Minimising the Health Consequences of Nuclear Accidents – Do We Need to Reassess Our Response?

Gerry Thomas, Imperial College London
gerry.thomas@imperial.ac.uk
The problem with radiation....

• Long history of being made to fear radiation (from atomic weapons)
• General acceptance of medical radiation exposure, and exposure to natural radiation (e.g. Spas) believed to be beneficial
• Relationship between dose and response to all toxins (including radiation)
• Individual dose from radiation in the environment depends on many factors
• Perception that individual dose from nuclear accidents is much higher than it is
Individual dose depends on

\[ P(A|B) = \frac{P(A \text{ and } B)}{P(B)} \]
The problem with radiation risk communication

- Too much jargon
- Political football
- Lots of misinformation and very little understandable science
- Constant emphasis on safety – must be unsafe
Nuclear Power’s Image Problem

Pros

- Cheaper than other energy sources
- More efficient than other energy sources
- Cleaner than other sources such as burning coal

Cons

- Lack of information on nuclear energy
- Radiation and its impact on health
- Lack of solutions for safe disposal of nuclear waste
- Possibility for disaster (i.e. Fukushima, Chernobyl)
- Long-term environmental impacts
- Non-renewable resource

Ipsos Mori 2014 - >21,000 people in 23 countries

G Thomas

ARPS 13/9/16
## Radiation releases in perspective

<table>
<thead>
<tr>
<th></th>
<th>131-I</th>
<th>137-Cs</th>
</tr>
</thead>
<tbody>
<tr>
<td>A-bomb tests in 1960s</td>
<td>675,000 PBq</td>
<td>948 PBq</td>
</tr>
<tr>
<td>Chernobyl</td>
<td>1,760 PBq</td>
<td>85 PBq</td>
</tr>
<tr>
<td>Fukushima</td>
<td>100-500 PBq</td>
<td>6-20 PBq</td>
</tr>
</tbody>
</table>

Rings represent 2 and 3 km from epicentre

Douple et al., doi: 10.1001/dmp.2011.21

McClean et al., in preparation
What does this mean for us?

Public Perception of Radiation – myth and reality

New Book Concludes – Chernobyl death toll: 985,000, mostly from cancer


2065 toll

The mainstream view puts the toll in five figures. Environmental physicist Jim Smith of the University of Portsmouth, UK, prefers to cite a 2006 study by Elisabeth Cardis of the International Agency for Research on Cancer in Lyon, France. This predicted that by 2065 Chernobyl will have caused about 16,000 cases of thyroid cancer and 25,000 cases of other cancers, compared with several hundred million cancer cases from other causes.

http://www.newscientist.com/article/dn20403-25-years-after-chernobyl-we-dont-know-how-many-died.html
The Public and Nuclear Accidents

Living with the fallout of Chernobyl 30 years later: Harrowing photographs show children living 40 miles from site of world's worst nuclear disaster and 'still suffering radiation effects'

- Thirty years after the Chernobyl nuclear disaster, high rates of health conditions remain for those living nearby
- Children in the area are still born at greater risk of immune system deficiencies and heart rhythm disorders
- Adults living near the decommissioned power plant also suffer higher rates of heart disease and thyroid cancer

By COREY CHARLTON FOR MAILONLINE
PUBLISHED: 12:16 GMT, 12 April 2016 | UPDATED: 06:54 GMT, 13 April 2016
• The radionuclides of concern for the population at large are 131-I and Cs-137
• The likely health effects are determined by the dose of radiation delivered by these isotopes to tissues in the body
• Low dose = smaller health effect, large dose = larger health effect
• The dose to an individual can be affected by many different things – what they were doing, their diet etc
131-I has a short physical half-life of 8 days, but concentrates in the thyroid. Its biological half life is approx 100 days.

Cs-137 has a longer physical half-life (30 years), is not concentrated in any tissue in the body. Its biological half-life is also approx 100 days.

Doses to individual tissues are lower from Cs-137 than 131-I.
Chernobyl – Health effects

- 28 from ARS
- 15 deaths from thyroid cancer in 25 years
- 1% death rate overall predicted for thyroid cancer.
  16,000 excess thyroid cancers in total predicted – therefore 160 deaths
- 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
- No proven increase in any other cancer (including liquidator cohorts)

Fukushima Health effects

- No radiation related deaths compared with >1500 who died as a result of the evacuation or stress related to it, and approx 20,000 in tsunami
- Unlikely to be any increase in thyroid cancer at the doses received
- Psychological harm due to evacuation and radiophobia
- Huge economic effect on local area and Japan as a whole

Why the difference?

• Mean doses to thyroid have been measured as 4.2 mSv: 100 fold less than in Chernobyl evacuees

• 93% of residents (both evacuees and still resident) in Fukushima had estimated doses of less than 2mSv in first 4 months post accident

• Measured doses were around half of this

• WBC at later time points show the majority of people have no detectable levels of Cs-137.
Thyroid cancer and Fukushima?

- Fukushima health survey will produce large amounts of data that must be interpreted for the public – or it will be misinterpreted by the press and others.

Rise in childhood cancer in Fukushima sparks debate

Three years after the worst nuclear accident in a generation, the Japanese prefecture is reporting a rise in the number of children showing cancer symptoms.

Study finds higher cancer rates in kids near Fukushima.
Thyroid screening – how you look matters

Incidence of nodules

- 2-6%
- 19-35%
- 8-65%

Thyroid cancer and age at diagnosis - Japan (non-screened population)


© The Author 2014. Published by Oxford University Press. All rights reserved. For Permissions, please email: journals.permissions@oup.com
• Scientific studies indicate that the measures put in place by the Japanese authorities have led to extremely low doses of radiation being received.
• At these doses there will be no discernible effect on health of the radiation.
• However, the societal dislocation and stress caused by the prolonged evacuation will have effects on psychological health.
• Action to mitigate against this will prevent transfer into physical health effects.
• Some sections of the population state that they are worried about acute radiation syndrome and transgenerational effects.

• The *scientific* evidence indicates that this will not occur.

• Scientists and the media should work together to dispel the myths that surround the effects of low doses of radiation on health – or the opinions of pseudoscientists will prevail.
Making the invisible visible – D shuttle

Comparison of the individual doses (annual basis)

- Outside of Fukushima
- Inside of Fukushima
- France
- Belarus
- Poland

Flight to Tokyo

French Embassy security

CDG security

Iwaki

Tomioka

Courtesy Prof Ryogo Hayano and Dr Masaharu Tsubukura
Comparative health risks

Megacity versus small town living

Exposure of 250mSv (Chernobyl Liquidator)

Passive smoking

Exposure of 100mSv (Chernobyl Liquidator)

Source: Smith J BMC Public Health 2007 7:49
<table>
<thead>
<tr>
<th>Scenario</th>
<th>Increased Risk of Mortality</th>
</tr>
</thead>
<tbody>
<tr>
<td>Megacity versus small town living</td>
<td>2.8%</td>
</tr>
<tr>
<td>Passive smoking</td>
<td>1.7%</td>
</tr>
<tr>
<td>Exposure of 250mSv (Chernobyl Liquidator)</td>
<td>1.0%</td>
</tr>
<tr>
<td>Exposure of 100mSv (Chernobyl Liquidator)</td>
<td>0.4%</td>
</tr>
</tbody>
</table>

Source: Smith J BMC Public Health 2007 7:49
Health effects of energy production

Deaths and illness expressed as per TW \((W \times 10^{12})/hr\) for different sources of energy

<table>
<thead>
<tr>
<th></th>
<th>Deaths from accidents</th>
<th>Air pollution-related effects</th>
<th></th>
<th></th>
<th>Serious illness†</th>
<th>Minor illness‡</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Among the public</td>
<td>Occupational</td>
<td></td>
<td></td>
<td></td>
<td></td>
</tr>
<tr>
<td>Lignite(^{30})</td>
<td>0.02 (0.005-0.08)</td>
<td>0.10 (0.025-0.4)</td>
<td>32.6 (8.2-130)</td>
<td>298</td>
<td>(74.6-1193)</td>
<td>17 676 (4419-70 704)</td>
</tr>
<tr>
<td>Coal(^{31})</td>
<td>0.02 (0.005-0.08)</td>
<td>0.10 (0.025-0.4)</td>
<td>24.5 (6.1-98.0)</td>
<td>225</td>
<td>(56.2-899)</td>
<td>13 288 (3322-53 150)</td>
</tr>
<tr>
<td>Gas(^{31})</td>
<td>0.02 (0.005-0.08)</td>
<td>0.001 (0.0003-0.004)</td>
<td>2.8 (0.70-11.2)</td>
<td>30</td>
<td>(7.48-120)</td>
<td>703 (176-2813)</td>
</tr>
<tr>
<td>Oil(^{31})</td>
<td>0.03 (0.008-0.12)</td>
<td>..</td>
<td>18.4 (4.6-73.6)</td>
<td>161</td>
<td>(40.4-645.6)</td>
<td>9551 (2388-38 204)</td>
</tr>
<tr>
<td>Biomass(^{31})</td>
<td>..</td>
<td>..</td>
<td>4.63 (1.16-18.5)</td>
<td>43</td>
<td>(10.8-172.6)</td>
<td>2276 (569-9104)</td>
</tr>
<tr>
<td>Nuclear(^{31,32})</td>
<td>0.003</td>
<td>0.019</td>
<td>0.052</td>
<td>0.22</td>
<td>..</td>
<td></td>
</tr>
</tbody>
</table>

# Attributable deaths

## Worldwide deaths (per year)

<p>| | |</p>
<table>
<thead>
<tr>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td>Residential Radon</td>
<td>99,000</td>
</tr>
<tr>
<td>Air pollution, ambient particulate PM2.5</td>
<td>3,200,000</td>
</tr>
<tr>
<td>Tobacco smoking</td>
<td>6,300,000</td>
</tr>
</tbody>
</table>

## Nuclear accidents*

approx 200-25200

* Total deaths, not per year as a direct result of radiation: Chernobyl 28 from ARS, 160 deaths from thyroid cancer, 25,000 from other cancers (?)
Take home messages

• Health effects of radiation relate to dose
• Individual doses from nuclear accidents much lower than people believe
• An energy mix that favours nuclear and renewables over carbon based technologies will reduce the health consequences of particulate emissions and climate change
• If we want a modern society we need to generate energy – perhaps we should start to use scientific facts rather than urban myths to decide future energy policy
• We must learn lessons from our response to Fukushima and Chernobyl
  – Scientists
  – The media
  – Society

ELSEVIER

Special Issue Publication
Radiation exposure and health effects – is it time to reassess the real consequences?
http://www.clinicaloncologyonline.net/issue/S0936-6555(16)X0003-9
Life is a balancing act

“We’ve considered every potential risk, except the risks of avoiding all risks”

We all need energy – but nothing is risk free