ORAHS 2014 Lisbon

Geoff Royston
Immediate Past President
The OR Society

Exploring New Worlds for Applying Operational Research to Health Services

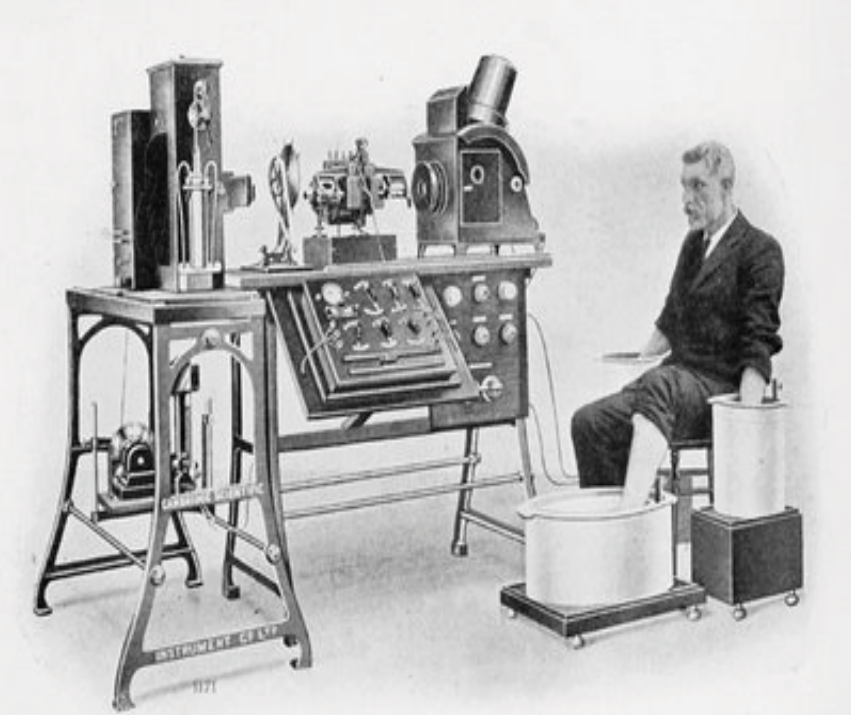
- New Worlds in Health
- Old Worlds in Health O.R.

- Our Challenge

- Reframing the World of O.R.?
- (Some) New Worlds in Health O.R.

New Worlds in Health

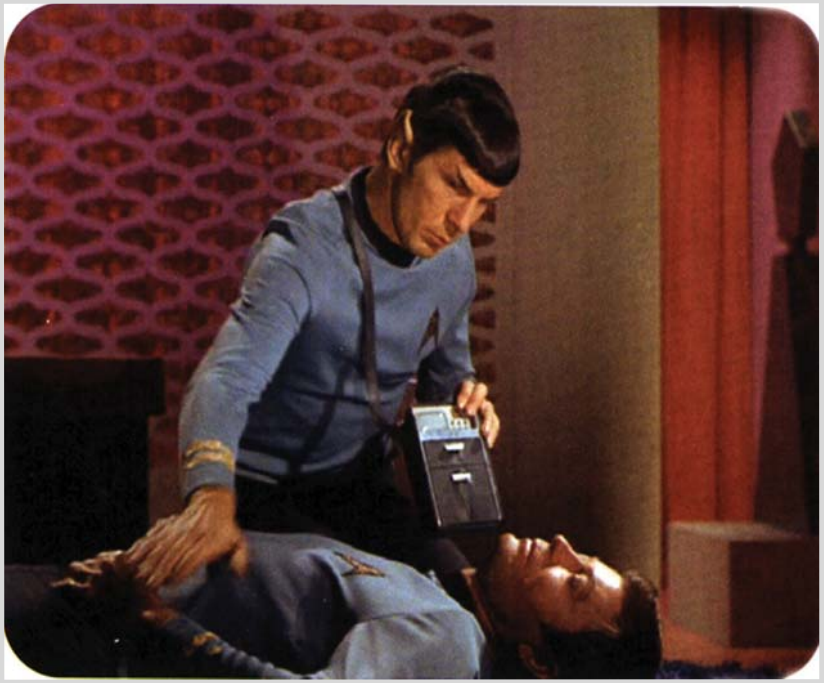
Yesterday's World



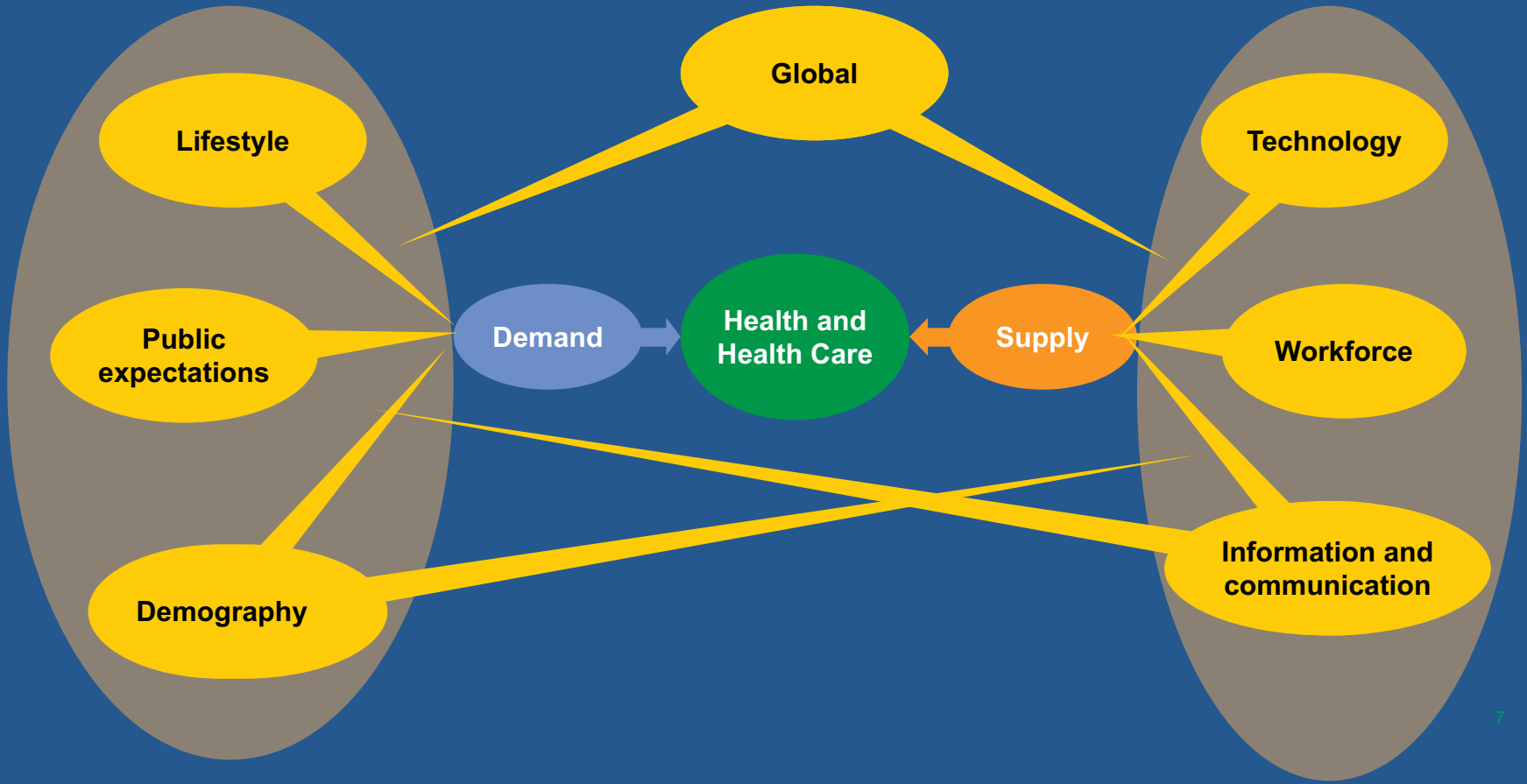
PHOTOGRAPH OF A COMPLETE ELECTROCARDIOGRAPH, SHOWING THE MANNER IN WHICH THE ELECTRODES ARE ATTACHED TO THE PATIENT, IN THIS CASE THE HANDS AND ONE FOOT BEING IMMERSED IN JARS OF SALT SOLUTION

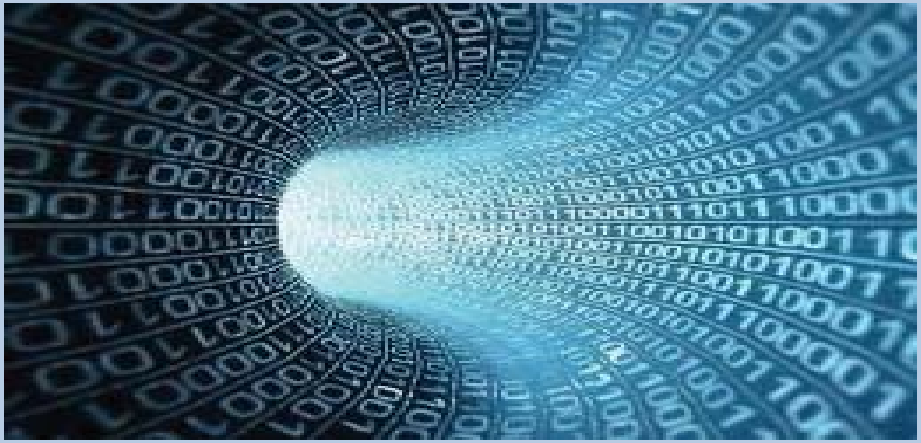
Today's World

Tomorrow's World?



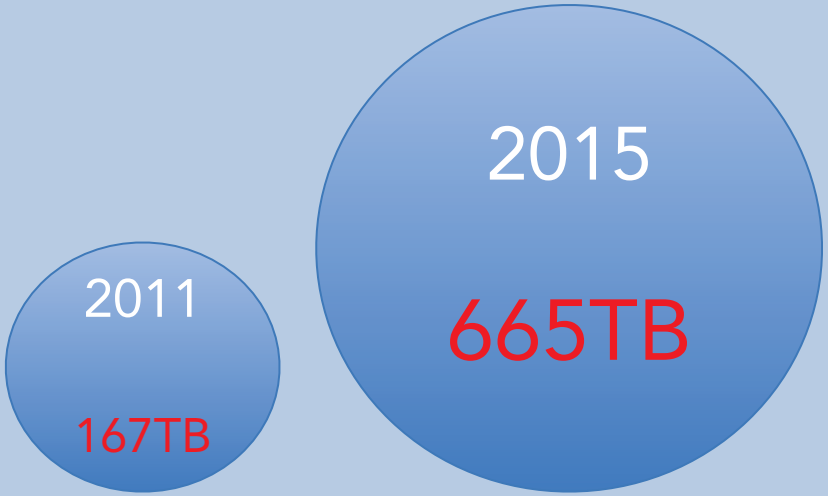
Many factors drive health and healthcare





“Big data” will have a major impact on health care

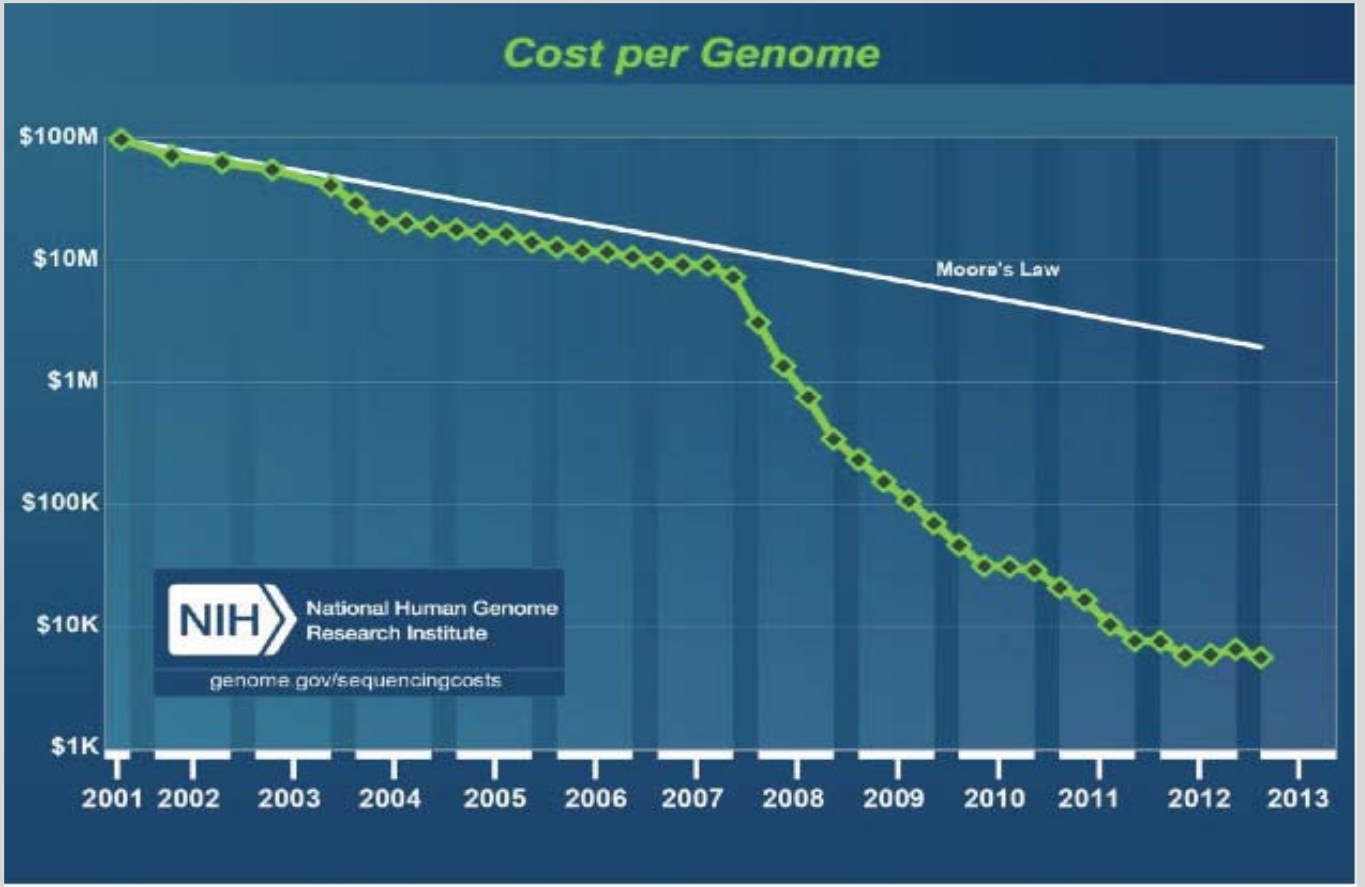
For organisations

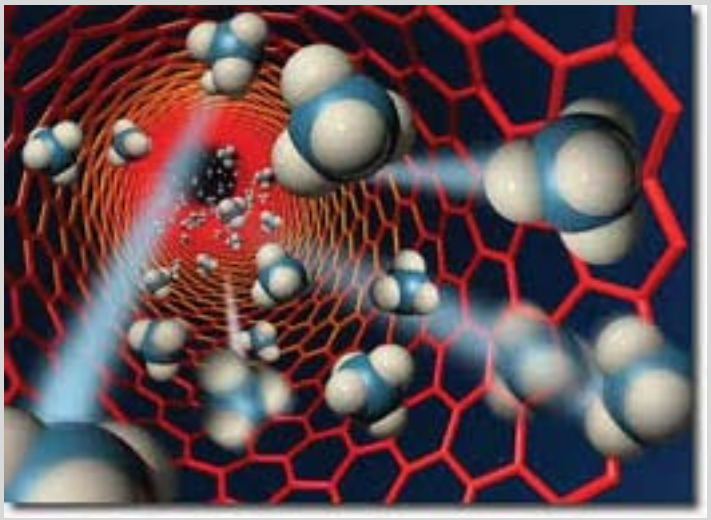


For individuals

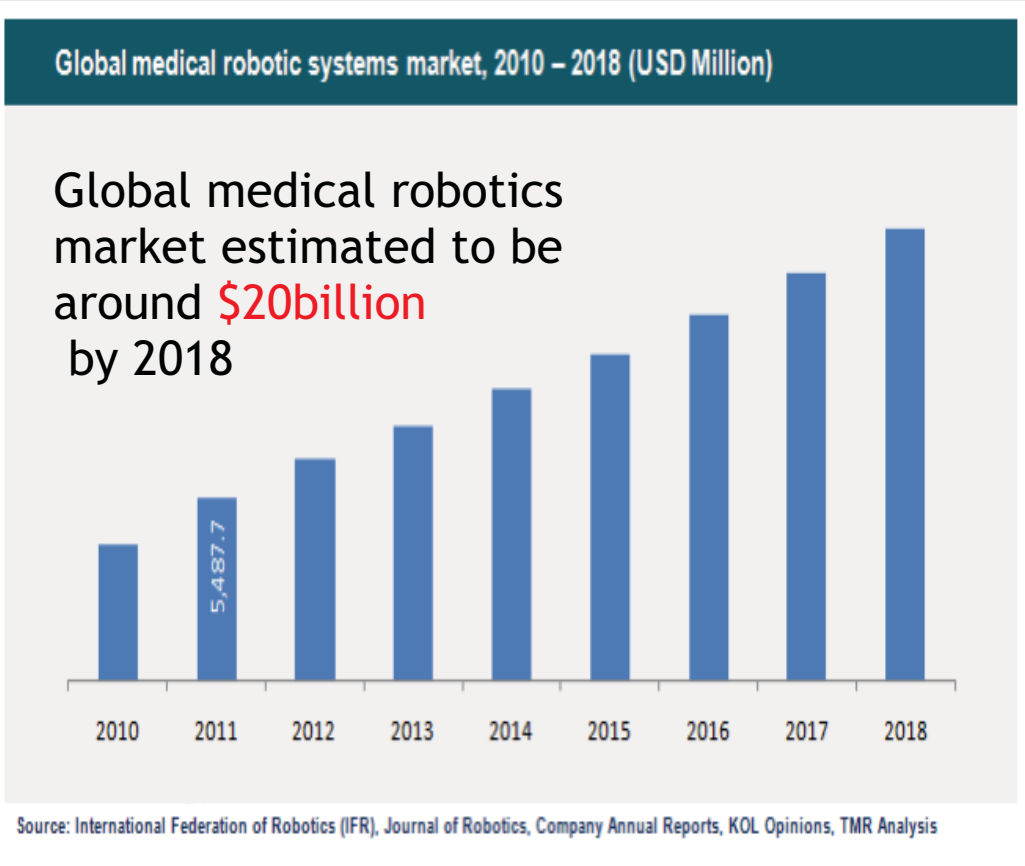
Genomics will foster personalised healthcare

Genome sequencing costs *10,000 times less* than it did 10 years ago

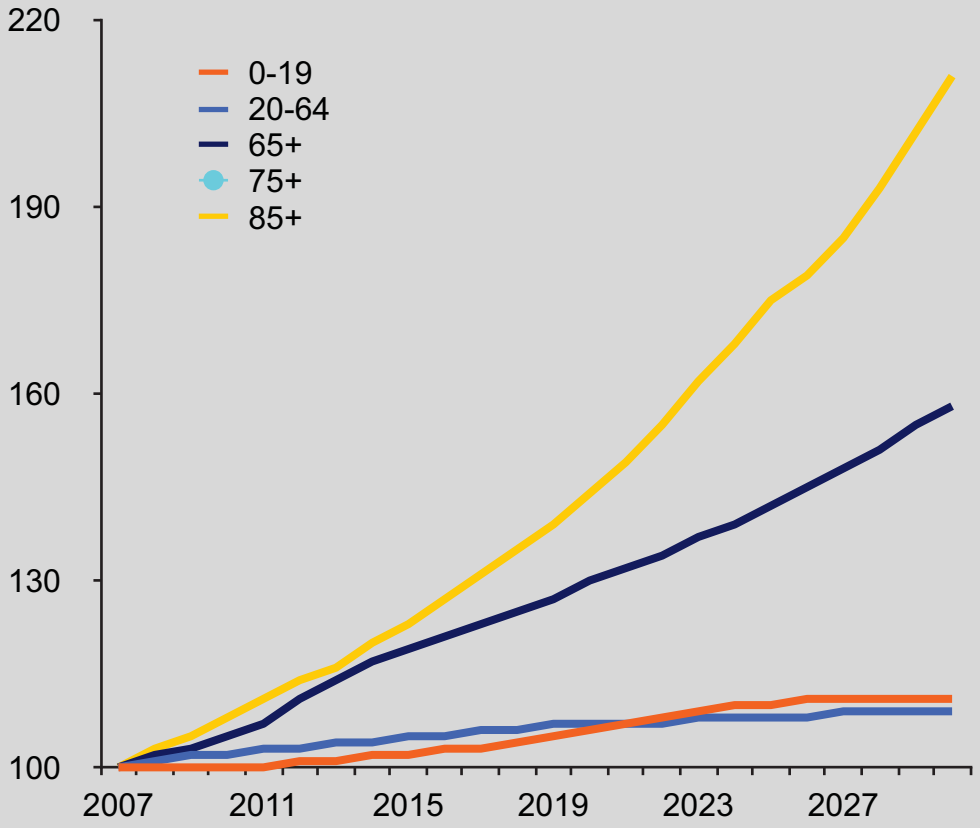




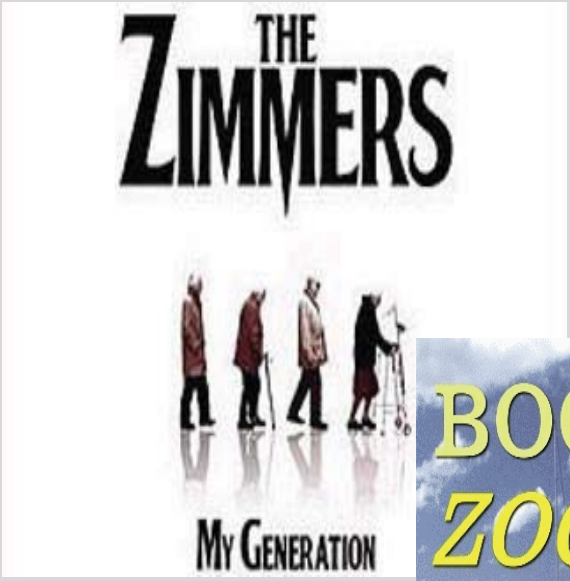
Nanotechnology and robotics will play an increasing role in medicine and health

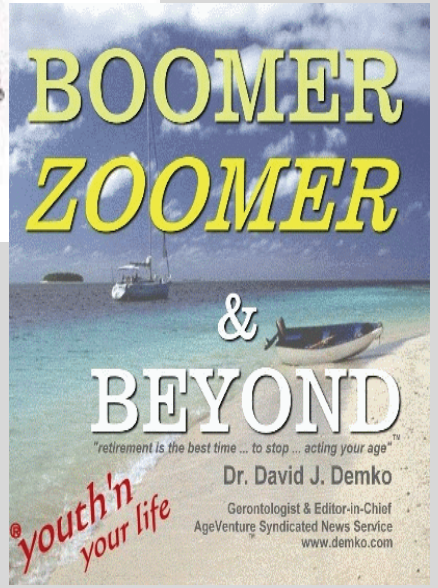


The aging population will place increased demands on health care

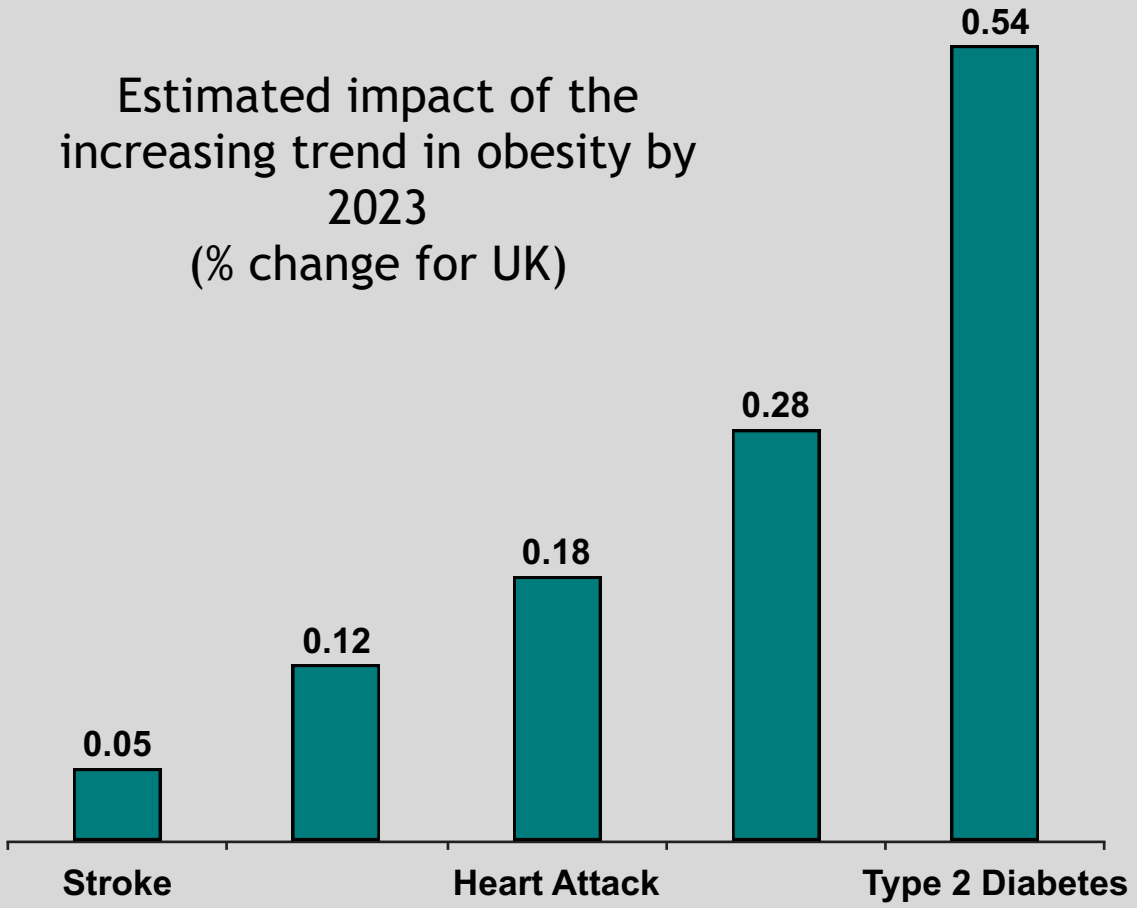


But might 80 be the new 40?





Lifestyle factors like obesity are having increasing adverse impacts on health



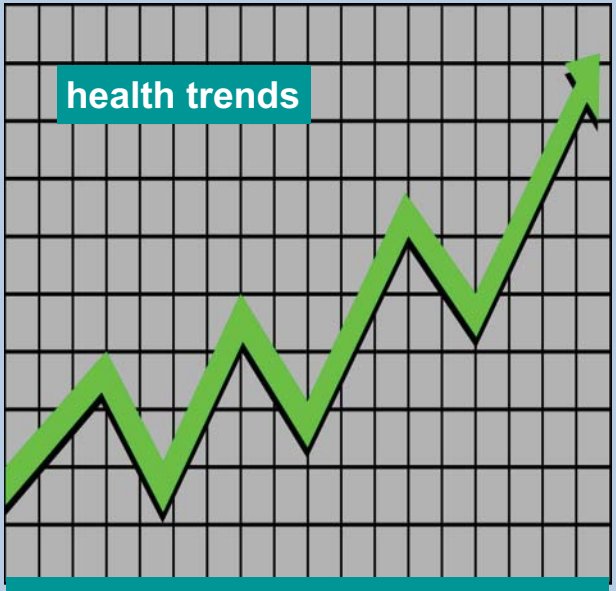
Some things are more predictable than others

Some things – “white sails” - can be seen clearly coming over the horizon, like demographic change.

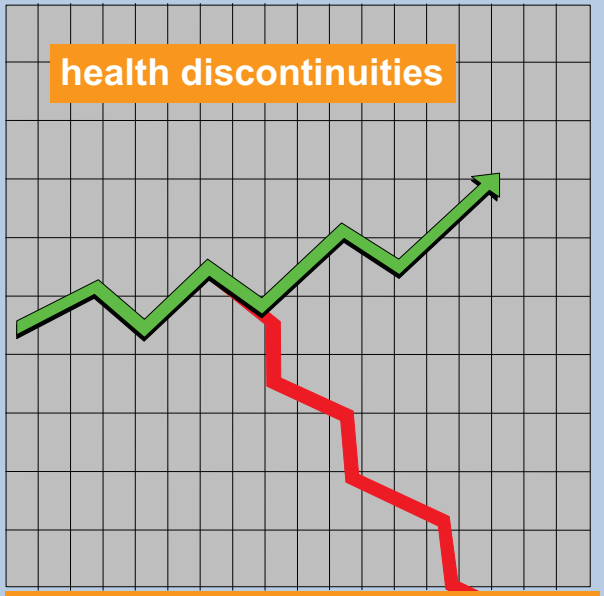
Some things are hazy - “grey shadows” - emerging from the mist, such as how technology will affect our lifestyles.

And then there are the big surprises – the “black swans” - think of AIDS.

We need to watch for trends and for discontinuities

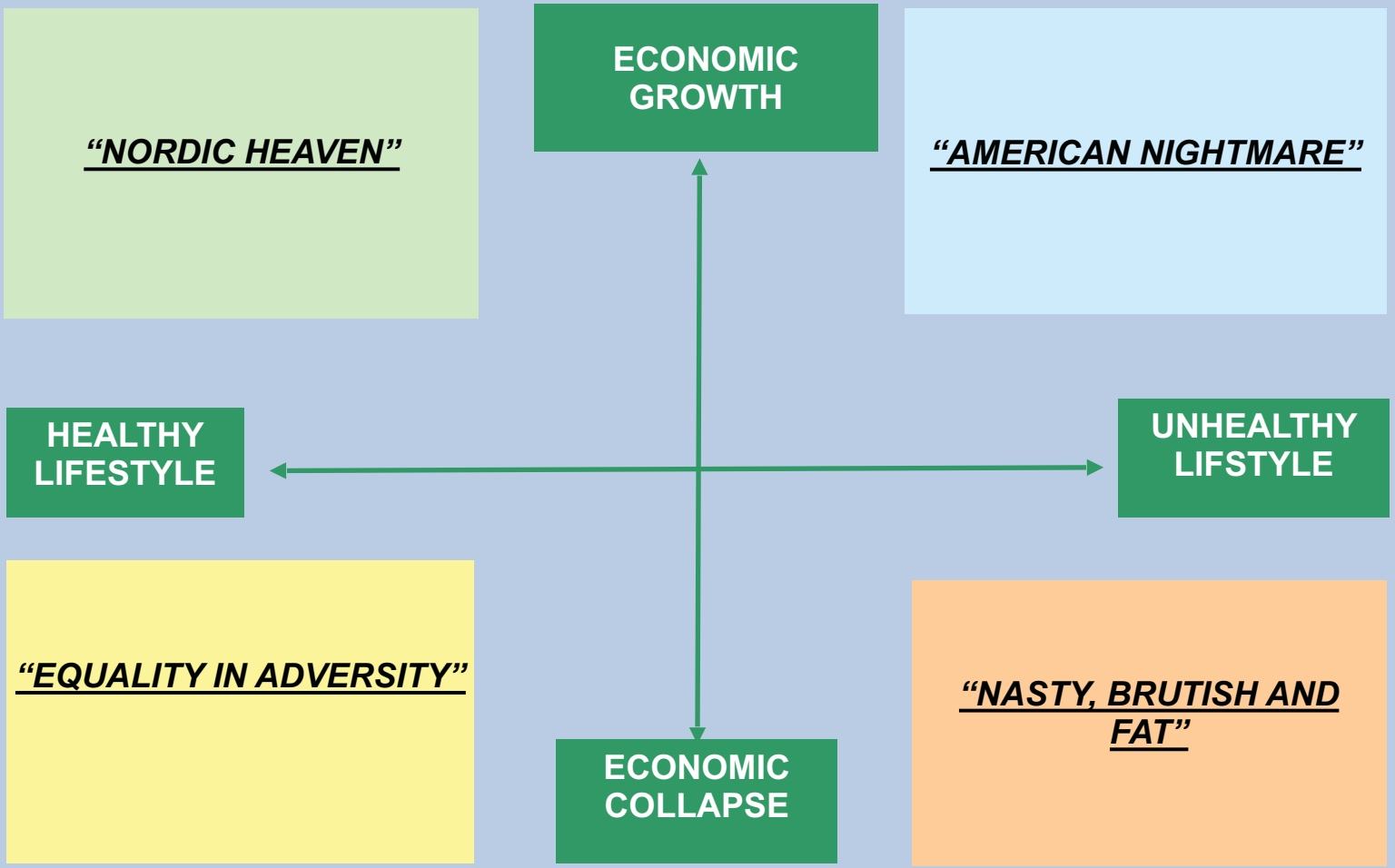


e.g. ageing population,
obesity,
telecare



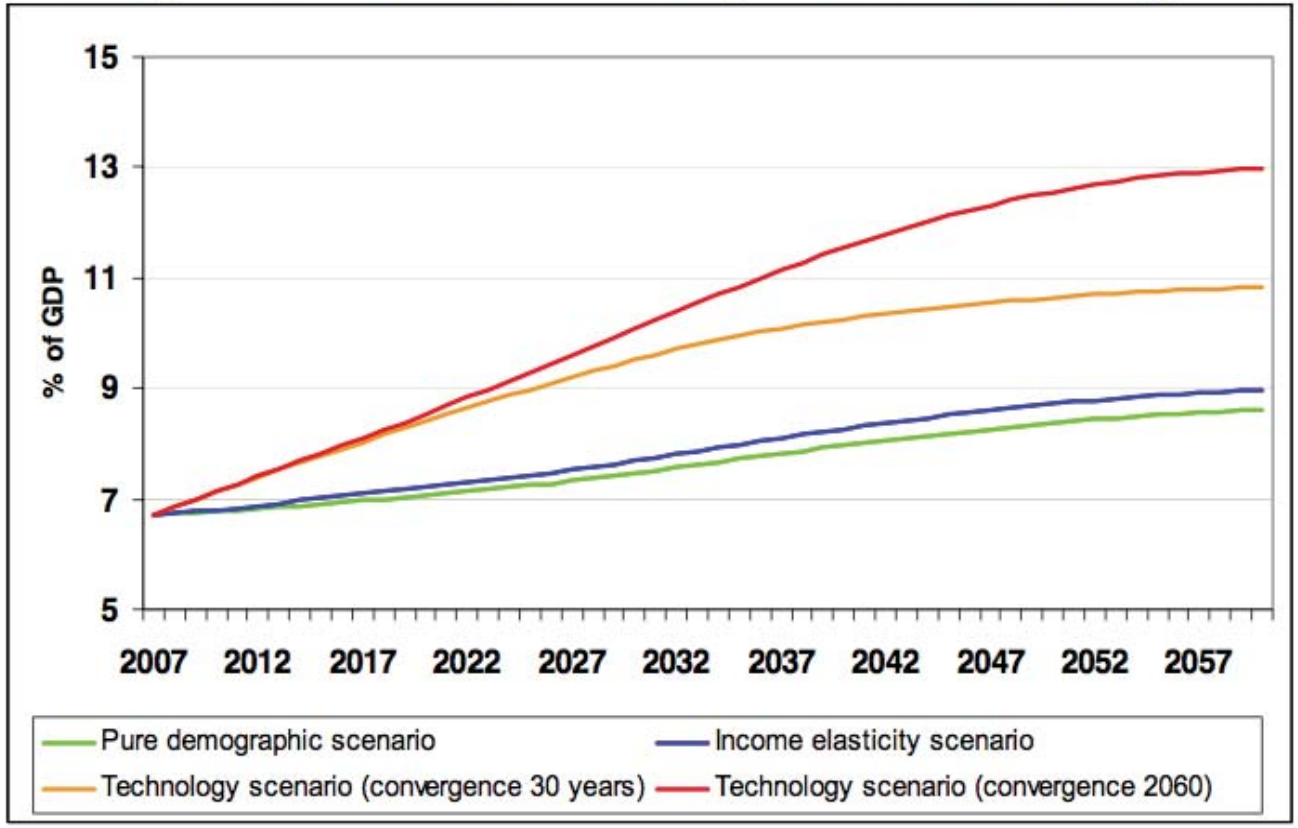
e.g. AIDS,
Viagra,
Avian Flu

There are many possible health futures



Though most of them entail increasingly tough challenges about resources

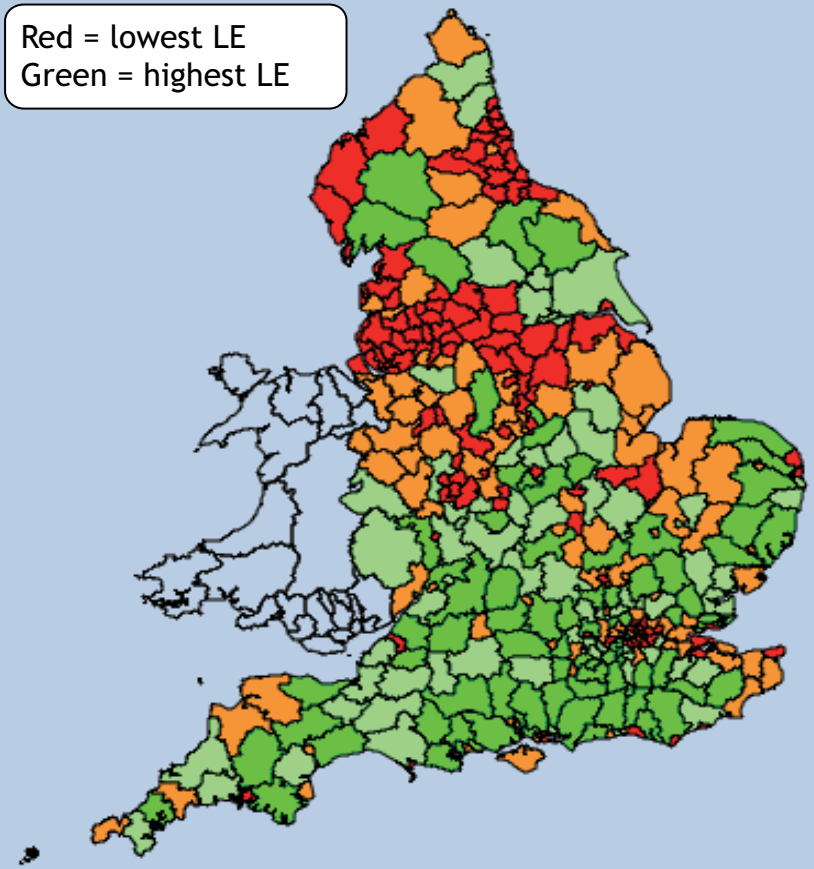
Graph 12 Comparison of health care expenditure projections (% of GDP, EU27 average) according to income elasticity and technology scenarios, 2007-2060



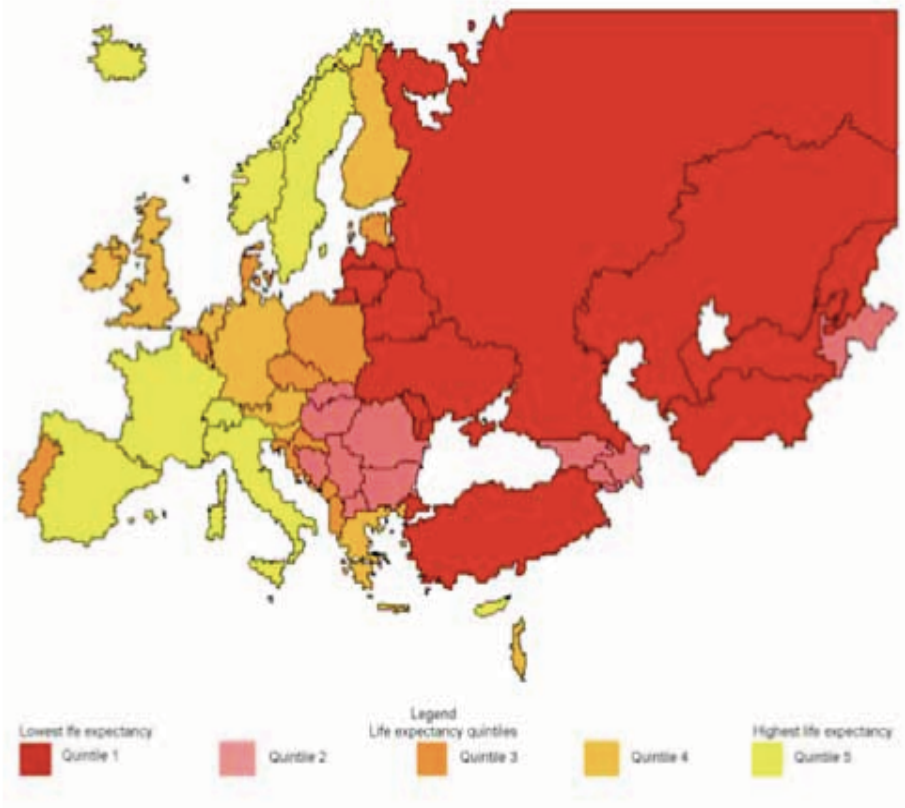
Source: based on European Commission and Economic Policy Committee (2009)

And tough challenges about health inequalities - within and between European countries

Red = lowest LE
Green = highest LE



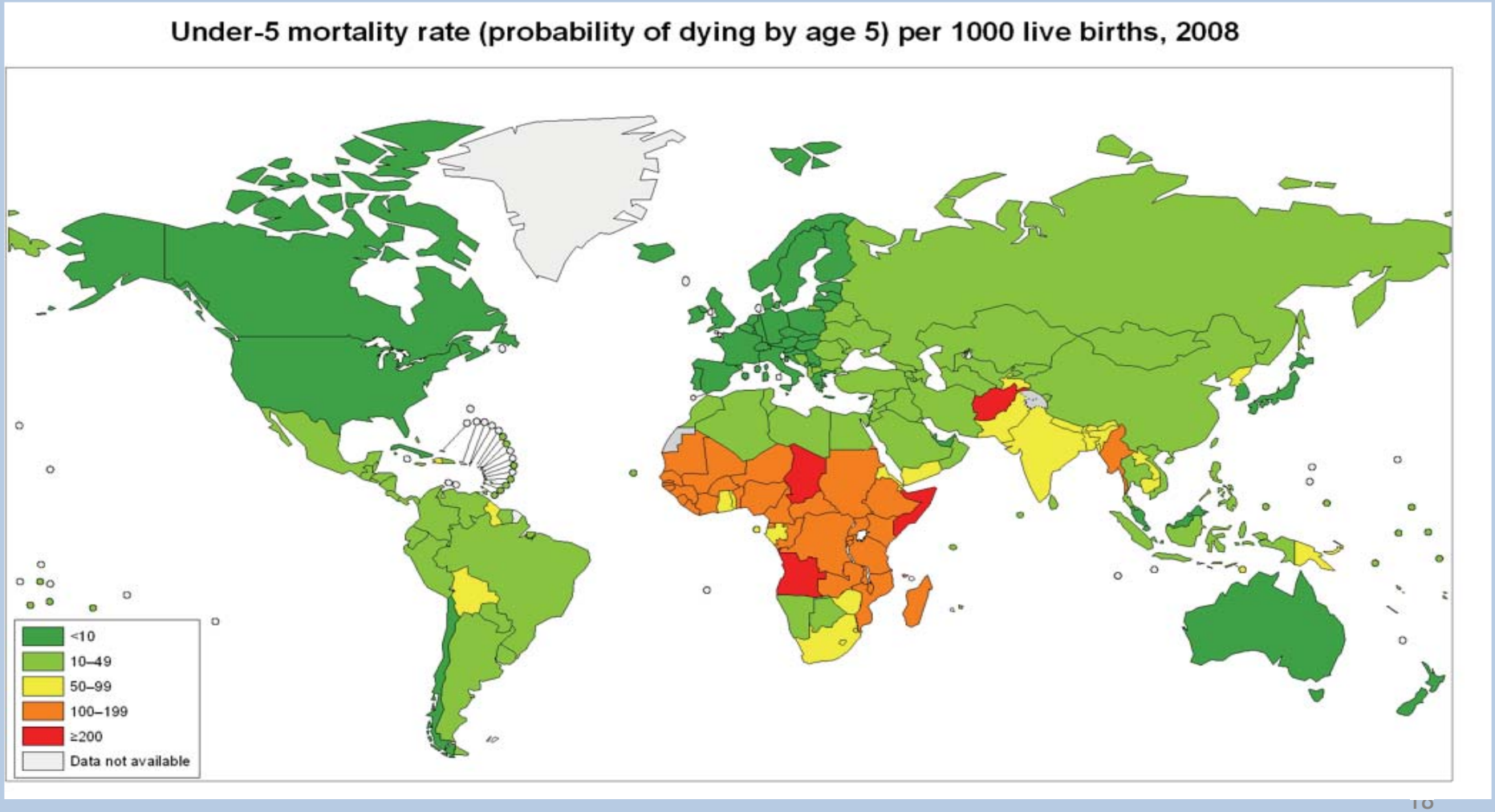
Map 1 Life expectancy, in years, for countries in the WHO European region



Source: European Health for All database [online database] (8)

-and of course across the rest of the globe

e.g. childhood mortality varies by a factor of *20* across countries



OLD WORLDS IN HEALTH O.R.

Health O.R. analysts have contributed on a worldwide front since the 1950s

1952

OPERATIONAL RESEARCH IN MEDICINE

by

NORMAN T. J. BAILEY

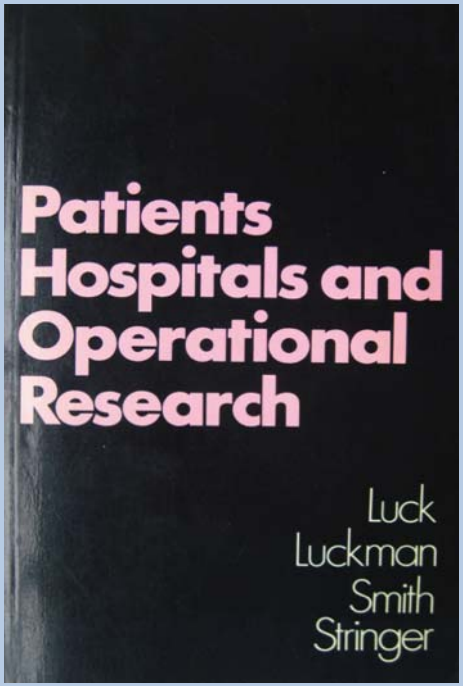
A GREAT deal of medical research is directly aimed at improving some specific aspect of curative or preventive medicine such as the development of a more powerful chemotherapeutic agent, a new serum giving greater protection against some infectious disease, a new surgical technique, more accurate and reliable methods of diagnosis, and so on. The activities involved may range all the way from biochemical or physiological laboratory experiments, or an abstract mathematical analysis of the behaviour of an epidemic, to controlled clinical trials in hospital wards and out-patient departments, or a complex ecological study of the whole environmental situation associated with a particular disease. The research workers concerned may either be relatively isolated individuals working more or less independently of each other, or they may be organised into teams of investigators, including doctors, social workers, statisticians, and so on.

None of the pursuits broadly outlined in the previous paragraph qualifies as operational research in its own right, although it may be part of such a programme. Operational research in medicine is concerned with the organisation of existing clinical techniques and facilities so as to make them more widely available to patients in need; with the replanning of wards, clinics and practices so as to employ present resources to the greatest advantage; and with the general administration and planning of medical services. All the disciplines of scientific research in general and medical research in particular can be made to subserve these ends.

The initial stages of the transition from the investigation of narrowly circumscribed problems to the broader operational level are excellently illustrated by the recently published M.R.C. report: *The application of scientific methods to industrial and service medicine* (1951, H.M.S.O.). This report is essentially the proceedings of a conference held in March, 1950, the subject of which was comprehensively defined by Dr. Himsworth in his opening address "as the solution of the problems that are raised both for the individual and for the group by the organisation of human effort."

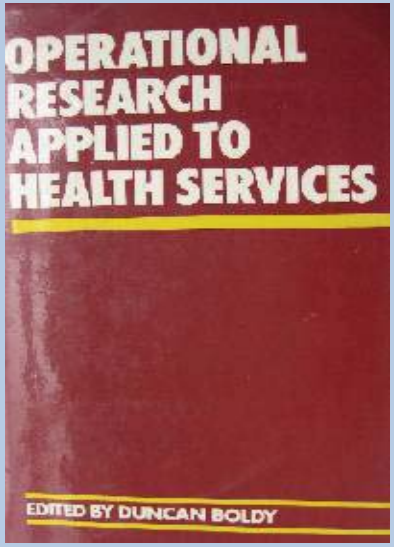
Operational research of any kind (and the medical field is no exception) usually entails a considerable amount of survey work, especially of the type commonly encountered in socio-medical investigations. In order to ensure that such surveys are adequately designed at the beginning and are efficiently analysed and reliably interpreted at the end, it is usually necessary to have competent statistical advice. At the same time there is much to be gained if the other investigators are at least acquainted with some of the statistical requirements, and are on their guard against the pitfalls associated

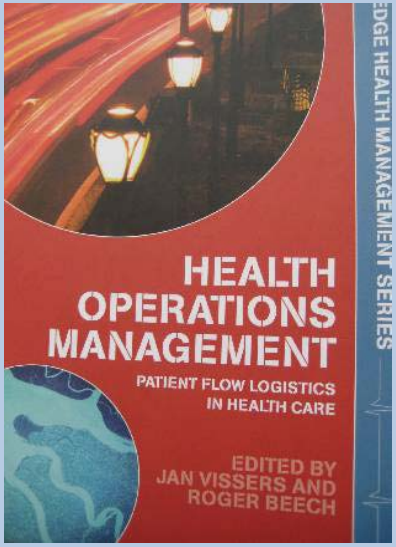
24

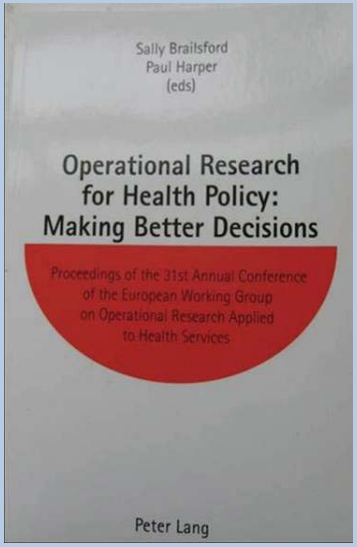


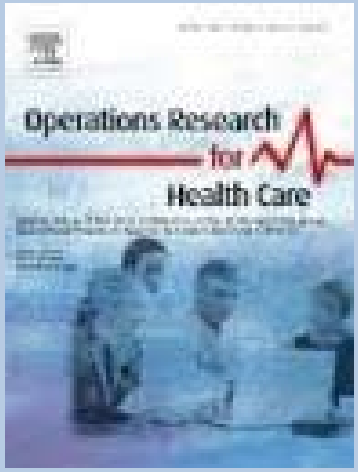
1971

With a strong contribution from ORAHS Working Group members





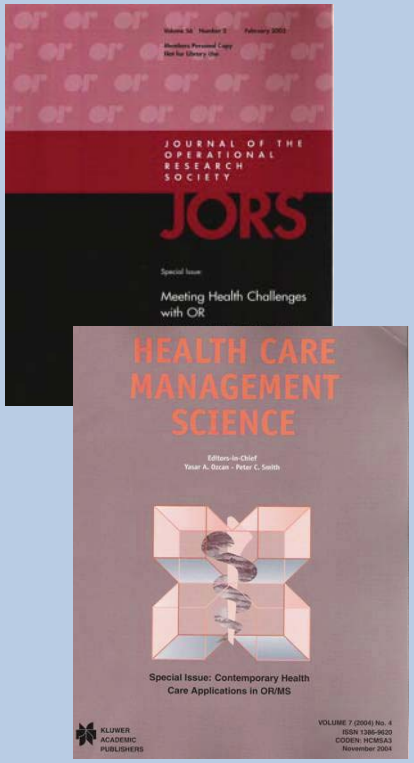




But health O.R. does not appear very visible to managers or clinicians

Large growth in publication of papers on health topics in OR/MS journals

But not of OR papers in the literature that managers and clinicians read



Year Search using Google Scholar, July 2008	In all publications (search on OR + health)	In BMJ only (search on OR)
1975	114	0
1985	126	0
1990	146	0
2000	681	4
2005	1260	5
2007	1720	9

Other disciplines have higher visibility

Search of 2007 publications for :	All publications (search on discipline + health)	BMJ (search on discipline)
OR and health	1700	9
Health Services Research	7700	105
Economics and health	48000	183
Statistics and health	68000	966

Searched with Google Scholar in July 2008

Many fashionable management approaches do not recognise their debt to O.R.

Six Sigma

System and process mapping

Lean Thinking

Theory of Constraints

There are also issues about lack of implementation of modelling work

1981 review of 200 simulation projects in health care found only 16 (8%) reported successful implementation

JCT Wilson, Implementation of computer simulation projects in health care
JORS, **32**, 825-832, 1981

2004 review found 182 papers on simulation in health (1980-99) but only a few reported on implementation so their "value could not be assessed".

Fone D et al, Systematic review of the use and value of computer simulation modelling in population health and health care delivery
J Public Health Med, 2003, **25**(4) 325-335

A telling observation?

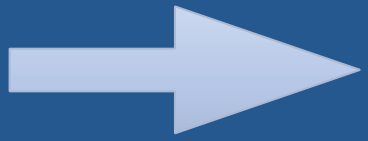
'Compared with many other organisations, hospitals have been slow in adopting operational research as a means to improve their performance. Applications are scattered and the results not always used, even if they are relevant and reliable. The implication is that, so far, hospitals have largely failed to use one of the most potent methods currently available for improving the performance of complex organisations'.

BMJ (Buhaug, 2002),

Our challenge

Meeting the health problems and opportunities of the future

Overcoming the weaker points of health O.R.in the past



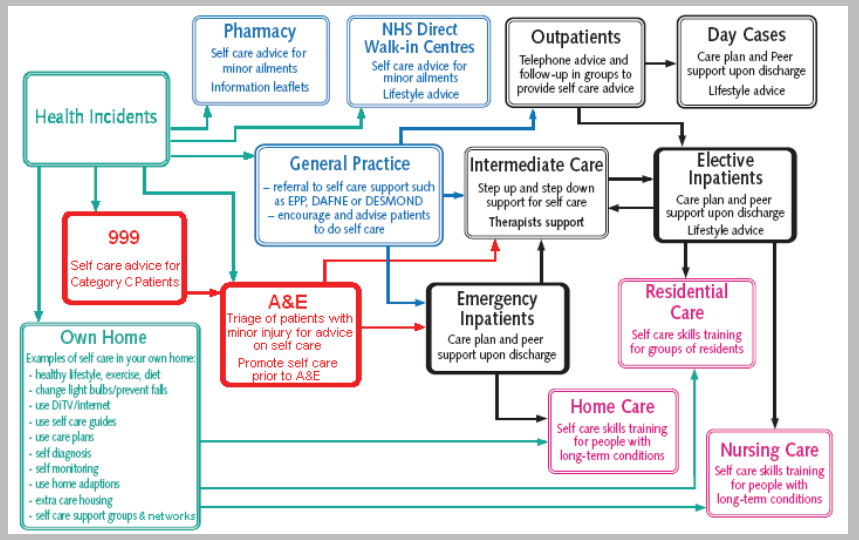
To raise our game - so that O.R. in health care moves from a “nice to have” to a “must have”.

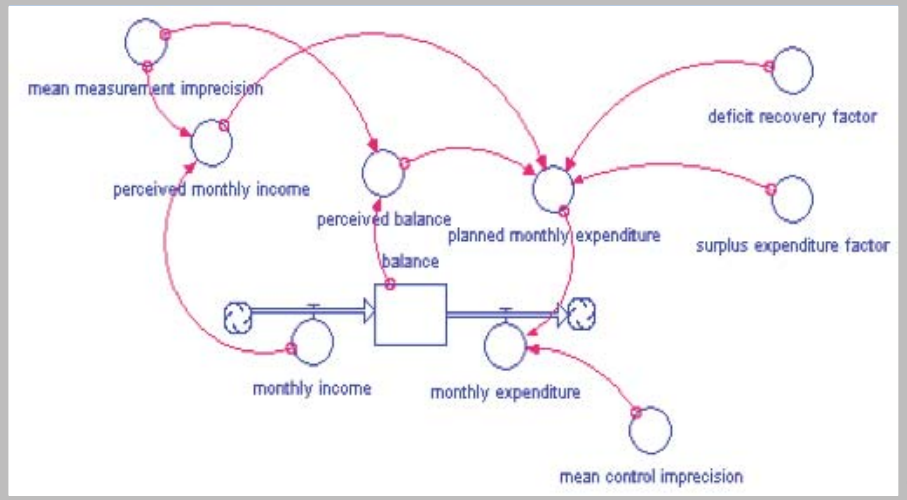
Reframing the World of Operational Research?

OPERATIONS RESEARCH: THE SCIENCE OF BETTER®

TIME-STARVED EXECUTIVES ARE MAKING BOLDER DECISIONS WITH LESS RISK AND BETTER OUTCOMES. THEIR SECRET: OPERATIONS RESEARCH.

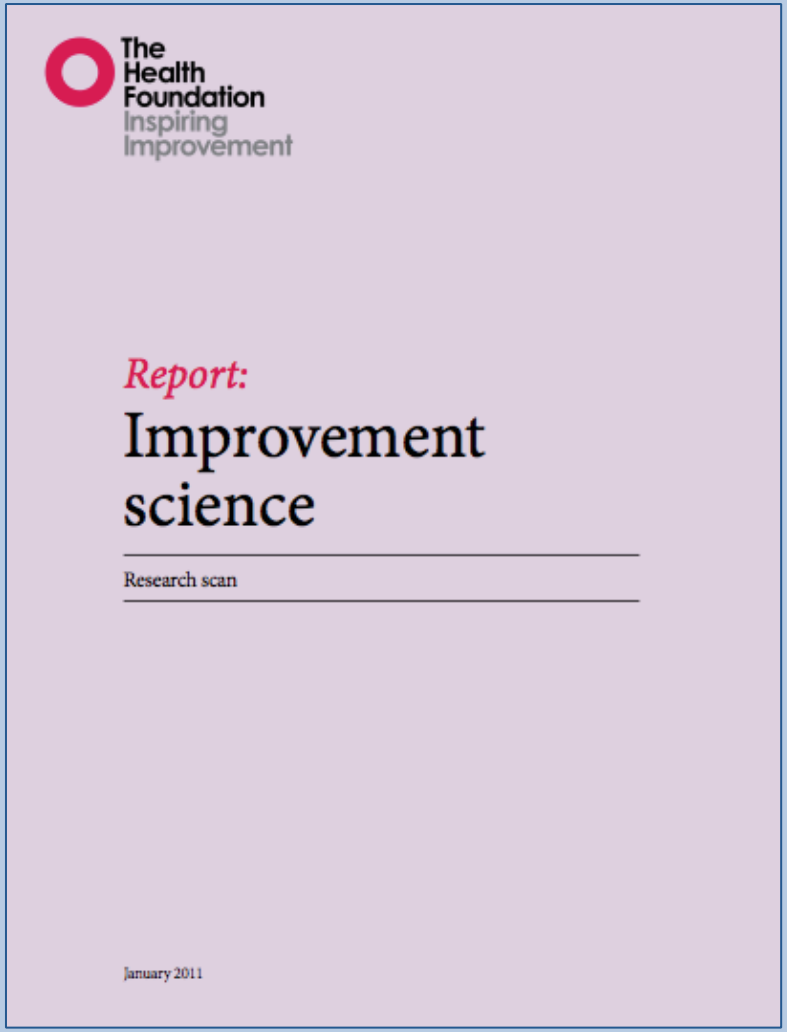
O.R. as the science of improving systems ....for the real world






Systems
Improvement
Science

In the health field there has recently arisen some relevant - but so far largely separate – thinking about "improvement science"

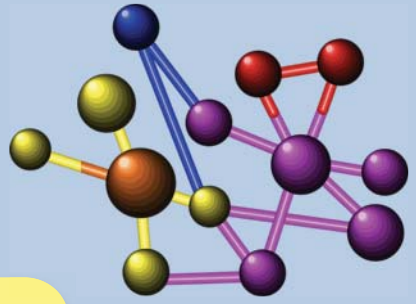


*"The term **improvement science** recently emerged to identify a field of research focused on healthcare improvement. The primary goal of this scientific field is to determine which improvement strategies work as we strive to assure effective and safe patient care."*

We have a wide range of relevant tools - with systems thinking at their core

accepting uncertainty

GROUP USE



- brainstorming
- management “games”
- scenario analysis
- soft systems
- system mapping

QUALITATIVE

QUANTITATIVE

- system dynamics
- discrete event and agent simulation
- mathematical modelling
- statistical analysis

INDIVIDUAL USE

seeking certainty

The problem

a focus on **tools**

does not get to the heart

of a science whose primary focus is on **systems improvement**

OPERATIONS RESEARCH: THE SCIENCE OF BETTER®

TIME-STARVED EXECUTIVES ARE MAKING BOLDER DECISIONS WITH LESS RISK AND BETTER OUTCOMES. THEIR SECRET: OPERATIONS RESEARCH.

Systems improvement entails addressing questions like….

- How well is this system performing?Why?
- What would count as an improvement. For whom?
- What changes might bring about improvements? How could we test them?
- How do we compellingly present our findings about change?
- How can desired changes be implemented?

Articulating the “science of better”….

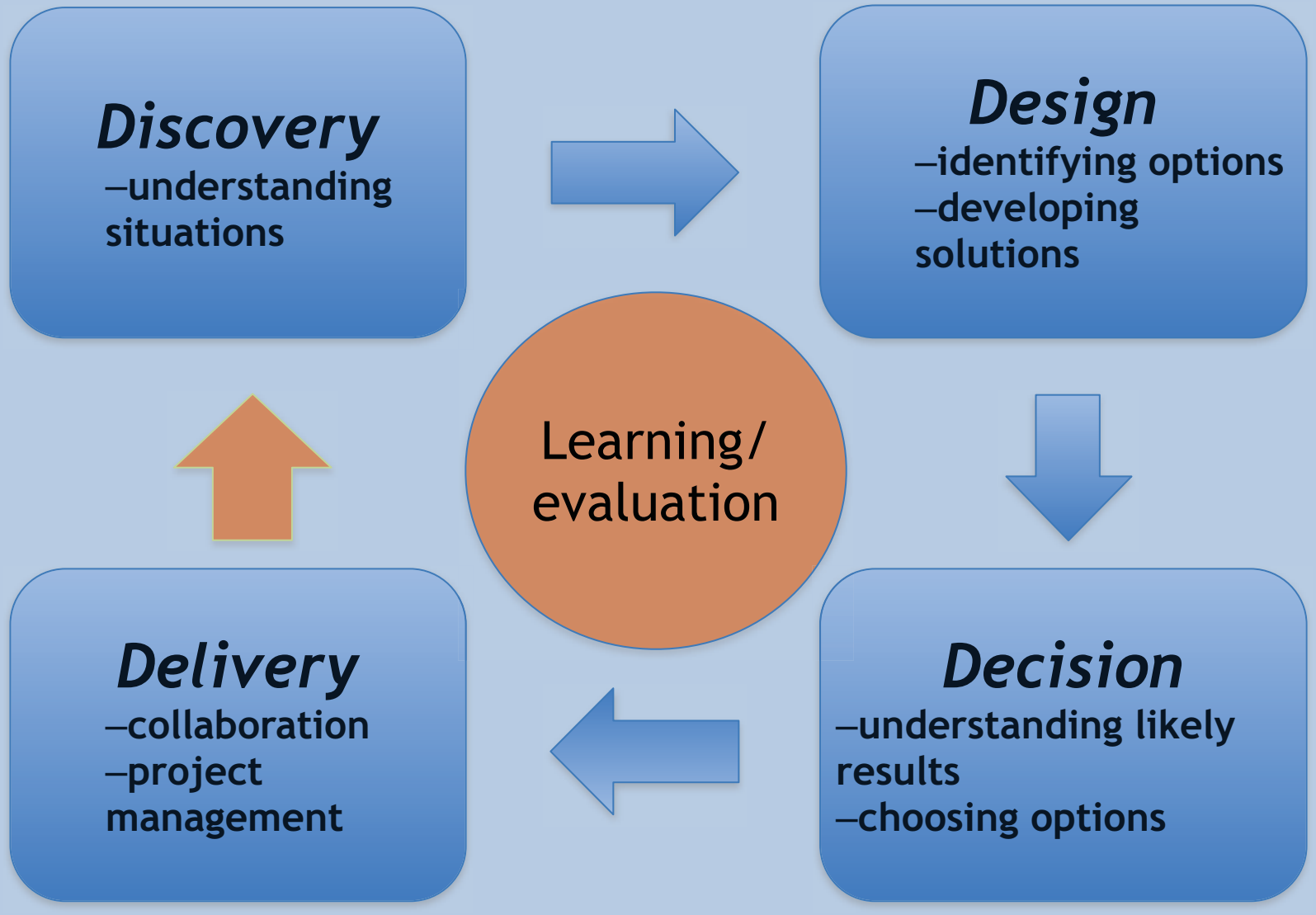
….requires O.R.
to be

not just about a bag of
tools and techniques

but to be

rigorously and systematically based on the
theory and practice of system improvement.

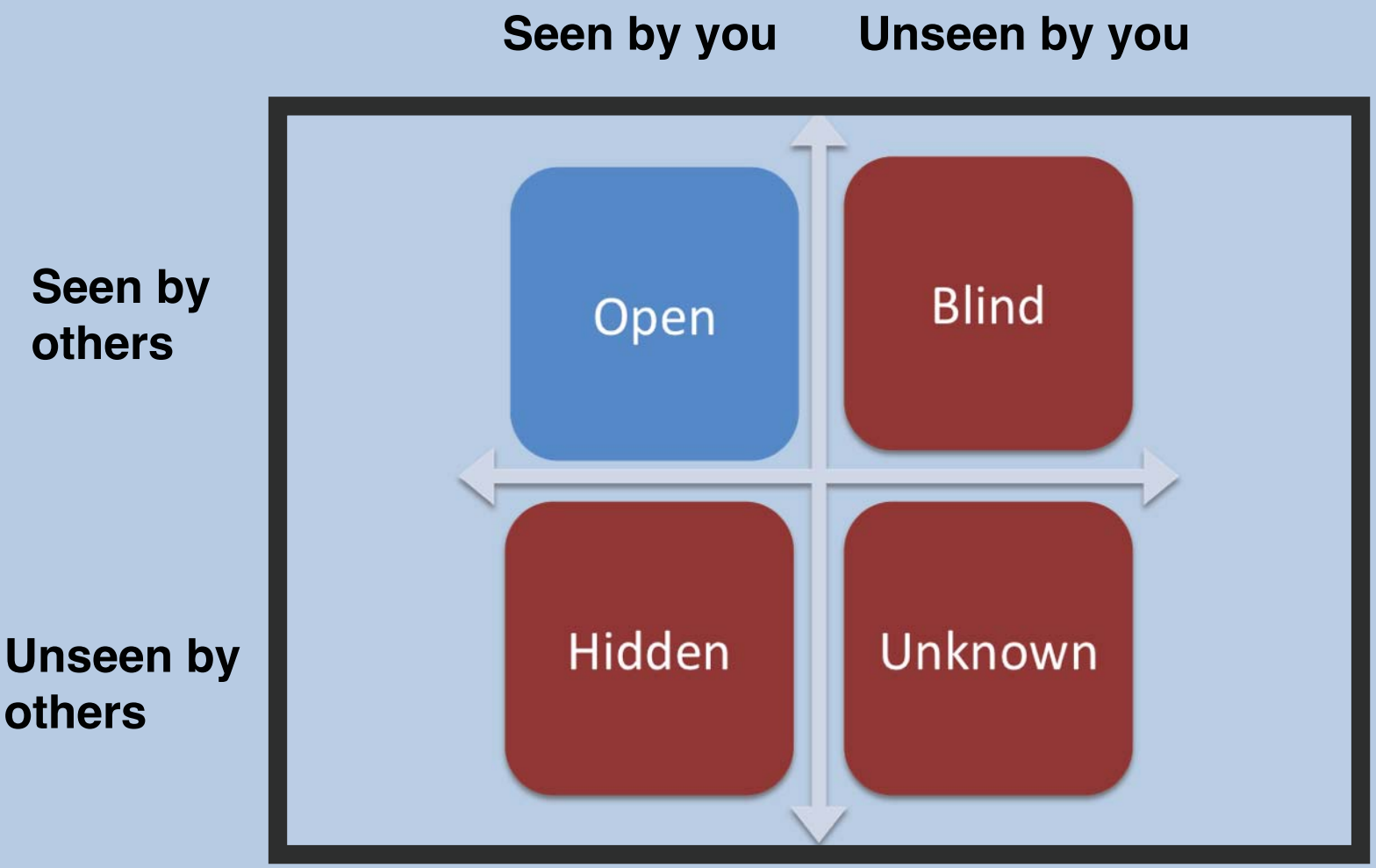
Using something along the lines of the "four D's" problem solving cycle as its foundation



This would involve some reframing of practice (and of education and training) in O.R.

How might we start this?

The Johari Window



A Johari Window for O.R.?

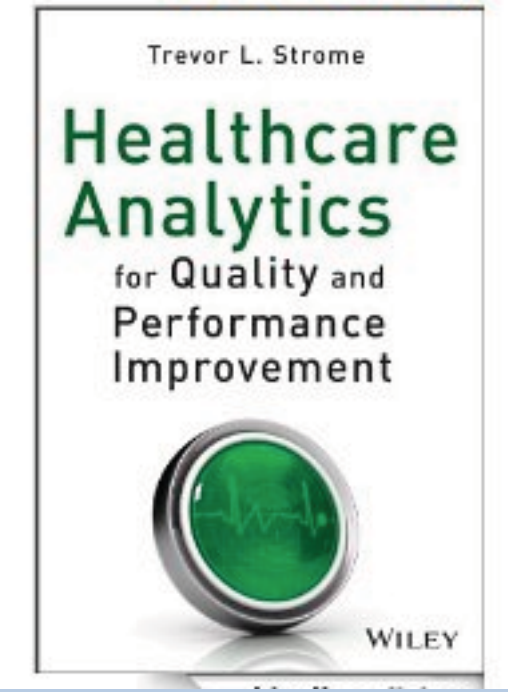
	Seen by us as central to O.R.?	Not seen by us as central to O.R.?
Seen by clients as something that O.R. can offer?	"decision physics"	behavioural analysis
Not seen by clients as something that O.R. can offer?	problem-structuring	design thinking

An abbreviated alphabet of promising growth areas for O.R.*

A. Analytics and big data
B. Behaviour modelling
C. Complexity modelling
D. Design thinking
E. Evaluation

* See Royston G, Operational Research for the Real World: Big Questions from a Small Island, *Journal of the Operational Research Society* (2013) **64**, 793–804

OR societies are engaged with analytics, and healthcare analytics is on the map



THE OR SOCIETY

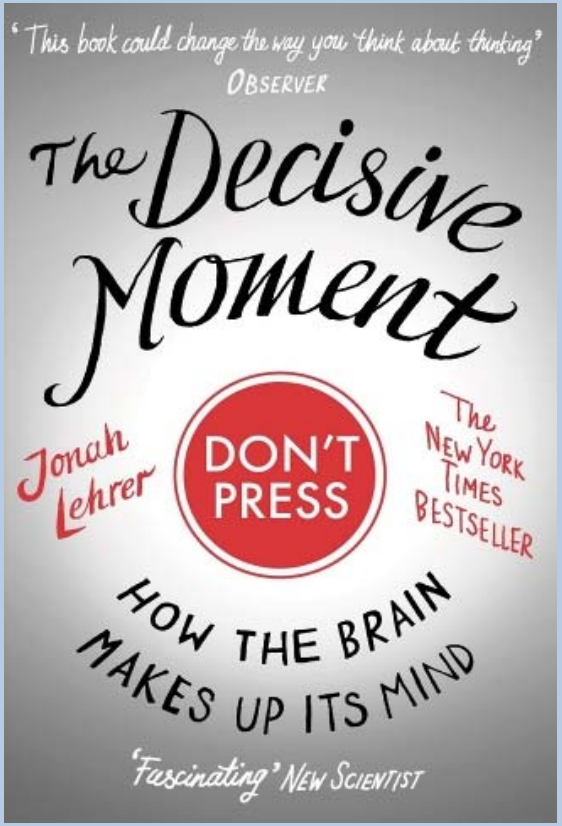
the Analytics Network

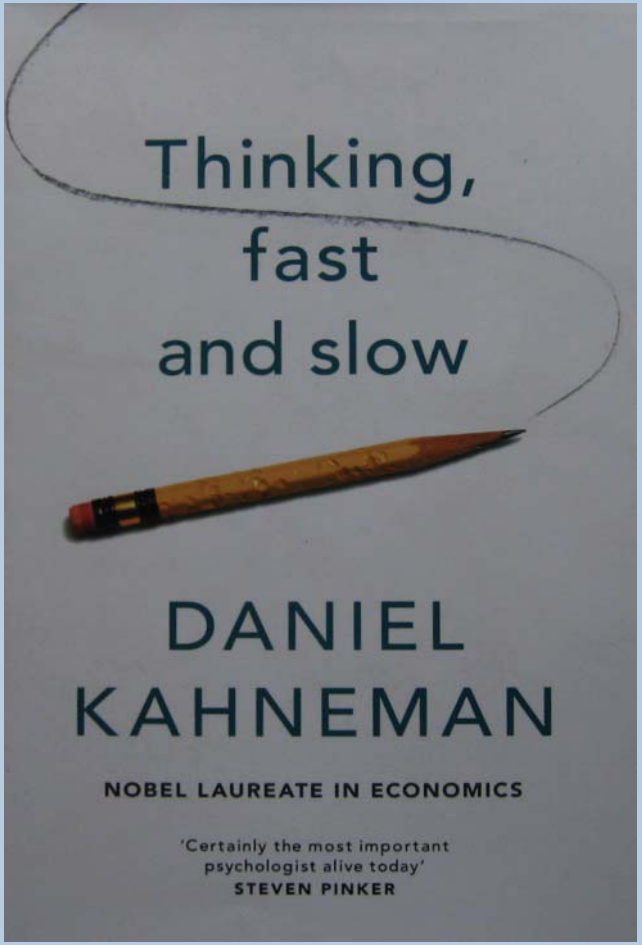
a section of the OR Society

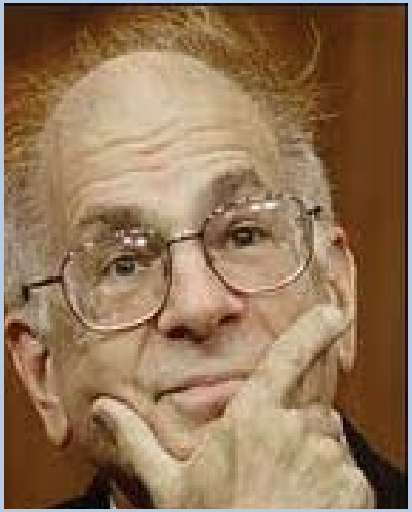
But we are not paying enough attention to behavioural analysis

	Seen by us as central to O.R.?	Not seen by us as central to O.R.?
Seen by clients as something that O.R. can offer?	"decision physics"	behavioural analysis
Not seen by clients as something that O.R. can offer?	problem-structuring	design thinking

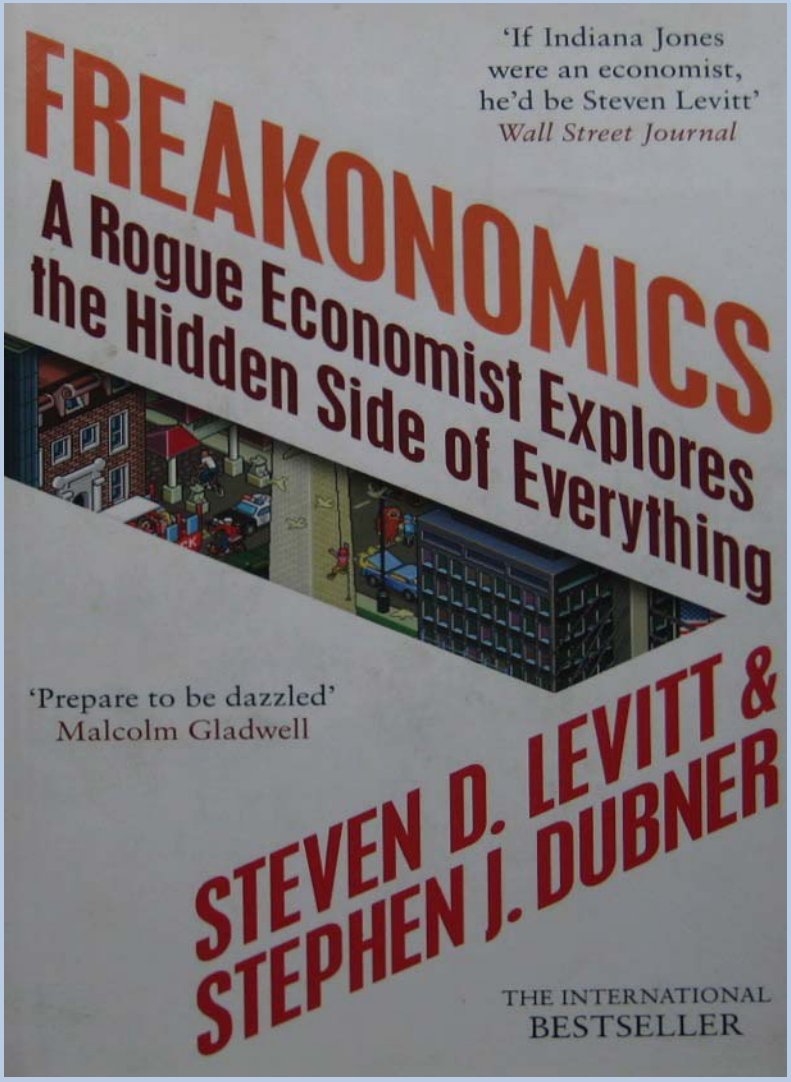
There have been major advances in decision science

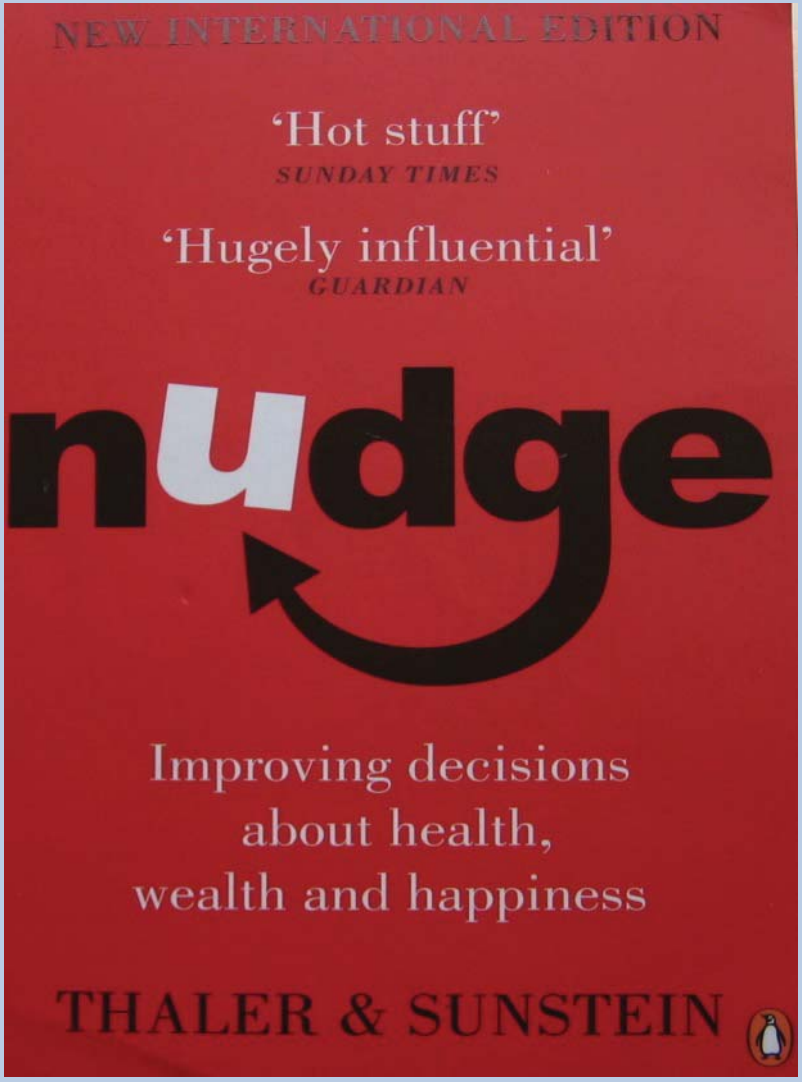




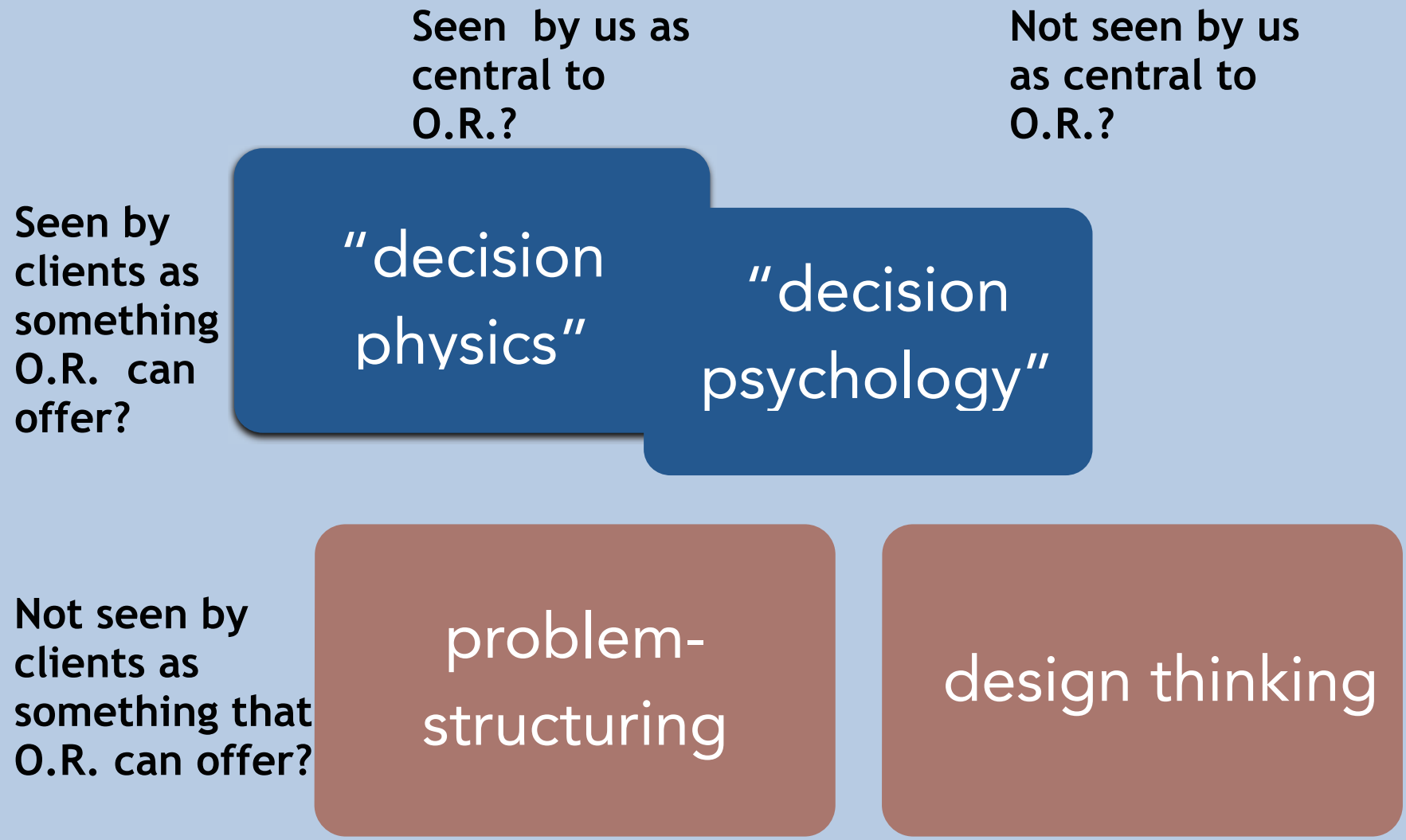


Economists have got the message





A first step in opening up the O.R. window :"decision physics" + "decision psychology"?



(Some) New Worlds in Health Operational Research

1. A world in which we pay attention to the findings of cognitive and behavioural sciences about decision making - to help keep health care models simple and relevant

Real decision making blends analysis and intuition

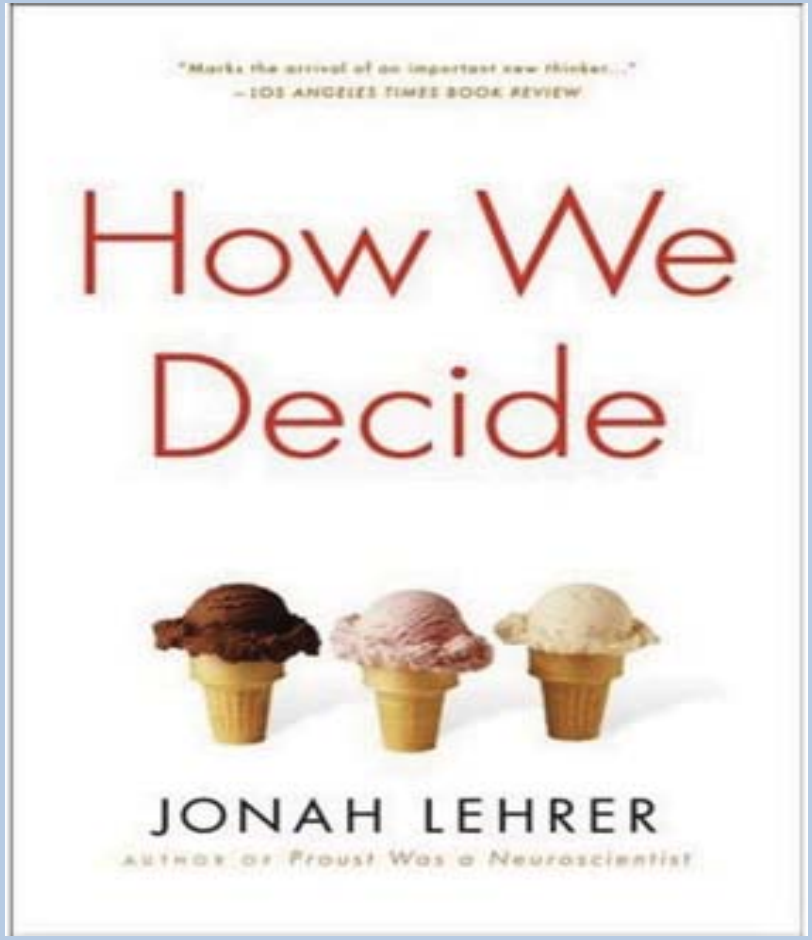
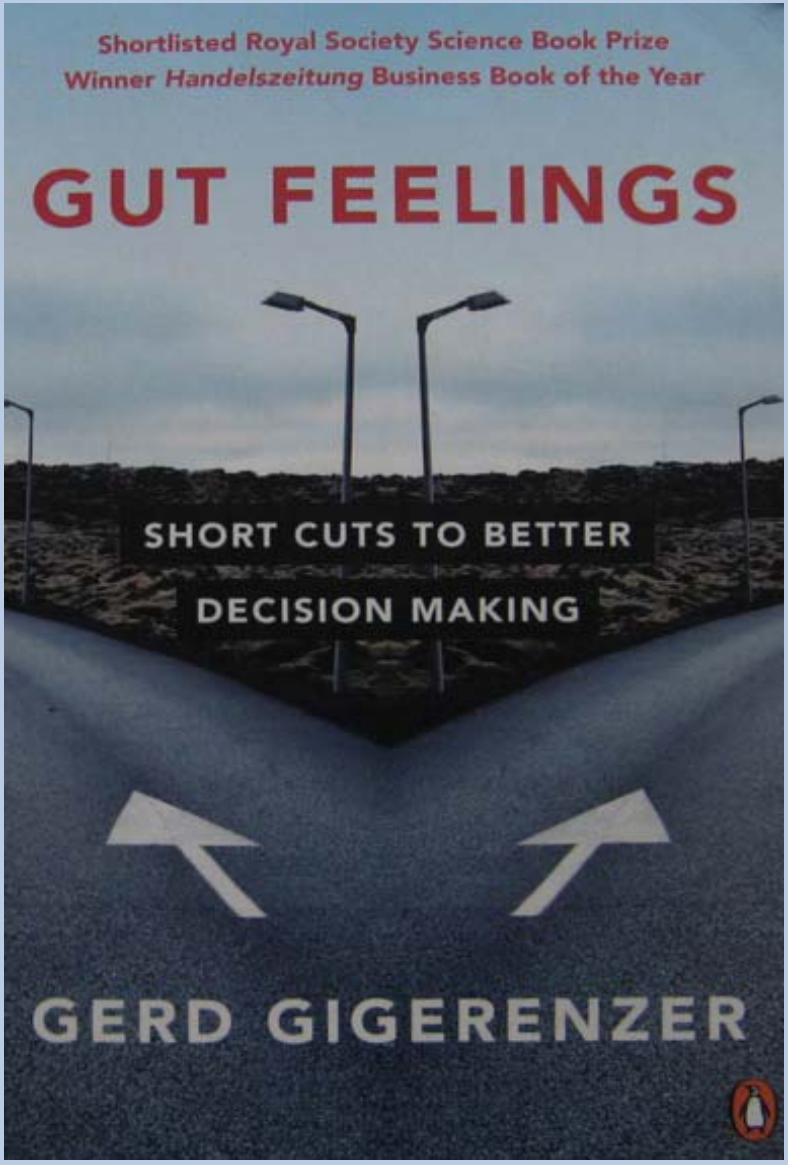


Exhibit 1 – fast and frugal decision aids

Less can be More



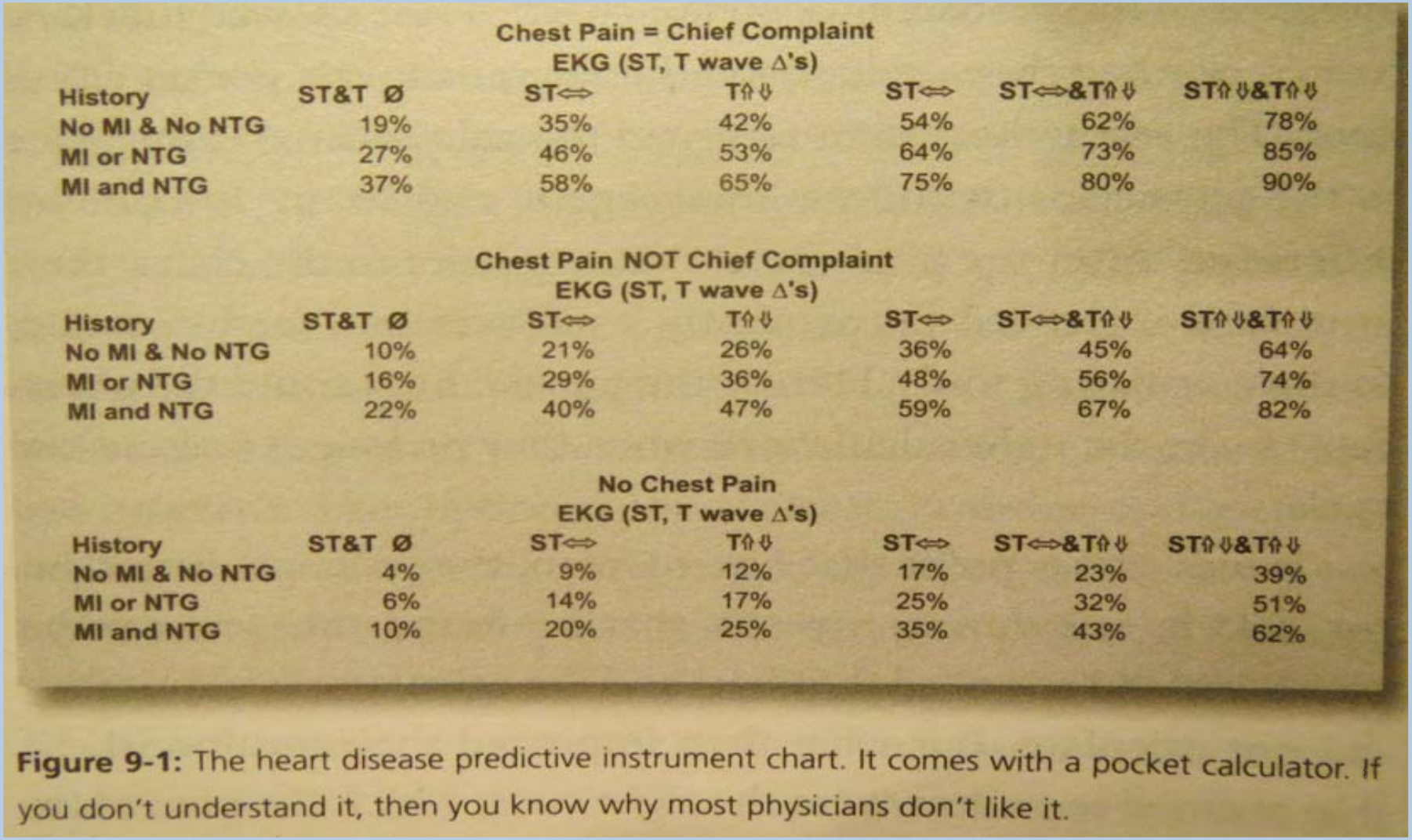
Three possible approaches to clinical decision support

1. **Standard decision theory** (probabilities and utilities) – time consuming and difficult to operationalise

2. **Statistical aids** (predictive instruments) – better but not transparent and still not popular with clinicians

3. **Fast and frugal decision tree** (blend of analytical and intuitive decisions) - easy to use and ***often more accurate*** than the other approaches!

Statistical aids to clinical decision making can be useful – up to a point



Chest Pain = Chief Complaint
EKG (ST, T wave Δ's)

History	ST&T Ø	ST⇔	T⇑⇓	ST⇔	ST⇔&T⇑⇓	ST⇑⇓&T⇑⇓
No MI & No NTG	19%	35%	42%	54%	62%	78%
MI or NTG	27%	46%	53%	64%	73%	85%
MI and NTG	37%	58%	65%	75%	80%	90%

Chest Pain NOT Chief Complaint
EKG (ST, T wave Δ's)

History	ST&T Ø	ST⇔	T⇑⇓	ST⇔	ST⇔&T⇑⇓	ST⇑⇓&T⇑⇓
No MI & No NTG	10%	21%	26%	36%	45%	64%
MI or NTG	16%	29%	36%	48%	56%	74%
MI and NTG	22%	40%	47%	59%	67%	82%

No Chest Pain
EKG (ST, T wave Δ's)

History	ST&T Ø	ST⇔	T⇑⇓	ST⇔	ST⇔&T⇑⇓	ST⇑⇓&T⇑⇓
No MI & No NTG	4%	9%	12%	17%	23%	39%
MI or NTG	6%	14%	17%	25%	32%	51%
MI and NTG	10%	20%	25%	35%	43%	62%

Figure 9-1: The heart disease predictive instrument chart. It comes with a pocket calculator. If you don't understand it, then you know why most physicians don't like it.

Traditional decision trees quickly become computationally and cognitively intractable – but fast and frugal ones do not

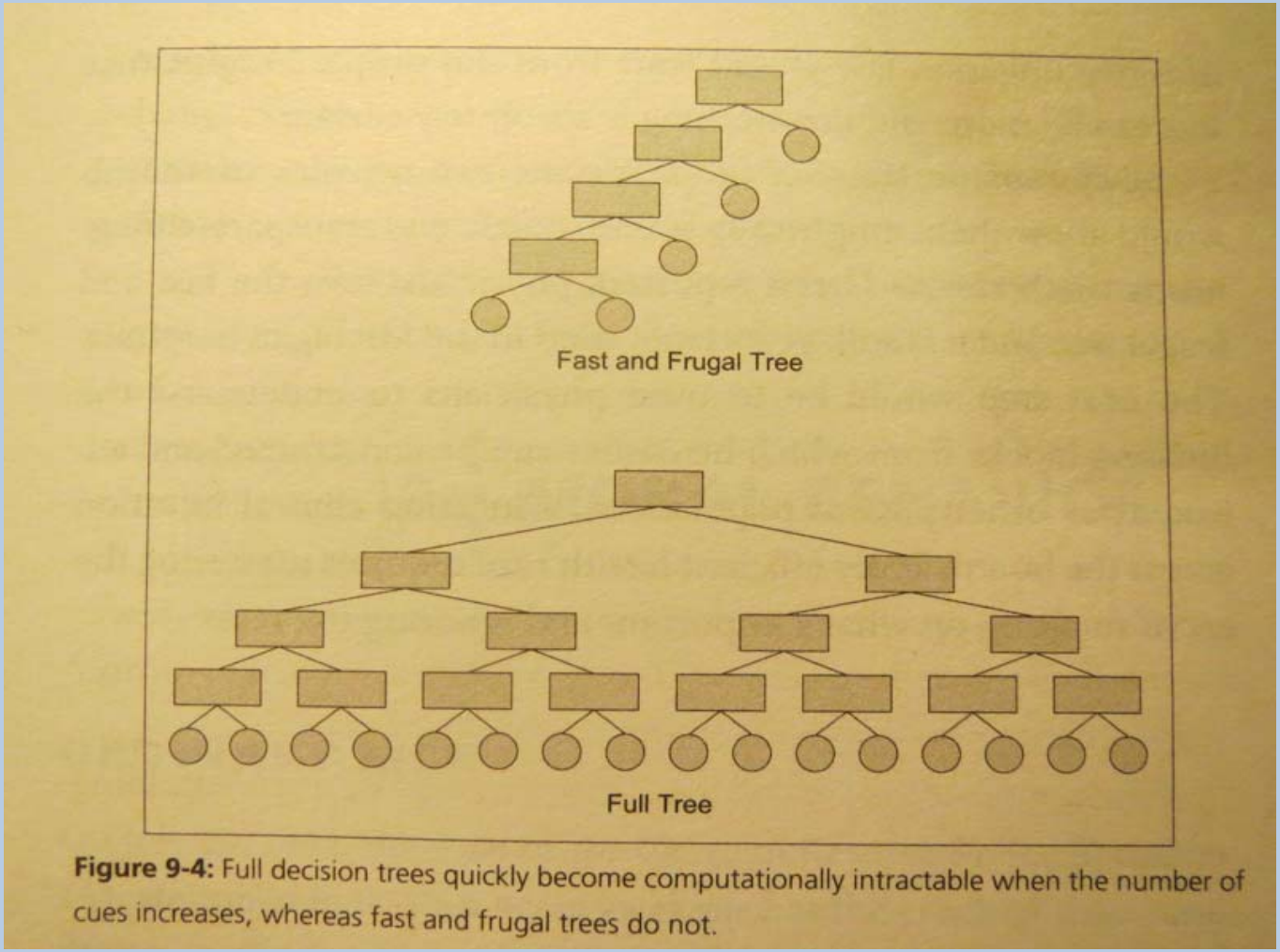
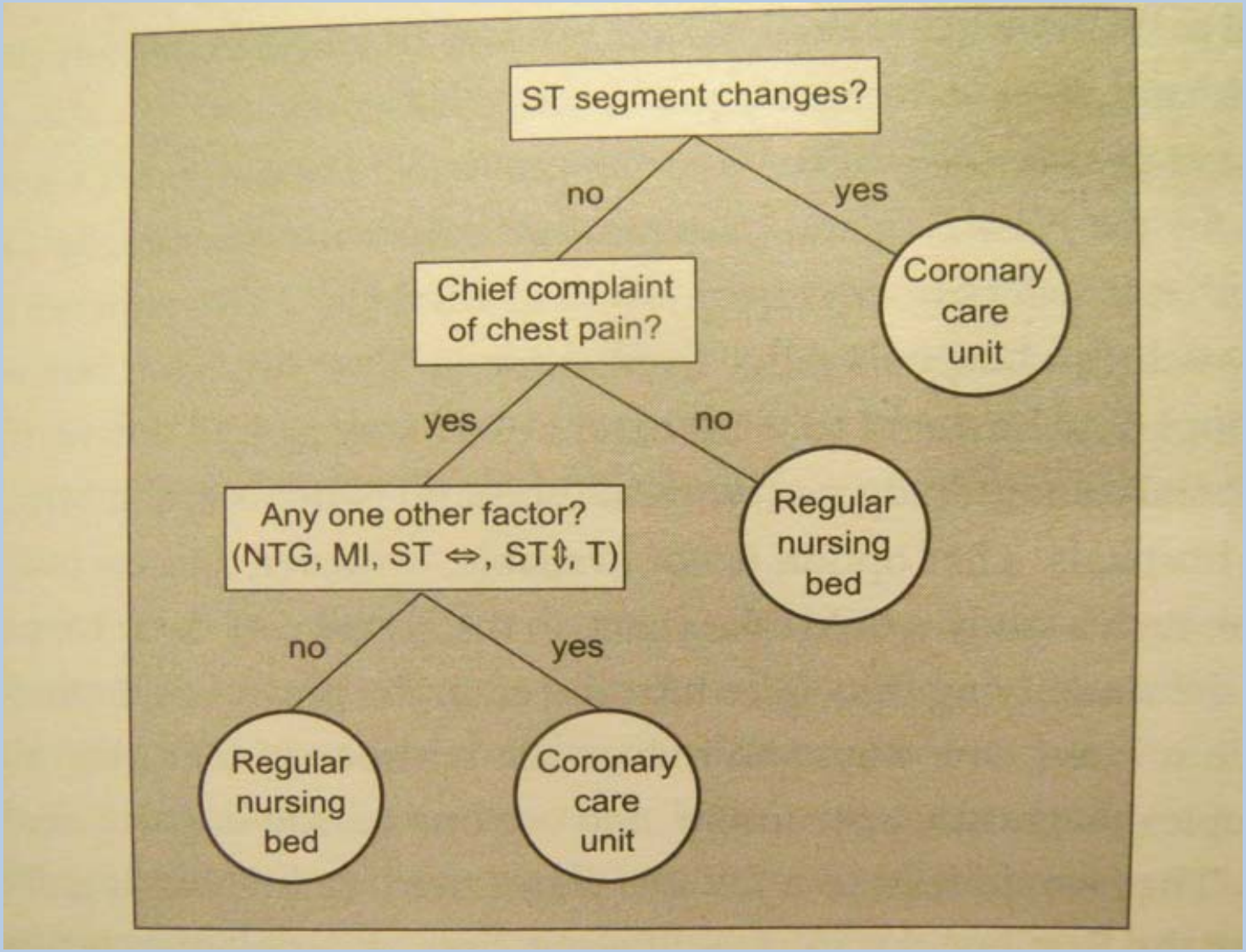
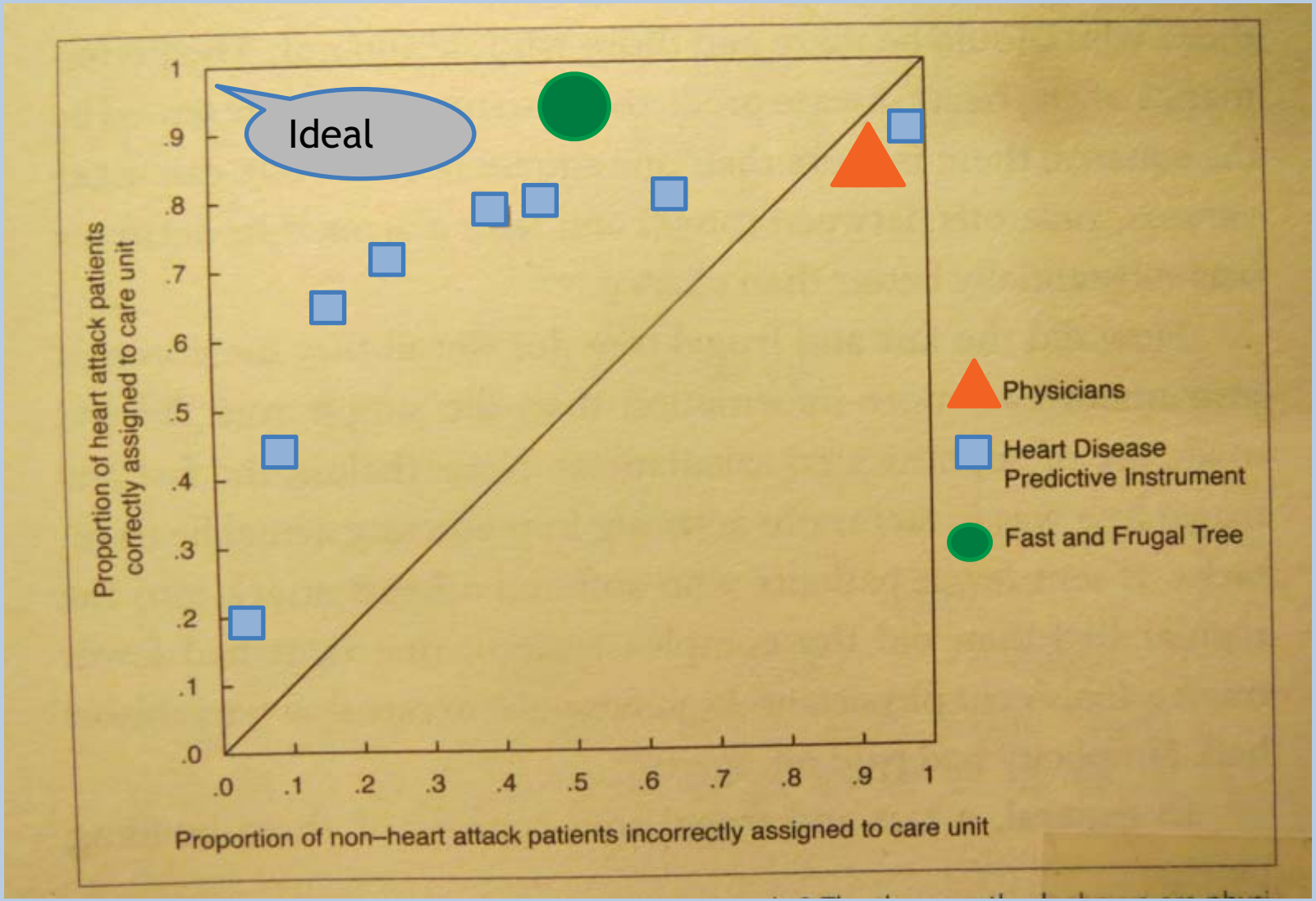


Figure 9-4: Full decision trees quickly become computationally intractable when the number of cues increases, whereas fast and frugal trees do not.

Fast and frugal decision making aids are user friendly….



….and can work better than more complex approaches!

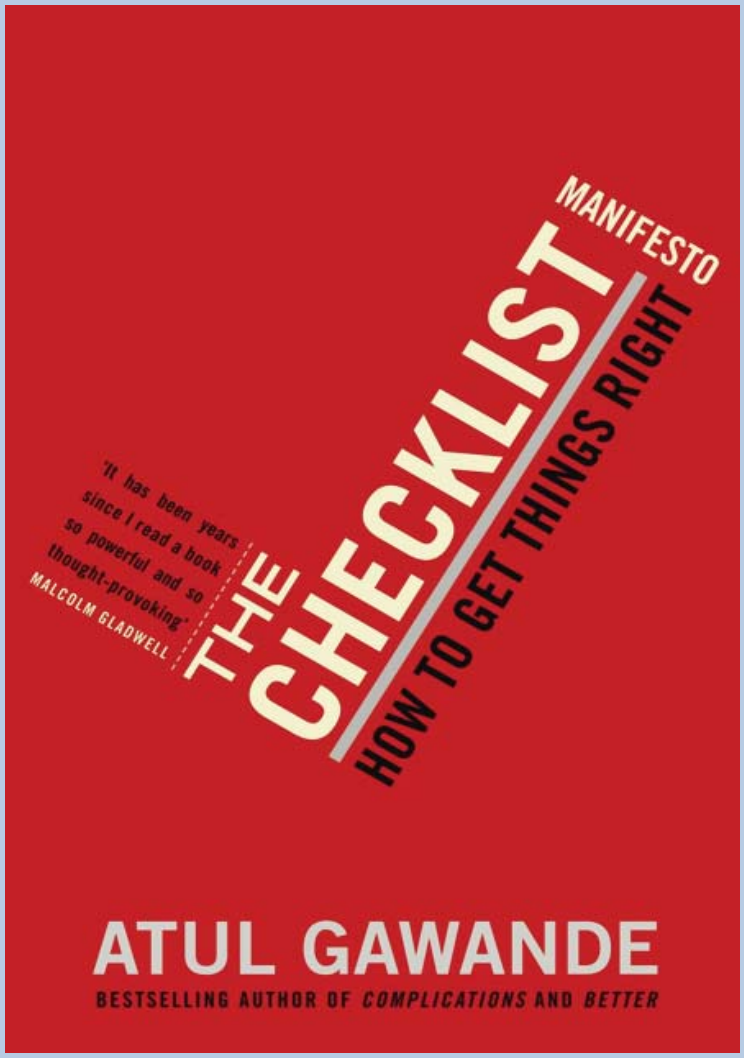


A "fast and frugal" approach underpins the Apgar test for newborn babies which has saved many lives

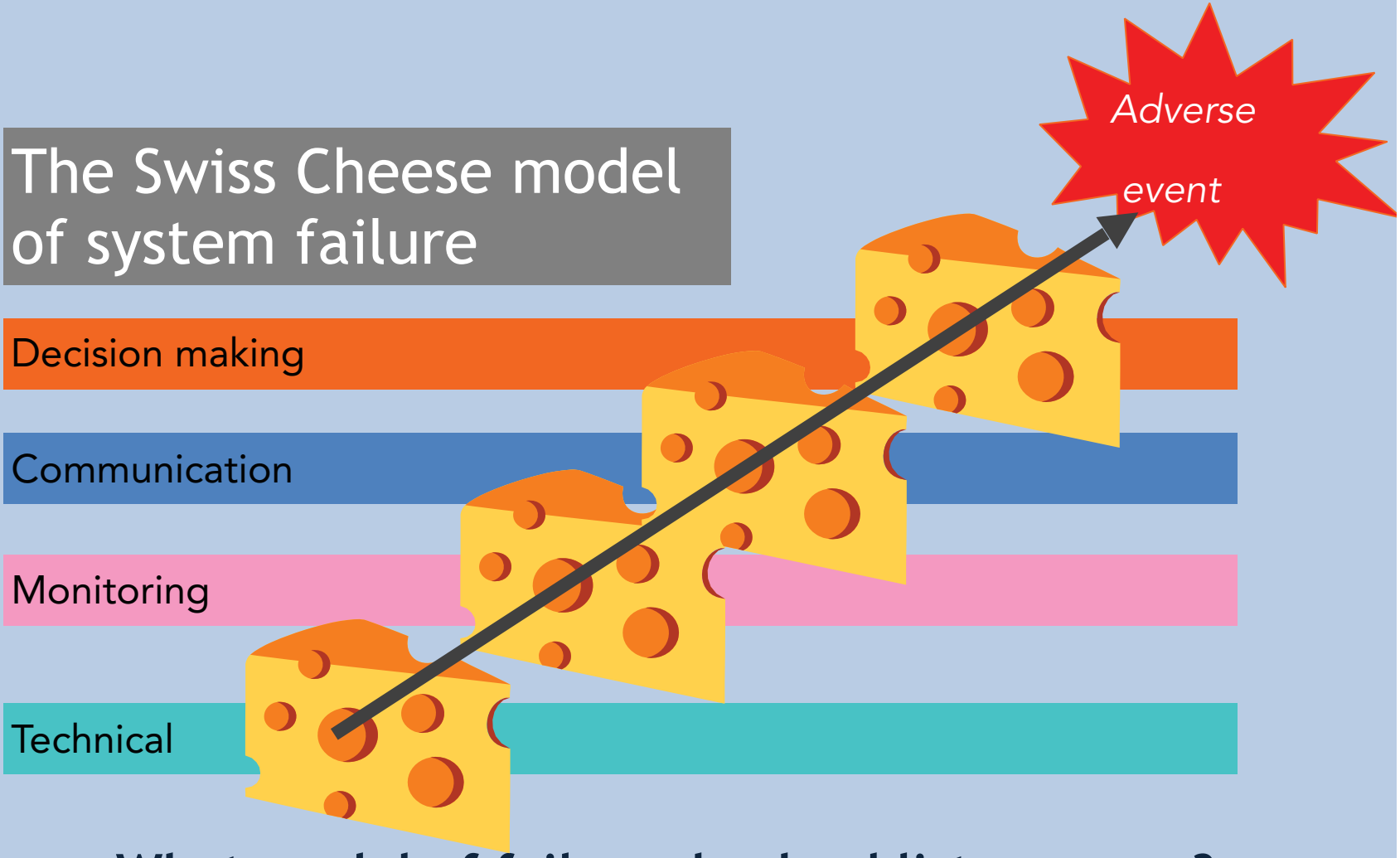
A ppearance (Skin color)		
Blue	Body pink	All pink
P ulse (Heart rate)		
No pulse	< 100	> 100
G rimace (Reflex irritability)		
None	Grimace	Cough
A ctivity (Muscle tone)		
Limp	Some	Active
R espiration (Respiratory efforts)		
Absent	Irregular	Good

Please evaluate all five items...

Checklists are another example of a “fast and frugal” approach



Opportunity for some O.R. on the use of checklists in health care?



What model of failure do checklists assume?

2. A world in which human behavioural factors are incorporated and integrated with the "physics" of health and healthcare models - to help ensure models are realistic and compelling

Exhibit 2 – modelling obesity and weight change

Behavioural modelling can be integrated into traditional modelling e.g. weight loss

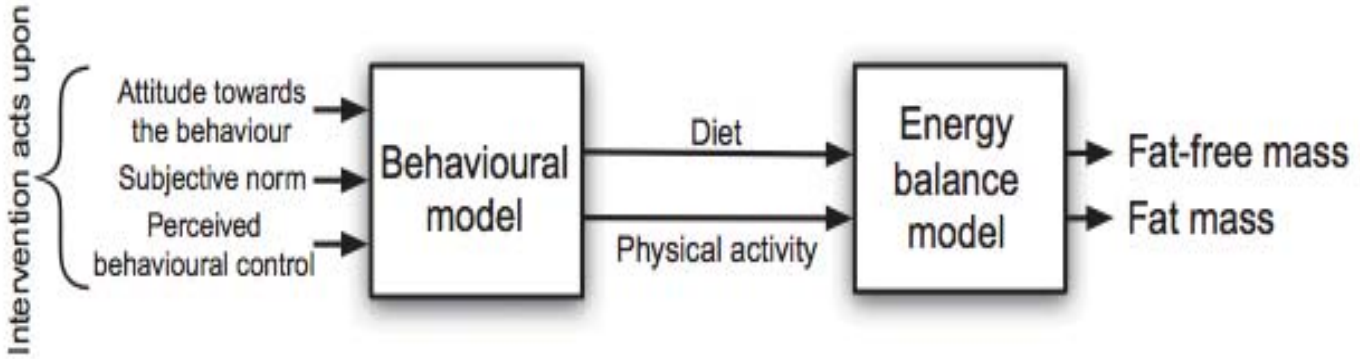
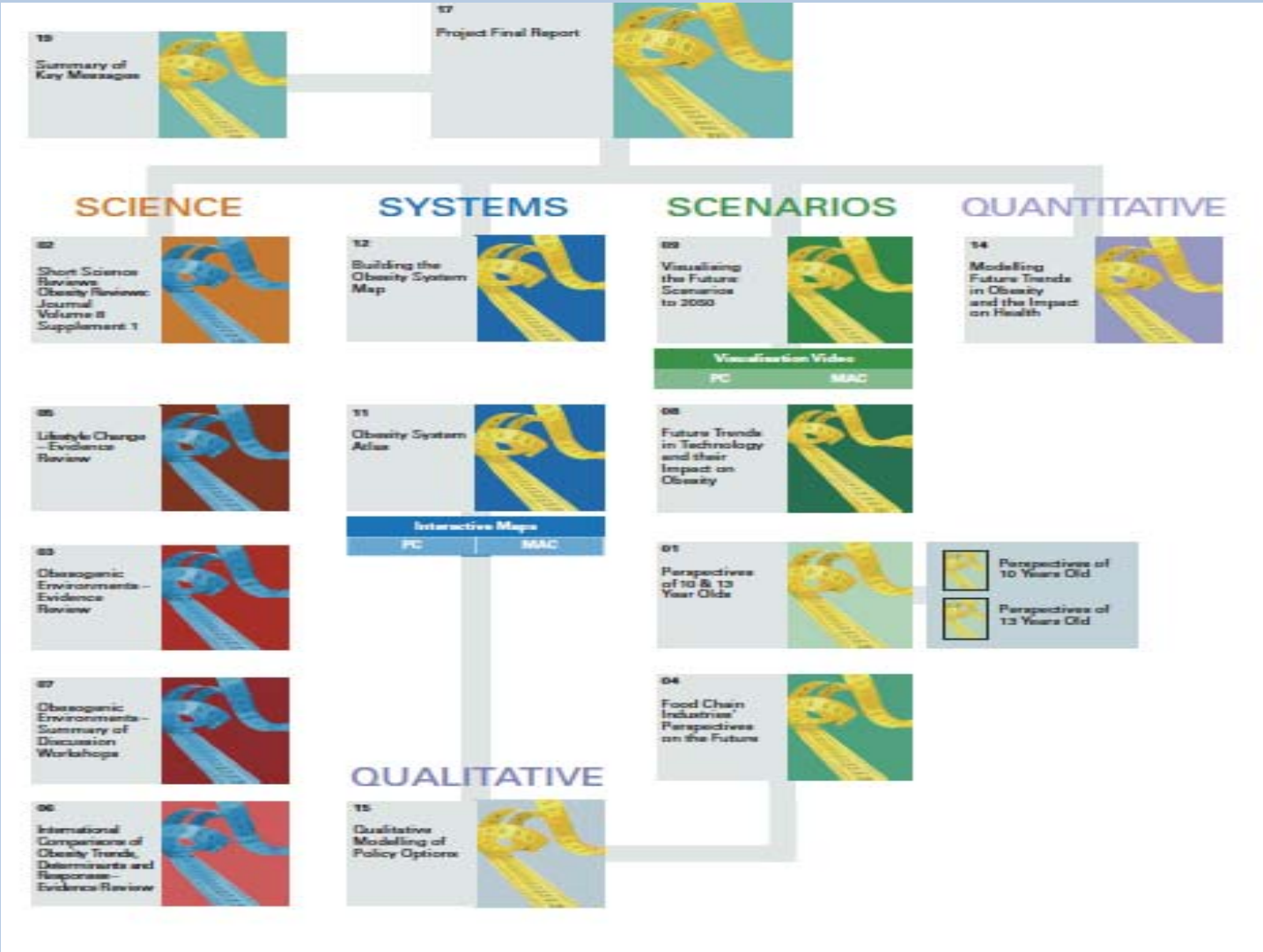


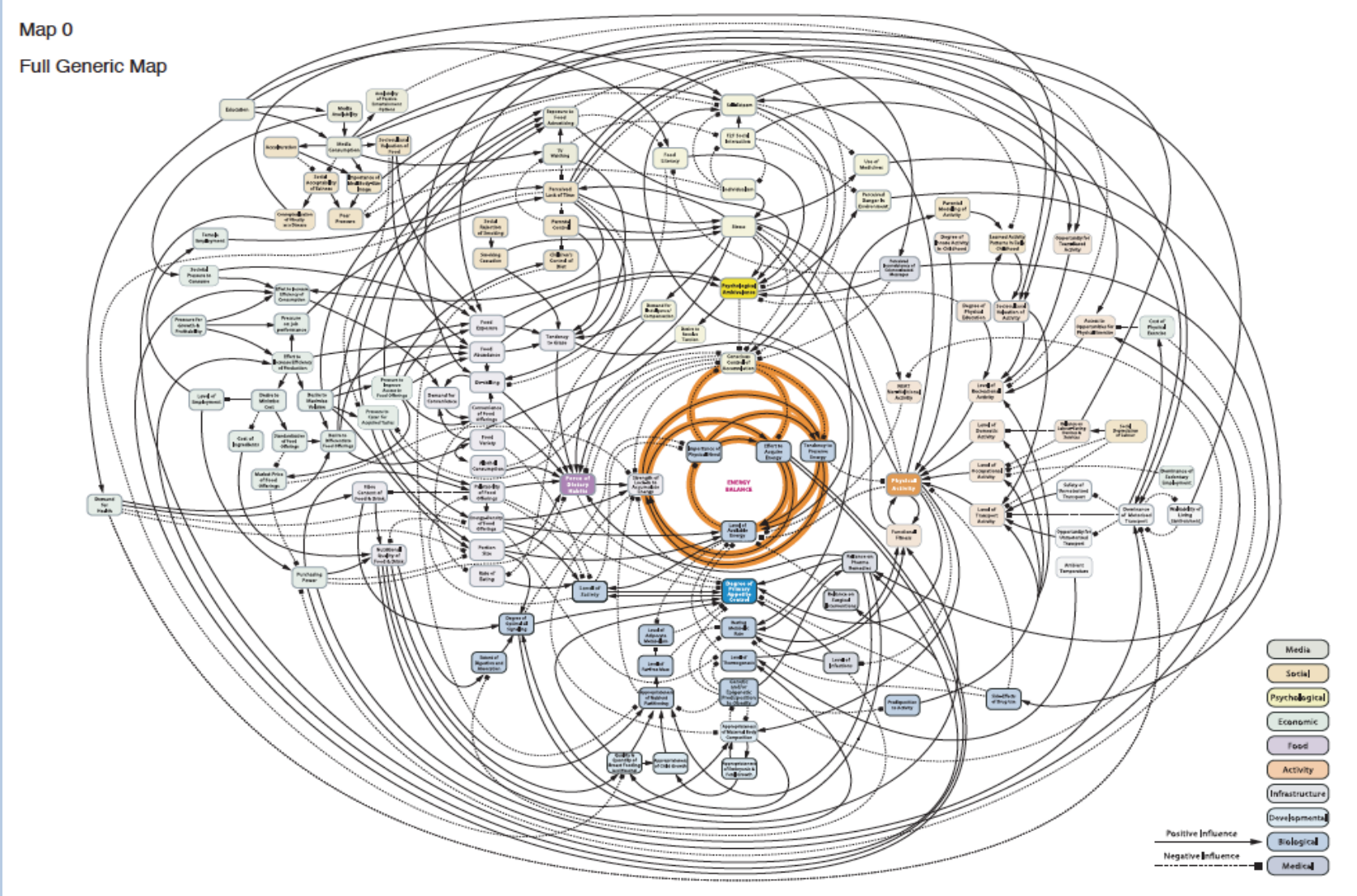
Figure 1. General diagram of the dynamical model for body mass and composition change.

Navarro-Barrientos, J.-Emeterio , Rivera, Daniel E. and Collins, Linda M.(2011) 'A dynamical model for describing behavioural interventions for weight loss and body composition change', *Mathematical and Computer Modelling of Dynamical Systems*, **17**: 2, 183 — 203,

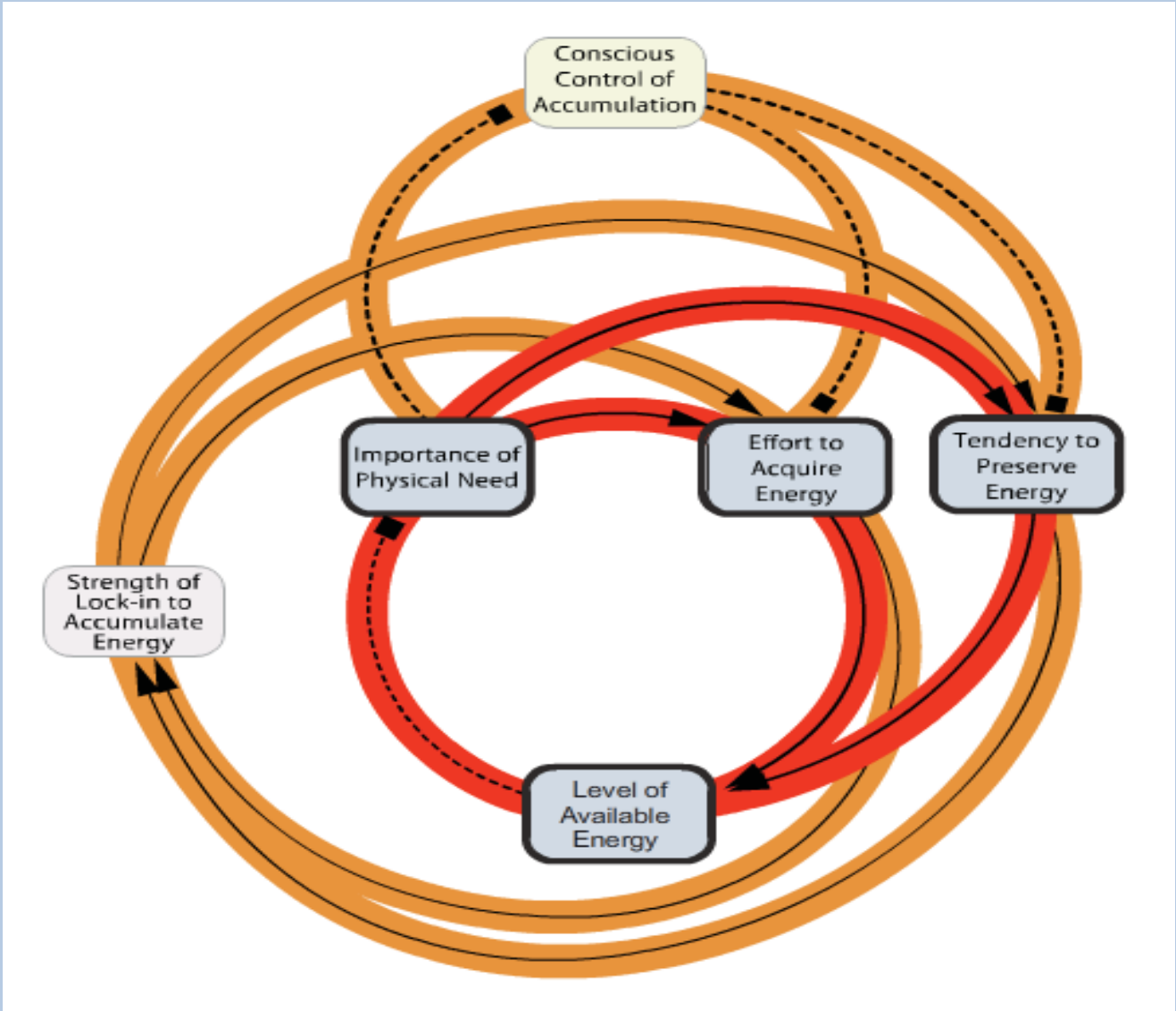
The Foresight Study on Obesity was an influential UK report by the UK Government Office for Science - it had systems and behavioural modelling at its core



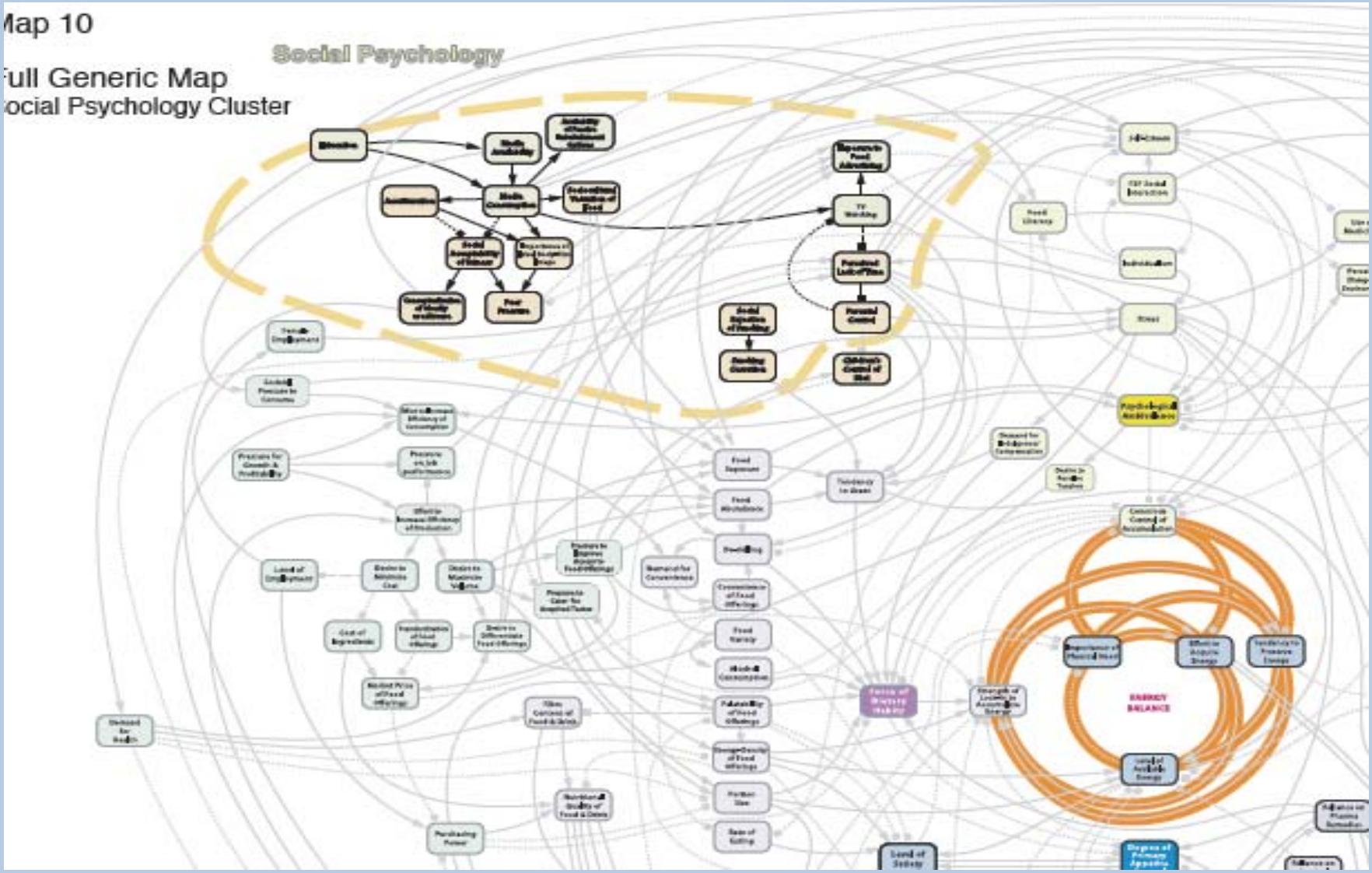
The Foresight Study obesity system is complex and the map is complicated!



But at its heart is simple feedback loop about individuals' behaviour



But it also recognises the influence of social psychology



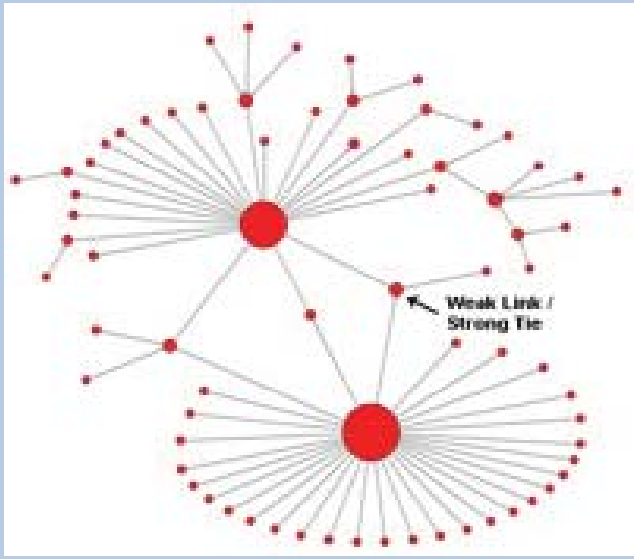
Obesity seems to be contagious

As certain unhealthy behaviours and attitudes become the norm in an area then they spread to neighbouring populations, through family, friends and colleagues etc.

- For instance in 1988-9 childhood obesity in the UK was concentrated in deprived areas of the Wirral, by 2002-3 obesity had spread to other areas.

- This “contagion” theory is supported by a US 32 year longitudinal study of the spread of obesity through social networks

There are links between modelling behaviour and modelling complex networks



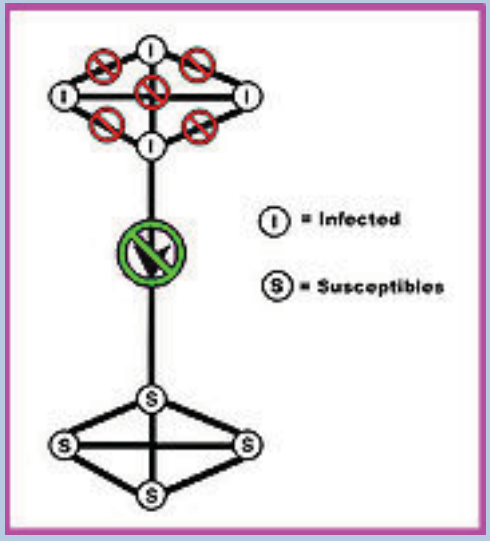


Exhibit 3 – modelling disease control and global eradication

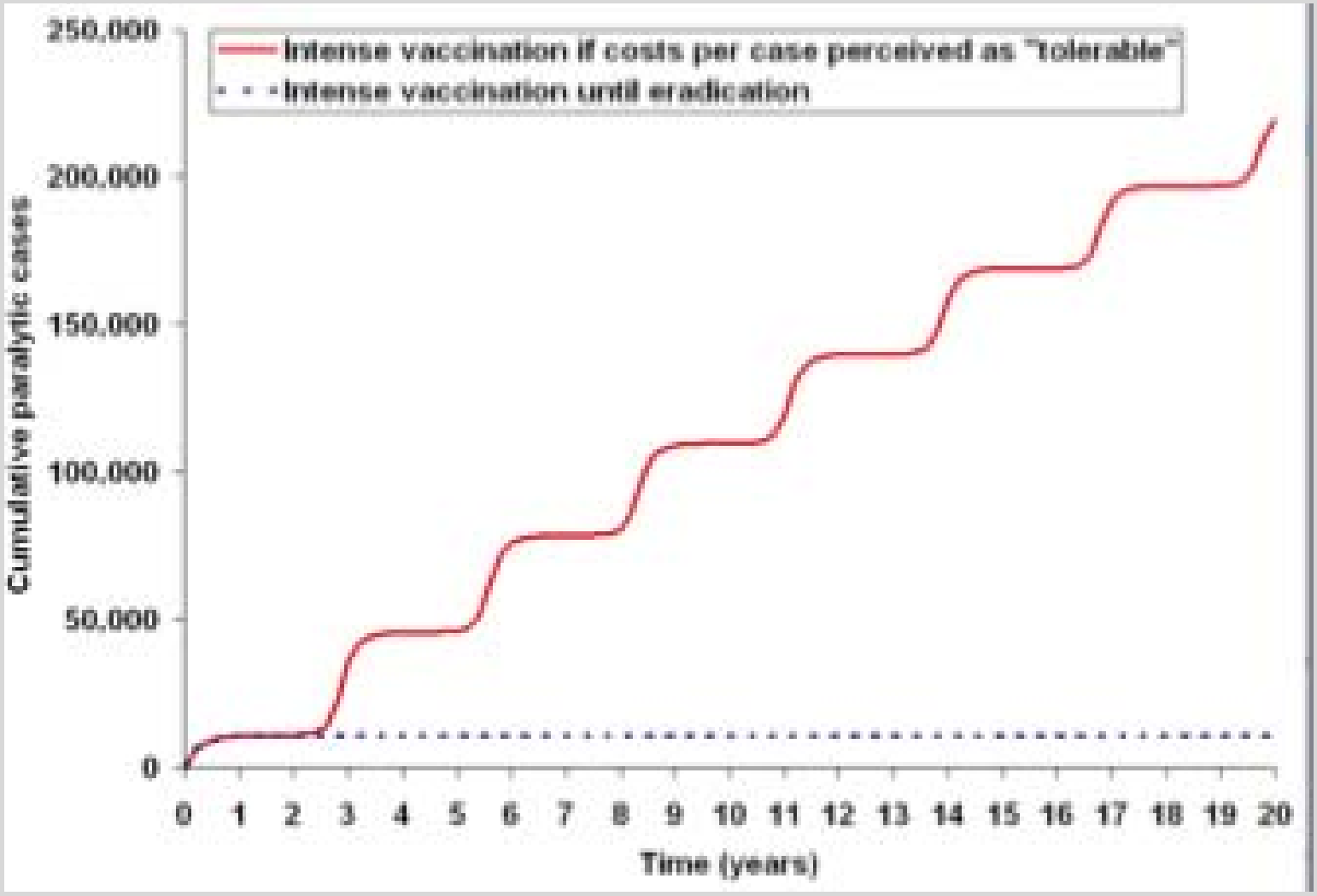
The prestigious Edelman award for 2014 has gone to health care modelling work which has a crucial behavioural component

CDC Wins INFORMS Edelman Award, Leading Prize in Analytics, Operations Research for Polio Eradication

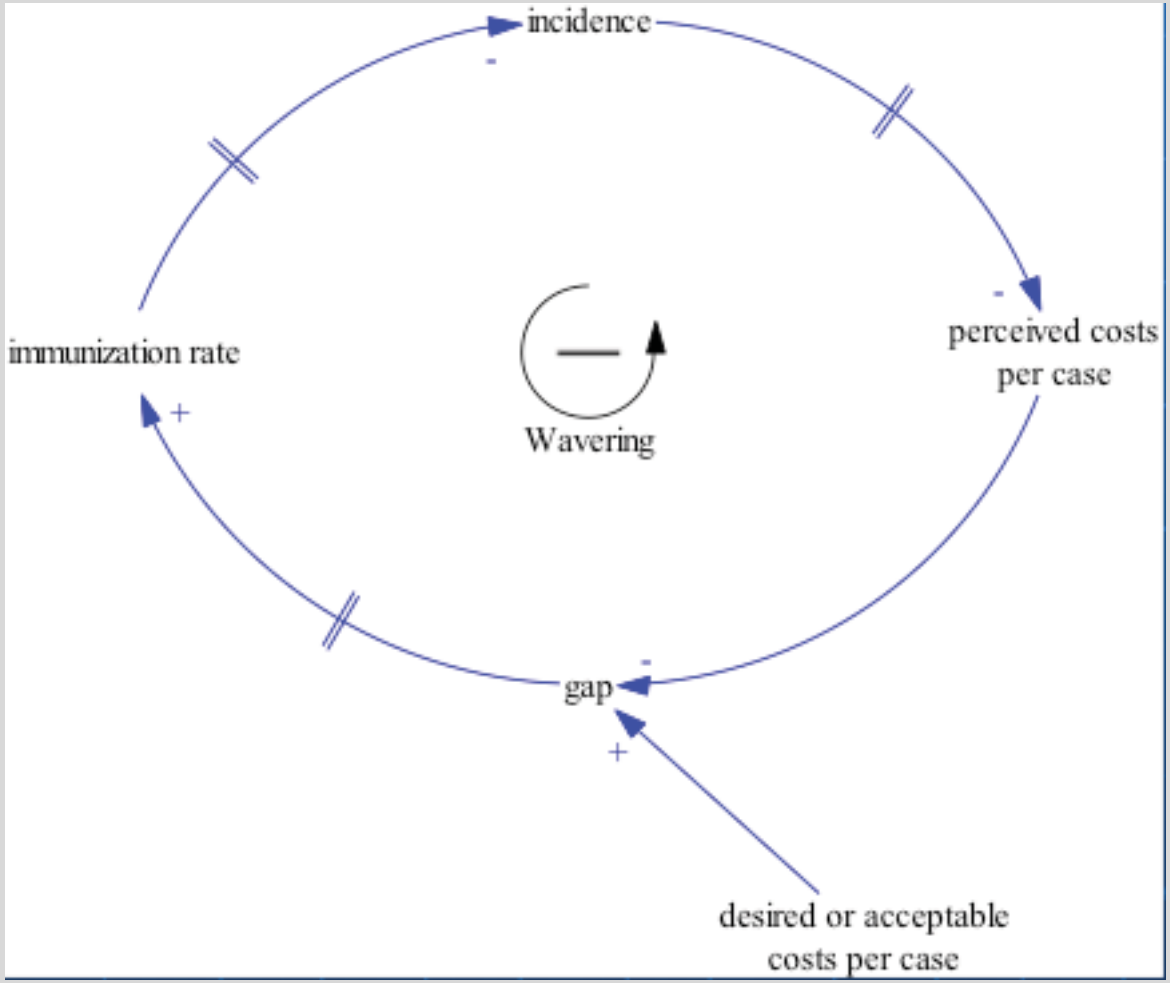
CDC
CENTERS FOR DISEASE CONTROL AND PREVENTION

Kid Risk, Inc.

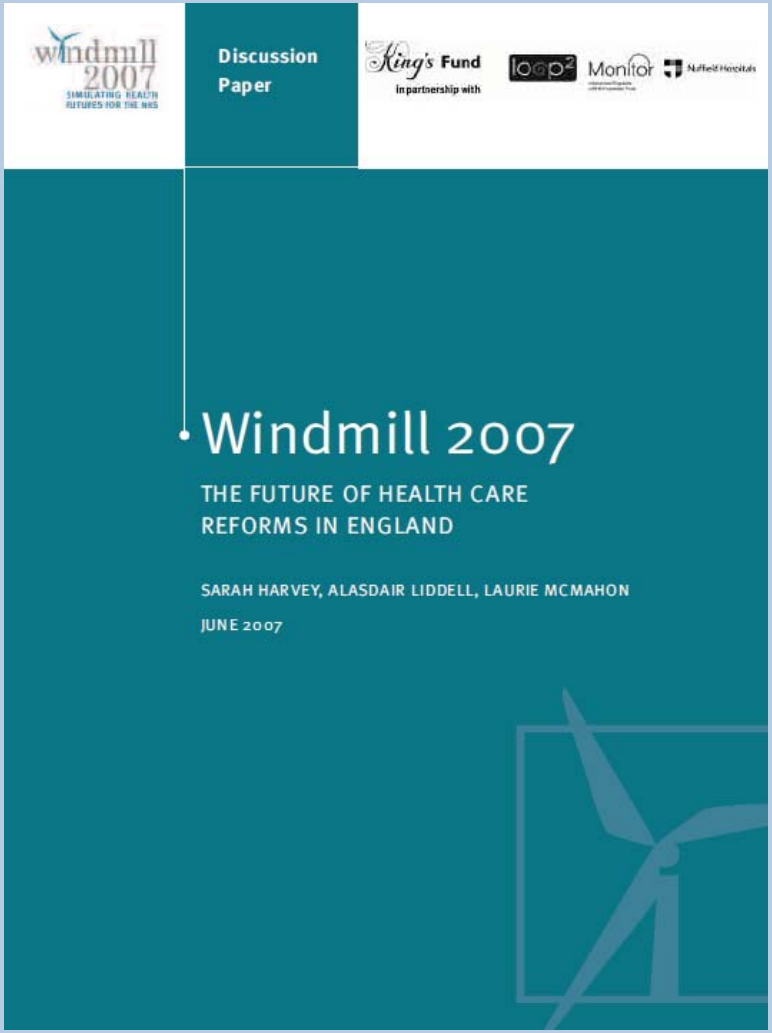
Policy "wavering" leads to a sub-optimal strategy for polio vaccination



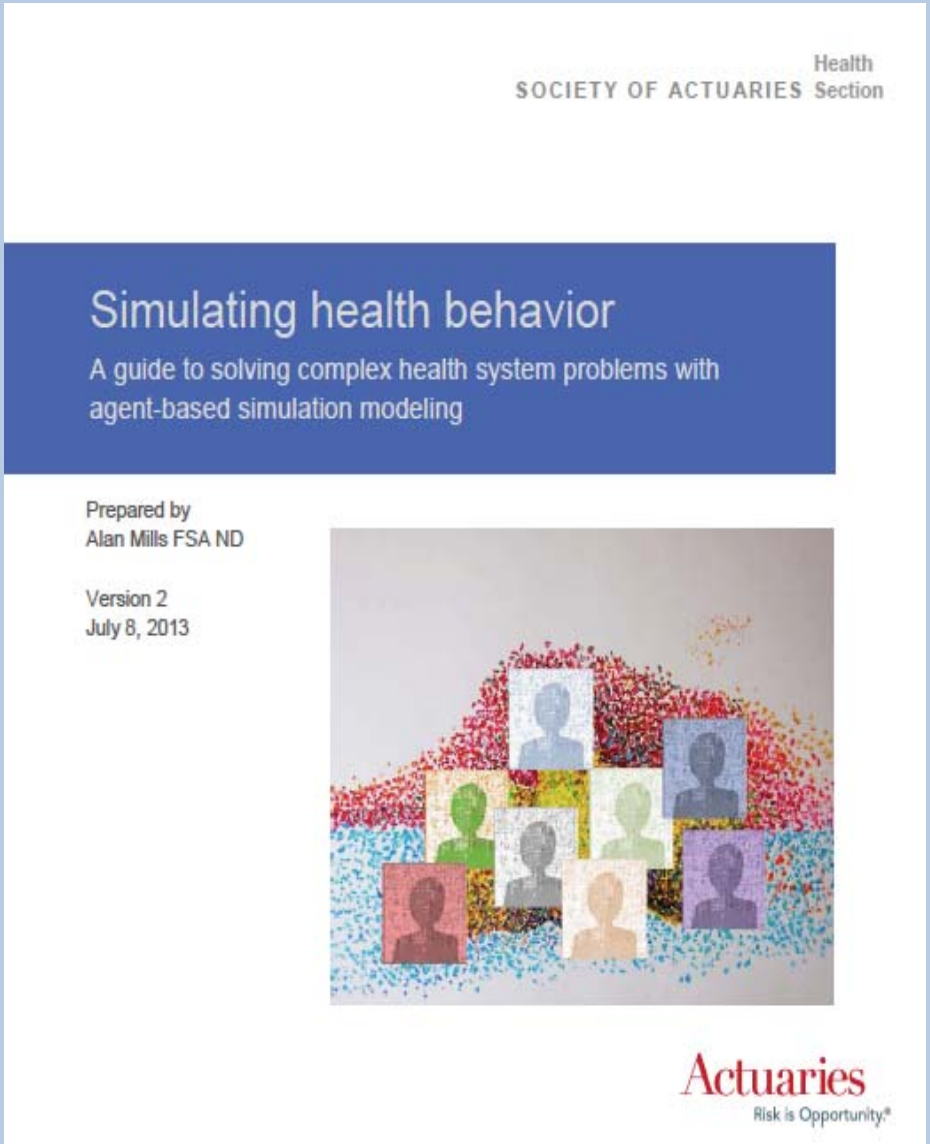
This “wavering” was a behavioural effect and was a driver in the vaccination policy model



Behavioural simulation - "management games" in health



Behavioural simulation: agent-based modelling in health



3. A world in which we pay much more attention to how our clients think about (model!) health and health care …..and how we talk with them about it - to help ensure our message gets across

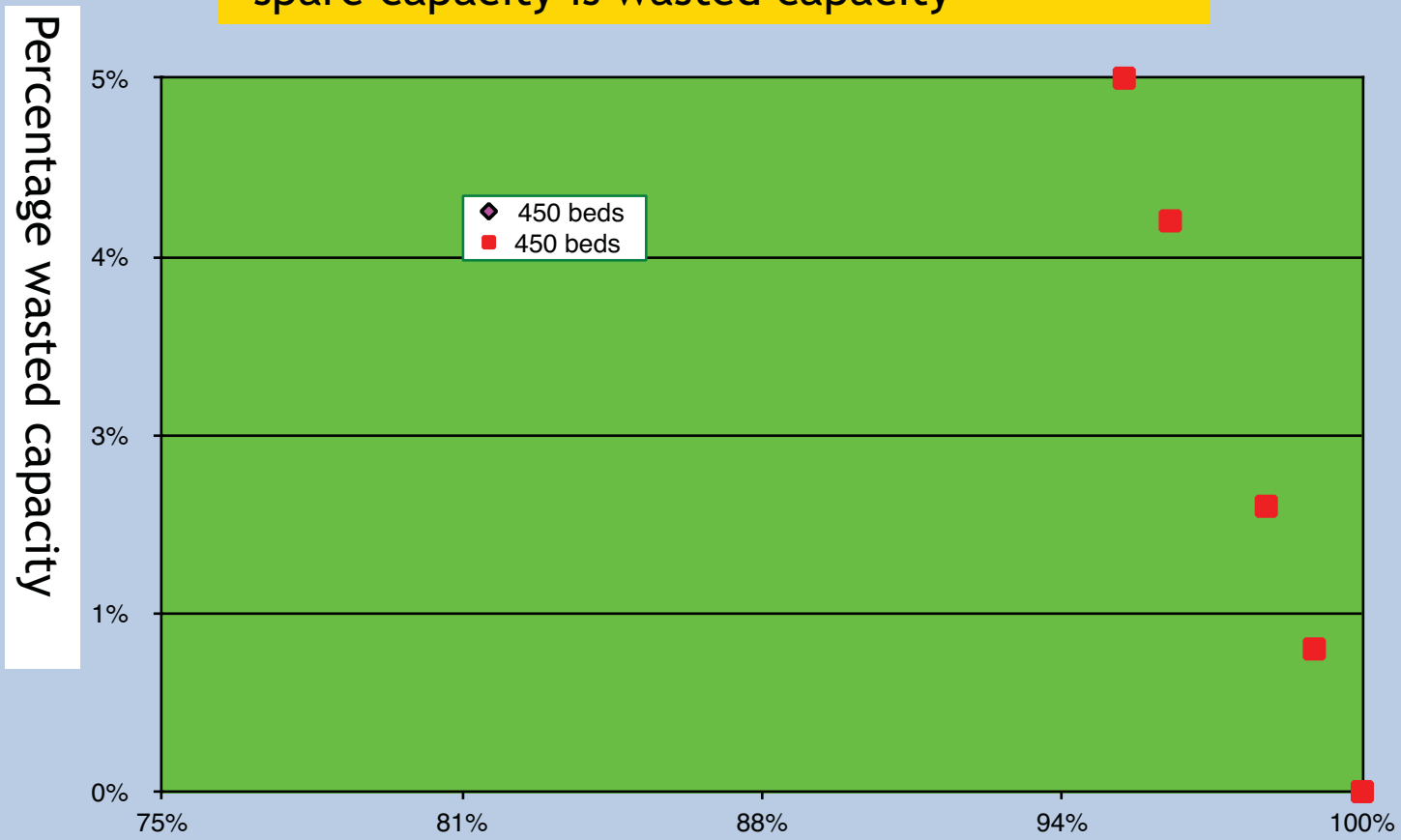
WARNING!

Poor
mental models
can be damaging to
health.

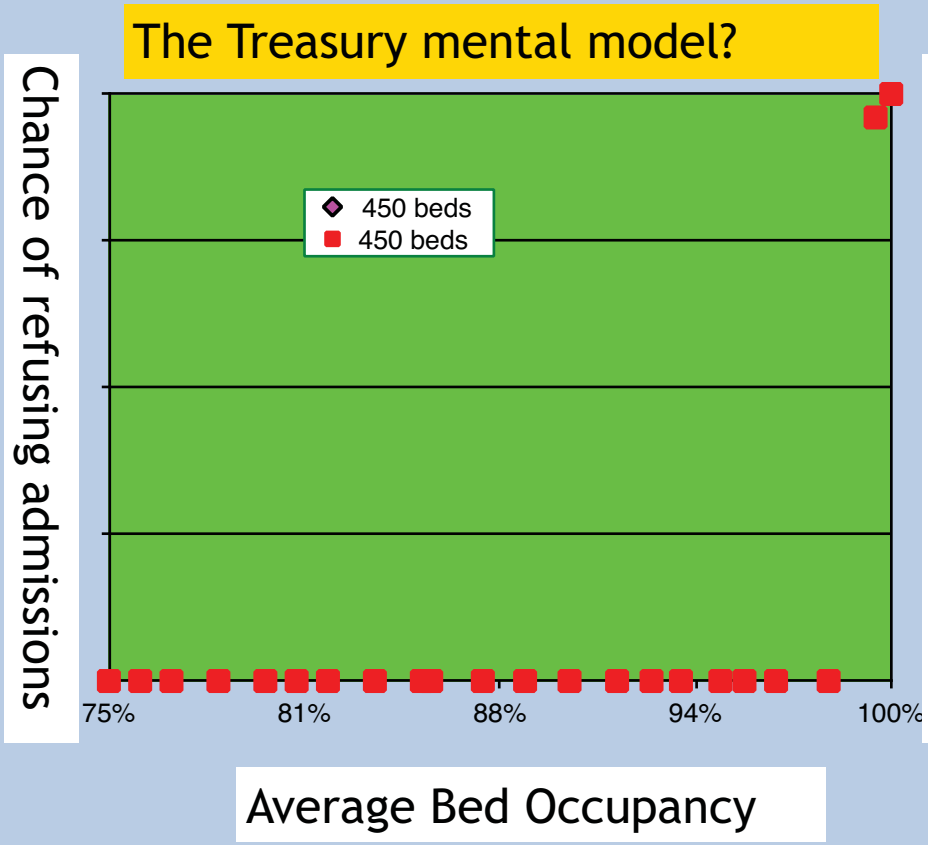
Exhibit 4 - the flaw of averages

A dangerous misconception about hospital bed occupancy

The Treasury mental model –
"spare capacity is wasted capacity"



Mental models were shifted by introducing the concept of the "price of responsiveness"



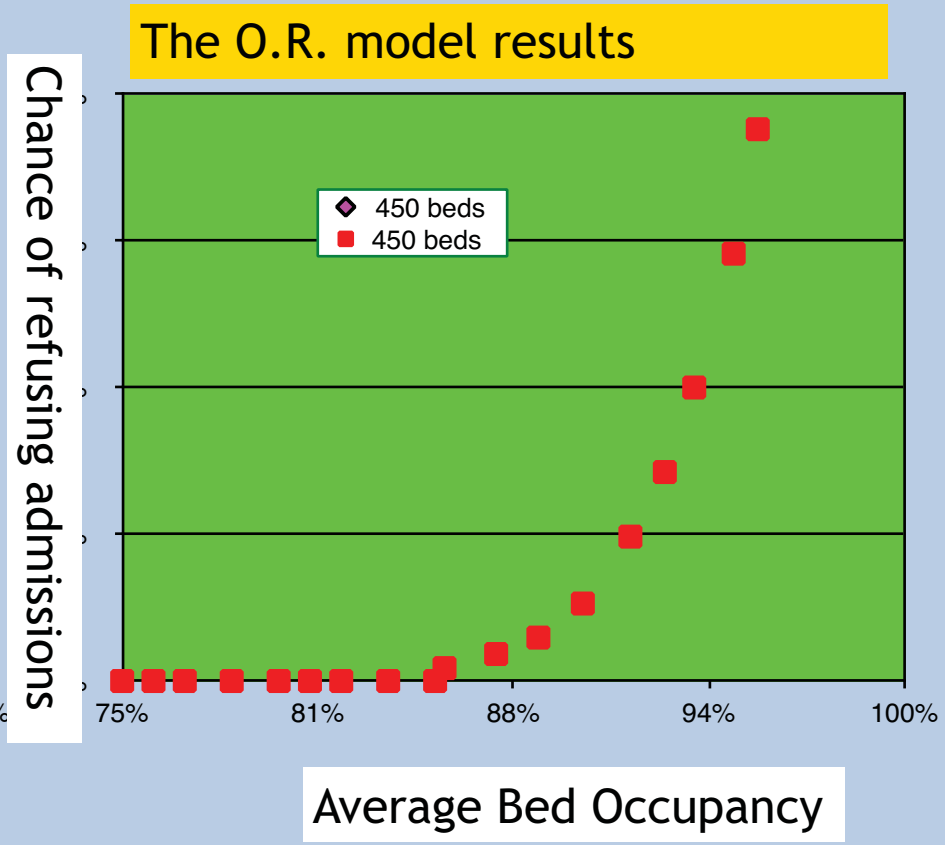


Exhibit 5 – risk misperception by clinicians

The fog of percentages and probabilities

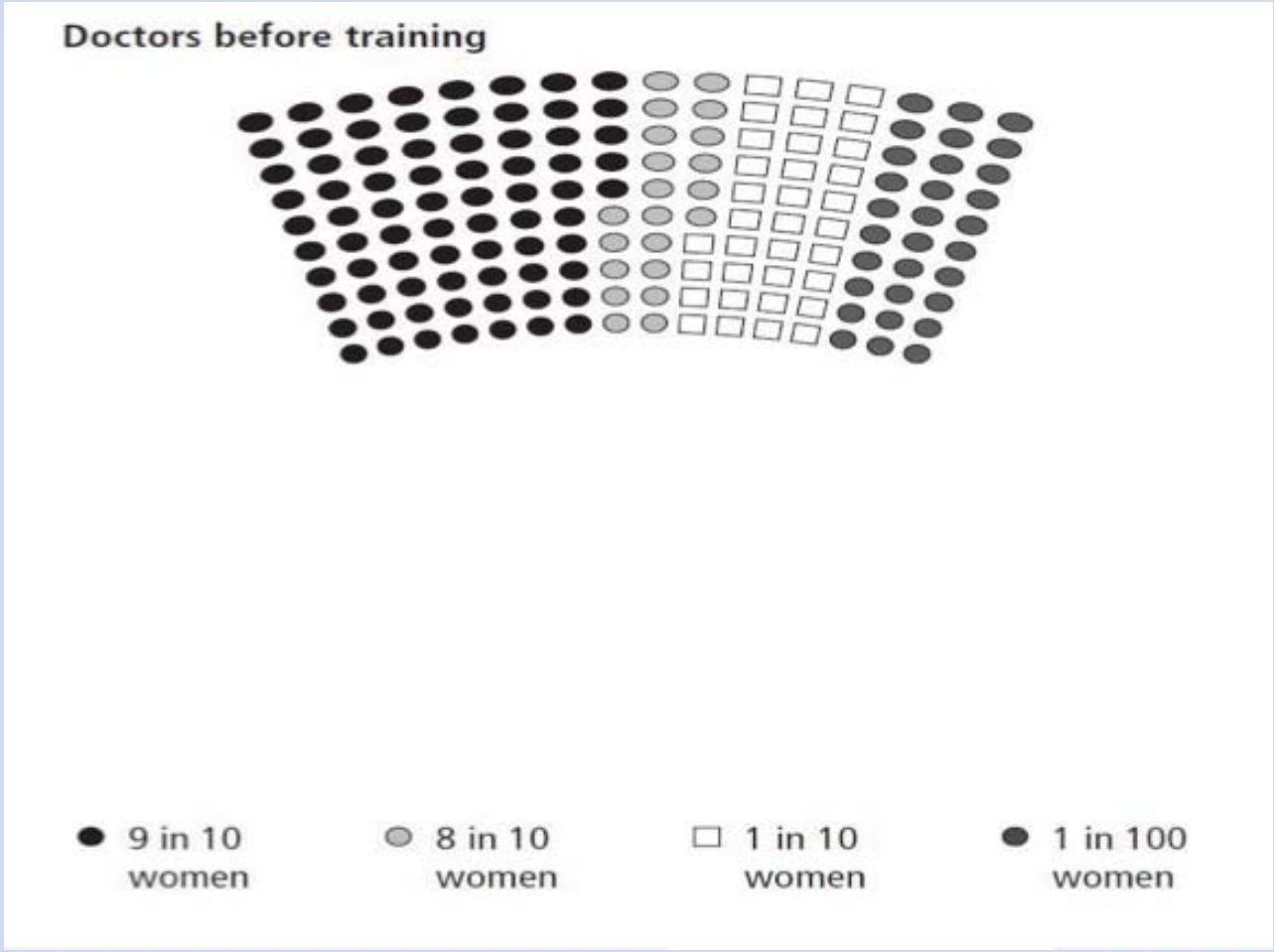
"About 1% of women in a particular group have breast cancer. If a woman has breast cancer the probability that she tests positive on a screening mammogram is 90%. If she does not have breast cancer the probability that she tests negative is 95%."

What are the chances that a woman in the group who tests positive actually has breast cancer?

Are they nearest to 90%, 80% , 10% or 1%?

Adapted from *Risk Savvy* G Gigerenzer 2013

Doctors' estimates of the risk varied considerably



Adapted from *Risk Savvy* G Gigerenzer 2013

A dangerous confusion

In the screening example many of the clinicians are confusing:

- *"what are the chances that someone with cancer will have a positive test"?*

with

- *" what are the chances that someone with a positive test has cancer?"*

Sensitivity and Specificity of Diagnostic Tests

	Patient does have the disease	Patient does not have the disease
Probability that the test indicates the disease is present ("positive" test)	Sensitivity (e.g. 90%)	False positive rate (e.g. 5%)
Probability that the test indicates the disease is absent ("negative" test)	False negative rate (e.g. 10%)	Specificity (e.g. 95%)

The standard way of calculating the risk - using sensitivity, specificity and Bayes' rule

Probability of having the condition, given a positive test *

=

Prevalence x Sensitivity /[Prevalence x Sensitivity+ (1-Prevalence)x(1 –Specificity)]

in this case:

Probability of having breast cancer, given a positive screening test = 0.01x0.9/[0.01x0.9 +0.99x0.05]

* this probability is known as "the positive predictive value " of a test.

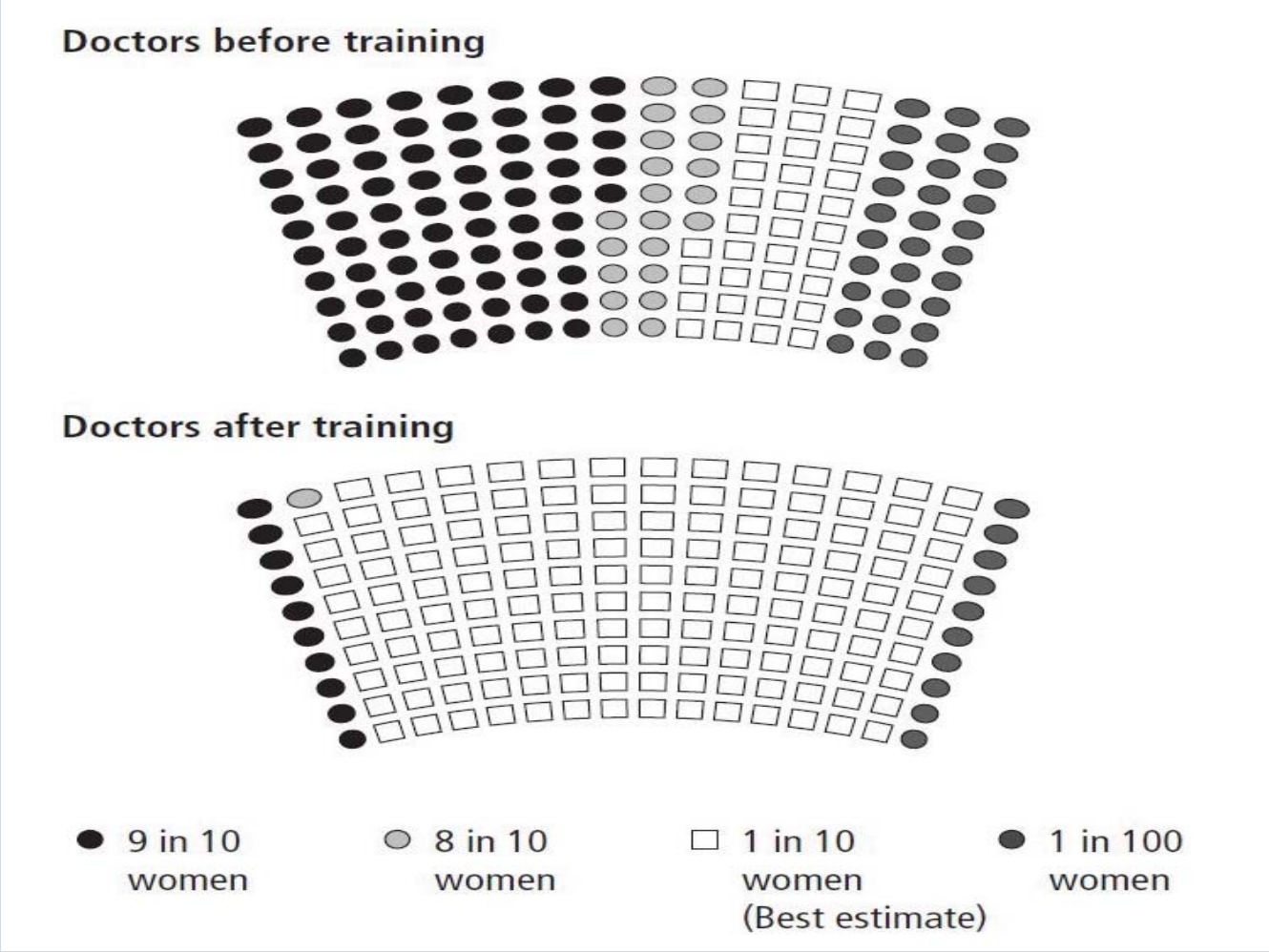
The easy way - using natural frequencies

"Of 1000 women in a particular group, 10 will have breast cancer. 9 of these will test positive for breast cancer on a screening mammogram and 1 will test negative. Of the other 990 women - who don't have breast cancer - 940 will test negative but 50 will test positive."

What are the chances that a woman in the group who tests positive actually has breast cancer?

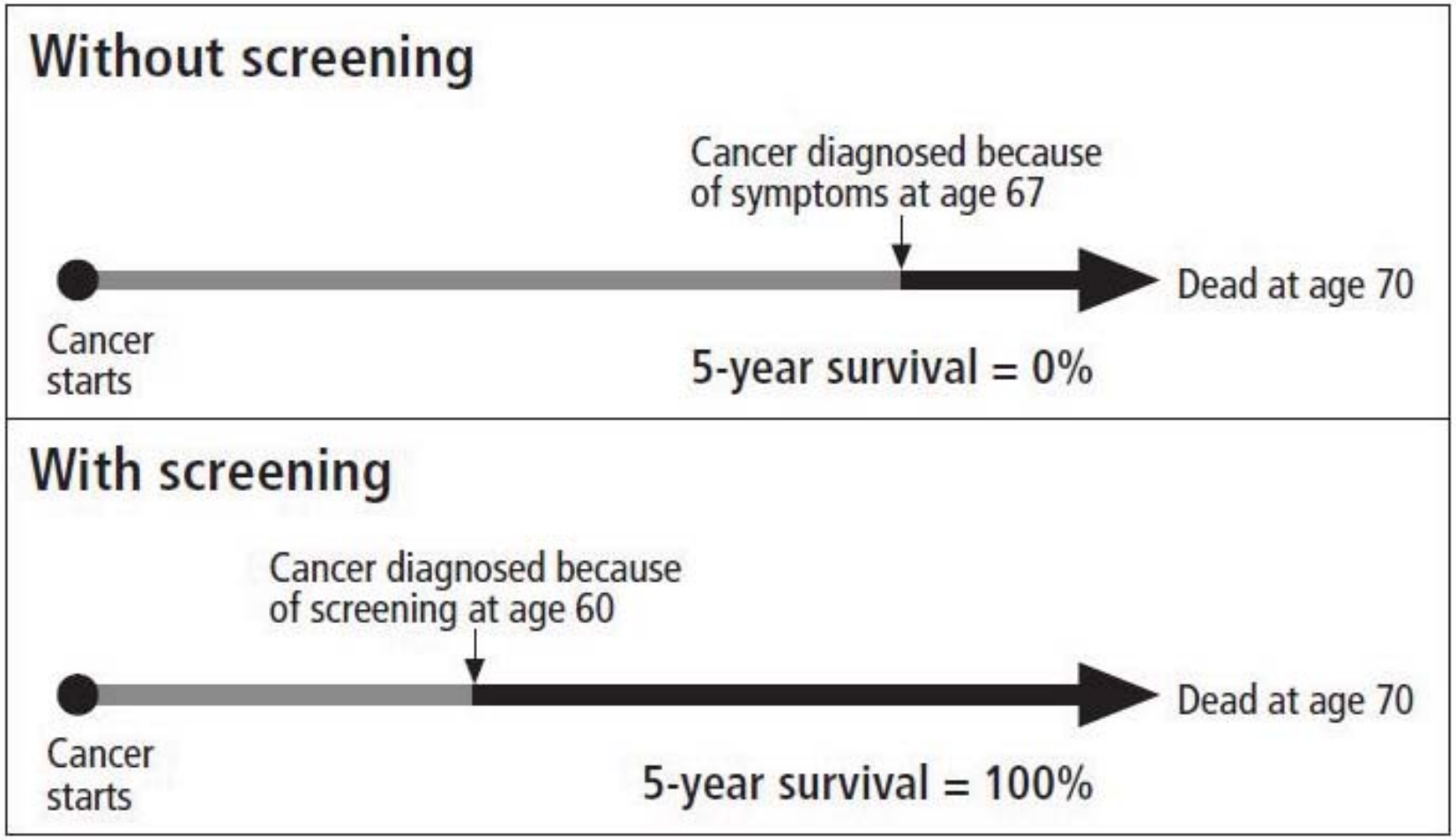
Adapted from *Risk Savvy* G Gigerenzer 2013

Training doctors in this approach works wonders!



Adapted from *Risk Savvy* G Gigerenzer 2013

Survival rates can be a misleading measure because of "lead time bias"



from *Risk Savvy* G Gigerenzer 2013

Do doctors understand survival rates ?

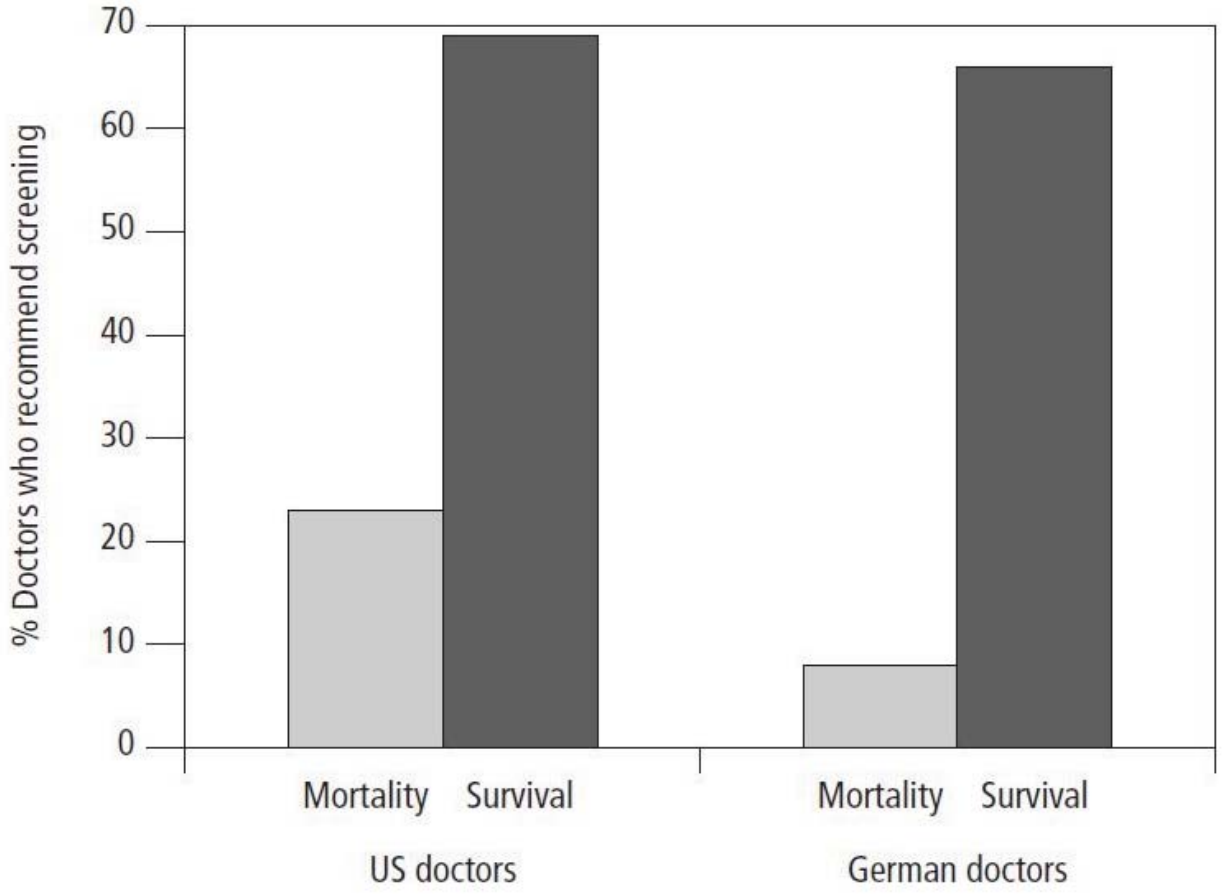


Figure 10-5. Do doctors understand five-year survival rates? Most do not. If the information is presented in terms of mortality rates, very few doctors recommend screening to their patients. If the same information is presented in terms of misleading survival rates, most recommend screening. Based on a national sample of 412 U.S. doctors and 65 German doctors.

from *Risk Savvy* G Gigerenzer 2013

Exhibit 6 – risk communication

What you don't know can hurt you – information often not provided about screening risks

TABLE 5-2: ***Information about mammography screening in 58 leaflets distributed by Australian health organizations.*** For instance, in 60 percent of the leaflets the lifetime risk of developing breast cancer was mentioned. (Adapted from Slaytor and Ward, 1998.)

Information	How often provided
Lifetime risk of developing breast cancer	60%
Lifetime risk of dying from breast cancer	2%
Survival of breast cancer	5%
Relative risk reduction of death from breast cancer	22%
Absolute risk reduction of death from breast cancer	Never
Number that must be screened to avert one death from breast cancer	Never
Proportion of screened women who would be examined further	14%
False negative rate, or sensitivity	26%
False positive rate, or specificity	Never
Proportion of women with a positive mammogram who have breast cancer (positive predictive value)	Never

from *Reckoning with Risk* G Gigerenzer 2002

A template for communicating about screening for breast cancer

Breast Cancer Early Detection

HARDING CENTER FOR RISK LITERACY

by mammography screening

Numbers for women aged 50 years or older who participated in screening for 10 years on average.

	1,000 women without screening	1,000 women with screening
Benefits		
How many women died from breast cancer?	5	4*
How many women died from all types of cancer?	21	21
Harms		
How many women without cancer experienced false alarms, biopsies or psychological distress?	–	100
How many women with non-progressive cancer had unnecessary treatments, such as complete or partial breast removal?	–	5

* This means that about 4 out of 1,000 women (50+ years of age) with screening died from breast cancer within 10 years – one less than without screening.

Source: Gøtzsche, PC, Nielsen, M (2011). *Cochrane database of systematic reviews* (1): CD001877. Where no data for women above 50 years of age are available, numbers refer to women above 40 years of age.

from *Risk Savvy* G Gigerenzer 2013

Communicating risk - relative or absolute?

The West of Scotland Coronary Prevention Study
Press release:

"People with high cholesterol can rapidly reduce their … risk of death by 22%, by taking a widely prescribed drug called pravastatin sodium."

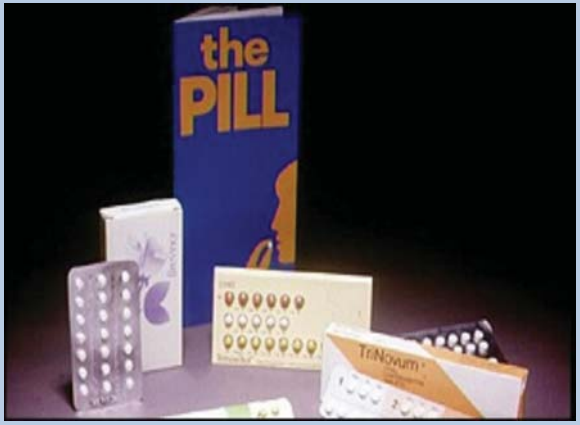
The study figures – not given in the press release - show that the 22% is the reduction in the *relative* risk of death.

Consider the following much less dramatic way of presenting the same results in terms of reduction in *absolute* risk :

"People with high cholesterol can reduce their risk of death in a five year period from about 4% to about 3% (an absolute reduction of about 1%), by taking a widely prescribed drug called pravastatin sodium "

What difference in prescribing behaviour do you think such a presentation of the results might have made?

See J-A Skolbekken, Communicating the risk reduction achieved by cholesterol reducing drugs, *BMJ* 1998 316;1956



The third generation pill scare was a result of confusion between relative and absolute risk


FREE 200 GLORIOUS SUMMER BULBS

The Mail

Lying Nazi shame MP, his Tory Party fiancee – and ANOTHER German uniform

Every GP in Britain told to warn about threat from popular contraceptive

DEADLY RISK OF PILL USED BY 1M WOMEN

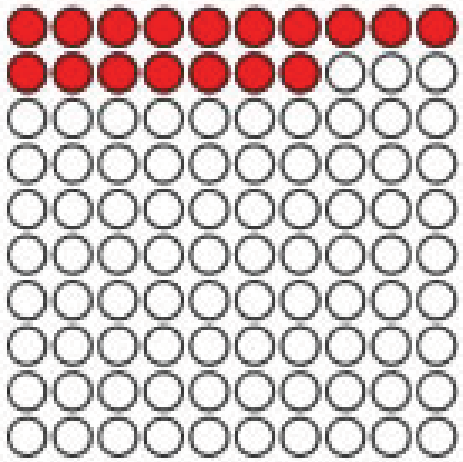
REVEALED: KATE'S ROYAL MAKEOVER

The papers screamed "new pill doubles risk of fatal thrombosis"

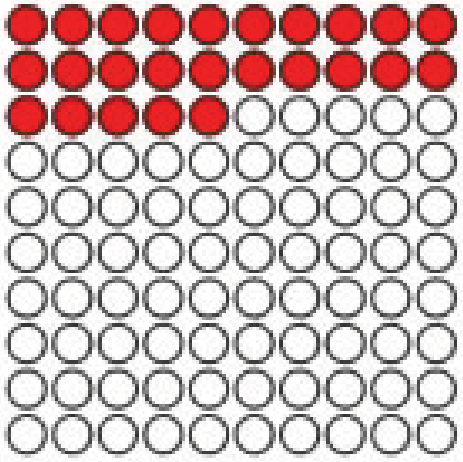
This mortality risk (possibly) had doubled - from about 2 per million women per year to about 4 per million

The scare has been estimated to have led to an extra 13,000 abortions in the UK alone

The sheet of a hundred (or a thousand) dots

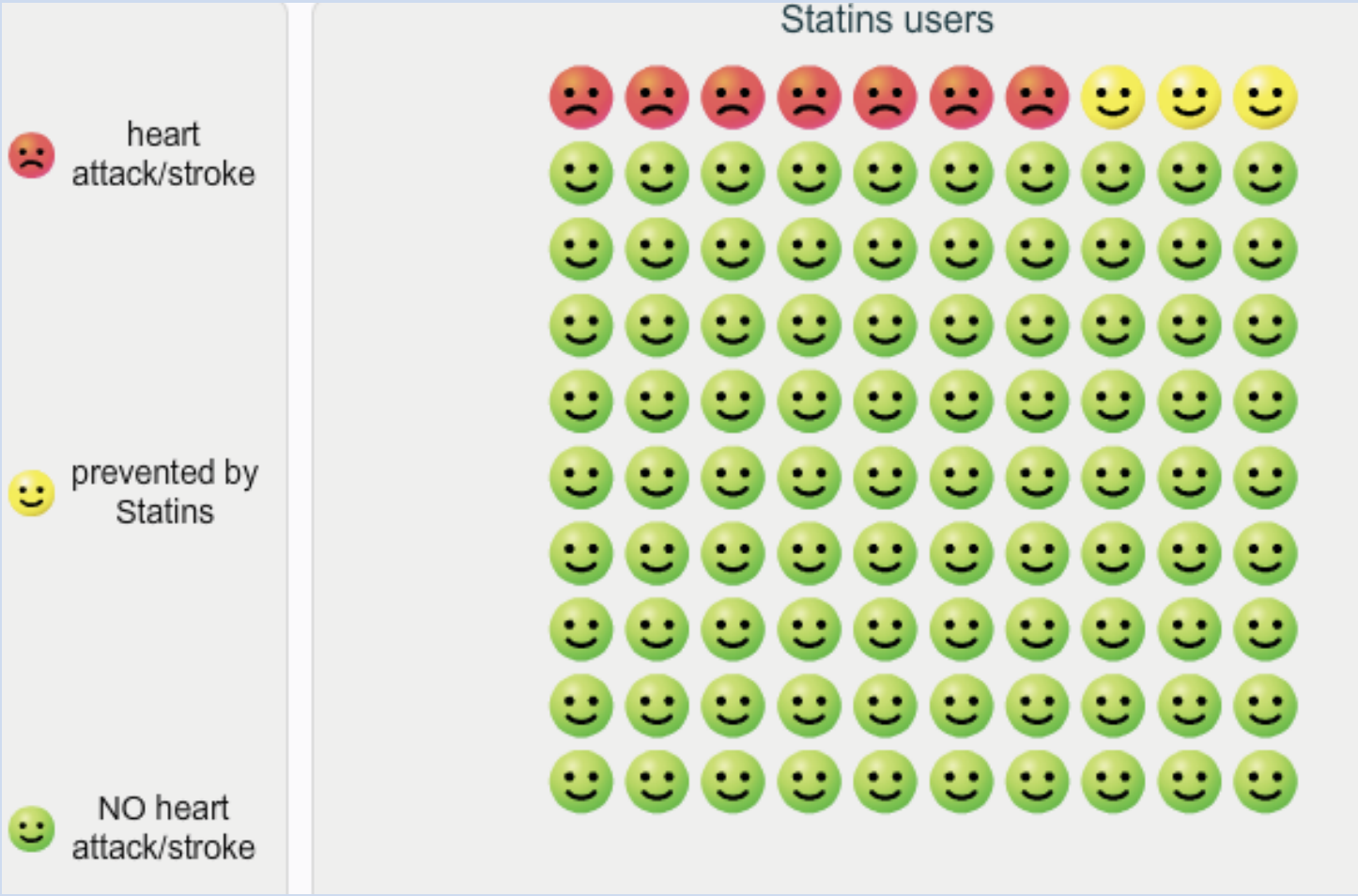


The chances are that 17percent of patients who have this surgery will lose feeling in their fingers.



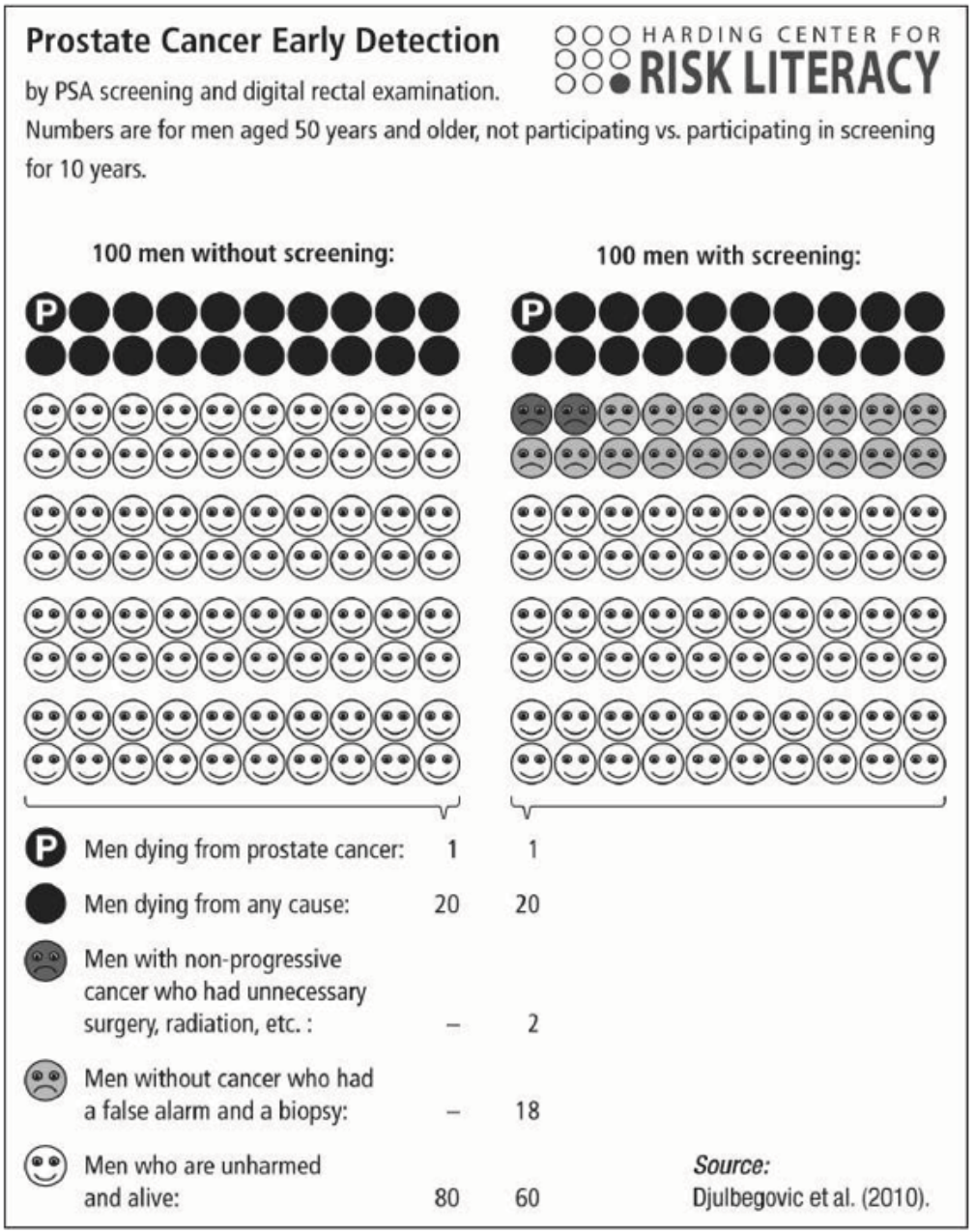
There is a 25 percent chance this drug will not help you.

Emoticons



From http://understandinguncertainty.org/

Use of these ideas in a patient leaflet about prostate cancer screening



from *Risk Savvy* G Gigerenzer 2013

New Worlds for O.R. in Health - Summary

1. A world in which we pay attention to the findings of the cognitive and behavioural sciences about decision making - to help keep health care models simple and relevant.

2. A world in which human behavioural factors are incorporated and integrated with the "physics" of health and healthcare models - to help ensure our models are realistic and compelling.

3. A world in which we pay much more attention to how our clients think about (model!) health and health care …..and how we talk with them about it - to help ensure our message gets across.


THANK YOU
geoff.royston at gmail.com