
- **For every 10 people with  back pain given Potters, one case of back pain is improved**


Line of no difference
?
Less
moRe

# Relative Risk

- How much more likely one group is to recover than the other
- Twice as many recovered on Potters means the relative risk is 2, or RR = 2.0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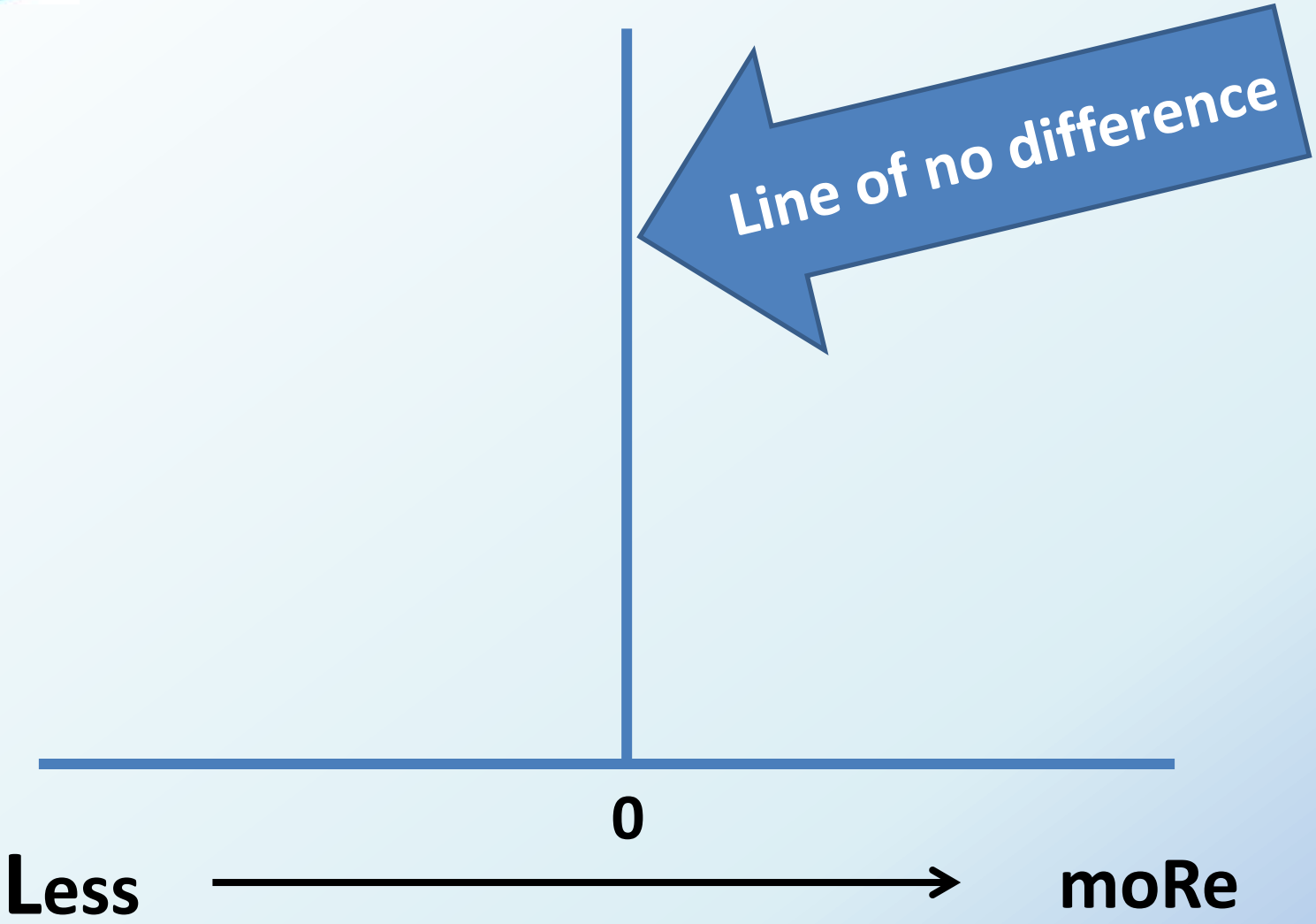
# Risk difference

- The difference in the proportions recovering – the proportion of patients benefitting from treatment
- 20% improved on Potters, but 10% improved on placebo, so the risk difference is 10%


Line of no difference
0
Less
moRe

# Number needed to treat (NNT)

- The number of patients to whom the new intervention needs to be given to produce one *extra* patient who is helped
- NNT = 1/risk difference
- Why?

# How were the results summarised?

Two basic ways to summarise results of studies that compare groups:

1. Difference (take them away)
2. Ratio (divide)

# Do you think this study proves that Potters works?


I THINK I'VE DISCOVERED SOMETHING

# “It could have happened by chance!”

# “It could have happened by chance!”

- If there had been 1000 people in the trial
  - 200 got better with Potters
  - 100 got better on placebo
- Would you believe Potters works?

# So how many would you want before you believe the results?

- 10 in each arm?
- 20 in each arm?
- 100?
- 1000?

The secret ballot

# What is the minimum number you would want in each arm to believe the trial?

*Assume similar effect size:*

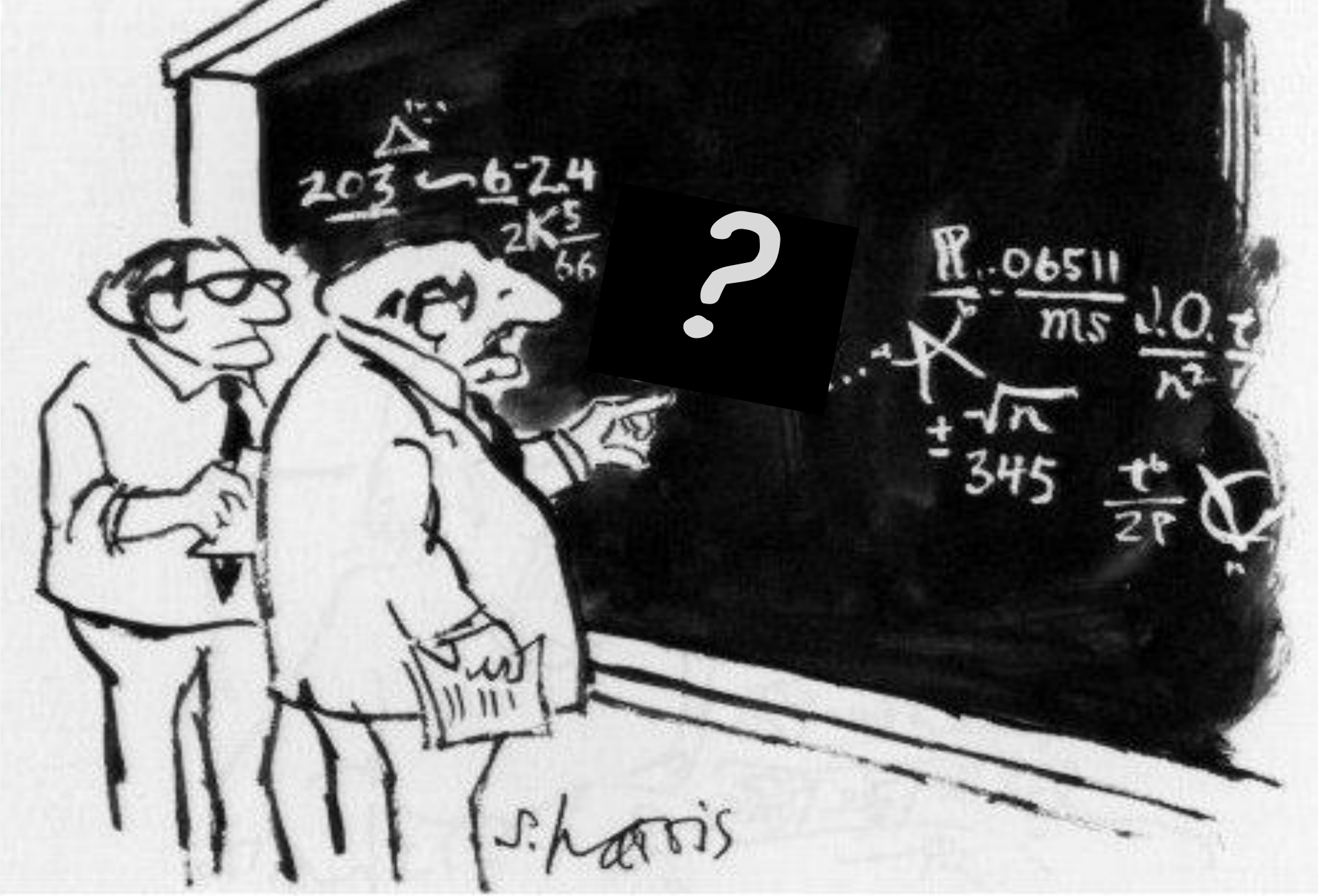
*10% better with placebo*

*20% with Potters*

- Write on a piece of paper your estimate
- Fold your paper in half and half again
- Swap it with your neighbour
- Swap the paper again with someone else
- Keep swapping until you don’t know who’s paper you have

# Scores

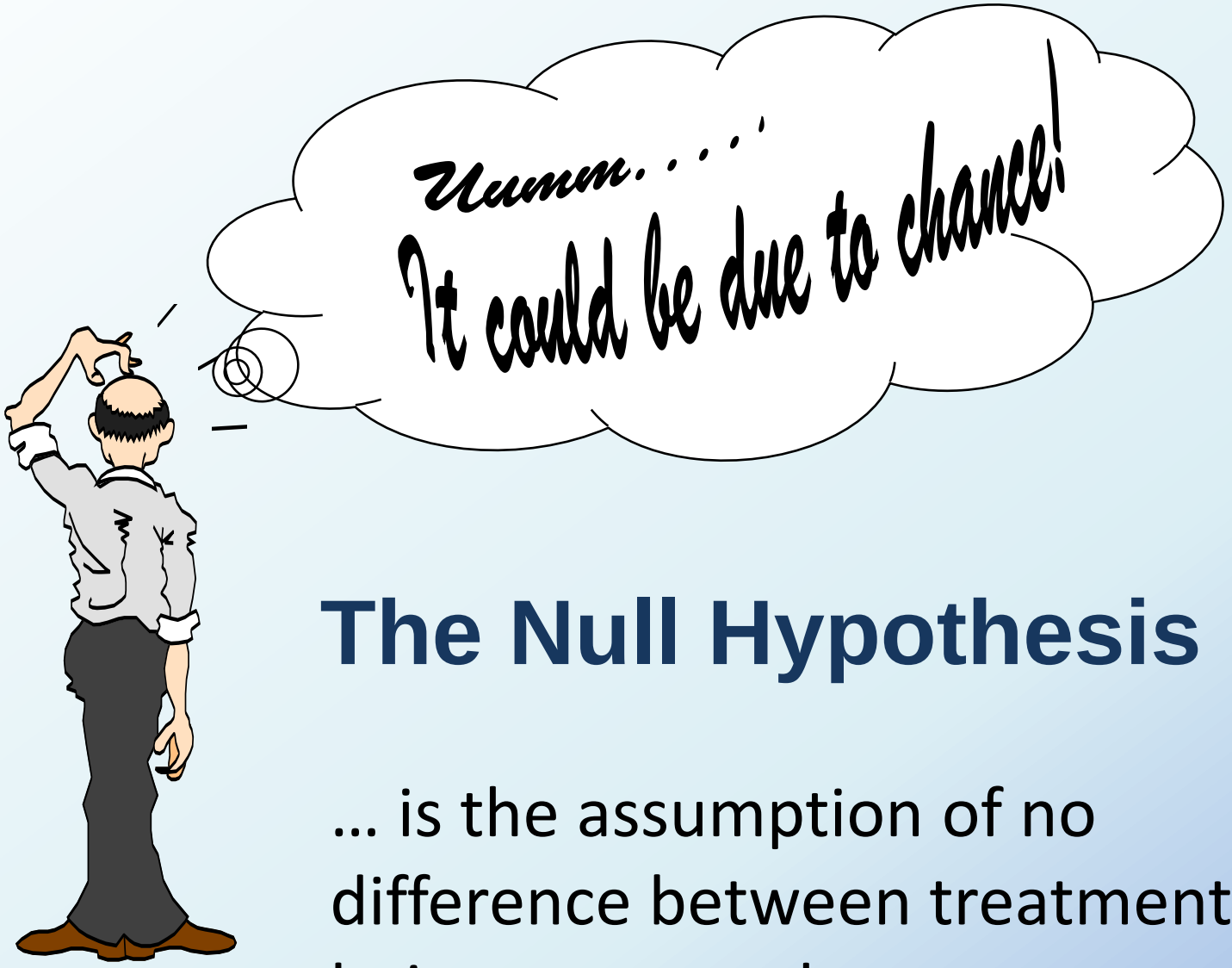
- 0-20
- 21-40
- 41-60
- 61-99
- 100
- 101-200
- >200




"I think you should be more explicit here in step two."

# Quantifying uncertainty due to chance

# p-value




# The Null Hypothesis

… is the assumption of no difference between treatments being compared

*So what does p=0.5 mean?*

*So what does p=0.1 mean?*

*So what does p=0.05 mean?*

**0**

**1**

*Impossible*

*Absolutely certain*

# Bag of 20 sweets

# Bag of 20 sweets

# Bag of 30 sweets

# “Statistical significance”

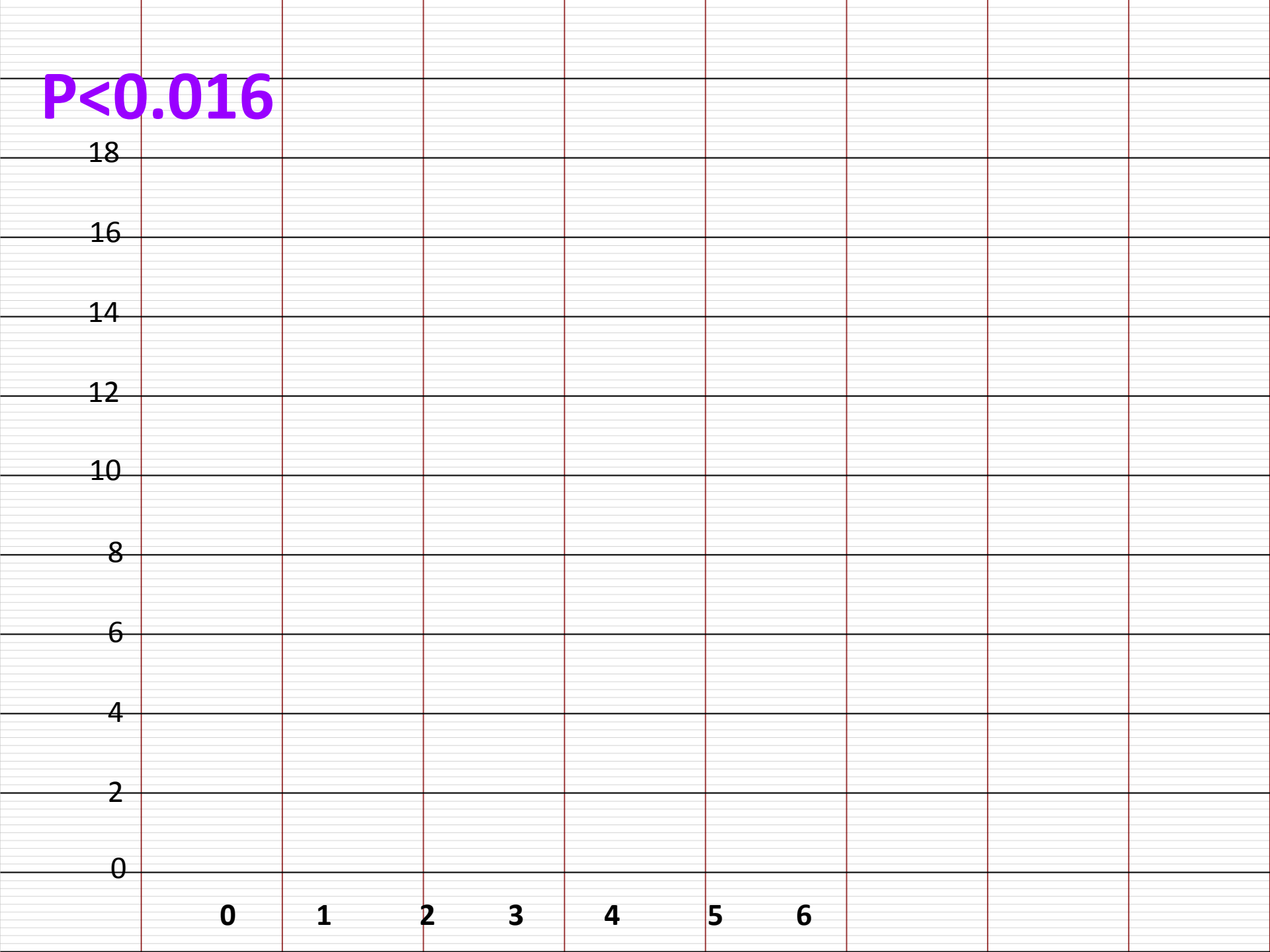
- When a similar result would happen by chance on fewer than 1 in 20 occasions
- $p<0.05$

| Potters | Placebo | P-value |
|---|---|---|
| 2/10 | 1/10 | P = 0.531 |
| 4/20 | 2/20 | P = 0.376 |
| 6/30 | 3/30 | P = 0.278 |
| 8/40 | 4/40 | P = 0.210 |
| 10/50 | 5/50 | P = 0.161 |
| 12/60 | 6/60 | P = 0.125 |
| 14/70 | 7/70 | P = 0.097 |
| 16/80 | 8/80 | P = 0.076 |
| 18/90 | 9/90 | P = 0.060 |
| 20/100 | 10/100 | P = 0.048 |
| 100/500 | 50/500 | P < 0.0001 |
| 200/1000 | 100/1000 | P < 0.0001 |

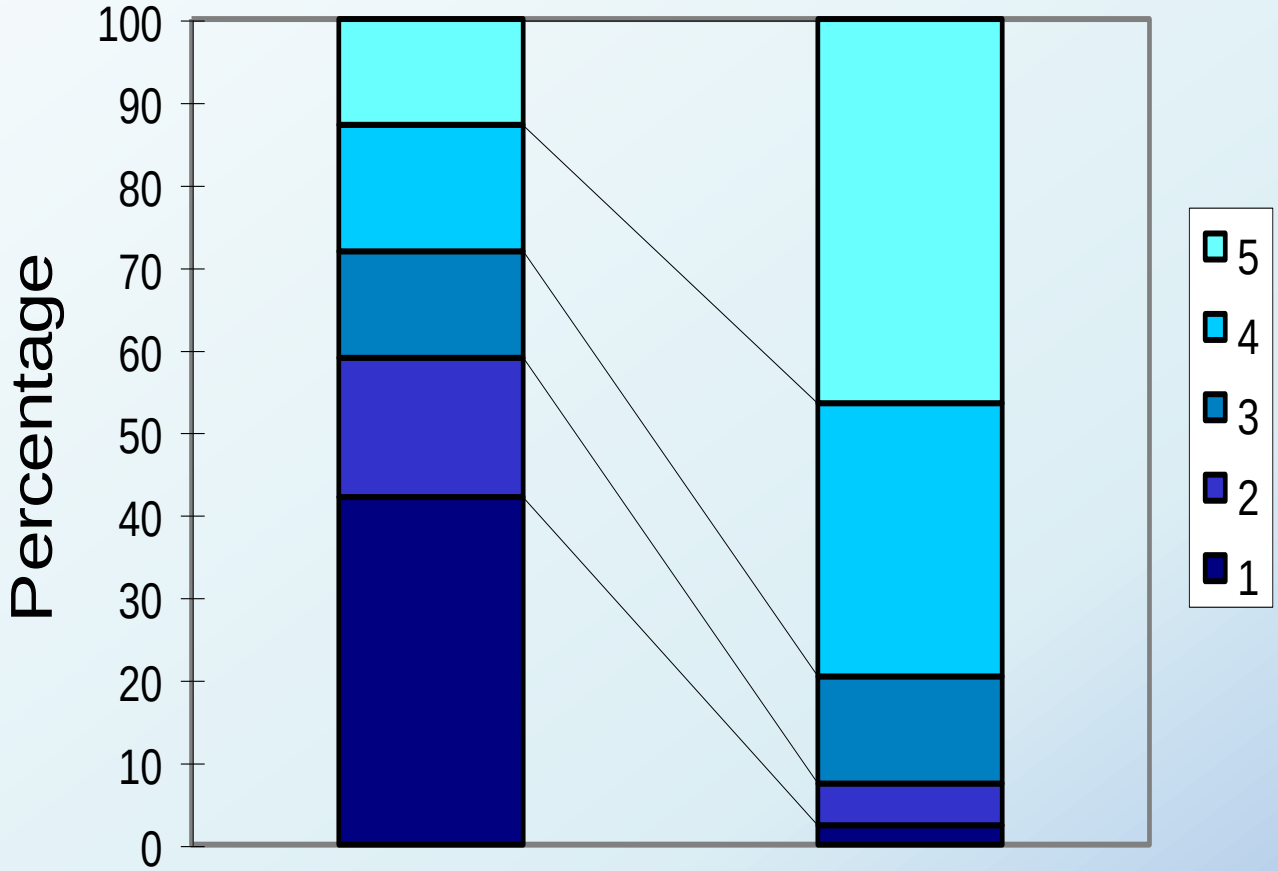
# Why $p<0.05$ as the cut-off?

- Convention!
- There is no magic cut-off between “statistically significant” and not
- Although many behave as if there were!

******************************************


P<0.016
18
16
14
12
10
8
6
4
2
0
0
1
2
3
4
5
6

# “Odds ratio”




Pre and Post Workshop Scores

**Do you think this is likely to have happened by chance?**

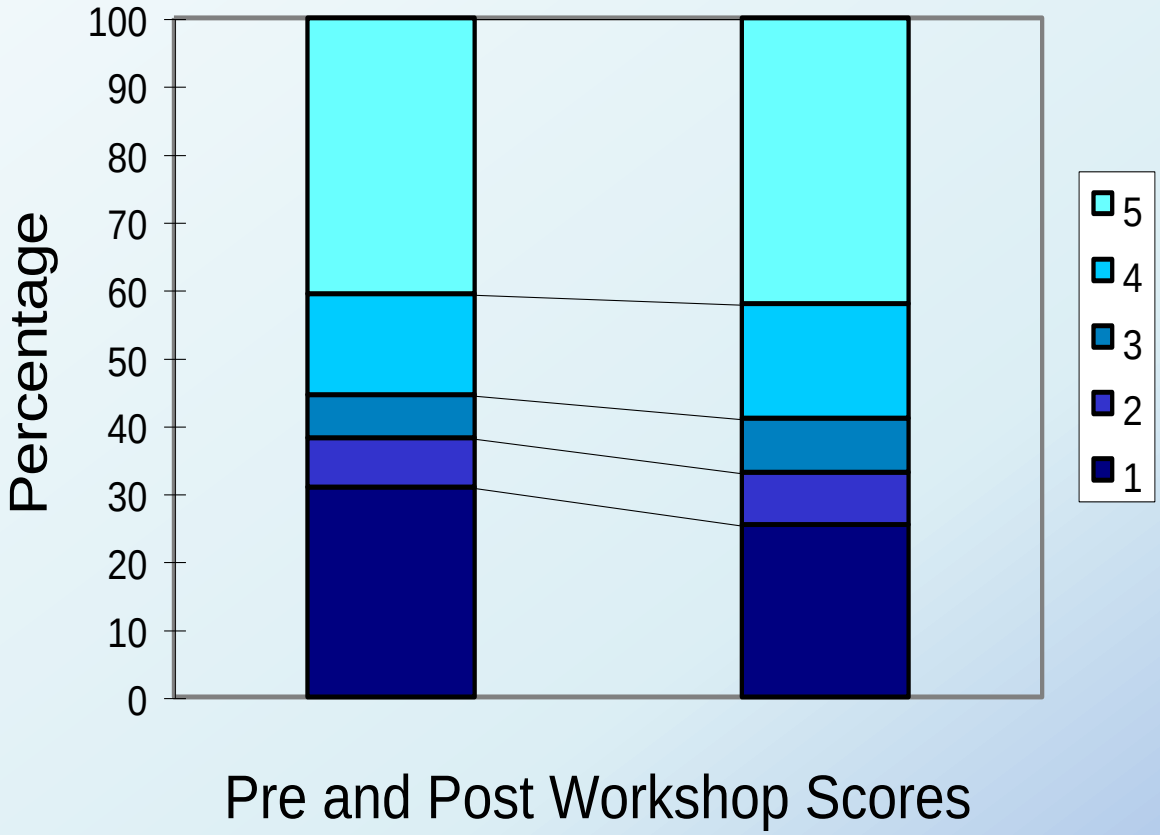
1. Yes
2. Don’t know
3. No

**Do you think this is likely to have happened by chance?**

1. Yes
2. Don’t know (~1000)
3. No

**P<0.00001**

# “MAAG”


100
90
80
70
60
50
40
30
20
10
0
Percentage
5
4
3
2
1
Pre and Post Workshop Scores

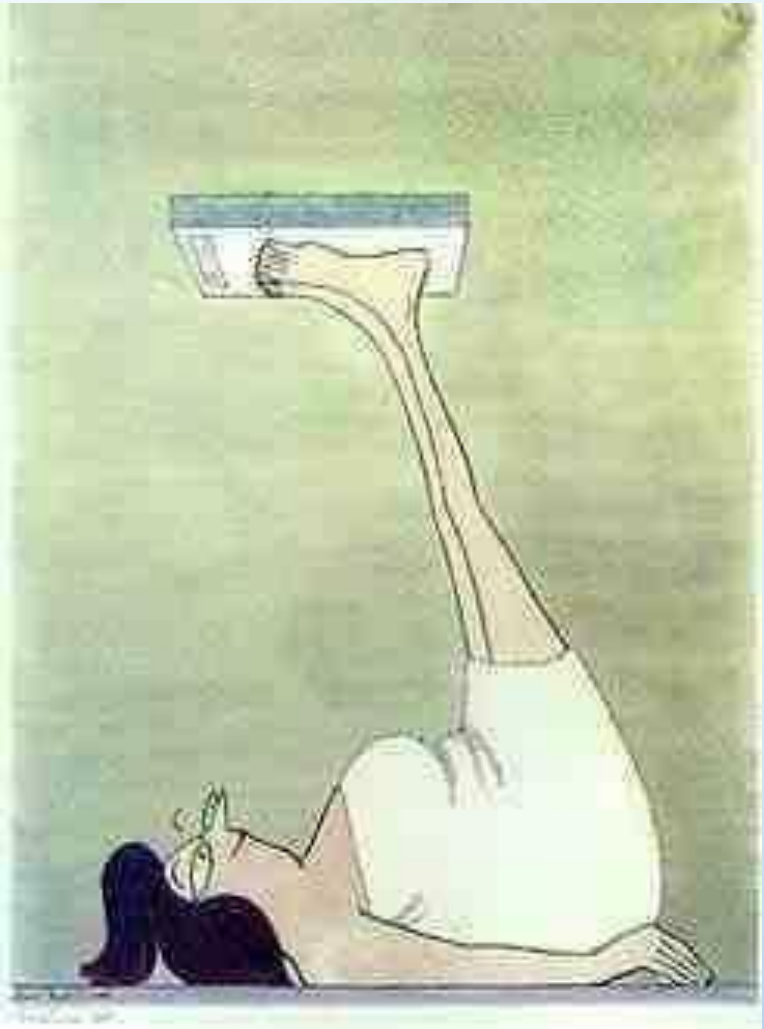
**Do you think this is likely to have happened by chance?**

1. Yes

2. No

**P<0.00001**

# Statistical significance does not imply clinical significance!



# Limitations of the p-value

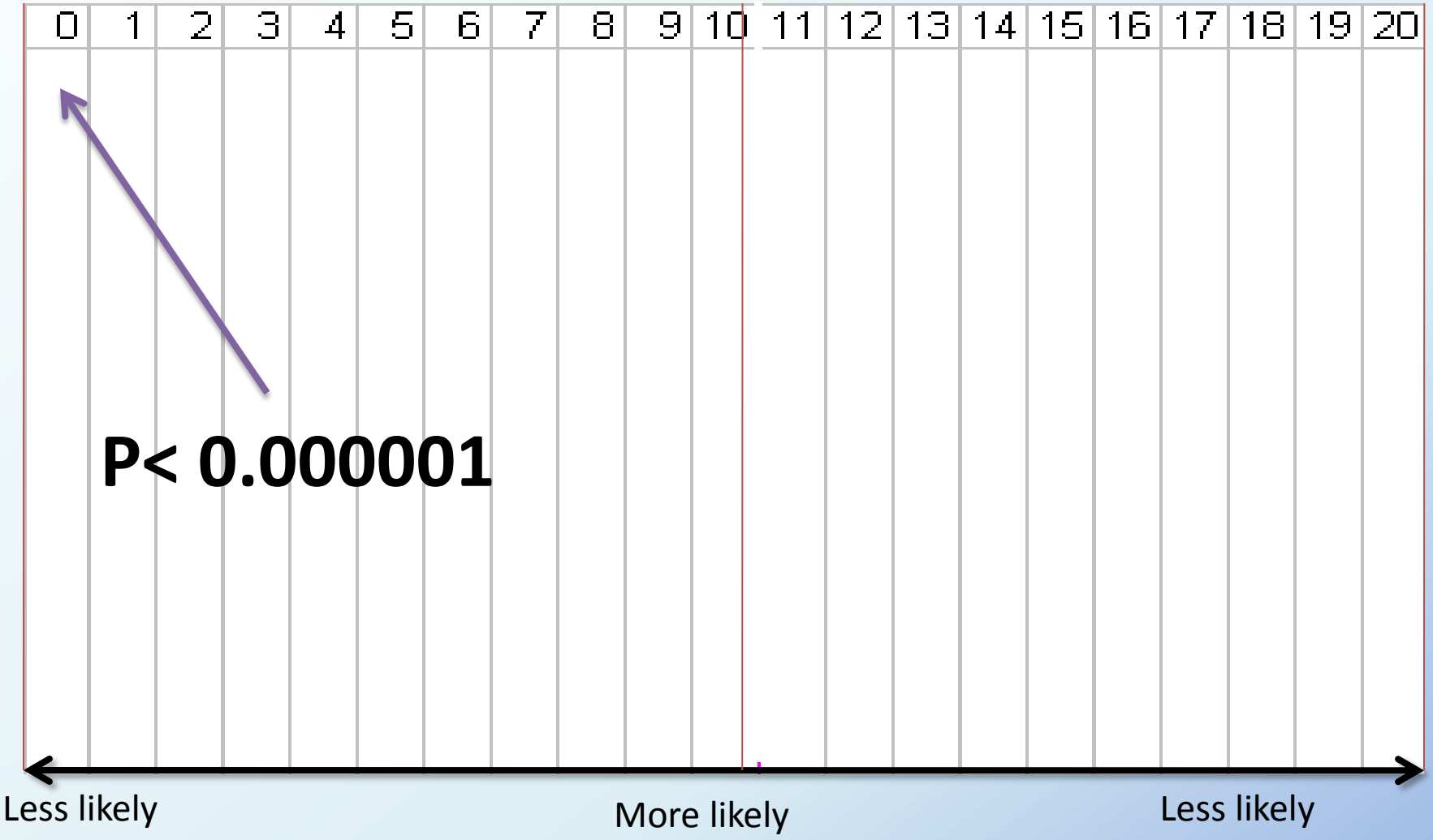
Any genuine difference between two groups, *no matter how small*, can be made to be "statistically significant" - at *any* level of significance - by taking a sufficiently large sample.

We need a better way to express *uncertainty due to chance….. [?]*

# Introduction to confidence intervals

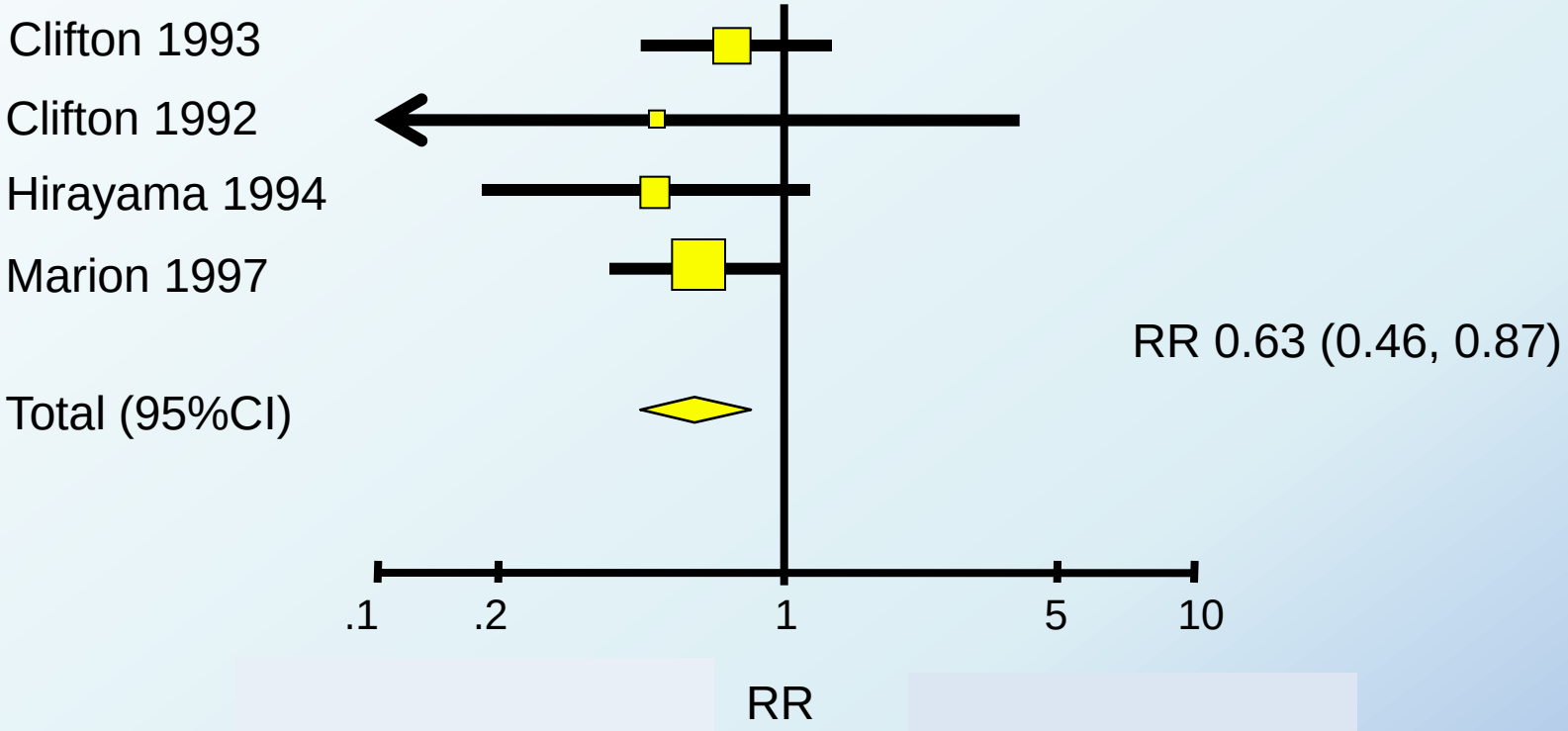
- CIs are a way of showing the uncertainty surrounding a point estimate.

# How many Red sweets did I pick?



# Hypothermia vs. control

*In severe head injury*
*Mortality or incapacity (n=158)*



# Hypothermia vs. control

*In severe head injury*
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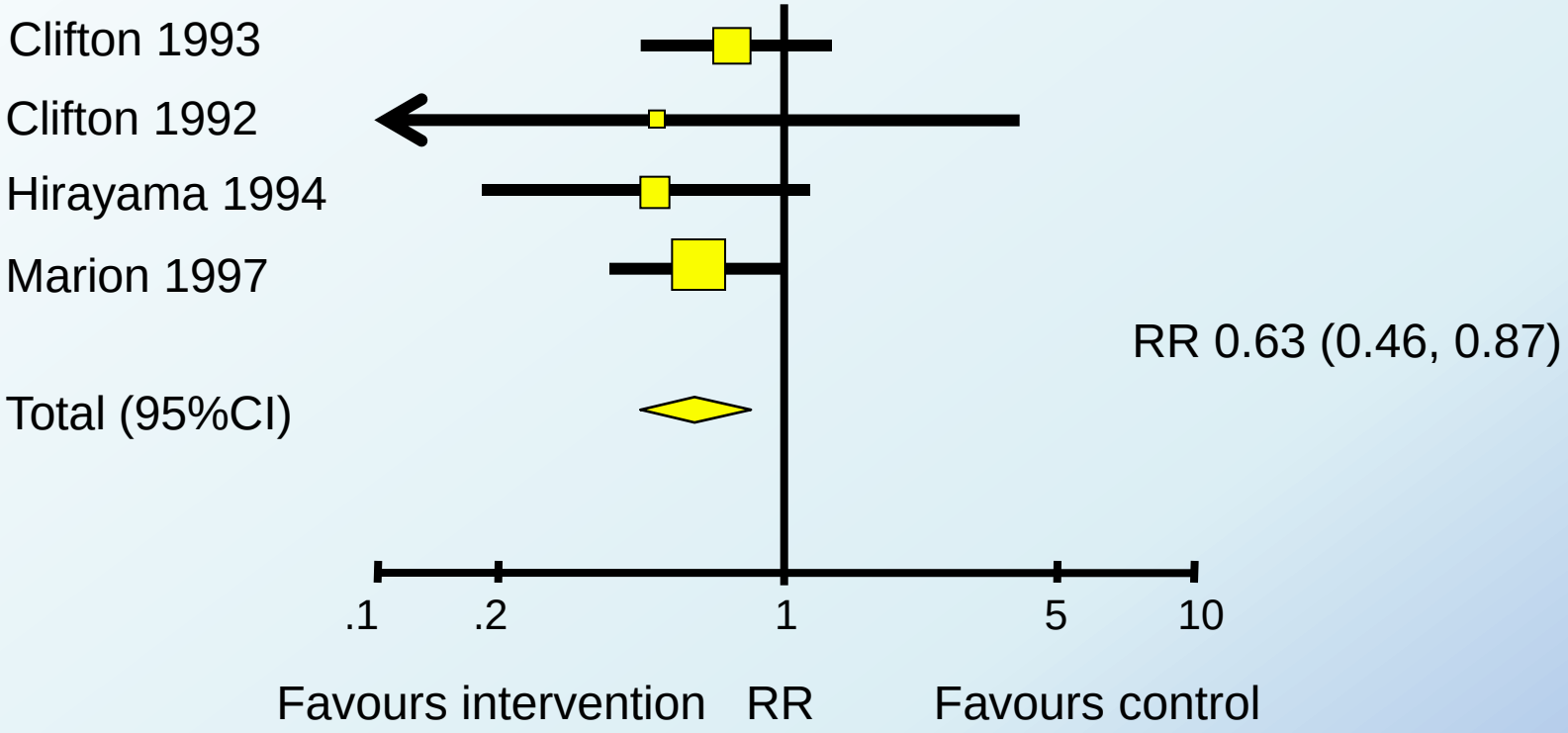


# When making health care decisions we often want to know

- The chance that people with a specific disease have a certain risk factor
- The chance that people with a specific trait have or are likely to develop a particular outcome
- Or the chance that a patient given a treatment will get better (or be harmed)

# How are these things summarised?

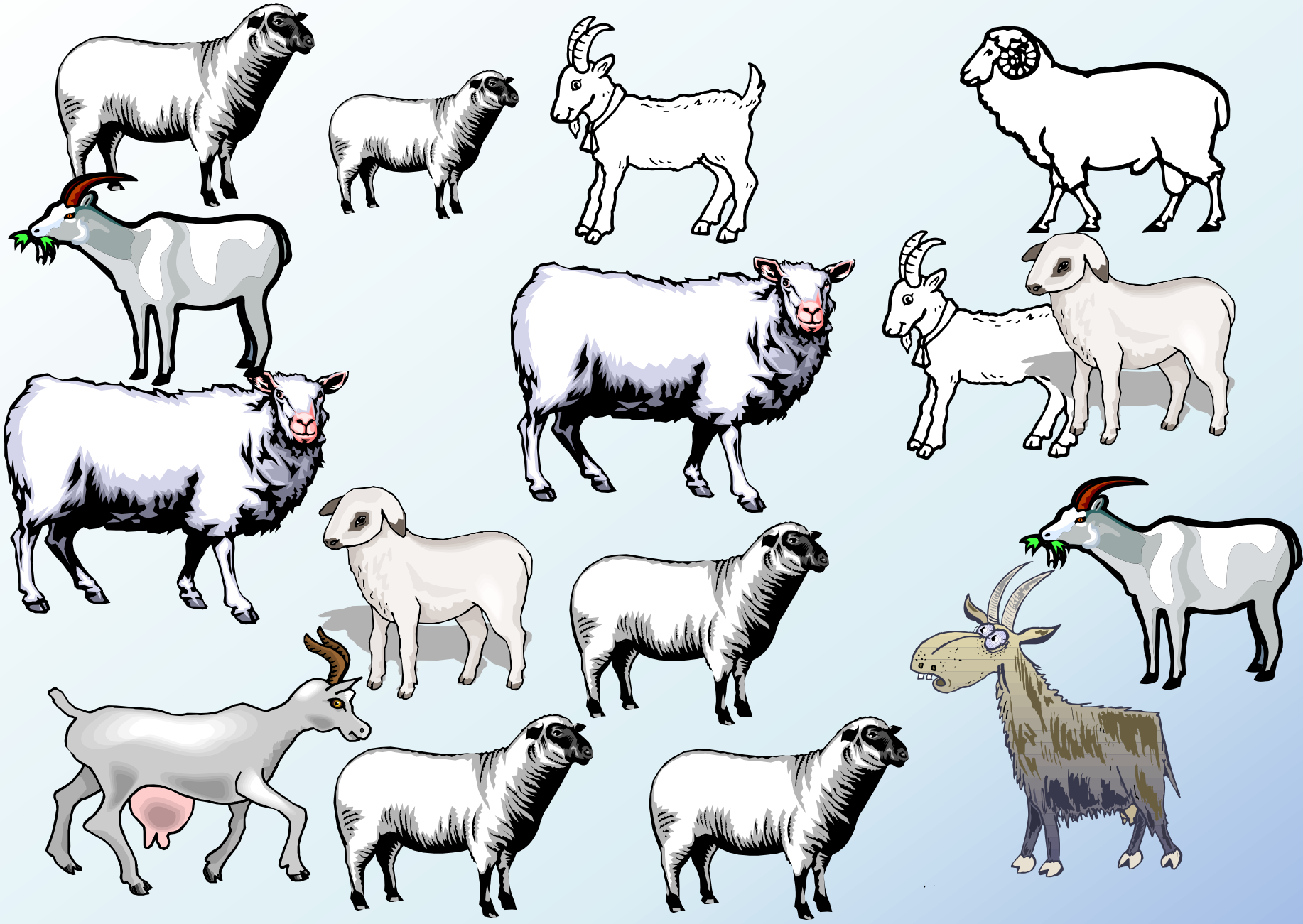
- Write down as many measures of comparison and association as you can

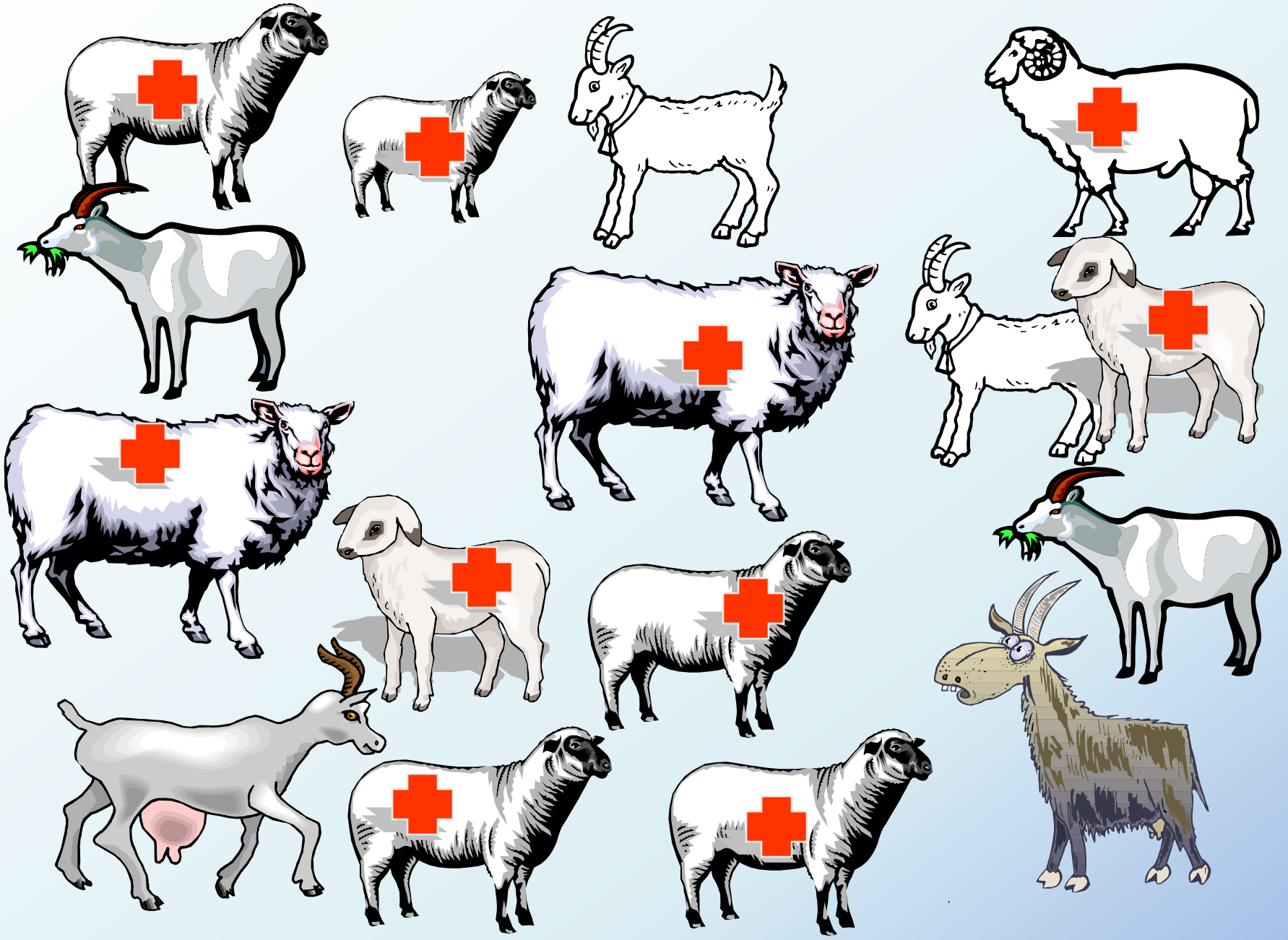
End


Photo by
Clément Gault
Designetrecherche

# On the next slide

- There is a field
- Write down how you could summarise quantitatively what you see to someone who cannot see the field
- Talk to your neighbour if you want





# Possible summaries

- There are sixteen animals in the field
- There are sixteen sheep and goats in the field
- There are sixteen animals in the field, of which 10 are sheep and 6 are goats

# Calculate (you have I minute)

- The risk of being a sheep

(note that in epidemiology we use the word “risk” to mean “chance” – it doesn’t necessarily mean something unwanted)

- The odds of being a sheep

**End**

# Answers

- Risk
  - 10/16
  - 0.625
- Odds
  - 10:6
  - 1.66

# Odds

- Odds are when you separate the sheep from the goats!

**Odds** are a way of describing how many people in a population have a disease, risk factor or other outcome of interest.

e.g. The **odds** could be the number of people with the disease compared to the number without the disease:

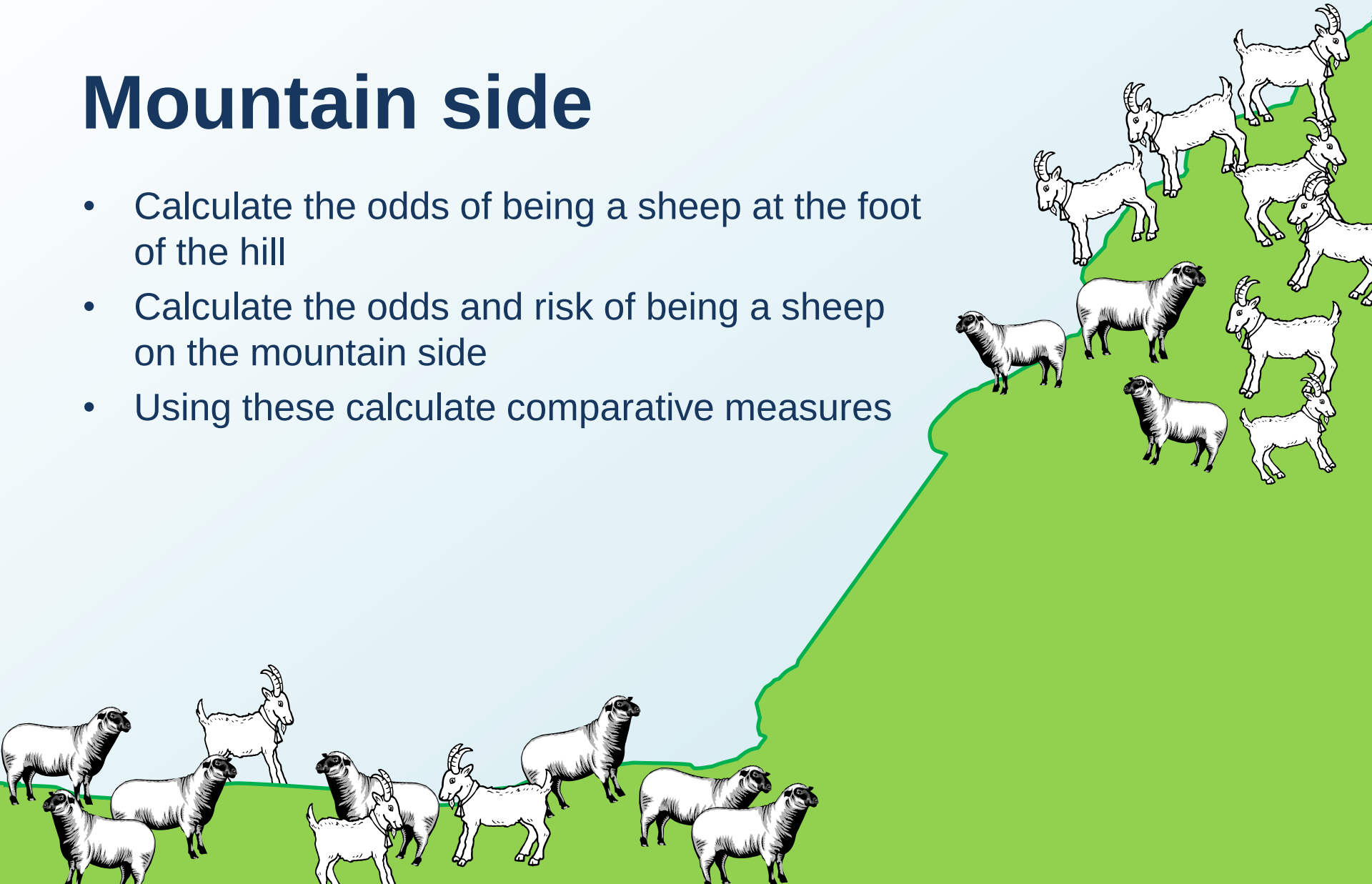
number **with** disease
---
number **without** disease

# Comparing two or more groups…

- The difference between the groups
- The ratio between the groups (e.g. experimental/control, exposed/not expose)

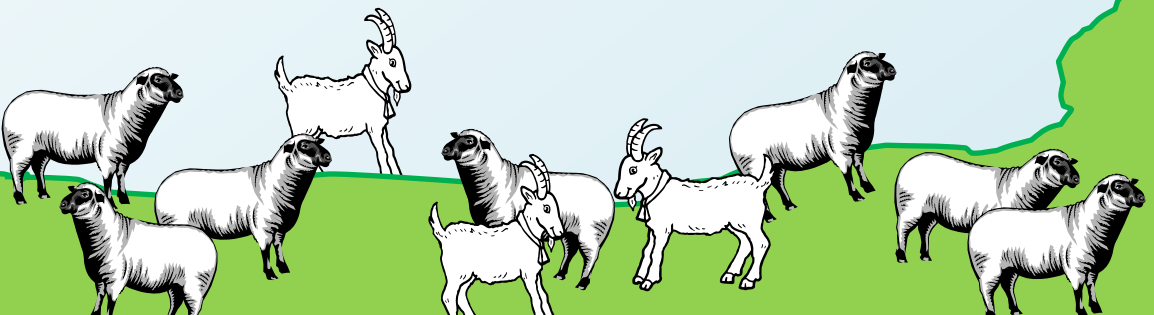
# Mountain side

- Calculate the odds of being a sheep at the foot of the hill
- Calculate the odds and risk of being a sheep on the mountain side
- Using these calculate comparative measures



# Summarise the relative risk of being in the field compared to the mountain in terms of odds and risks

- Odds of being a sheep at the foot = 7:3 = 2.3
- Risk of being a sheep at the foot = 7/10 = 0.7 of the hill
- Odds of being a sheep on the mountain 3:7 = 0.43
- Risk of being a sheep on the mountain 3/10 = 0.3
- Odds ratio (OR) = 5.4
- Risk ratio (RR) = 2.3



**Is it reasonable to conclude that there is an association between being in the field and being a sheep?**

1. Yes
2. No
3. Don’t know

# P-value

- > 0.07

- http://www.vassarstats.net/odds2x2.html

# How likely is it that we would get a result as big (or as small) as the one observed if there is nothing going on?

The answer is given as a p-value

- Write down the letter of the studies you would believe, if :
  A. P = 0.24
  B. P<0.5
  C. P=0.05
  D. P=0.049
  E. P<0.01
  F. P>0.001

# How likely is it that we would get a result as big (or as small) as the one observed if there is nothing going on?

A. P = 0.24 ☒
B. P<0.5 ☒
C. P=0.05 ☒
D. P=0.049 ☑
E. P<0.01 ☑
F. P>0.001 ☒

# Meta-analysis

# More fun!

**Fixed effects**

- Each bag of sweets have been drawn from the same barrel

**Random effects**

- Each bag of sweets is drawn from a random barrel and all we know about the proportions of sweets in the barrels in the world is what we can deduce from our samples

Review: Hypothermia for traumatic head injury
Comparison: 1 Immediate hypothermia versus normothermia
Outcome: 1 Death at final follow-up

| Study or subgroup | Hypothermia n/N | Control n/N | Odds Ratio M-H,Fixed,95% CI |
|---|---|---|---|
| Adelson 2005 HYPO1 | 4/25 | 4/25 | 1.00 [ 0.22, 4.54 ] |
| Adelson 2005 HYPO2 | 3/14 | 3/13 | 0.91 [ 0.15, 5.58 ] |
| Aibiki 2000 | 1/15 | 3/11 | 0.19 [ 0.02, 2.15 ] |
| Biswas 2002 | 3/8 | 0/6 | 8.27 [ 0.35, 197.61 ] |
| Clifton 1992 | 1/5 | 1/5 | 1.00 [ 0.05, 22.18 ] |
| Clifton 1993 | 8/23 | 8/22 | 0.93 [ 0.28, 3.16 ] |
| Clifton 2001 | 53/190 | 48/178 | 1.05 [ 0.66, 1.66 ] |
| Harris 2009 | 6/12 | 4/13 | 2.25 [ 0.44, 11.52 ] |
| Hashiguchi 2003 | 1/9 | 0/8 | 3.00 [ 0.11, 84.56 ] |
| Hirayama 1994 | 4/12 | 5/10 | 0.50 [ 0.09, 2.81 ] |
| Hutchison 2008 | 23/102 | 14/103 | 1.85 [ 0.89, 3.84 ] |
| Jiang 2000 | 11/43 | 20/44 | 0.41 [ 0.17, 1.02 ] |
| Marion 1997 | 9/39 | 10/42 | 0.96 [ 0.34, 2.69 ] |
| Meissner 2003b | 3/15 | 3/13 | 0.83 [ 0.14, 5.08 ] |
| Qiu 2007 | 9/40 | 13/40 | 0.60 [ 0.22, 1.63 ] |
| Shiozaki 1993 | 8/16 | 14/17 | 0.21 [ 0.04, 1.05 ] |
| Shiozaki 1999 | 0/8 | 0/8 | 0.0 [ 0.0, 0.0 ] |
| Shiozaki 2001 | 8/45 | 6/46 | 1.44 [ 0.46, 4.55 ] |
| Smrcka 2005 | 5/35 | 11/37 | 0.39 [ 0.12, 1.28 ] |
| Yan 2001 | 13/24 | 16/20 | 0.30 [ 0.08, 1.15 ] |
| Zhang 2000 | 41/123 | 50/123 | 0.73 [ 0.43, 1.23 ] |
| **Total (95% CI)** | **803** | **784** | **0.85 [ 0.68, 1.06 ]** |

Total events: 214 (Hypothermia), 233 (Control)
Heterogeneity: $Chi^2 = 21.91$, df = 19 (P = 0.29); $I^2 = 13\%$
Test for overall effect: Z = 1.44 (P = 0.15)

Review: Hypothermia for traumatic head injury
Comparison: 1 Immediate hypothermia versus normothermia
Outcome: 2 Death at final follow-up stratified by trial quality

| Study or subgroup | Hypothermia n/N | Control n/N | Odds Ratio M-H,Fixed,95% CI | Odds Ratio M-H,Fixed,95% CI |
|---|---|---|---|---|
| 1 Concealed allocation | | | | |
| Adelson 2005 HYPO1 | 4/25 | 4/25 | | 1.00 [ 0.22, 4.54 ] |
| Adelson 2005 HYPO2 | 3/14 | 3/13 | | 0.91 [ 0.15, 5.58 ] |
| Clifton 1992 | 1/5 | 1/5 | | 1.00 [ 0.05, 22.18 ] |
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| Clifton 2001 | 53/190 | 48/178 | | 1.05 [ 0.66, 1.66 ] |
| Harris 2009 | 6/12 | 4/13 | | 2.25 [ 0.44, 11.52 ] |
| Hutchison 2008 | 23/102 | 14/103 | | 1.85 [ 0.89, 3.84 ] |
| Marion 1997 | 9/39 | 10/42 | | 0.96 [ 0.34, 2.69 ] |
| Qiu 2007 | 9/40 | 13/40 | | 0.60 [ 0.22, 1.63 ] |
| **Subtotal (95% CI)** | **450** | **441** | | **1.11 [ 0.82, 1.51 ]** |
| Total events: 116 (Hypothermia), 105 (Control) | | | | |
| Heterogeneity: Chi² = 4.33, df = 8 (P = 0.83); I² =0.0% | | | | |
| Test for overall effect: Z = 0.66 (P = 0.51) | | | | |
| 2 Non-concealed allocation | | | | |
| Aibiki 2000 | 1/15 | 3/11 | | 0.19 [ 0.02, 2.15 ] |
| Biswas 2002 | 3/8 | 0/6 | | 8.27 [ 0.35, 197.61 ] |
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| Shiozaki 1999 | 0/8 | 0/8 | | 0.0 [ 0.0, 0.0 ] |
| Shiozaki 2001 | 8/45 | 6/46 | | 1.44 [ 0.46, 4.55 ] |
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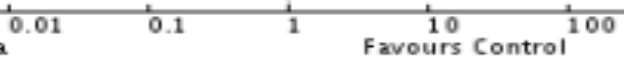
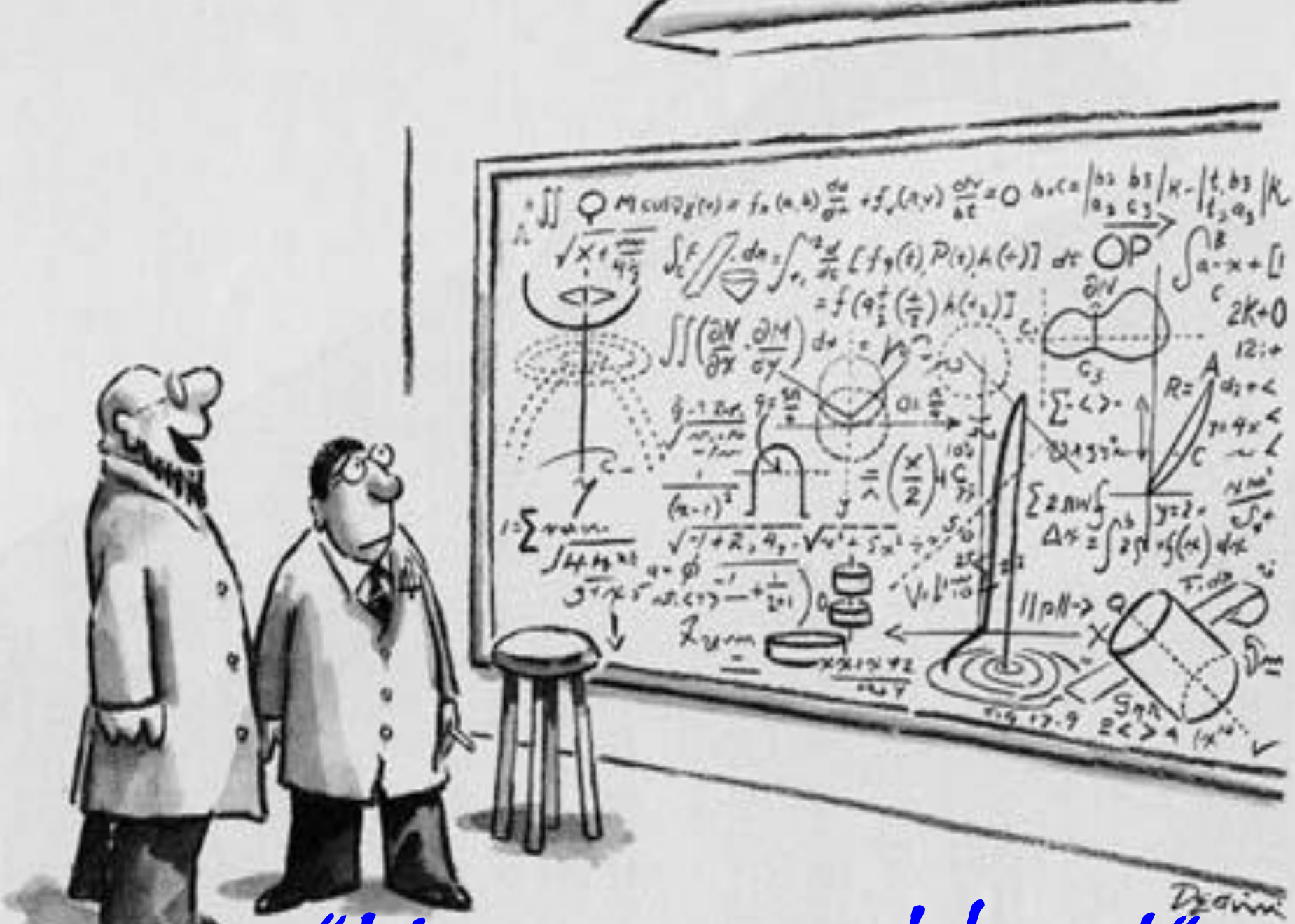
| Yan 2001 | 13/24 | 16/20 | | 0.30 [ 0.08, 1.15 ] |
| Zhang 2000 | 41/123 | 50/123 | | 0.73 [ 0.43, 1.23 ] |
| **Subtotal (95% CI)** | **353** | **343** | | **0.62 [ 0.44, 0.86 ]** |
| Total events: 98 (Hypothermia), 128 (Control) | | | | |
| Heterogeneity: Chi² = 11.14, df = 10 (P = 0.35); I² =10% | | | | |
| Test for overall effect: Z = 2.83 (P = 0.0046) | | | | |
| **Total (95% CI)** | **803** | **784** | | **0.85 [ 0.68, 1.06 ]** |
| Total events: 214 (Hypothermia), 233 (Control) | | | | |
| Heterogeneity: Chi² = 21.91, df = 19 (P = 0.29); I² =13% | | | | |
| Test for overall effect: Z = 1.44 (P = 0.15) | | | | |





"Hey, no problem!"

# Statistics scary? – Nah, all bark and no bite