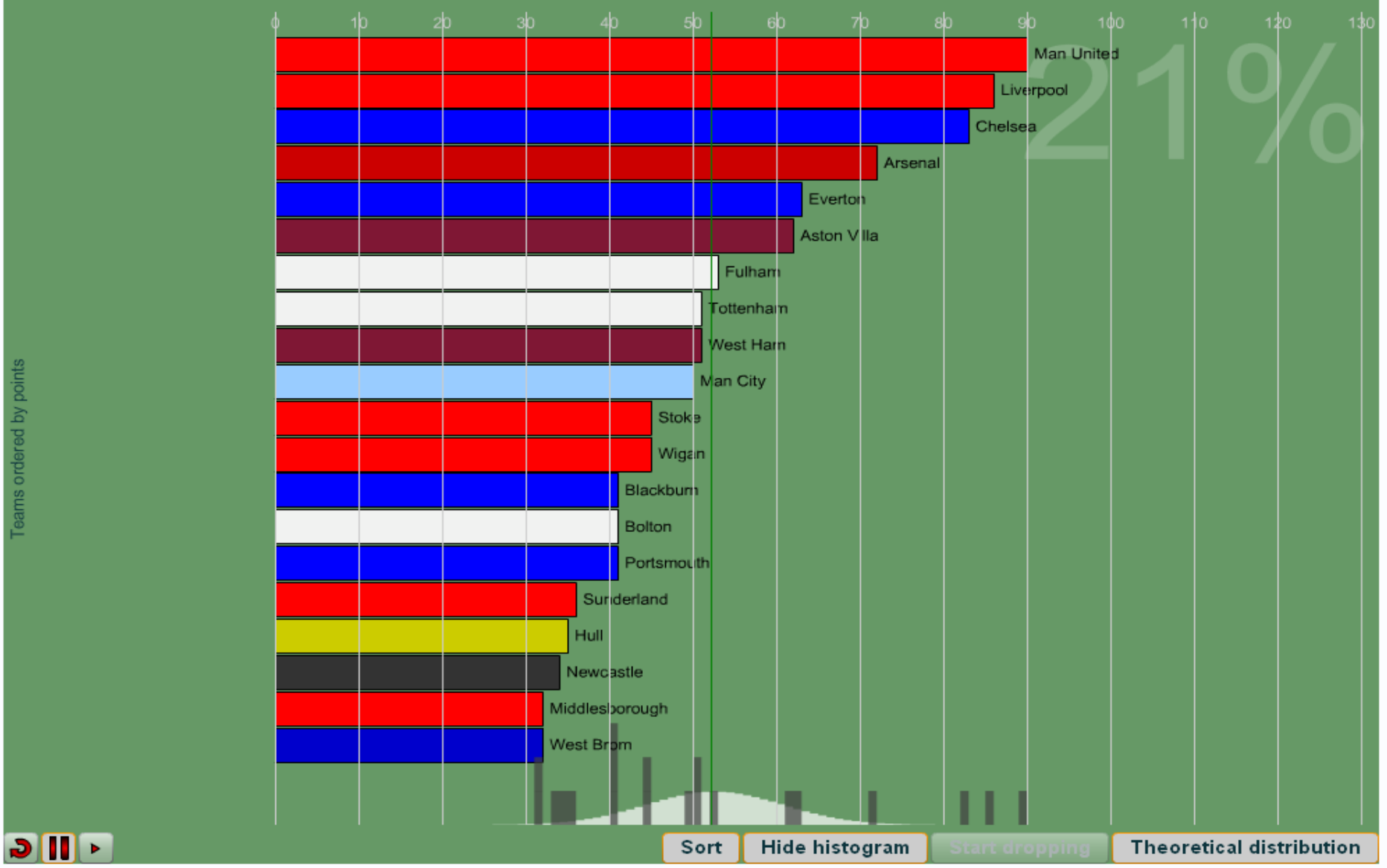


Match 380 (24/05/2009) Wigan v Portsmouth - home win Premier League 2008-2009



# Visualising Uncertainty

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David Spiegelhalter

*winton professor of the public understanding of risk,  
university of cambridge*

Alumni Weekend, Cambridge 2009

*With thanks to Mike Pearson, Ian Short, Hauke Riesch, Owen Smith,  
Arciris Garay, etc etc*

# Derren Brown leaves more questions than answers as he explains lottery trick



Derren Brown, the illusionist, left viewers with more questions than answers after the programme in which he promised to disclose how he predicted the winning National Lottery numbers.

By Lucy Cockcroft

Published: 7:00AM BST 12 Sep 2009



Derren Brown predicted the National Lottery numbers. Photo: CH

 Text Size 

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**News**

**UK News**

**Lucy Cockcroft**

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Indeed, this method was rubbish by mathematicians.

David Spiegelhalter, professor of public understanding of risk at Cambridge University, said: "There is a difference between guessing between the weight of an ox and guessing lottery balls, which is unguessable.

"this is just a clear wind-up and complete nonsense."

Find out which numbers have been drawn the most frequently, and which have been drawn the least. Despite the draws being totally random, some numbers have a habit of cropping up more than others, while others hardly appear at all! Please note, these results include the Lotto Bonus Draws held on 18th May 2002, 1st June 2002, 6th November 2004, and the £5 million jackpot-only draw held on 29th April 2006.

All numbers

Individual number

Game

Lotto

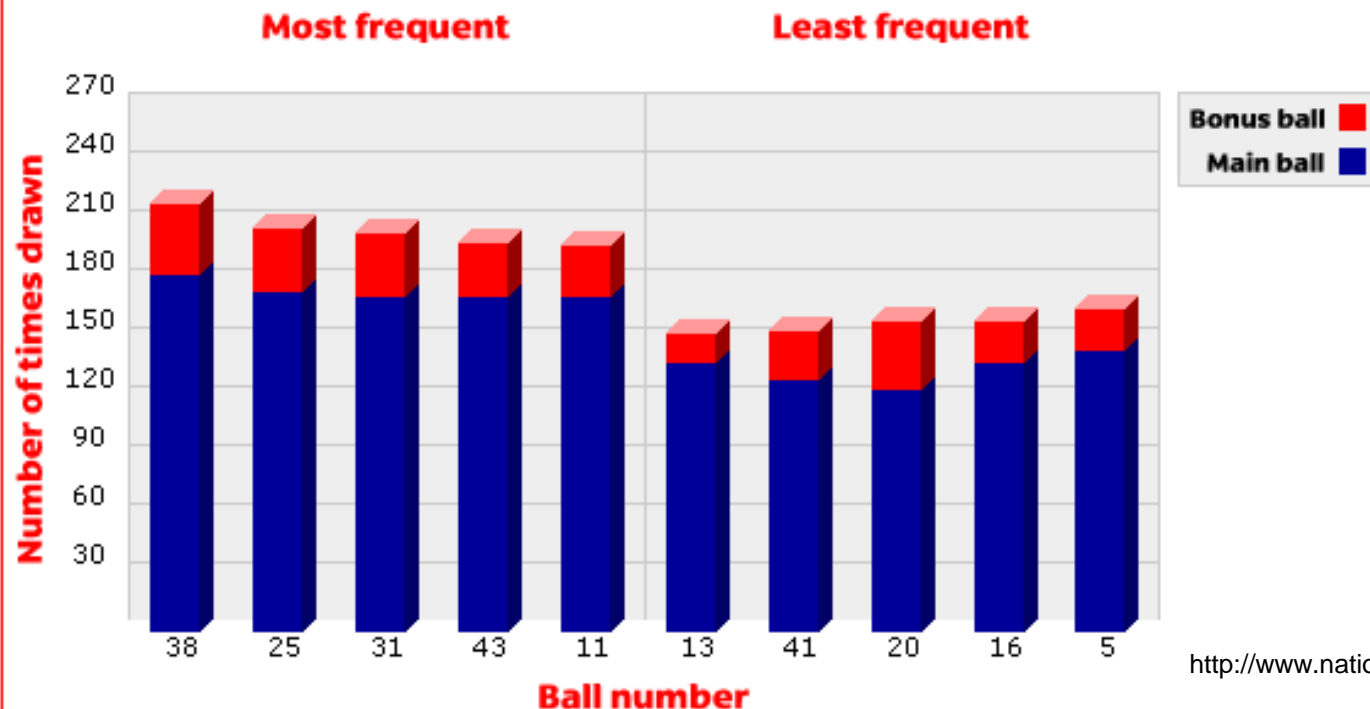
Time period

To Date

GO

lotto

## Five most and least frequently drawn balls



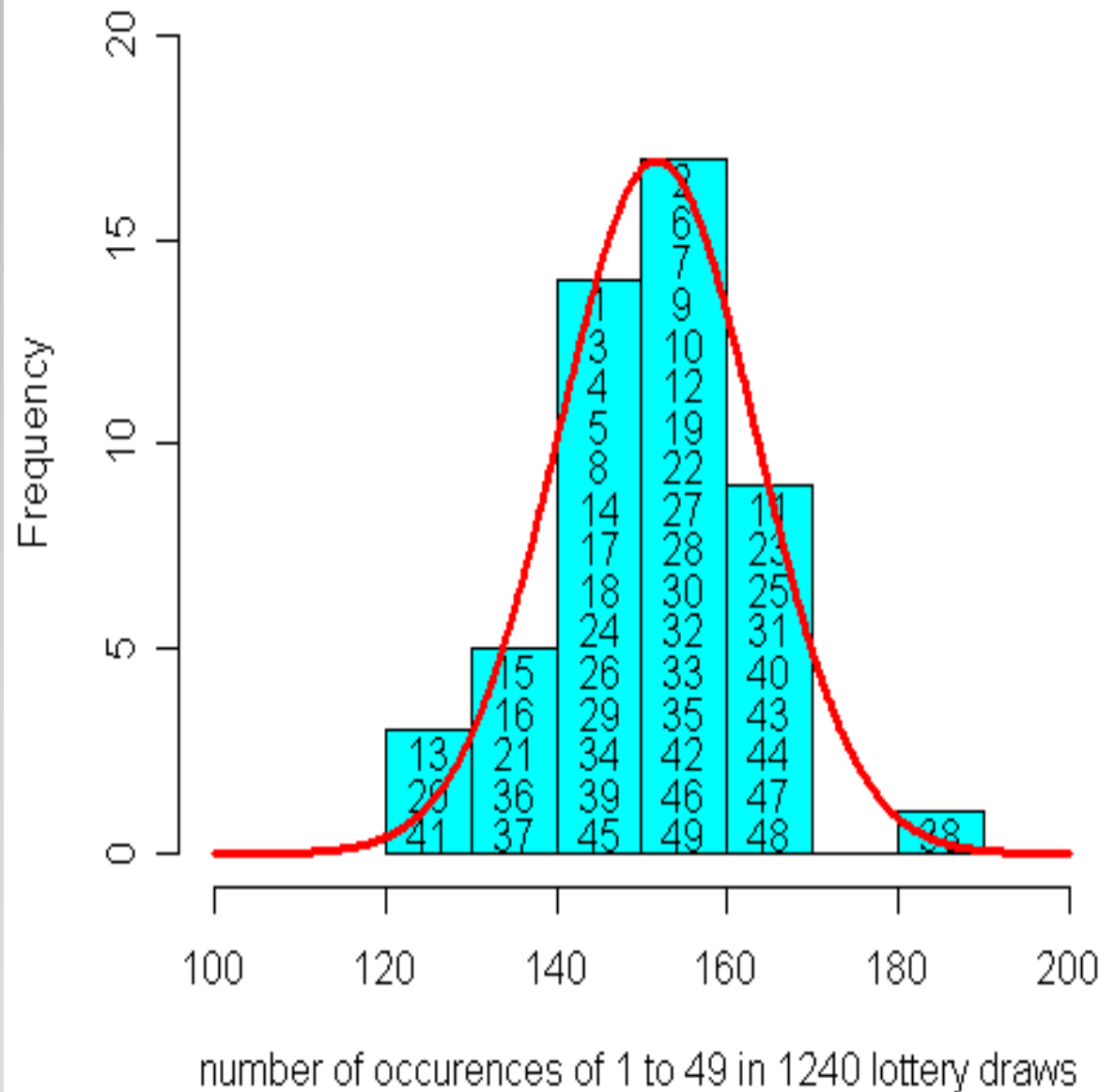
Week 1 1994-11-19

# UK Lottery Results

49  
40  
30  
20  
10  
1



Counts  
obey the  
rules of  
probability



# What is the Winton programme trying to do?

---

Improve the public handling of quantitative aspects of risk and uncertainty, through

- Educational lectures, workshops
- The 'Risk Roadshow'
- Website
- Engagement with media
- Working with people who want to communicate risk
- Inter-disciplinary research



## European Football - How much is chance?

Posted August 6th, 2009 by gmp26 in [level 1](#), [sport football](#)



*Is football just a matter of luck? Just because a team ends up top of the league, does it really mean it is the best team? We have taken most of the major league football games played in Europe since 1993 and created an animation that shows what happened in each league and how much of the apparent difference between the teams was due to chance alone.*

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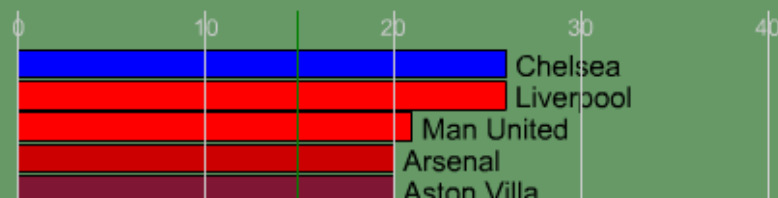


### Football Leagues

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Match 106 (01/11/08) Tottenham v Liverpool - home win

Premier League 2008-2009



 E-mail this to a friend

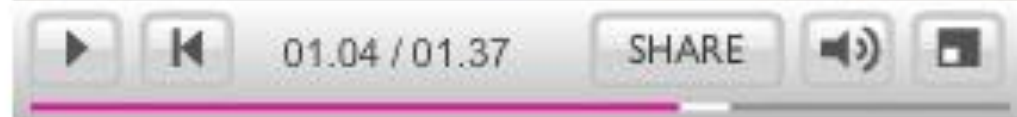
 Printable version

# Fears swine flu 'on the way back'

Swine flu looks to be on its way back, according to Sir Liam Donaldson, England's chief medical officer.

Figures showed that there were an estimated 5,000 new cases in England last week - up from 3,000.

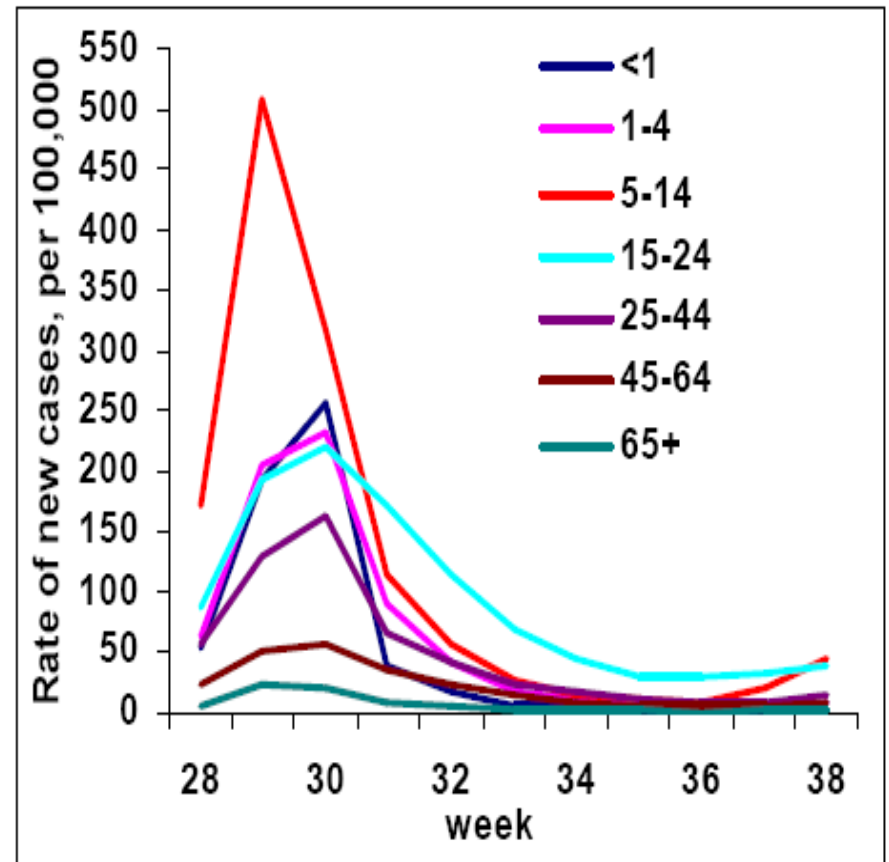
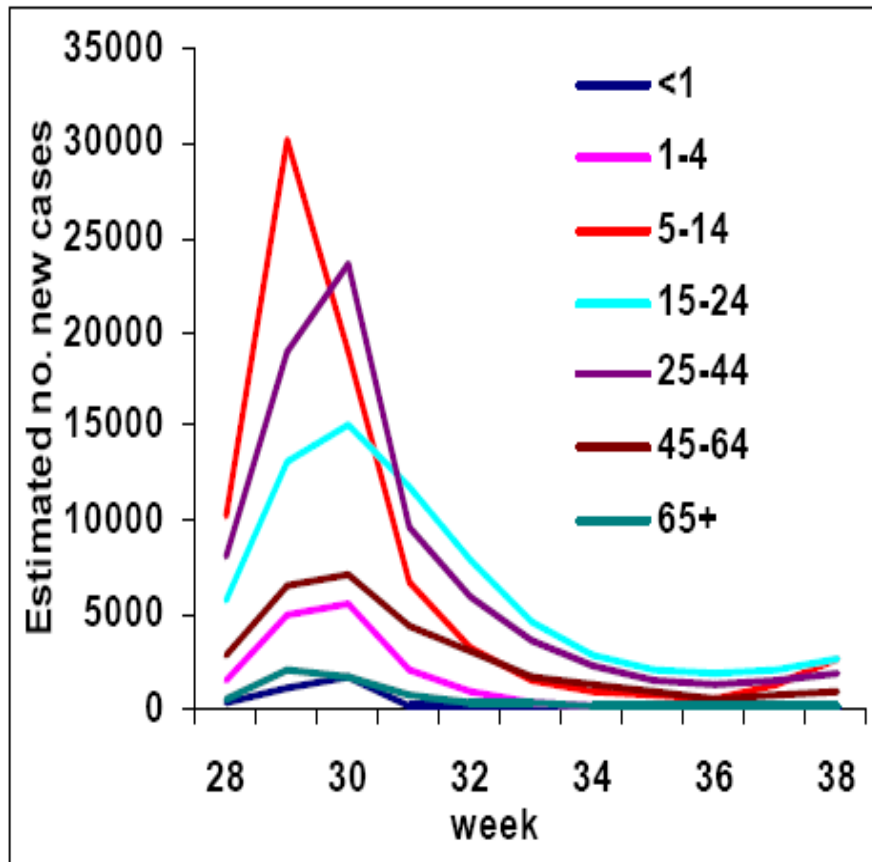
It is the first increase since the end of July, but the levels are still below what would be expected in a bad winter.



Sir Liam Donaldson: "We might be beginning to see the beginning of this second peak"

# Health Protection Agency (24<sup>th</sup> sept 2009)

Figure 10: Estimated number and rate per 100,000\* of new cases of pandemic influenza in England by week and age group.





Guadalajara, May 2009

# The risk of swine flu? I haven't a clue...

... writes a professor of risk. But I'm still sending my daughter in Mexico some Tamiflu

**David Spiegelhalter**



**I**t could have been designed to make me feel inadequate. I am a professor of risk, and when my daughter Rosie wanted to spend part of her gap year working on a newspaper, she chose, with a true nose for a story, to go to Mexico.

So it is assumed that I know the chances of her, and everyone else, getting or even dying of, swine flu. But I just don't know; risk is such an odd thing — no instrument can measure it but it constantly changes as we find out more information, just as the odds on Barack Obama being President oscillated wildly in the year before the election. What do we really mean by chance and risk anyway?

In some circumstances we can comfortably put a number on risk: if I spend £1 on a lottery ticket, I can calculate from the number of ways the balls can be drawn that there is a 1 in 14 million chance of winning the jackpot. Doing the sums for swine flu is a different matter: a heavenly compere doesn't pull balls with our names on out of a large bag, so epidemiologists resort to computer models of how epidemics work.

But instead of just having pure, unavoidable chance, ignorance of the mechanics of the epidemic starts to dominate the calculations. It's a bit like trying to work out the odds of

winning the lottery when you don't know how many balls there are.

The shape of the epidemic would be a lot more predictable if we knew all about this virus, and in particular something called the "reproductive number", which is how many people each case is expected to infect in an unaffected and unprotected population. For example, each case of measles would be expected to infect twenty people, which is why the fall in MMR vaccinations is viewed so anxiously; for smallpox it's about five and Sars about three.

Epidemiologists and insurers are rushing to estimate this quantity from the limited data: for this virus, it seems to be less than two, so a bit of effort might push it below the magic threshold of one, when the epidemic should disappear.

Meanwhile, my girl in Guadalajara reports that nobody there seems to care much about the reproductive number, and the lack of any clear information has brought a mixture of blind terror and indifference. For every few people not wearing masks someone is wearing four at once, just in case. And it's never long before the wearer's intrinsic Mexican-ness overrides instructions and face masks are yanked down to kiss a cheek or smoke a cigarette. The masks sold out completely on the second day of the scare, leading many people to fashion their own from dishclothes and bits of string.

The health minister in Guadalajara has only just admitted that there may possibly be some local cases, whereas in the UK the papers are providing full histories of every



## Rosie reports that for every Mexican without a mask, another has four

contact — invaluable information for the epidemic model. But our ignorance goes beyond not knowing how infectious the virus is and the proportion of cases that die — the virus could mutate or, the feared outcome, join with avian flu to create a new strain: despite the opportunities for flying-pig jokes, this would be no laughing matter.

At least we can think of these possibilities and weigh them up, inevitably using a lot of judgment stirred in with the science. But our journey through ignorance can lead into the pitch-black of deep uncertainty — Donald Rumsfeld's unknown unknowns. It can be disastrous to believe that you have thought of everything — it seems

clear that a big reason for the financial crisis was a belief that risk models were somehow "true" and that the world really worked according to the rules, and there was no preparation for when events did not fit the model.

So we need some humility and to admit that we may be wrong. Pundits may mock the level of uncertainty that says the eventual UK body count could be none or could be a million, but that is simply an expression of honest ignorance. The need is to have emergency systems that are precautionary at first, and then rapidly adapt to new knowledge obtained from good data. Deciding which vaccines to prepare for the winter flu season will require a delicate balance of risks and benefits — a real gamble in the face of uncertainty.

And even if a judgment is inevitable, the reasoning should at least have some science behind it, unlike Egypt's slaughter of the innocent pigs. Perhaps even that is better than the conspiracy theories circulating in Mexico, inviting us to believe that the virus was introduced by the Americans, the pharmaceutical industry or to distract attention from the drug cartels.

Anyway, my gut feeling is that the chances we will see the girl again are looking quite good. But we've sent out Tamiflu just in case.

**David Spiegelhalter is Winton Professor of the Public Understanding of Risk at the University of Cambridge. Rosie Spiegelhalter is sticking it out in Mexico**

# Flipping coins



# Two types of uncertainty

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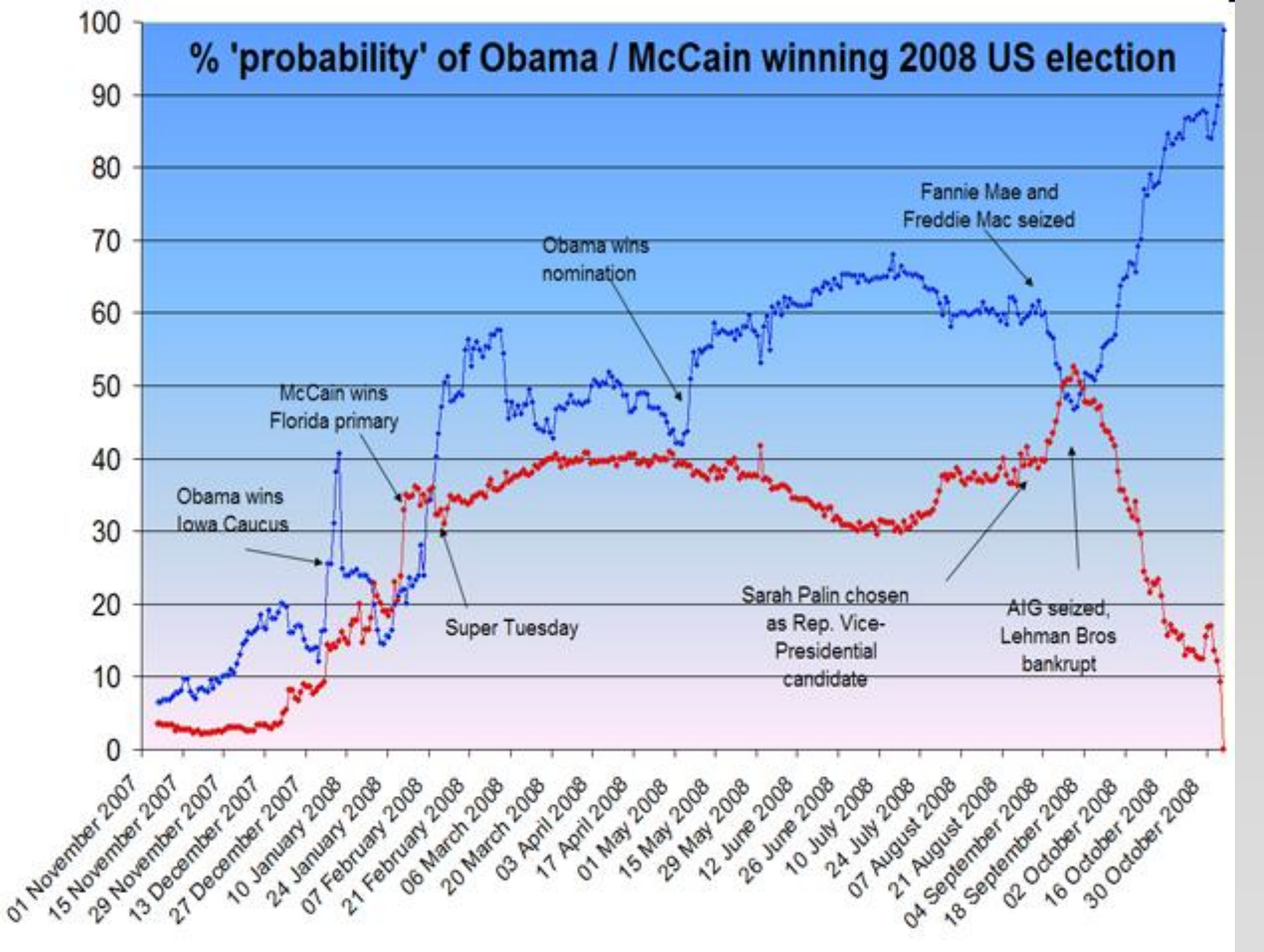
## *Aleatory*

- chance, unpredictable

## *Epistemic*

- lack of knowledge,  
ignorance

# % 'probability' of Obama / McCain winning 2008 US election



# Want to bet? (January 2008)

<http://www.williamhill.com/>



Account Username :

Password :

Login

Lost Your Lo

Bet Finder : **U S Presidential Election 2008**

Fractional Odds

Politics : U S Presidential Election 2008

Bet Until : 17:00 01/11/2008

Who will win the 2008 US Presidential Election?

Multibet	Competitor	Price	Unit Stake
<input type="checkbox"/>	Hilary Clinton	1/1	<input type="text"/>
<input type="checkbox"/>	Barack Obama	5/1	<input type="text"/>
<input type="checkbox"/>	Rudolph Giuliani	5/1	<input type="text"/>
<input type="checkbox"/>	Fred Thompson	6/1	<input type="text"/>
<input type="checkbox"/>	Al Gore	7/1	<input type="text"/>
<input type="checkbox"/>	Mitt Romney	14/1	<input type="text"/>

# Some epistemic uncertainties about swine flu

---

- Infectiousness (' $R_0$ ')
- Severity ('case fatality ratio')
- Risk of recombination with other flu viruses
- Resistance to anti-virals
- Pattern of re-emergence
- Vaccine effectiveness and side-effects
- etc

# Government response?

---

- Try to appear calm, consistent, concerned
- Fronted by CMO and not politicians
- Standard approach in face of major epistemic uncertainties

*Precautionary*

# Government response?

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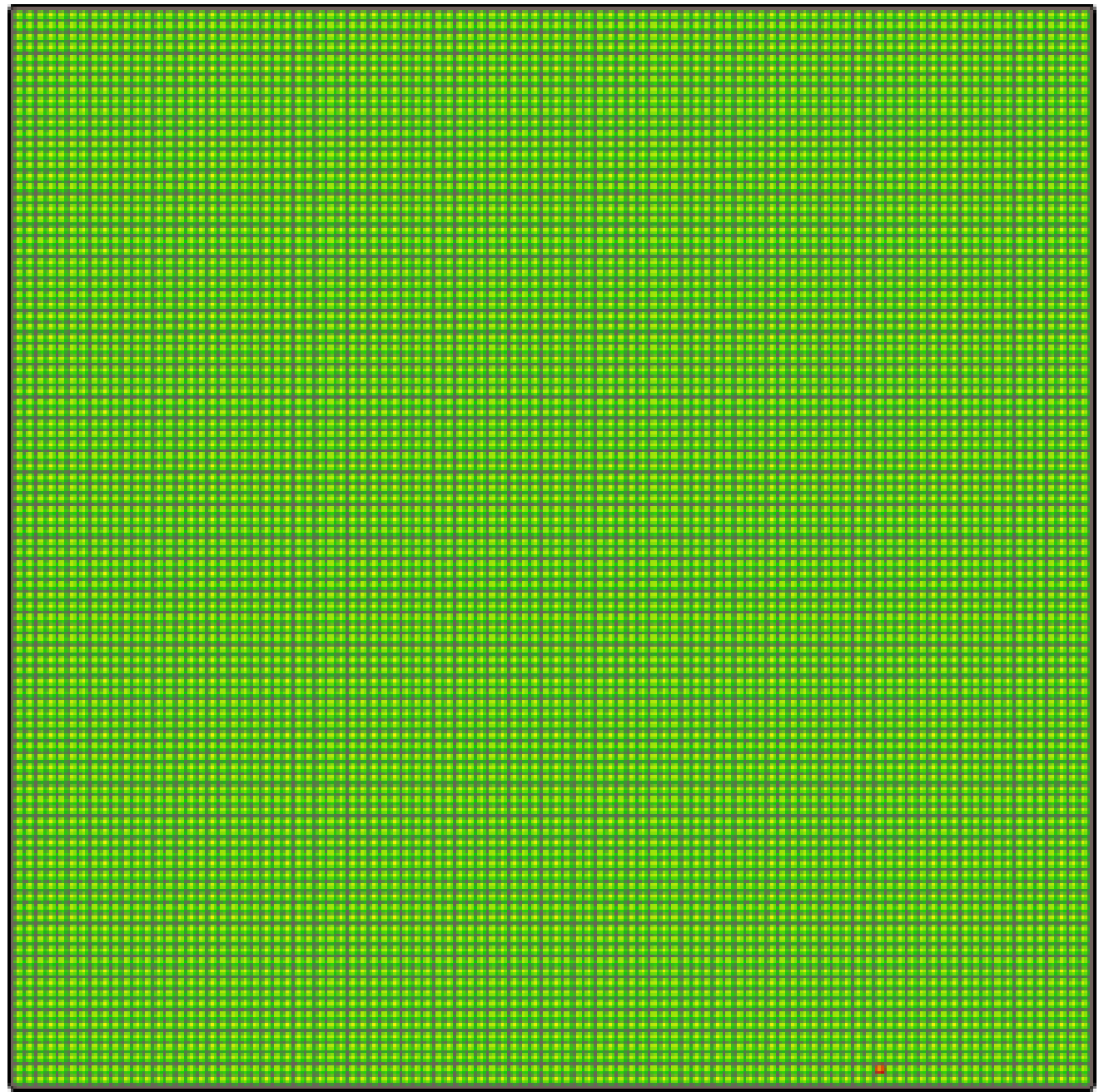
- Extensive use of mathematical models to inform policy (with many assumptions)
- 'Worst case scenarios'
  - 65,000 deaths (July)
  - 19,000 (3<sup>rd</sup> Sept)
- Based on 30% clinical cases, of which
  - 1/100 hospitalised
  - 1/400 need intensive care
  - 1/1000 die

# Is this big or small?

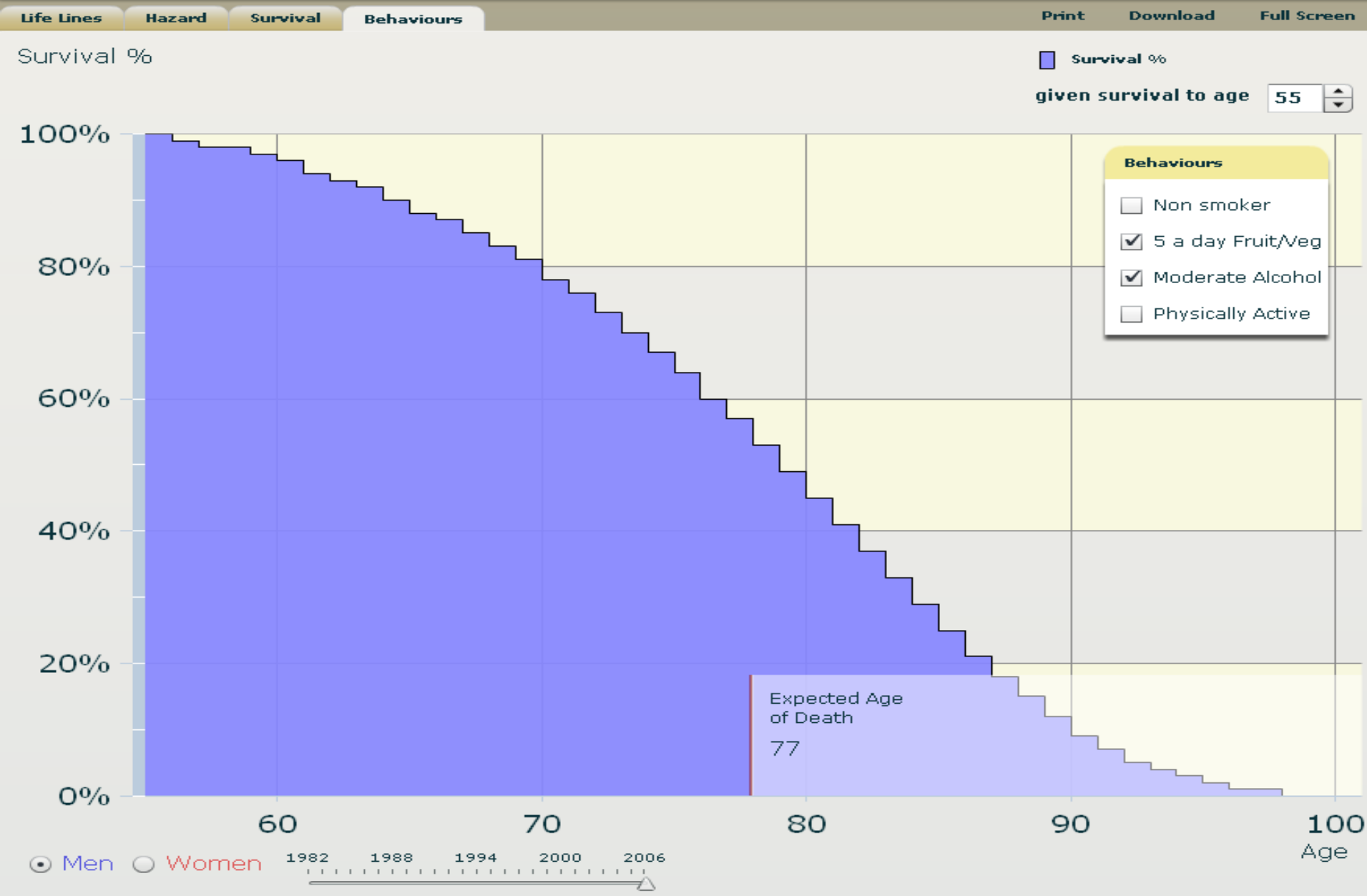
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- Suppose 20% clinical attack rate, 1/2000 case fatality, so 1 in 10,000 die across all ages
- On average, chance of dying each year (women) is
  - aged 80: 1 in 20
  - aged 60: 1 in 200
  - aged 40: 1 in 1,000
  - aged 20: 1 in 4,000
  - aged 10: 1 in 10,000
- Would double childhood deaths
- Back to rate in 1980

10,000 10  
year-old  
girls



1 death  
before  
aged 11



# How do people respond to risk?

---

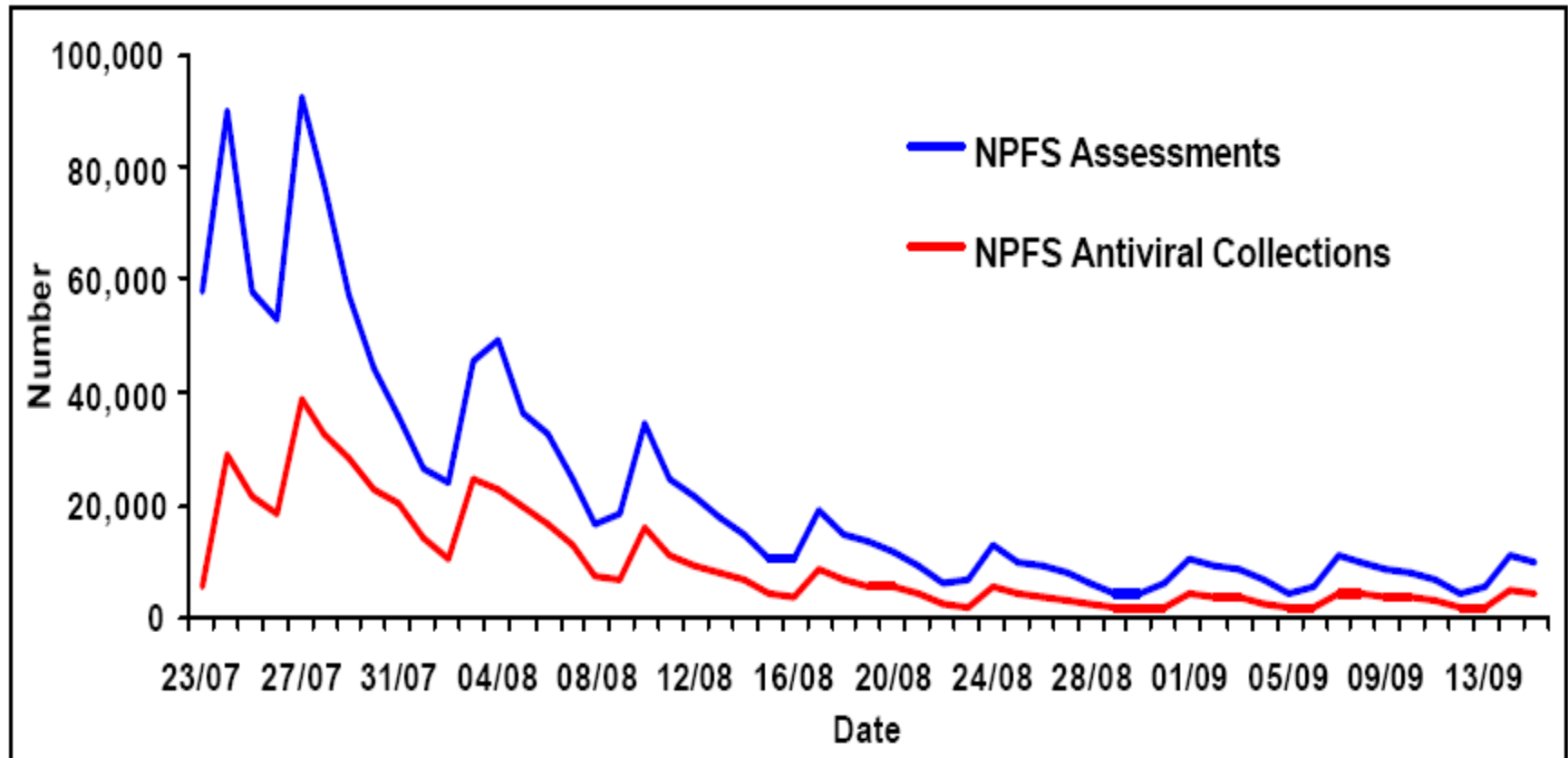
Personal responses dominated by

- Emotion and personality
- Personal experiences
- Feelings of control / imposition
- Trust (or lack of it) of authority
- Familiarity / 'dreadness' of hazard
- 'Innocence' of victims

'Probabilities' are largely ignored

# Use of National Pandemic Flu Service

Figure 6: Daily number of assessments and antivirals collected, through NPFS England.



# Use of National Pandemic Flu Service

(week ending 17th September)

---

- Of 324 swabs returned, 32 were positive for H1N1
- Official assumption: 95% of people receiving Tamiflu from NFPS do *not* have swine flu
- Unofficial reaction:
  - tendency to believe symptoms are due to swine flu
  - may delay and distract ('availability bias')

# Vaccination

---

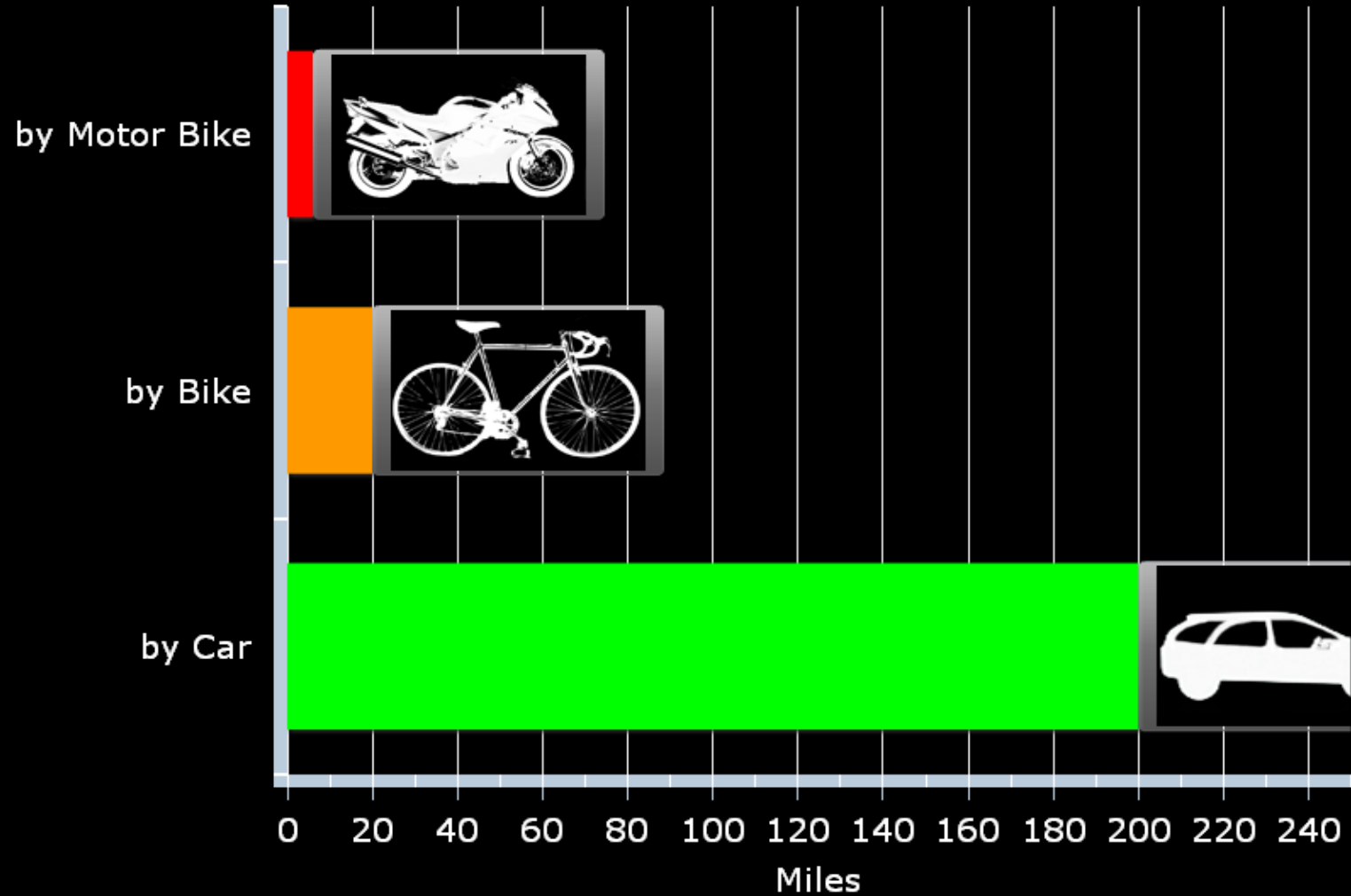
- Will people be willing to be vaccinated?
- Official line: *it's safe*
- People: balancing uncertainties about swine flu with uncertainties about vaccine
- May not be convinced unless perceive possible severe consequences of swine flu for themselves or others

# “*What are the risks?*”

---

- Need a friendly unit of deadly risk
- A ***Micromort*** is a 1-in-a-million chance of dying
- Each day 50 people die of *non-natural* causes in England and Wales (about 50 million)
- So we (on average, in good health) experience a micromort every day

# How far can you travel per micromort?

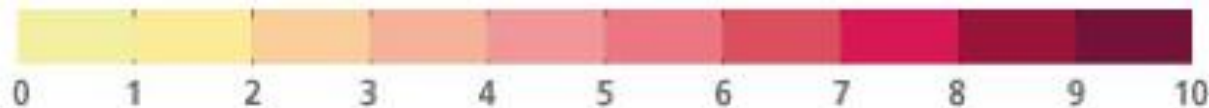


Micromort animation:

# Ways of spending a micromort

---

- Hang-gliding?  
~ 8 each trip
- Scuba?  
~ 5 each dive
- Horse-riding?  
~ 0.5 each ride
- Taking ecstasy?  
~ 1 each tablet
- Being admitted into hospital?  
~ ??? ?



**Change in winter mean temperature (°C) Medium emissions**

**2020s**  
**90% probability level:**  
**very unlikely to be greater than**

[Link to customisable version](#)



**2050s**  
**90% probability level:**  
**very unlikely to be greater than**

[Link to customisable version](#)

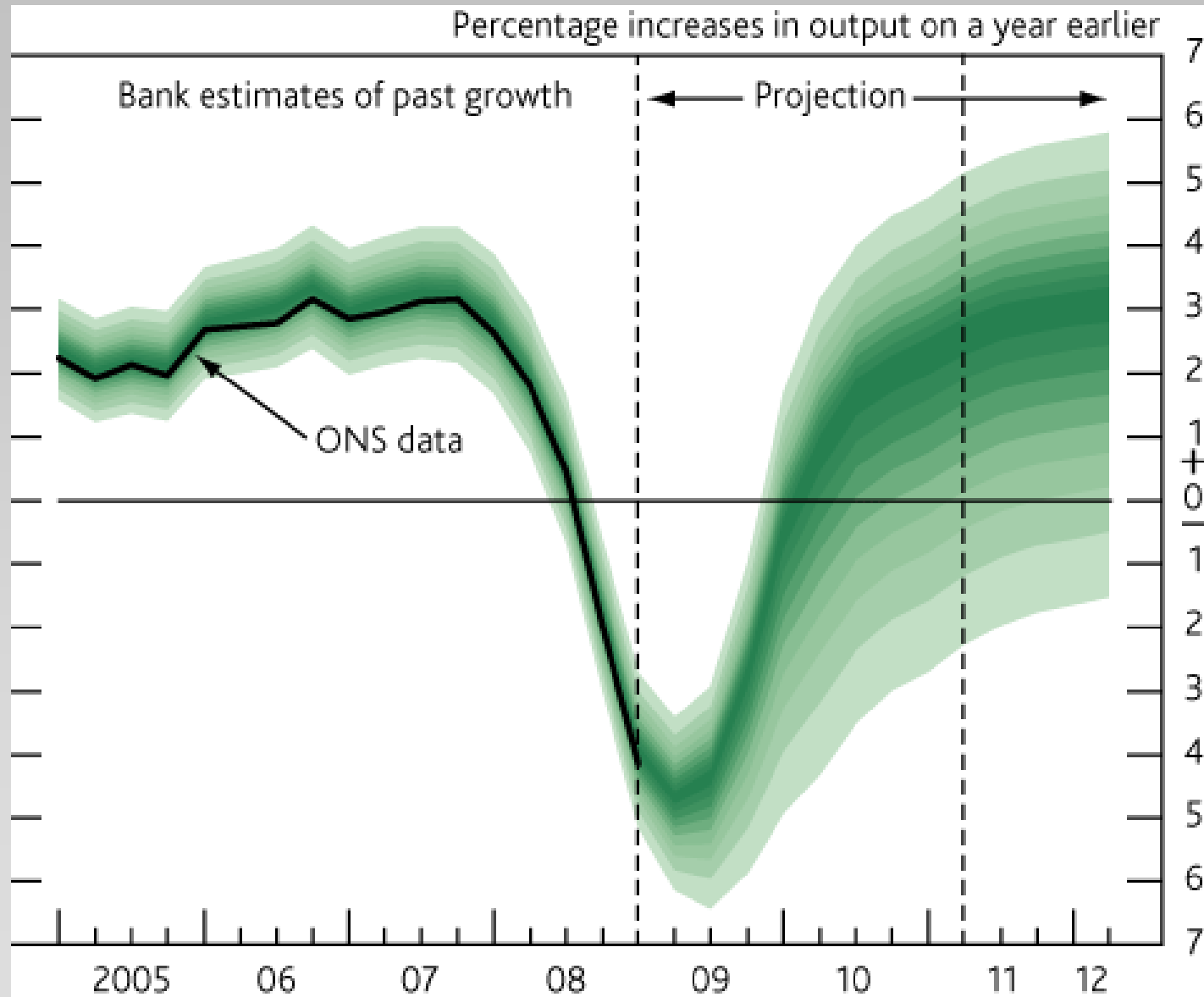


**2080s**  
**90% probability level:**  
**very unlikely to be greater than**

[Link to customisable version](#)

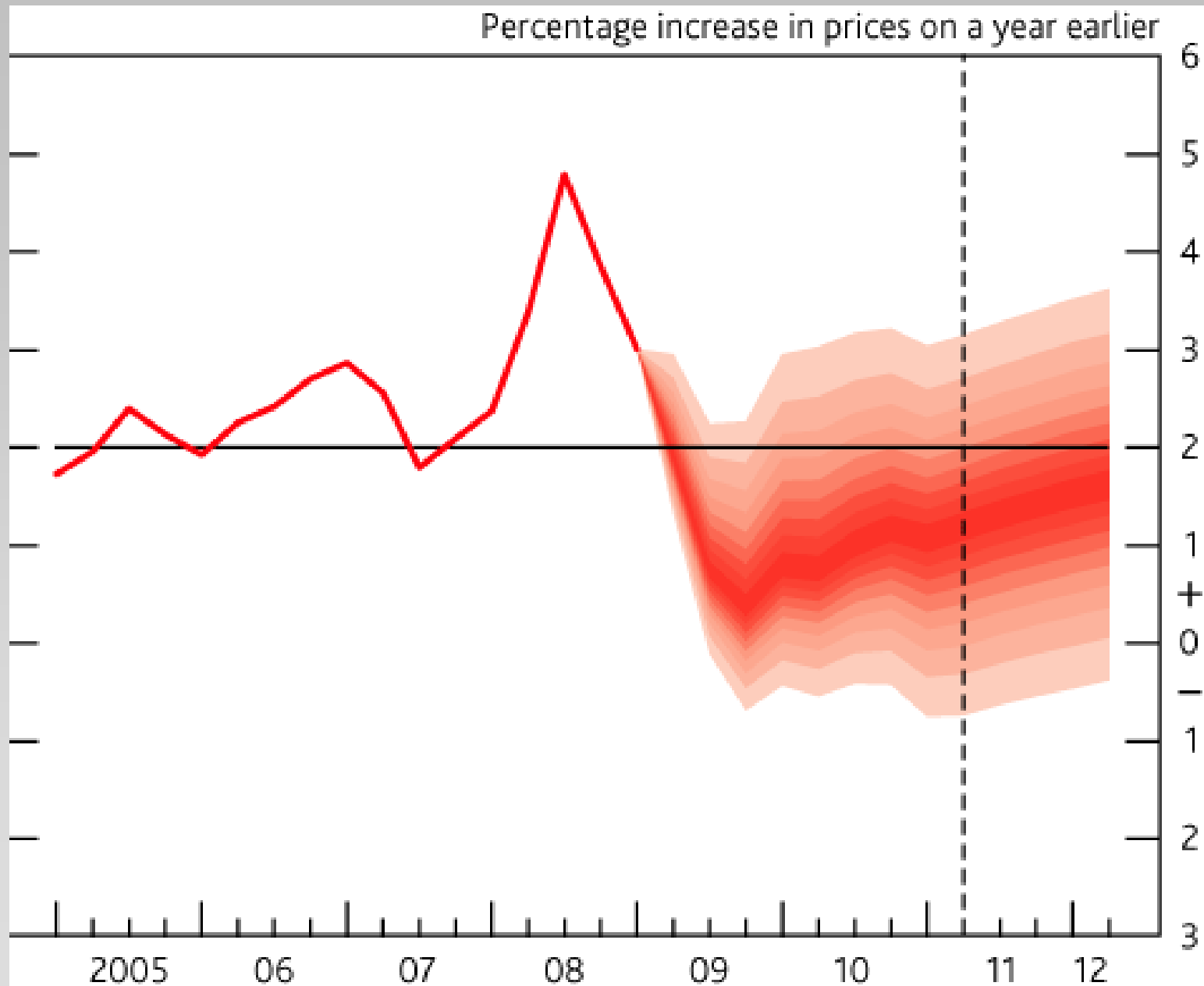


# Express as a probability distribution, such as Bank of England fan charts for GDP



May 09

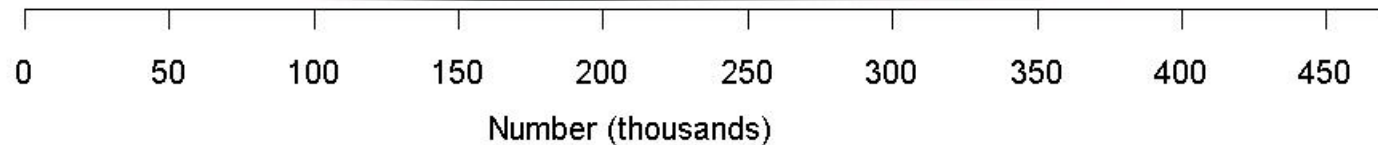
# Bank of England 'fan charts'



May 09

# Hepatitis C prevalence in UK

**Total**



**Contribution by risk-group**

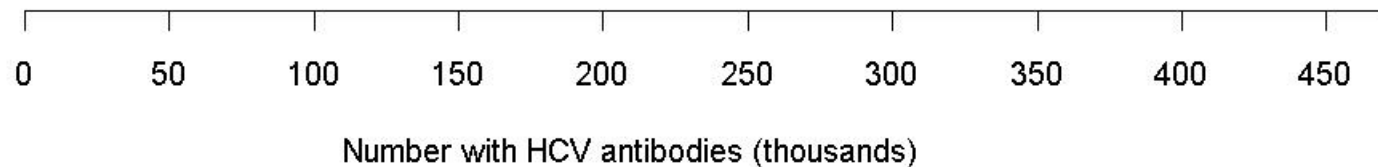
**Current  
injecting  
drug users**



**Ex-injecting  
drug users**



**All other  
risk-groups**



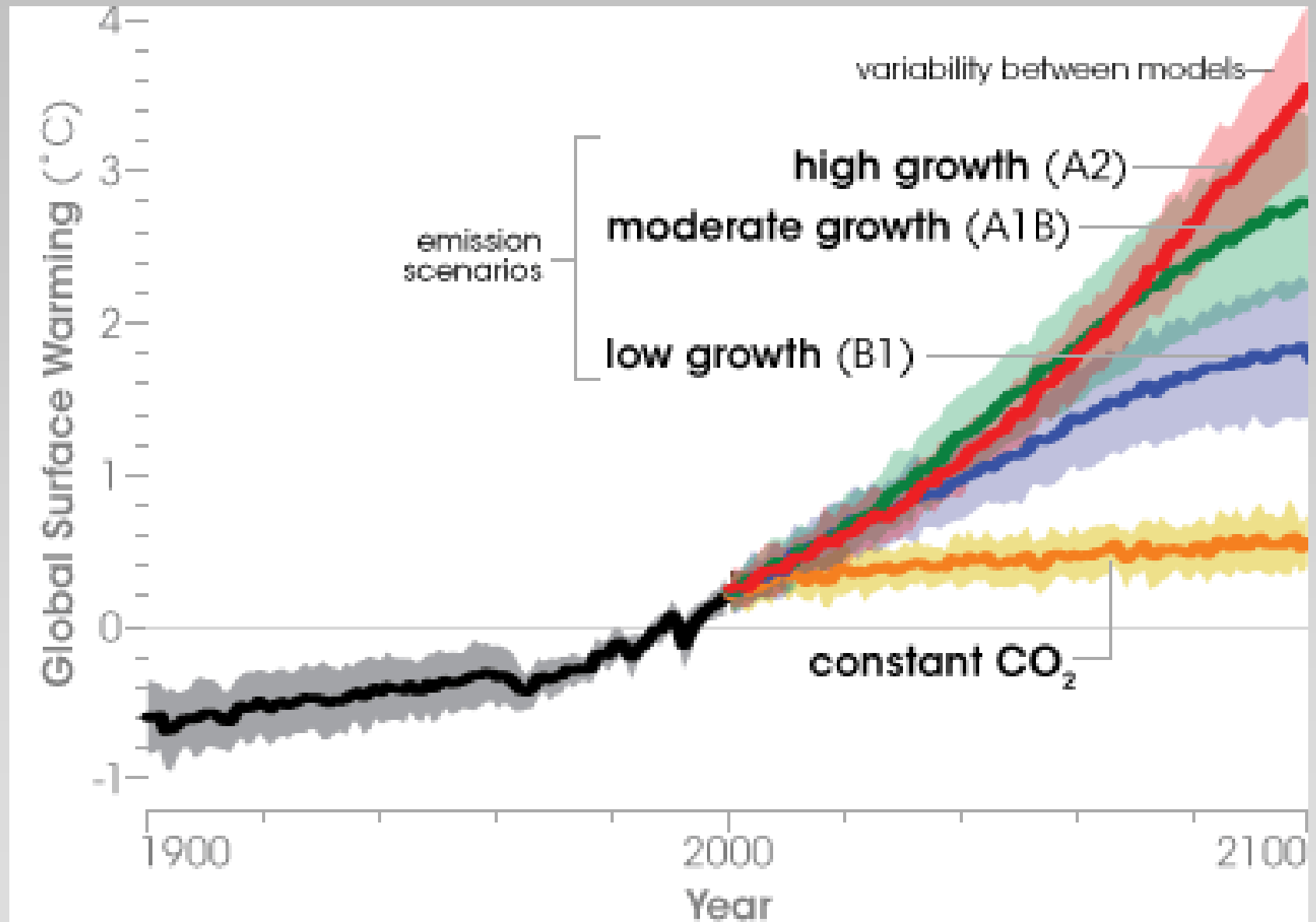
# Memorable quote #325

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*"But there are also unknown unknowns. There are things we do not know we don't know"*

# IPCC projections



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# Nine in 10 people carry gene which increases chance of high blood pressure

Nine out of 10 people carry a gene which significantly increases their chance of developing high blood pressure, scientists have found.

By Kate Devlin, Medical Correspondent

Last Updated: 7:57PM GMT 15 Feb 2009

 Text Size  

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Real story:

1 in 10 people carry a low-risk gene

## Coronary Heart Disease Risk Calculator

Risk Factor	Your Answer	Points	Relative Risk
Sex:	<input checked="" type="radio"/> Male <input type="radio"/> Female		
Age:	54 years	3	
Smoker:	<input type="radio"/> Yes <input checked="" type="radio"/> No	0	Low
Diabetes:	<input type="radio"/> Yes <input checked="" type="radio"/> No	0	Low
Blood Pressure:	148 / 94 mm Hg	2	High
Total Cholesterol:	224 mg/dl	1	Moderate
HDL Cholesterol:	54 mg/dl	0	Low
<input type="button" value="Calculate, with Incomplete Values"/> <input type="button" value="Calculate"/>			
<b>Total Points:</b>		6	= 10 % risk of heart disease in 10 years
<b>Average 10-year risk</b>		= 14 %	(for others in your age group)
<b>Low 10-year risk</b>		= 6 %	(for others in your age group)

Information for this Coronary Heart Disease Risk Calculator comes from the Framingham Heart Study. The results are applicable *only* for the ages of 30 to 70 years. Please refer to:

Wilson, PW, *et. al.* **Prediction of Coronary Heart Disease Using Risk Factor Categories.** *Circulation* 1998 97 (18): 1837-1847.

My doctor quoted me a 10% risk of heart attack or stroke in 10 years  
– should I take statins?



# Lie detectors

---

- A terrorist hides in a room with 99 innocent people
- You have a lie detector that is 95% accurate
- You get people out one at a time and ask them if they are a terrorist
- They all say no
- Eventually the machine goes 'ping!'
- What is the chance that you have caught the terrorist?
- (a) 95% (b) 84% (c) 50% (d) 16% (e) 5%

Security checks ▾

100 people

◀ Back ▶

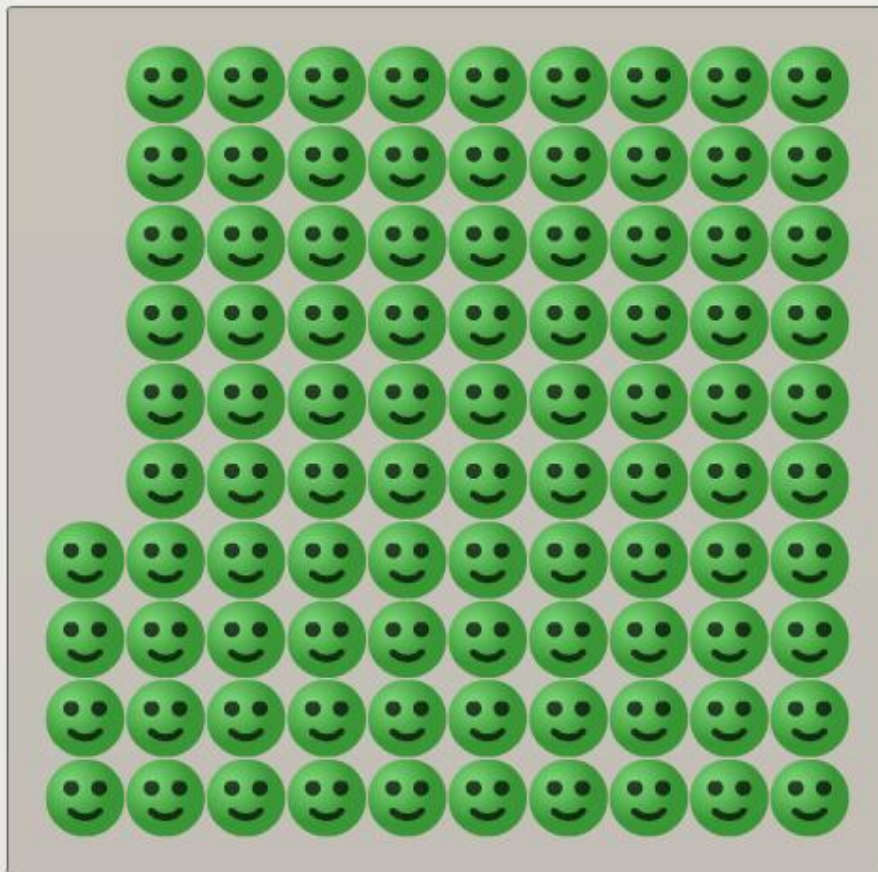
1 tests positive and is a terrorist



0 test negative and are terrorists



5 test positive and are not terrorists



94 test negative and are not terrorists