

# An application of triangles to safety research

Steve Gallivan

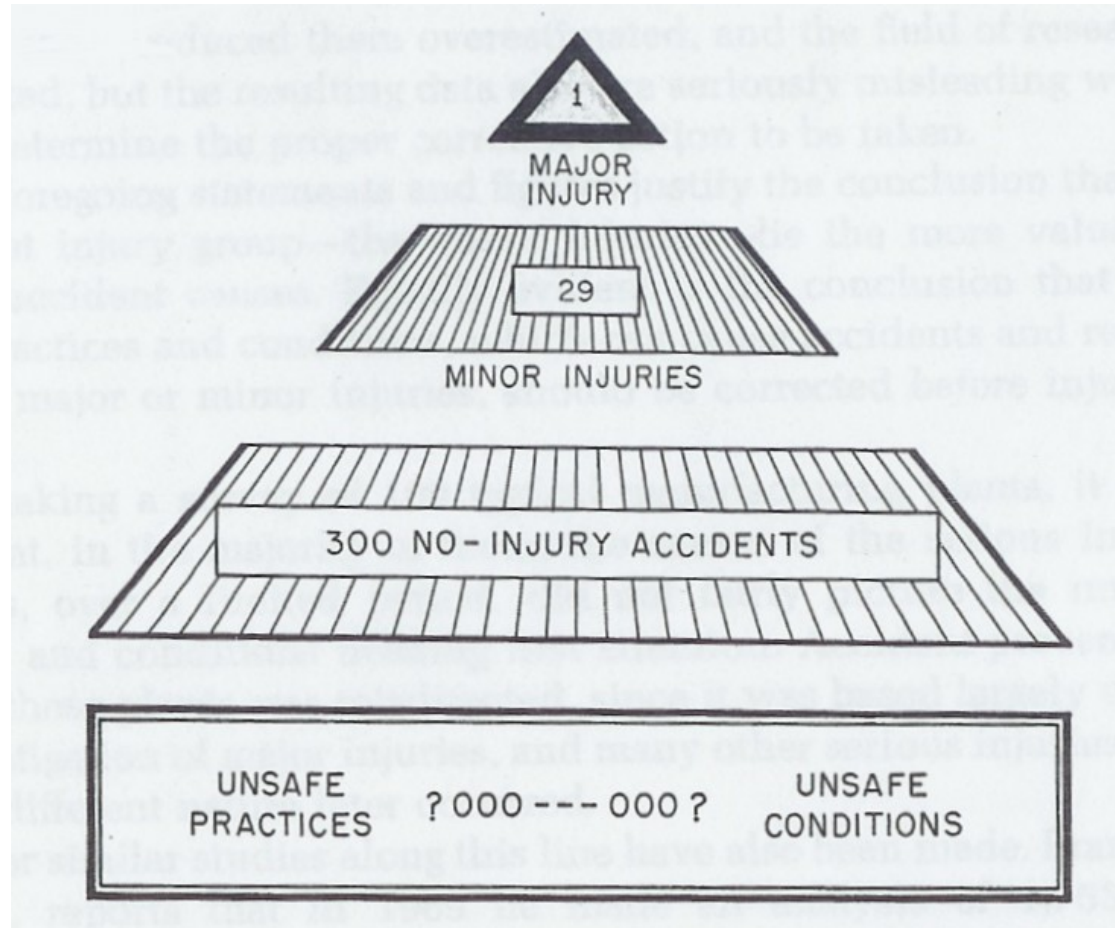
Clinical Operational Research Unit

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# Collaborators

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Bryony Dean Franklin,	Academic Pharmacy Unit, Hammersmith Hospital
Christos Paschalides	CORU
Martin Utley	CORU

# The Heinrich ratio



H.W. Heinrich, Industrial accident prevention (1931)

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## **Objectives**

1. Is there a stable ratio of minor:moderate:severe medication errors?
2. What are the values of the ratio?

# Methodological approach

- Logic – thought experiments
- Mathematical modeling
- Review of the literature
- Examination of empirical evidence

# Logical thought experiments and mathematical modelling

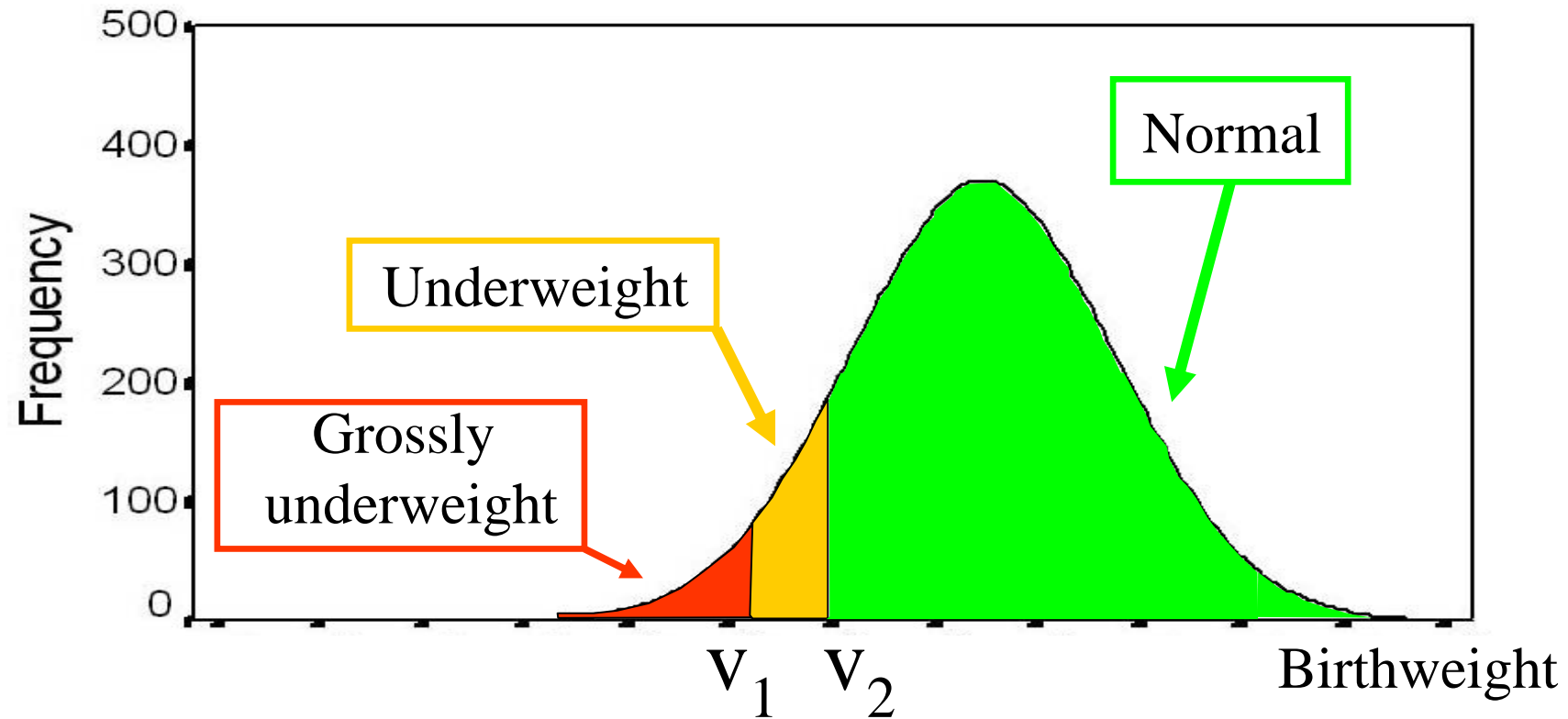


# Vignette 1: Irish roulette

	Original loading pattern
Live cartridge	1
Blank cartridge	2
Empty	3
<b>Ratio</b>	
Death:powder burn:no injury	1:2:3

Heinrich's concept would not be true

## Vignette 2 - Categorisation



Ratio is exquisitely sensitive to the thresholds used, in principle any ratio could exist

If you want ratio A:B:C what values for  $V_1$  and  $V_2$  give this?

Empirical evidence:  
Constructing Heinrich ratios  
from existing data

# Studies of medication errors

Included studies	Severe	Moderate	Minor
<b>Adverse drug events and medication errors (all types)</b>			
Bates et al 1995	1	4	525
Kaushal et al 2001	0	5	611
<b>Prescribing errors</b>			
Dean et al 2002	142	224	160
Dean et al 2002	123	289	160
Lesar 1997	43	96	537
<b>Administration errors</b>			
Dean and Barber 2000	0	58	199
Taxis and Barber 2003	4	39	22
Van den Bemt et al 2002	3	144	102
Hartley and Dhillon 1998	0	50	81
Tissot et al 1999	12	44	198

# Triangles – comparing studies

Suppose  $i$ -th study finds instances of:

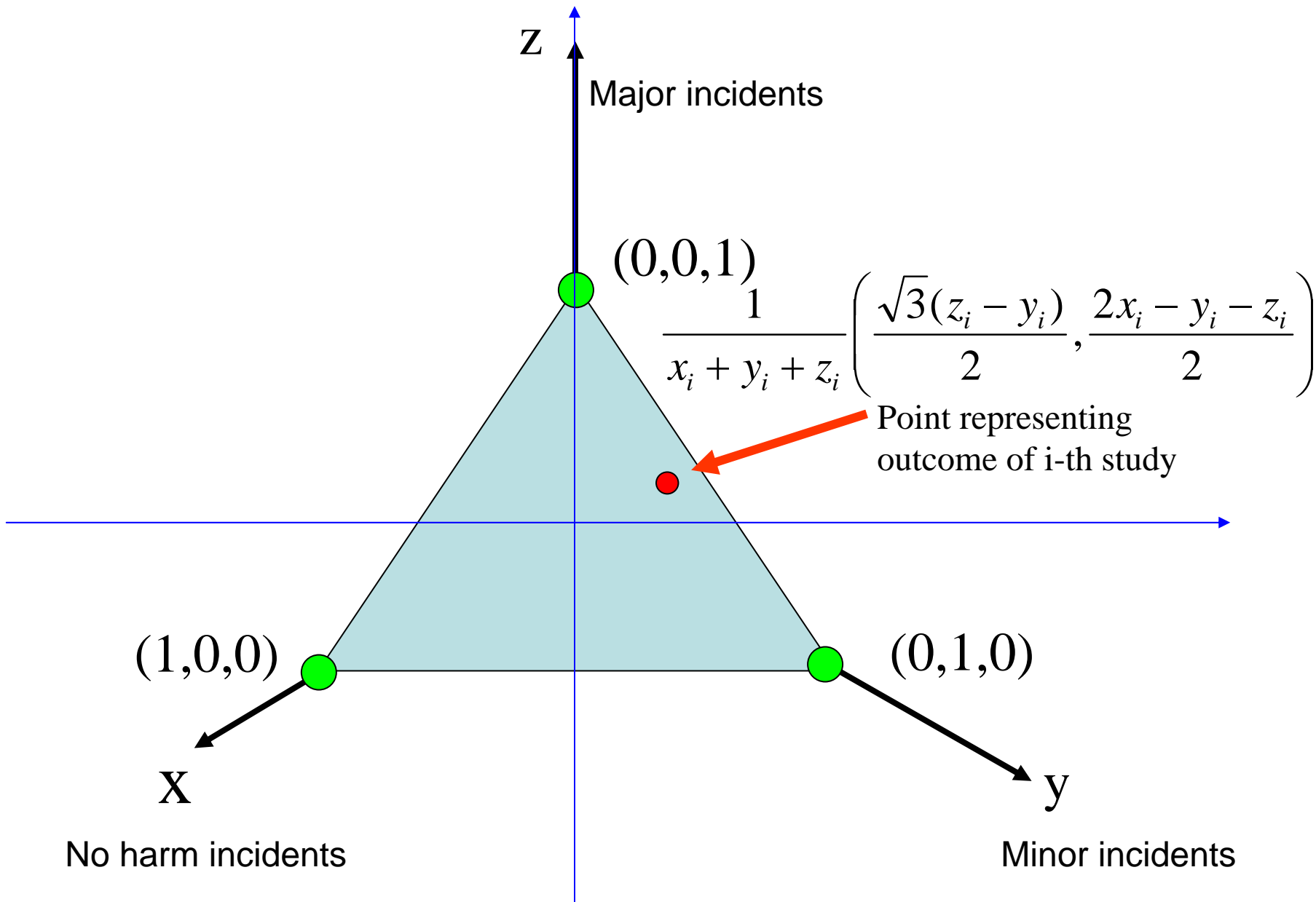
$x_i$  no-harm events    $y_i$  minor events    $z_i$  major events

Form vector of relative ratios:

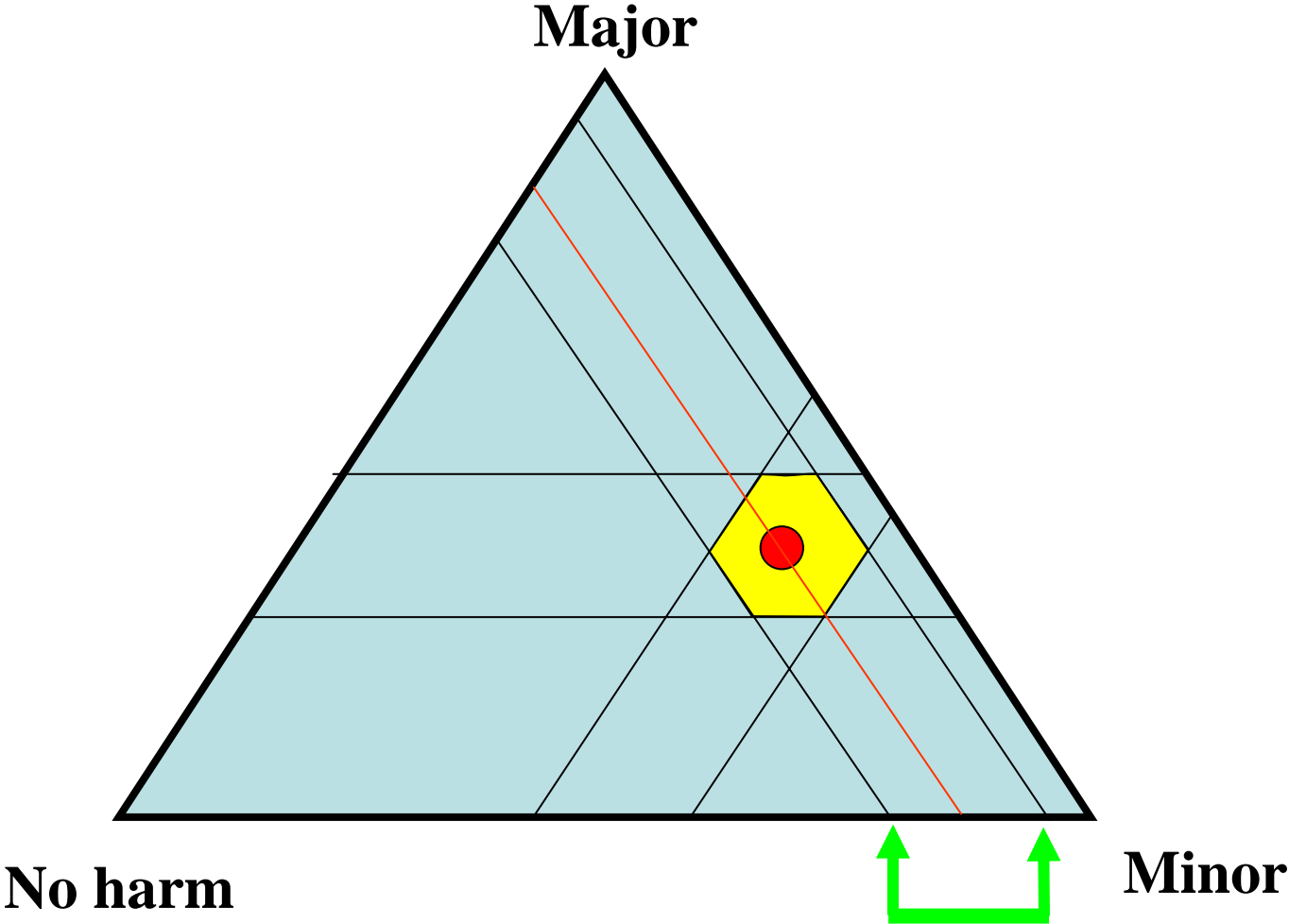
$$\mathbf{r}_i = (\hat{x}_i, \hat{y}_i, \hat{z}_i) = \left( \frac{x_i}{x_i + y_i + z_i}, \frac{y_i}{x_i + y_i + z_i}, \frac{z_i}{x_i + y_i + z_i} \right)$$

Note  $\hat{x}_i + \hat{y}_i + \hat{z}_i = 1$

So  $\mathbf{r}_1, \mathbf{r}_2, \mathbf{r}_3, \dots$  all lie in a plane with equation  $x + y + z = 1$

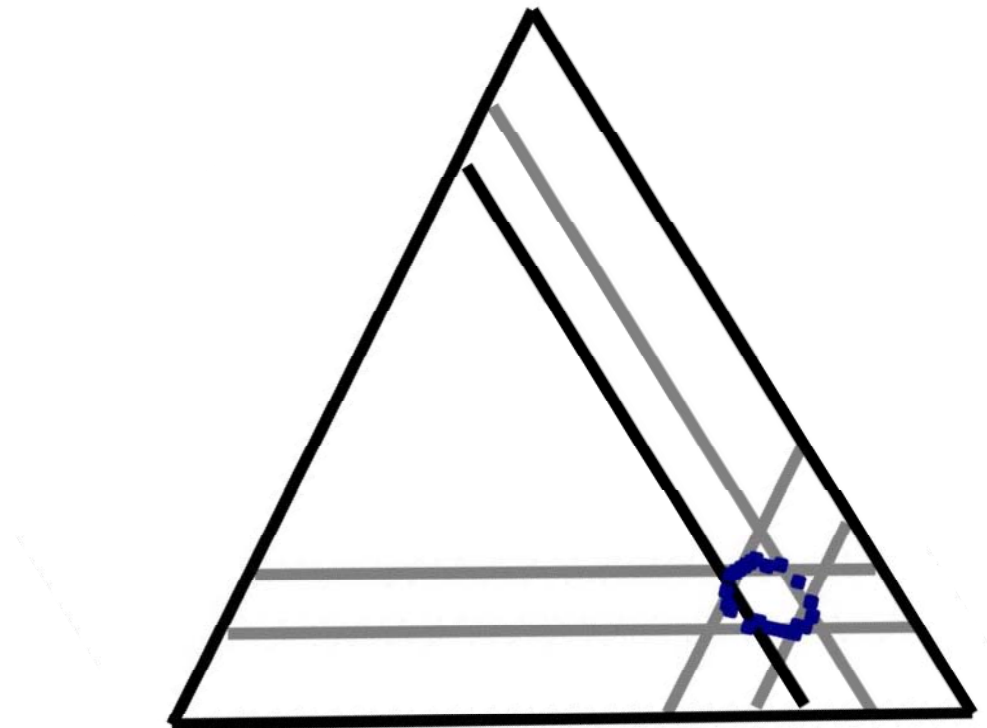


# Approximate 95% confidence region for relative ratios



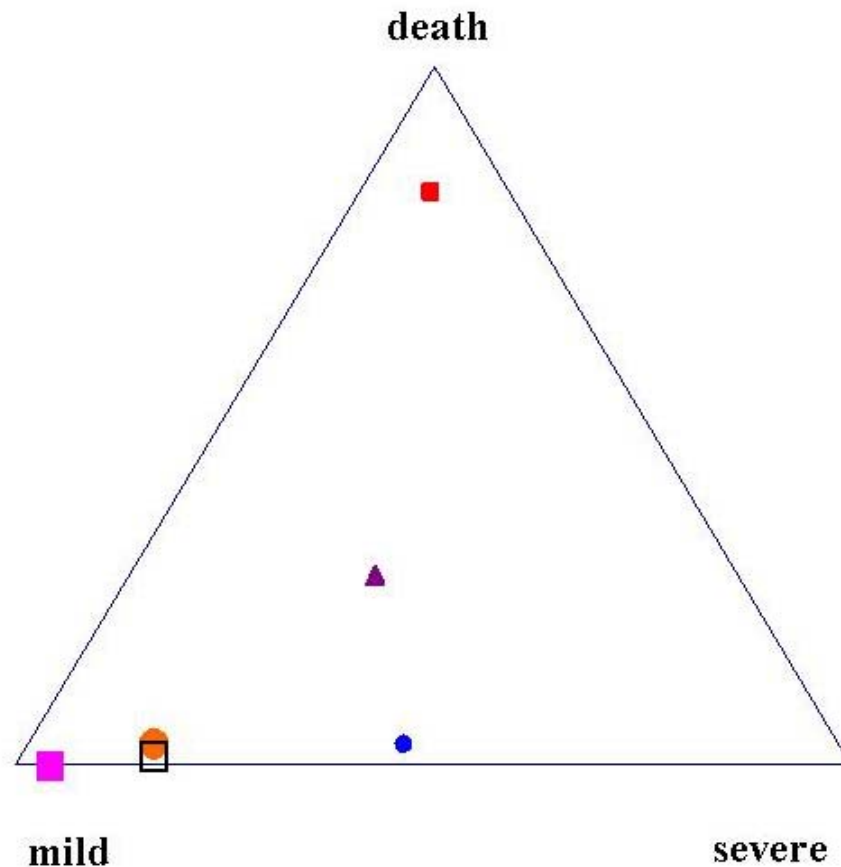
95% C.I. for proportion of 'No harm' incidents

# Approximate confidence region compared to exact version



# Example of a triangle plot

Data source:  
Wadman et al.2003



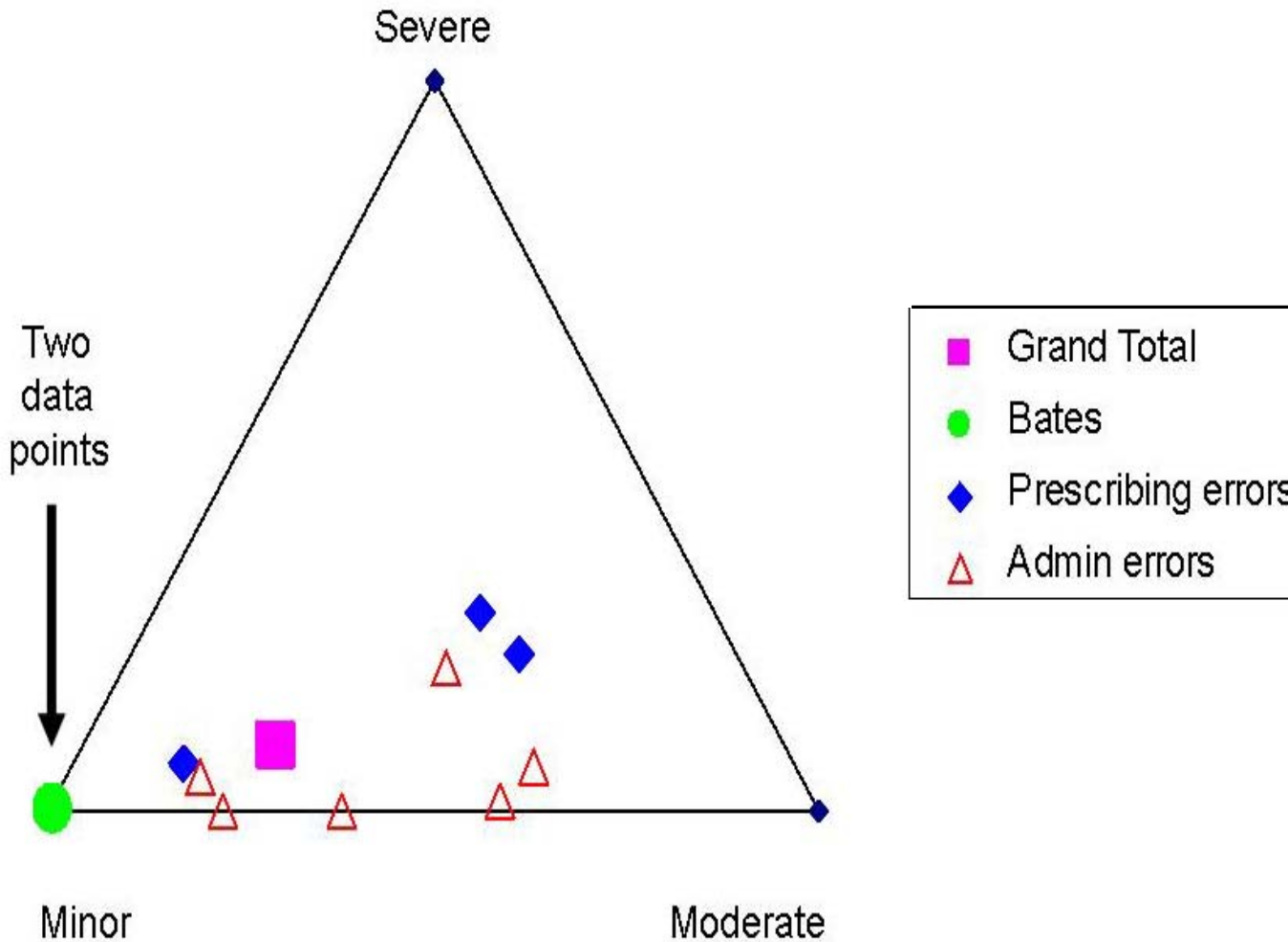
## ER outcomes

- Self-inflicted gunshot wound
- ▲ Assault-related gunshot wound
- Self-inflicted poisoning
- Assault related struck by/against
- Assault-related cut/pierced
- Self Inflicted cut/pierced

Ratios of outcome by type of accident from patients visiting emergency units are not stable

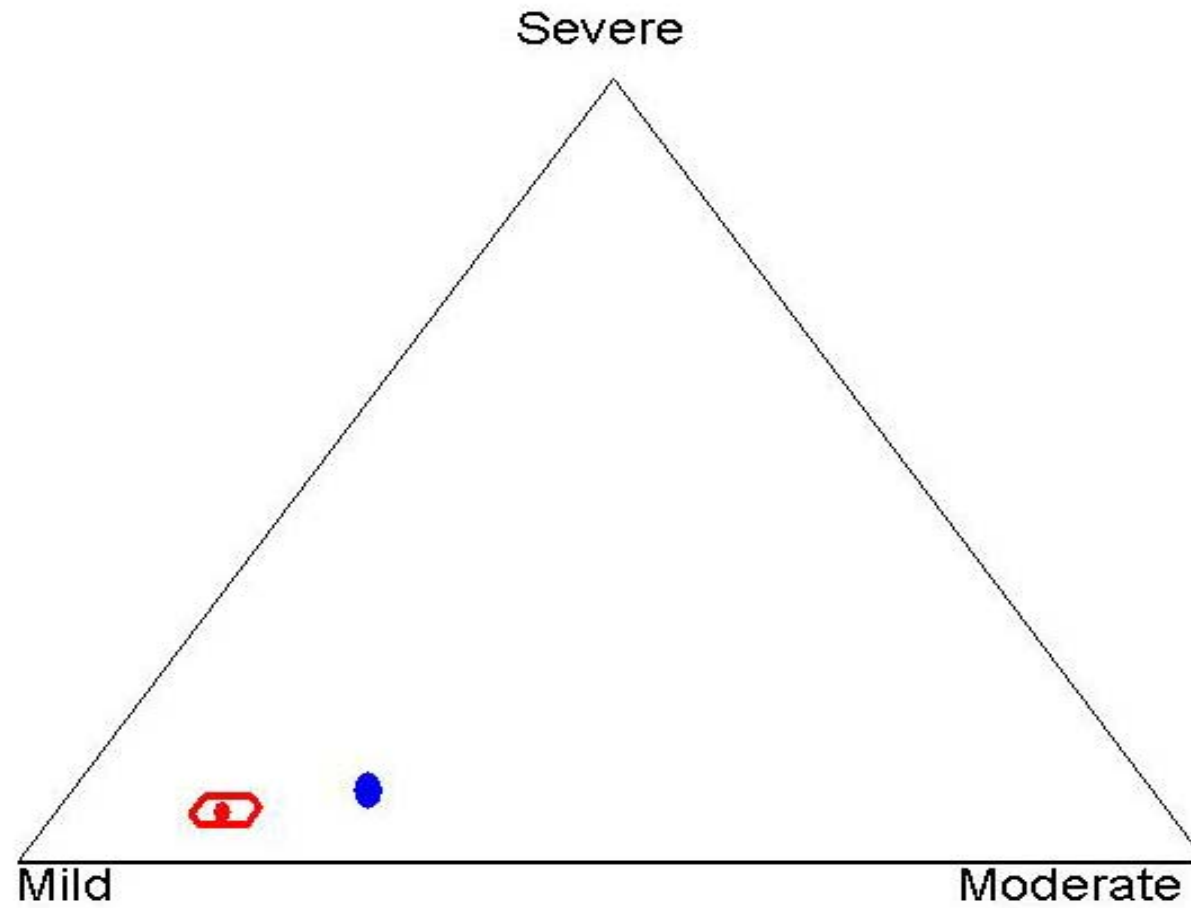
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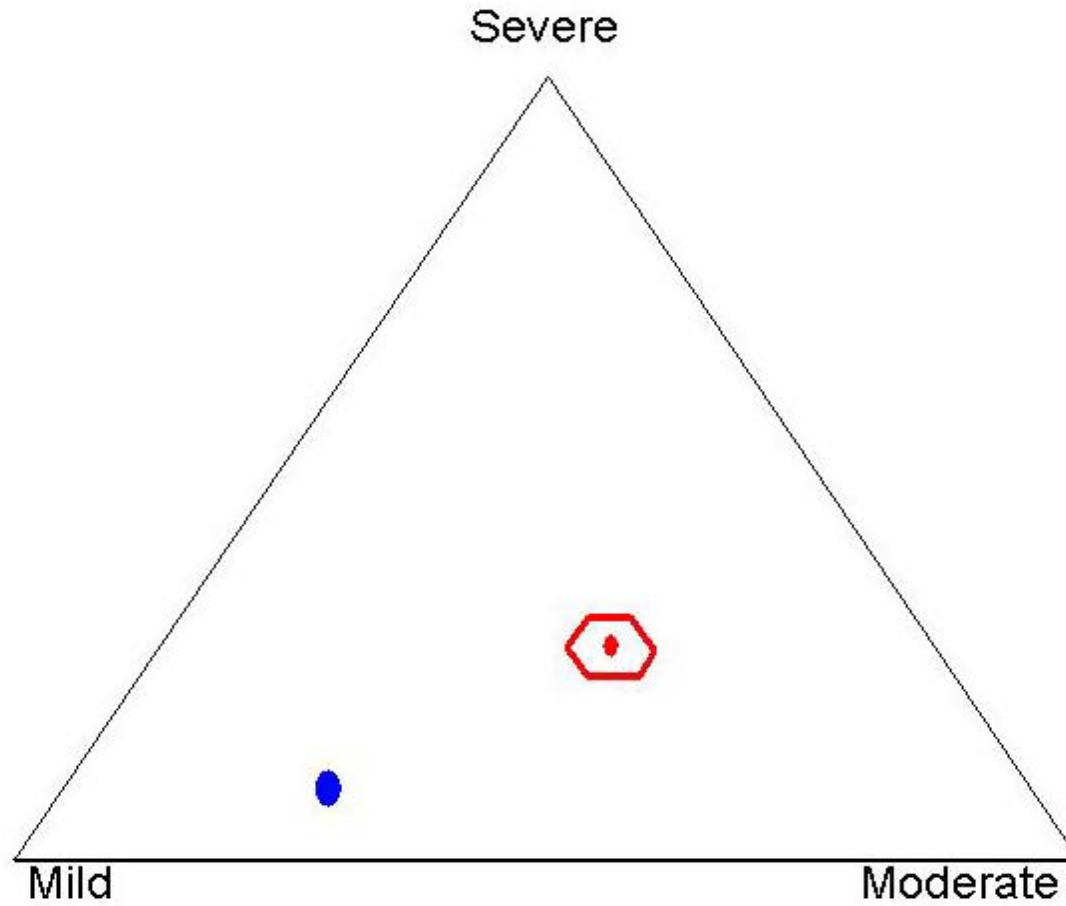


Ratios from medication error studies are widely different

# Lesar 1997



# Dean et al 2002



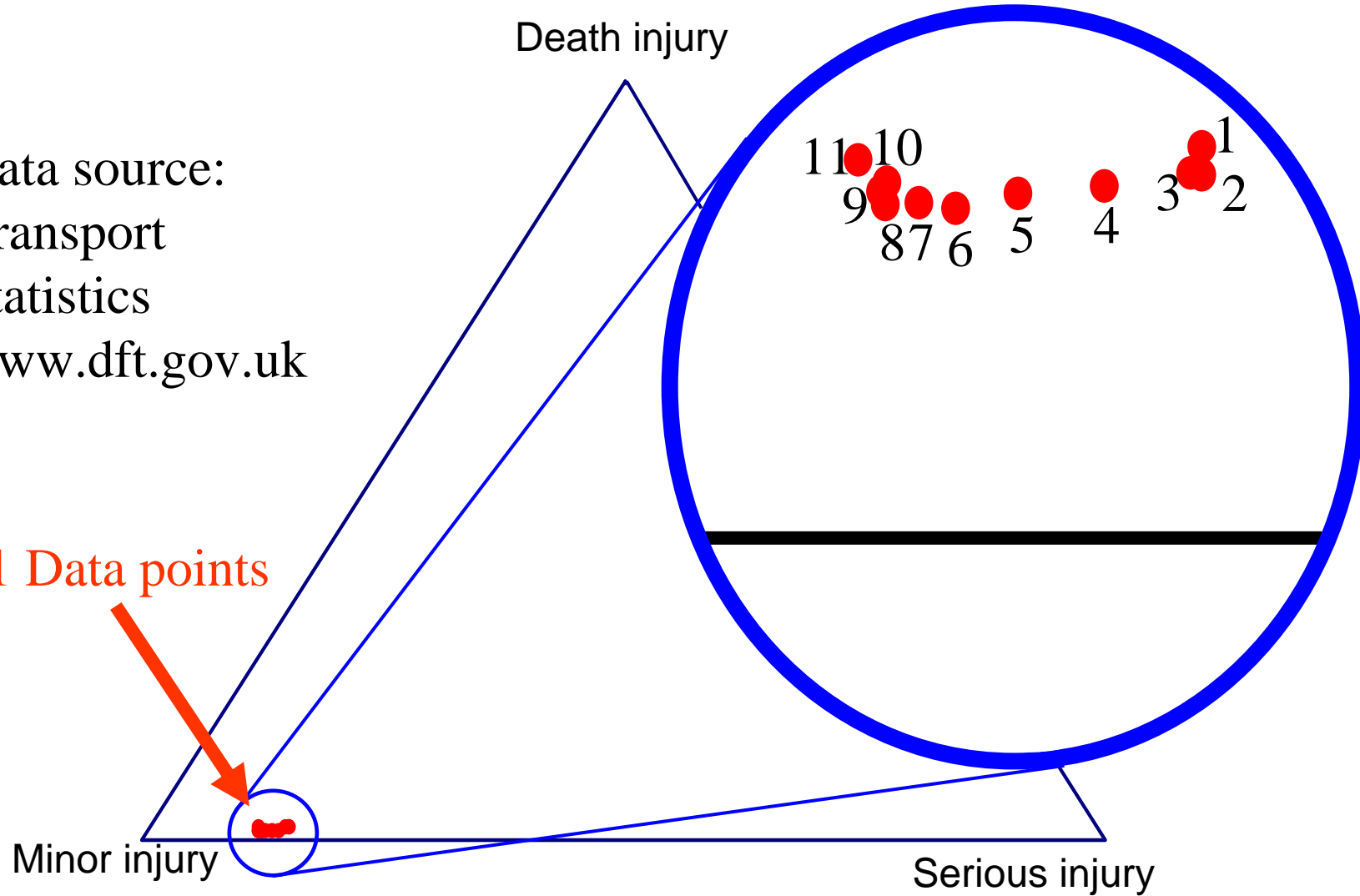
# Some of the variability in ratios may be due to

- Lack of generally agreed definitions for basic terms in medication error research
- Lack of assessing reliability and validity of research methods
- Poor standard of reporting details of methods and definitions in published studies
- So we studied examples with established definitions/methods.....

# Road Traffic Accidents '93-'03 for UK

Data source:  
Transport  
Statistics  
[www.dft.gov.uk](http://www.dft.gov.uk)

11 Data points



Ratios of outcomes of road traffic accidents are not stable, but change systematically over time

# Conclusions

We developed a novel graphical illustration of Heinrich ratios which allows statistical comparisons

There is no Heinrich ratio for harm resulting from medication errors

- Original concept may not be valid
- Logic shows other situations occur
- Mathematics shows that depending on the definition of boundaries any ratio could be achieved
- No empirical evidence for stable ratio analysing medication error and other data
- Definitions of medication errors and the ensuing harm are widely different

A simple “linear form” - halve the errors and you halve the harm - is for most cases not valid

