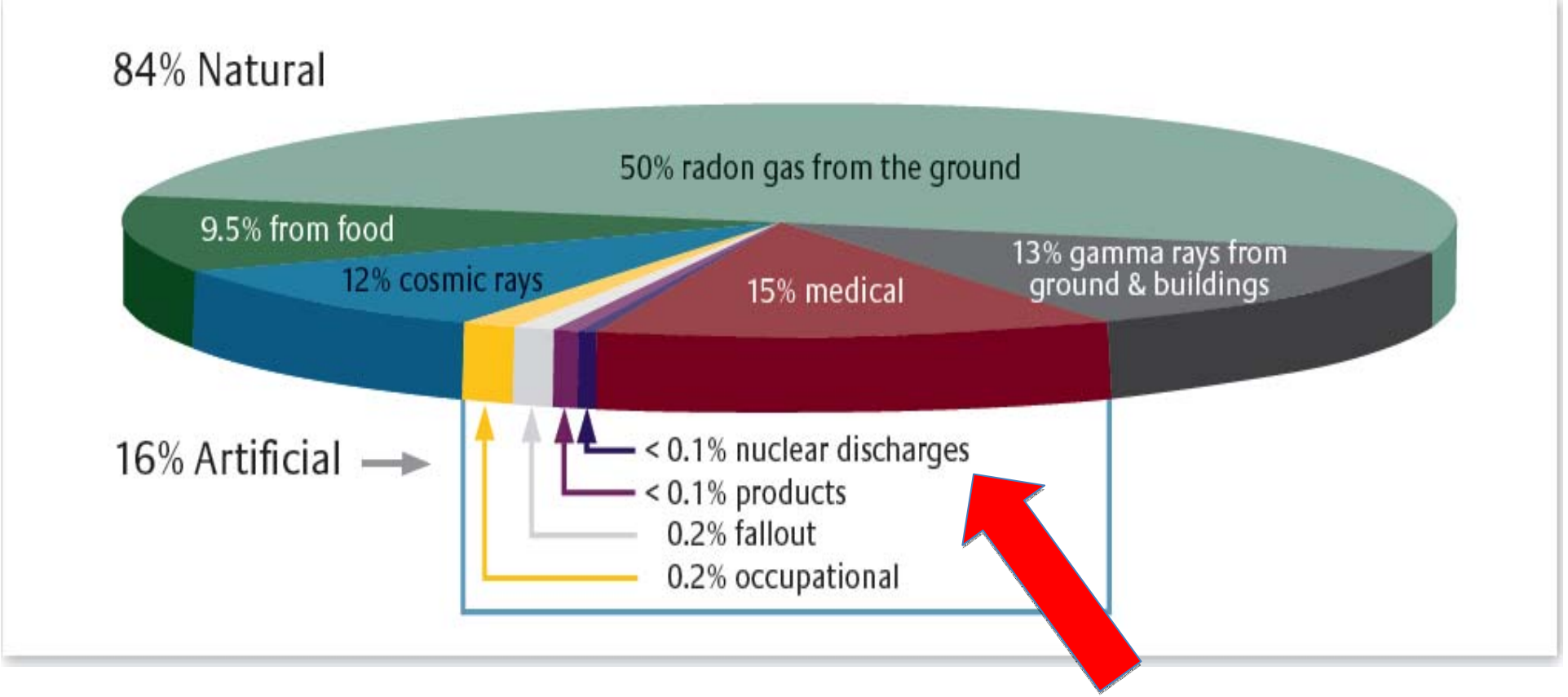
Health effects of nuclear accidents – providing facts not fiction

Professor Gerry Thomas

- Effect of any toxic substance depends on the amount received by the body's tissues
- We have developed very sensitive methods for detecting radiation
- Just because we can measure radiation does not necessarily mean that it is dangerous
- We live in a world that is full of natural radiation – yet our species thrives. **Therefore we must have developed mechanisms to cope with the biological effects of radiation**

Where does our background radiation come from?



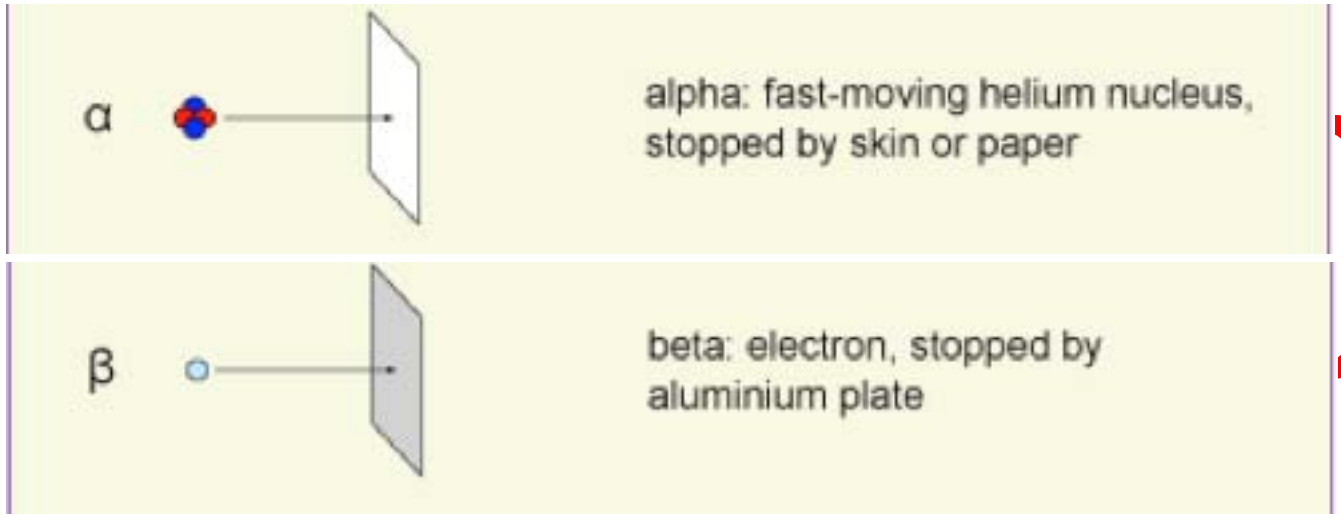
Fallout/nuclear discharges – A-bombs, nuclear accidents e.g. Chernobyl and Fukushima

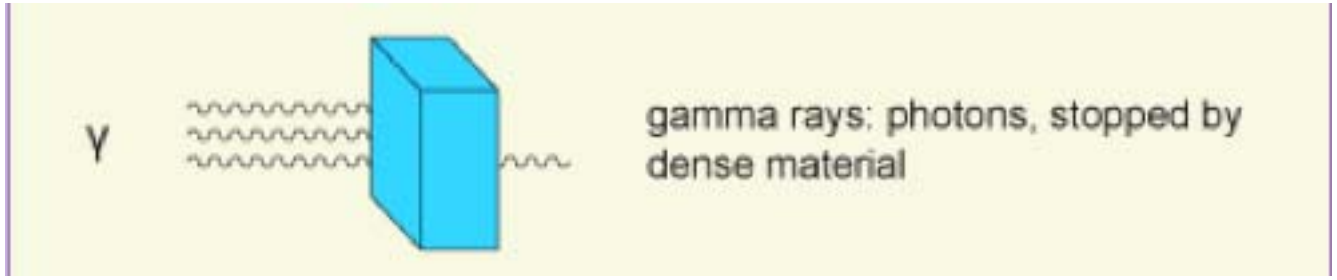
Relative radiation doses

Source of Exposure	Dose
Dental X-ray	0.005mSv
135g of Brazil Nuts	0.005mSv
Chest X-ray	0.02mSv
Transatlantic flight	0.07mSv
Nuclear Power station worker, average annual dose	0.18mSv
UK average annual radon dose	1.3mSv
CT scan of the head	1.4mSv
UK average annual dose	2.7 mSv
CT scan of the chest	6.6 mSv
Whole body CT scan	10 mSv
Annual limit for nuclear radiation workers	20mSv
Level at which increased cancer incidence seen	100mSv
LD50 (within a month of exposure)	5000mSv

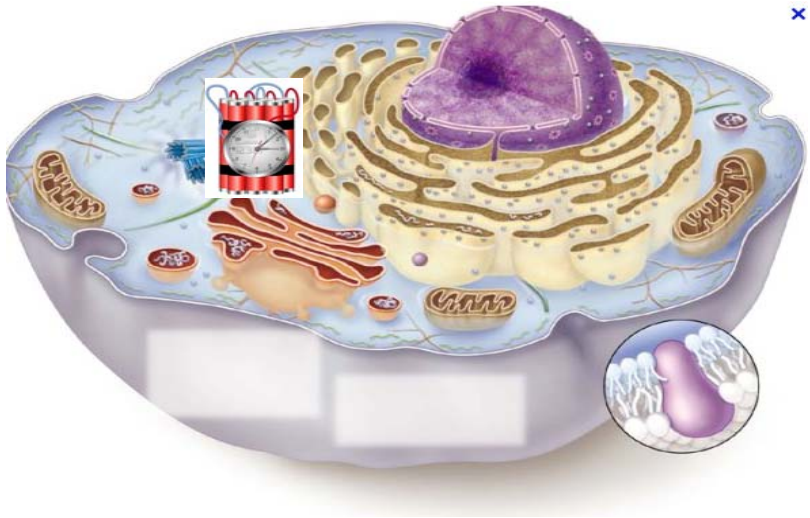
http://www.hpa.org.uk/Topics/Radiation/UnderstandingRadiation/UnderstandingRadiationTopics/DoseComparisonsForIonisingRadiation/

Facts about radiation – types of radiation





- For radiation to cause damage to cells, it must come into contact with them.
- Mechanism of contact depends on type of radiation – wave (γ, X-ray) or particulate (α, β).
- Radiation exposure can come from outside of your body (γ) or inside (α, β), if you breathe in or eat radioactive particles



Biological effect of radiation depends on the amount of time the radioactive isotope stays in the body (biological half-life) and the frequency with which the isotope emits radiation (physical half-life)

- Long physical half-life, short biological half-life – little effect
- Short physical half-life, long biological half-life – big problem

Health effects of nuclear accidents – where do we get our facts from?

- Atomic bomb (Hiroshima and Nagasaki)
  - large population exposed to high dose radiation close to explosion site
  - low doses to population further away
  - mainly gamma, but some α and β
- Chernobyl accident
  - Large dose to small numbers of people
  - Low dose to majority of population
  - Mainly β from isotopes of iodine and caesium

Health effects of the A-bomb

- Many people (120,000) were killed by the heat energy from the A-bombs
- Some people received very high doses of radiation and died of radiation sickness (20,000) within a few weeks
- Most people were exposed to smaller amounts of radiation.
- Radiation has resulted in 5% more cancers over 70 years
- No health effects for many people

Health effects from Chernobyl

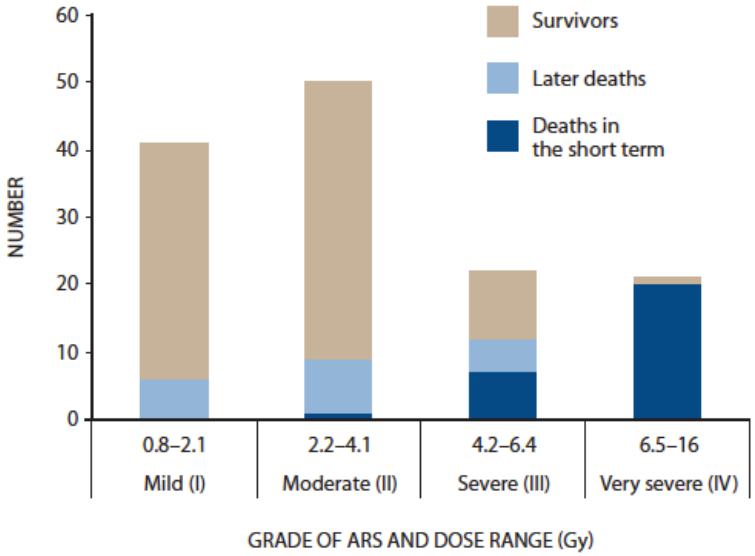
- Explosion and fire in reactor number 4
- Large amount of 131-I and 137-Cs released
- 131-I has a half-life of 8 days and 137-Cs of 30 years
- 3 people died in the explosion
- 28 firemen were exposed to large amounts of radiation and died of radiation sickness within a few months
- 10 million children in Belarus, Ukraine and Russia exposed to radioactive fallout

Radiation effects on health

Two types of health effects of radiation:

- Deterministic – effect is certain under specific conditions e.g. high dose/ARS
- Stochastic – may or may not occur. Difficult to predict on an individual level but effects seen at a population level e.g. cancer after radiation exposure

Chernobyl - deterministic



- 134 cases of ARS, 28 fatalities.
- 19 further deaths up to 2006 – but none thought to be related to radiation.
- Increased incidence of cataracts in those with highest doses

14 normal, healthy children born to ARS survivors within 5 years of the accident

www.unscear.org/docs/reports/2008/11-80076_Report_2008_Annex_D.pdf

Chernobyl – population radiation doses

- Evacuees – thyroid dose 500mGy
- Not evacuated but resident in contaminated areas - thyroid doses 100mGy
- Whole body doses to 6M residents = 9mSv
  - 80% of lifetime dose delivered by 2005
- 150,000 people living in most contaminated areas – 50mSv over 20 years (natural radiation average 1-2 mSv per year)

Chernobyl – health effects

- Consequences of exposure to radiation depend on the dose of radiation you are exposed to, and the type of radiation
- 131-I concentrates in the thyroid and is bound there – short physical half-life, long biological half-life
- Child's thyroid is small, and drink a lot of milk – higher dose than adults
- Child's thyroid still growing – higher risk of damage to cells, increases cancer risk

Chernobyl – health effects

- The only cancer to be increased is thyroid cancer in those who were young at exposure
- Thyroid cancer easy to treat and low death rate (estimated16,000 cancers in 50 years = 160 deaths)
- Thyroid cancer incidence falls back to normal in those born after radiation had gone
- Unlikely to see rises in other cancers – 137-Cs does not concentrate in the body, dose for most people less than one CT scan

  Long physical half-life, short biological half-life

Chernobyl 25 years on

- 28 from ARS
- 15 deaths from thyroid cancer in 25 years
- 1% death rate overall predicted for thyroid cancer. Predicted total death rate thus far approx 60
- No (scientific) evidence of increased thyroid cancer outside 3 republics
- No effect on fertility, malformations or infant mortality
- No conclusion on adverse pregnancy outcomes or still births
- Heritable effects not seen and very unlikely at these doses

Chernobyl vs Fukushima

• Move population away from source	☑	☑
• Limit inhalation by staying inside and keeping windows and doors shut	☒	☑
• Stop ingestion of contaminated foodstuffs	☒	☑
• Block uptake of radionuclides (e.g. stable iodine prophylaxis)	☒	?

Fukushima radiation doses

On site

- 19,594 workers, 167 received doses of >100 mSv (6 >250mSv)
- No ARS, no radiation related deaths

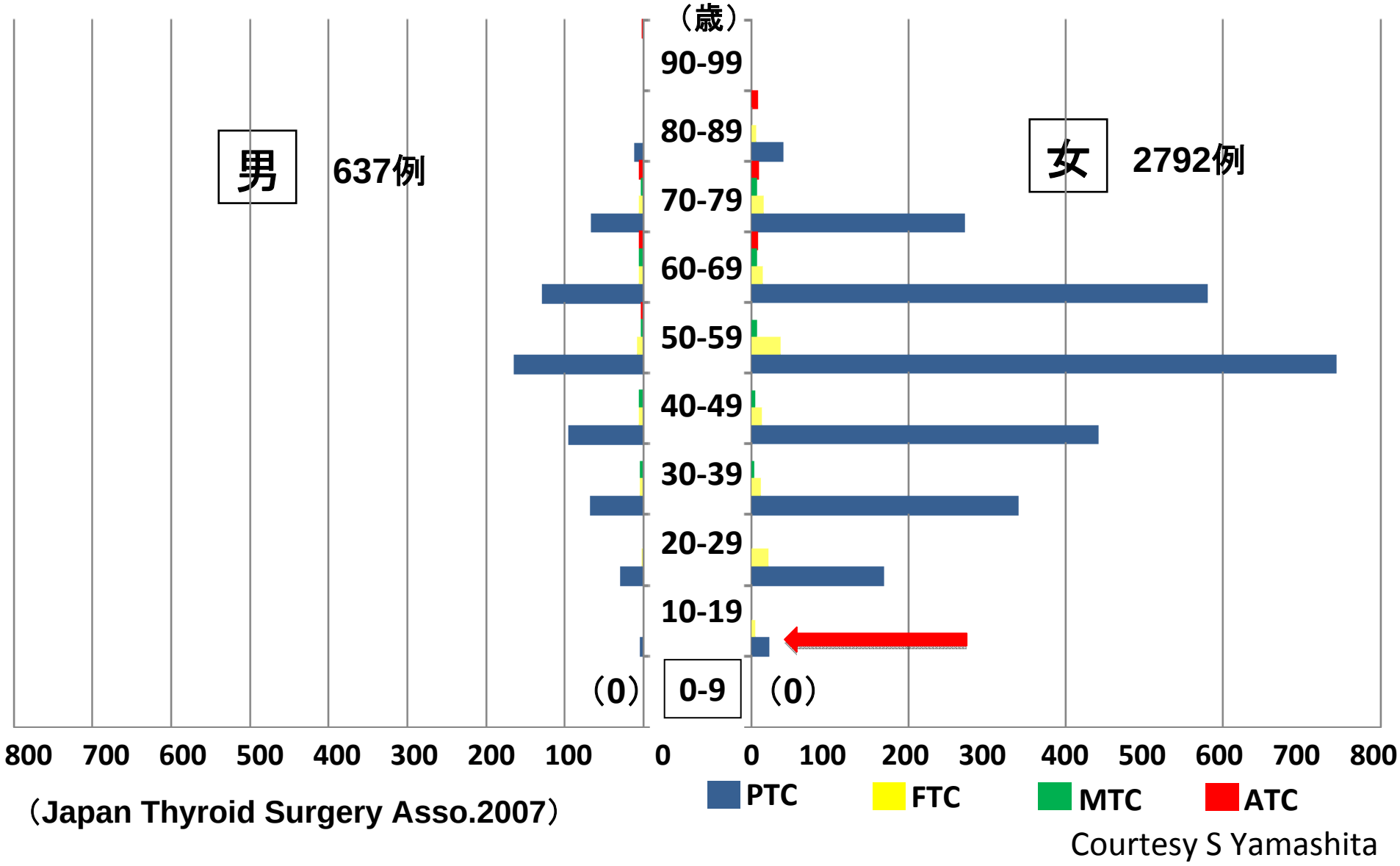
Population at large

- 150,000 people evacuated, sample of 1700 showed 98% <5mSv, only 10 >10mSv
- Mean thyroid dose 4.2mSv in children (3.5 mSv adults) compared with 500mSv in Chernobyl evacuees

Health effects of Fukushima

- No radiation related deaths compared with 761 who died as a result of the evacuation, and 20,000 in tsunami
- Unlikely to be any increase in thyroid cancer at the doses received
- Psychological harm due to evacuation and radiophobia – very likely. Economic effects also likely to have health effects
- Results of health survey must be put into context for general public

Thyroid cancer incidence in Japan (2005)



Courtesy S Yamashita

Comparative risks

Exposure scenario	Exposure	Health endpoint	Approximate lifetime increased mortality
Living in Central London compared to Inverness.	Mix of air pollutants indicated by average $PM_{2.5}$ = 6.9 μg m^{-3} higher.	Mortality	**2.8 %** Postulated 2.8% higher air pollution related mortality in central London compared to Inverness (see text).
N.B. Extrapolates from data in the US. May be confounding factors which, if accounted for, would change the excess risk. Time-lag between exposure and effect is uncertain.			
Passive smoking – risk to non-smoker at home if spouse smokes.	Mix of pollutants in secondhand smoke.	Mortality	**1.7 %** 1.7% lifetime excess IHD mortality risk from passive smoking: average for men and women [36].
N.B. Heart disease risk: does not include strokes or the (significantly lower) risk from lung cancer or other illnesses. May be confounding factors/ limitations of meta-analysis data.			
Chernobyl emergency workers in the 30-km Zone 1986–87.	Radiation exposure: 100 mSv 250 mSv	Mortality	 **0.4 %** **1.0 %**

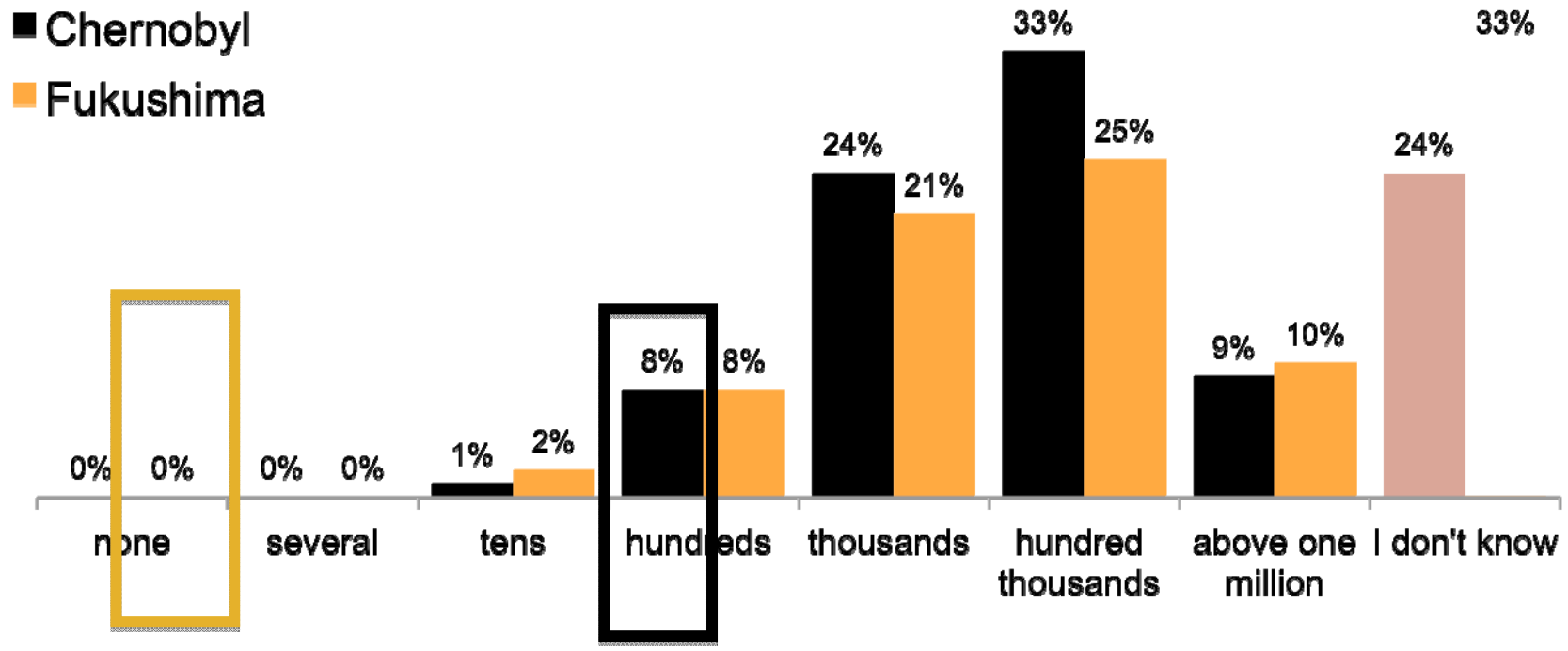
Smith BMC Pubic Health 2007 7:49

Comparative risks

Risk scenario	Average Years of Life Lost (YOLL)
Smoking Male doctor who is a lifetime smoker compared to non-smoker.	10
Obesity White male aged 35 who is obese (BMI = 30.0–39.9) or severely obese (BMI >40): risk relative to BMI = 24.	Obese: 1–4 [a] Severely obese: 4–10[a]
Radiation Atomic bomb survivor who was in the most exposed group: within 1500 metres of the hypocentre. Shielded whole body kerma > 1 Gy, mean 2.25 Gy.	2.6 (1.3–5.2)[a]

NB Radiation doses from nuclear accidents much lower than from A-bomb, so risk even lower

What do the general public think?



How many people died as a result of the Chernobyl and Fukushima accidents?

All Russia omnibus 24.10.12

Public communication

- Public communication is key
- Clear message given by independent scientists
- Important to tame sensationalist media
- Put risk into context with other common risks that public expose themselves to
- Persuade media to produce factual programmes based on science aimed at all sections of the population
- Communicate sensitively and put facts into context

Take Home Messages

- Health consequences of a Nuclear Power plant accident may not be as bad as we first thought
- We must separate fact from fiction to decide our future energy policy
- Effects of climate change likely to kill more (est. 150,000 per year) than nuclear accidents
- Don’t believe everything you read on the internet or in the media
- Politics gets in the way of good science