30 Years Later: Health Effects from Chernobyl

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Chernobyl Accident (1986)

“...the foremost nuclear catastrophe in human history” IAEA (1996)

“...its magnitude and scope, the size of the affected populations, and its long-term consequences make it, by far, the worst industrial disaster on record” IAEA/WHO (2005)
Displaced Persons (UNDP 2002)

Evacuated and resettled population

- Evacuated population:
  - Belarus: 24,000
  - Russia: 3,400
  - Ukraine: 111,000
  - Total: 118,400

- Resettled population:
  - Belarus: 49,000
  - Russia: 72,000
  - Ukraine: 135,000
  - Total: 231,000

- Total:
  - Belarus: 52,400
  - Russia: 46,000
  - Ukraine: 116,000
  - Total: 163,000

- Yet to be resettled:
  - Belarus: 7,000
  - Russia: 4,600
  - Ukraine: 11,600
  - Total: 350,400
## Latest doses from UNSCEAR 2008

<table>
<thead>
<tr>
<th>Category</th>
<th>Number</th>
<th>Ave dose mSv</th>
<th>Coll dose Man Sv</th>
</tr>
</thead>
<tbody>
<tr>
<td>Recovery workers</td>
<td>530,000</td>
<td>117</td>
<td>62,000</td>
</tr>
<tr>
<td>Evacuees</td>
<td>115,000</td>
<td>31</td>
<td>3,600</td>
</tr>
<tr>
<td>Residents in contam areas of Belarus, Russia and Ukraine</td>
<td>6.4 million</td>
<td>9</td>
<td>58,900</td>
</tr>
<tr>
<td>Inhabitants of Belarus, Russia and Ukraine</td>
<td>98 million</td>
<td>1.3</td>
<td>125,000</td>
</tr>
<tr>
<td>Inhabitants of W Europe</td>
<td>500 million</td>
<td>0.3</td>
<td>150,000</td>
</tr>
<tr>
<td>Total</td>
<td></td>
<td></td>
<td>400,000</td>
</tr>
</tbody>
</table>
## Estimated Deaths (all Europe)

<table>
<thead>
<tr>
<th>Source</th>
<th>Year</th>
<th>Deaths</th>
</tr>
</thead>
<tbody>
<tr>
<td>IAEA/WHO</td>
<td>2005</td>
<td>9,000</td>
</tr>
<tr>
<td>TORCH (2006)</td>
<td>2006</td>
<td>30,000 - 60,000</td>
</tr>
<tr>
<td>Cardis et al</td>
<td>2015</td>
<td>16,000 (6,700 to 38,000)</td>
</tr>
<tr>
<td>TORCH (2016)*</td>
<td>2016</td>
<td>40,000</td>
</tr>
</tbody>
</table>

*UNSCEAR 2008*
Some of the “liquidators…”
<table>
<thead>
<tr>
<th>DISEASE</th>
<th>STUDY</th>
<th>DISEASE</th>
<th>STUDY</th>
</tr>
</thead>
</table>
observed health effects

- thyroid cancers
- leukemias and solid cancers
- cardiovascular disease
- birth defects
- Ill health among children
- + many other effects

– see Torch (2016) in press
Epidemiology studies: care required

- differing diagnostic criteria used
- insufficient/poorly matched control groups
- small numbers – low statistical power
- confounding factors and biases
- nil or poor dose estimates

People move away, cases disappear
Political decisions NOT to do studies
Thyroid Cancer
Thyroid Cancer Incidence
(in those who were children and adolescents in 1986) source: Jacob et al (2005)
How large are thyroid cancer risks?

- estimated relative risk in the highest contam. areas are very high, ~8 (per gray)
- Ie 700% increase over background rate
- extraordinarily high, perhaps the largest increases in risk ever measured after exposures to toxic substances
- both in Ukraine and Belarus
Thyroid cancer in Austria
Thyroid Cancer in Austria

source: data plot and regression analysis by Körblein (2015)
Iodine-131 in Austria

Abbildung 4: Verteilung der gemessenen kumulativen $^{131}$I Aktivitätskonzentrationen (part.) in der Luft über Österreich (1986), Zellengröße: 50 × 50 km
Thyroid cancer - other countries

**Czech Republic:** Murbeth et al (2004) TC incidence increased by 2.6% per y (95%-CI: 1.2-4.1) after 1990


**East Slovakia:** Icso et al (1998) found TC incidence was 1.3x higher in 10 yr period after France than before

**Poland:** Roszkowska and Goryński (2004) observed substantial increases in TC incidence after 1991

**France:** Verger et al (2003) reported TC incidence increased x 5.2 in men and 2.7 in women, 1975 to 1995
How many excess thyroid cancers will occur?

- So far >6,000 cases (UNSCEAR, 2008)
- >16,000 cases (Cardis, 2015)
- My own estimate is 21,000 cases
Leukemia
Leukemia in Clean-up Workers

source: Ivanov (1997)
Leukemia in Europe

- Russian workers (500% increase/Gy)
- Ukrainian workers (240% increase/Gy)
- Increased incidences in Finland, Slovakia, Germany, Greece and Italy
- European Childhood Leukaemia-Lymphoma Incidence Study (IARC)
- Possible in utero effect
### Solid Cancers

Increase in cancer incidence (for ages 20-85 per 100,000 population) in Belarus liquidators 1997-2000, compared with control adults in least contaminated area.

<table>
<thead>
<tr>
<th>Cancer</th>
<th>Incidence in controls</th>
<th>Incidence in liquidators</th>
<th>Increase</th>
</tr>
</thead>
<tbody>
<tr>
<td>All sites</td>
<td>373.3</td>
<td>464.6</td>
<td>23%</td>
</tr>
<tr>
<td>Bladder</td>
<td>11.4</td>
<td>18.7</td>
<td>65%</td>
</tr>
<tr>
<td>Colon</td>
<td>16.7</td>
<td>22.2</td>
<td>33%</td>
</tr>
<tr>
<td>Lung</td>
<td>52.6</td>
<td>66.3</td>
<td>26%</td>
</tr>
<tr>
<td>Kidney</td>
<td>15.4</td>
<td>19.1</td>
<td>24%</td>
</tr>
<tr>
<td>Stomach</td>
<td>40.8</td>
<td>46.9</td>
<td>15%</td>
</tr>
</tbody>
</table>

Source: Okeanov et al (2014)
Radiogenic Cardiovascular Disease

- aetiology? inflammatory response?
- non-targeted effect of radiation?
- a stochastic effect? - long latency period, no threshold, progressive
- stroke+heart disease caused 1/3 of radiogenic deaths in atomic bomb cohort
- all cancer also caused 1/3 of radiogenic deaths in atomic bomb cohort
Cardiovascular Disease (LSS)
Stroke (LSS)

Graph showing the relationship between excess relative risk and weighted colon dose (Gy). The graph compares linear and linear-quadratic models.
Radiogenic Cardiovascular Disease - Risks

- Ivanov et al, 2000 (clean-up workers)
  $\text{ERR/Sv} = 0.54$ (95% CI 0.18 - 0.91)

- Shimizu et al, 2012 (LSS)
  $\text{ERR/Sv} = 0.14$ (95% CI 0.06 - 0.23)

- Buzunov et al, 2013
  observed risks down to 6-20 mSv!
Birth Defects
## Major study on birth defects

150,000 births, 10 years, (Timchenko et al, 2014)

<table>
<thead>
<tr>
<th>Frequency per 1000 live births</th>
<th>polluted areas</th>
<th>clean areas</th>
<th>% increase</th>
</tr>
</thead>
<tbody>
<tr>
<td><strong>all birth defects</strong></td>
<td>26.10 ± 0.80</td>
<td>24.23 ± 0.47</td>
<td>7.7%</td>
</tr>
<tr>
<td><strong>nervous system birth defects</strong></td>
<td>1.09 ± 0.17</td>
<td>0.75 ± 0.08</td>
<td>45%</td>
</tr>
</tbody>
</table>
Down Syndrome

- Scotland (Ramsay et al, 1991)
- Southern Germany (Sperling et al, 1991)
- Finland (Harjulehto-Mervaala et al, 1992)*
- Hungary (Czeizel et al, 1993)*
- Sweden (Ericson and Kallen, 1994)
- Berlin (Sperling et al, 1994, 1994b)
- England (Bound et al, 1995)
- Belarus (Zatsepin et al, 2007) (26 obs: 9.84 exp; O/E ratio=2.64; CI=1.72-3.76)
Persistent ill health in children
Persistent ill health in children

- Impaired lung function, increased breathing difficulties. Svendsen et al. (2010, 2015)
- Decreased blood count. Stepanova et al. (2008), Lindgren et al. (2015)
- Increased immunoglobulin factors. Titov et al. (1995), McMahon et al. (2014)
- Increased anaemias and colds. McMahon et al. (2015)
- Improvement with clean food. McMahon et al. (2015)
Chernobyl in a nutshell

- 5 million people in still live in highly contaminated areas
- 400 million people in less contaminated areas
- 42% of western Europe also seriously contaminated
- Half of Chernobyl’s fallout deposited on W Europe
- 40,000 fatal cancers of all types predicted
- 6,000 thyroid cancer cases, thousands more expected
- Increased thyroid cancers in Austria and other western European countries
- Increased radiogenic leukemia, cardio-vascular disease, breast cancers confirmed
- Radiogenic birth defects, mental health effects
- Children in contaminated areas suffer radiogenic illnesses
Chernobyl: conclusions

• nuclear power is a supremely unforgiving technology
• terrible consequences
• millions still in contaminated areas
• health effects still occurring
• need for more research in Europe
• need for more humanity towards affected peoples
Chernobyl Children Projects ✓
the future....
Good References

- Jacob P, Meckbach R, Ulansovski A, Schotola C and Pröhl G (2005) Thyroid exposure of Belarusian and Ukrainian children due to the Chernobyl accident and resulting thyroid cancer risk. GSF-Bericht 01/05, Neuberberg: GSF-Forschungszentrum mbH, 725; mit Anhang