Childhood Leukemia and Nuclear Power Plants

Epidemiology and its Politics

Wolfgang Hoffmann, MD, MPH

Institute for Community Medicine,
Ernst Moritz Arndt University Greifswald, Germany

19th IPPNW World Congress, Basel, Switzerland, August 25th – 30th, 2010
"Negative" ecologic study

$$SIR = \frac{N_{\text{observed}}}{N_{\text{expected}}} = 1.0$$
"Positive" ecologic study

\[ \text{SIR} = \frac{N_{\text{beobachtet}}}{N_{\text{erwartet}}} > 1.0 \]
**Childhood Leukemia in the Vicinity of the Geesthacht Nuclear Establishments near Hamburg, Germany**

*Wolfgang Hoffmann,¹ Claudia Terschueren,¹ and David B. Richardson²*

¹Institute for Community Medicine, Section Epidemiology of Health Care and Community Health, Ernst-Moritz-Arndt University of Greifswald, Greifswald, Germany; ²Department of Epidemiology, School of Public Health, University of North Carolina, Chapel Hill, North Carolina, USA

**Table 2.** Observed and expected numbers of childhood leukemia cases by calendar year in the 5-km study region located in the Elbmarsch, Germany (1990–2005).

<table>
<thead>
<tr>
<th>Year</th>
<th>No. observed</th>
<th>National referent expected</th>
<th>County referent expected</th>
</tr>
</thead>
<tbody>
<tr>
<td>1990</td>
<td>3</td>
<td>0.22</td>
<td>0.34</td>
</tr>
<tr>
<td>1991</td>
<td>2</td>
<td>0.23</td>
<td>0.34</td>
</tr>
<tr>
<td>1992</td>
<td>0</td>
<td>0.23</td>
<td>0.22</td>
</tr>
<tr>
<td>1993</td>
<td>0</td>
<td>0.24</td>
<td>0.22</td>
</tr>
<tr>
<td>1994</td>
<td>1</td>
<td>0.24</td>
<td>0.40</td>
</tr>
<tr>
<td>1995</td>
<td>2</td>
<td>0.23</td>
<td>0.21</td>
</tr>
<tr>
<td>1996</td>
<td>1</td>
<td>0.24</td>
<td>0.23</td>
</tr>
<tr>
<td>1997</td>
<td>0</td>
<td>0.25</td>
<td>0.25</td>
</tr>
<tr>
<td>1998</td>
<td>0</td>
<td>0.24</td>
<td>0.28</td>
</tr>
<tr>
<td>1999</td>
<td>0</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>2000</td>
<td>0</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>2001</td>
<td>1</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>2002</td>
<td>1</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>2003</td>
<td>1</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>2004</td>
<td>1</td>
<td>0.27</td>
<td></td>
</tr>
<tr>
<td>2005</td>
<td>1</td>
<td>0.27</td>
<td></td>
</tr>
</tbody>
</table>

*Expected counts were derived using annual age-specific German national childhood leukemia incidence rates as the referent. Expected counts were derived using annual age-specific childhood leukemia incidence rates for the six counties surrounding the study region as the referent.*
**Table 3.** SIRs for childhood leukemia (< 15 years of age) and observed numbers of cases in two categories of calendar time (1990–1998 and 1999–2005) and three categories of attained age (0–4, 5–9, and 10–14 years).

<table>
<thead>
<tr>
<th></th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>Obs</td>
<td>Exp</td>
<td>SIR</td>
</tr>
<tr>
<td>0–4</td>
<td>6</td>
<td>1.11</td>
<td>5.39</td>
</tr>
<tr>
<td>5–9</td>
<td>2</td>
<td>0.63</td>
<td>3.20</td>
</tr>
<tr>
<td>10–14</td>
<td>1</td>
<td>0.38</td>
<td>2.61</td>
</tr>
<tr>
<td><strong>Total</strong></td>
<td>9</td>
<td>2.12</td>
<td>4.24</td>
</tr>
</tbody>
</table>

Abbreviations: Exp, expected number of cases, derived using German national annual age-specific leukemia incidence rates; Obs, observed number of leukemia cases.
Criteria for inclusion:

1. a study examining leukaemia
2. study must have at least one age category less than 26
3. study must differentiate between leukaemia and lymphoma
4. study must indicate geographical zones in which cases or deaths occurred
5. study must include at least two of the following three variables: observed, expected, or end point [standardized incidence or mortality rate (SIR/SMR)] for individual nuclear sites
6. if a site has zero observed cases or deaths, it is considered 0.01 in calculations

- 17 / 37 studies eligible
- 136 nuclear sites in nine countries (USA, Canada, Britain, Japan, France, Spain and Germany)
Results: SIR

Table 6. Incidence meta-rates for childhood leukaemia in proximity to nuclear facilities by age group and geographic zone

<table>
<thead>
<tr>
<th>Age group</th>
<th>Geographic zone</th>
<th>Fixed effects</th>
<th>Random effects</th>
</tr>
</thead>
<tbody>
<tr>
<td>0–9</td>
<td>All</td>
<td>1.25</td>
<td>(1.13, 1.38)</td>
</tr>
<tr>
<td>0–9</td>
<td>&lt;16 km</td>
<td>1.23</td>
<td>(1.07, 1.40)</td>
</tr>
<tr>
<td>0–25</td>
<td>All</td>
<td>1.12</td>
<td>(1.06, 1.18)</td>
</tr>
<tr>
<td>0–25</td>
<td>&lt;16 km</td>
<td>1.11</td>
<td>(1.03, 1.18)</td>
</tr>
</tbody>
</table>

<16 km zones, incidence meta-rates
- age 0-9: 22% increased
- age 0-25: 10% increased

Discussion:

- 1st meta-analysis on this topic
- consistent increase in childhood leukeamia near nuclear facilities,
- some, but not all studies: evidence for increasing SIR after start of NPP operation
- no indication for major publication bias
- nuclear reactors from Sweden, Israel, China, former Soviet Union not represented
- no support for a hypothesis to explain the excess

Conclusion:

“…it is important to note that there are many questions still to be answered….”

Incidence of childhood malignancies in the vicinity of West German nuclear power plants

Jörg Michaelis, Birgit Keller, Günter Haaf, and Peter L

(Received 23 January 1992; accepted 29 January 1992)

The incidence of childhood malignancies in 20 areas surrounding the Federal Republic of Germany and includes 1,610 cases which were reported from 1980 to 1990. The relative risk (RR) was 0.97 for all malignancies within a 15 km radius of an installation. Increased RR was observed for lymphomas, especially in regions close to the South German and West German installations before 1970. Most of this increase was attributable to an increase in regions which could not be explained by analyzing possible confounders. A comparable and even more pronounced increase of R1 power plants have been projected.

Figure 1. Location of the regions defined around nuclear installations in West Germany with matched control regions and areas around projected installations.
SHORT REPORT

An extended study on childhood malignancies in the vicinity of German nuclear power plants

Peter Kaatsch, Uwe Kaletsch, Rolf Meinert, and Jörg Michaelis

(Received 5 March 1998; accepted in revised form 30 July 1998)

Objectives: The study was performed to validate exploratory results obtained in a former study on the incidence rates of childhood malignancies in the vicinity of German nuclear power plants and to evaluate the confirmatory results of this previous study.

Methods: Incidence rates near German nuclear installations were compared to rates in control regions based on the German Childhood Cancer Registry.

Results: No exploratory result could be reproduced. This is also true for children with acute leukemia younger than 5 years who were living within a 5 km radius of an installation: an observed relative risk (RR) of 1.39 was not significantly increased (95 percent confidence interval CI: 0.69-2.57). Former confirmatory results could be confirmed again. A pooled analysis of both studies based on 2390 cases resulted in RR of 0.99 for all malignancies (CI: 0.91-1.07) and of 1.00 for acute leukemias (CI: 0.87-1.16) (children younger than 15 years of age living within a 15 km radius).

Conclusions: Results did not show significantly increased incidence rates for any subgroup with previously significant exploratory results. Therefore, it appears to be most likely that the previous results were just due to chance. Evaluating the previously confirmatory results with the combined data from the two study periods reassures that incidence rates are not increased in children younger than 15 years who are living within a 15 km radius, either for all malignancies or for acute leukemias. We conclude that, at present, in Germany no further investigations of this kind are necessary. Cancer Causes and Control 1998, 9, 529-533

Key words: Cancer, cancer registry, children, nuclear power plants, risk assessment.
Childhood Cancer in the Vicinity of German Nuclear Power Plants

Alfred Körblein, PhD†, Wolfgang Hoffmann, MD, MPH‡‡

An epidemiologic study on childhood cancer risk was conducted near nuclear power plants. The conclusions of this study have raised concerns among lobbyists as proof of increased cancer risk. A reanalysis of the data from previous studies shows a significant increase of childhood leukemia in children living near nuclear power plants. The authors conclude that childhood leukemia is restricted to children living within 15 kilometers of nuclear power plants, and childhood leukemia cluster, is expected to decrease as children grow older. This conclusion is based on the finding that the number of observed cases of childhood leukemia is significantly higher near nuclear power plants compared to control areas.

Table 5: Early childhood leukemias (0-4 years, 0-5 km region)

<table>
<thead>
<tr>
<th></th>
<th>O (NPP)</th>
<th>E (NPP)</th>
<th>O(C)</th>
<th>E(C)</th>
<th>RR</th>
<th>p-value¹</th>
</tr>
</thead>
<tbody>
<tr>
<td>all facilities</td>
<td>31</td>
<td>21.4</td>
<td>174</td>
<td>179.4</td>
<td>1.49</td>
<td>0.029</td>
</tr>
<tr>
<td>15 NPP sites</td>
<td>24</td>
<td>13.3</td>
<td>103</td>
<td>100.0</td>
<td>1.76</td>
<td>0.012</td>
</tr>
<tr>
<td>BWRs</td>
<td>13</td>
<td>6.3</td>
<td>62</td>
<td>55.4</td>
<td>1.86</td>
<td>0.038</td>
</tr>
<tr>
<td>PWRs</td>
<td>11</td>
<td>7.0</td>
<td>41</td>
<td>44.6</td>
<td>1.71</td>
<td>0.087</td>
</tr>
<tr>
<td>other facilities</td>
<td>7</td>
<td>8.1</td>
<td>71</td>
<td>79.4</td>
<td>0.96</td>
<td>0.594</td>
</tr>
<tr>
<td>NPPs-Krümmel</td>
<td>19</td>
<td>12</td>
<td>101</td>
<td>95.3</td>
<td>1.49</td>
<td>0.077</td>
</tr>
<tr>
<td>BWRs-Krümmel</td>
<td>8</td>
<td>5</td>
<td>60</td>
<td>50</td>
<td>1.33</td>
<td>0.276</td>
</tr>
</tbody>
</table>

O = observed cases; E = expected cases; NPP = study area around nuclear power plants; C = control area; RR = relative risk

¹ one-sided p-value
Int. J. Cancer 1220(2008), 721-726

Leukaemia in young children living in the vicinity of German nuclear power plants
Peter Kaatsch, Claudia Spix, Renate Schulze-Rath, Sven Schmiedel and Maria Blettner
Institute for Medical Biostatistics, Epidemiology and Informatics, German Childhood Cancer Registry, Obere Lahibachstrasse 69, 55111 Mainz, Germany

Case–control study on childhood cancer in the vicinity of nuclear power plants in Germany 1980–2003
Claudia Spix\textsuperscript{a,}\textsuperscript{b}, Sven Schmiedel\textsuperscript{a}, Peter Kaatsch\textsuperscript{a}, Renate Schulze-Rath\textsuperscript{a}, Maria Blettner\textsuperscript{b}
\textsuperscript{a}German Childhood Cancer Registry, Institute for Medical Biostatistics, Epidemiology and Informatics, University Mainz, 55120 Mainz, Germany
\textsuperscript{b}Institute for Medical Biostatistics, Epidemiology and Informatics, University Mainz, 55120 Mainz, Germany

ABSTRACT
The 1984 Windscale study raised concerns about a possible association between living in the vicinity of nuclear power plants and childhood cancer. No such effect for all cancers was seen in ecological studies in Germany (1980–1995). Results from exploratory analysis led

Zusammenfassung/Summary

Int. J. Cancer 800, 000-000 (2007)
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FAST TRACK
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Epidemiological Study on Childhood Cancer in the Vicinity of Nuclear Power Plants (KiKK-Study), 2003 – 2007

Funding: Federal Office for Radiation Protection (BfS)
Commissioned to: German Childhood Cancer Register Mainz
Primary hypothesis: cancer incidence in children under 5 yrs associated with proximity to nuclear power plants in monotonic descending relation

Design: „Ecologic“ case control study
Two parts:
1) case control study without case or control contact
2) standardized interviews (CATI) with subgroup of Part 1)
   all cases with leukemia, lymphoma, CNS tumor and 1st Dx 1993-2003; and their matched controls
   to assess confounding by other known risk factors
Epidemiological Study on Childhood Cancer in the Vicinity of Nuclear Power Plants (KiKK-Study), 2003 – 2007

Methods

- 1st incidence of cancer in 0-5 year old children in Germany
- inclusion of commercial NPP with > “trivial” time of operation (N=15)
- study regions comprise 3 counties each:
  1) county of NPP site
  2) adjacent county with closest distance to NPP site
  3) adjacent county east of NPP site

• cases: all children with incident cancers:
  - ALL, ANLL, CNS tumors incl. medulloblastoma, embryonal tumors excl. medulloblastoma
  - under 5 years of age at the time of 1st Dx
  - living in one of the study regions at time of 1st Dx
  - reported to the German Childhood Cancer Registry (N= 1,592 cases)

• controls: random selection of 3 / 6 controls per case from popul. registries
  - matched by sex, age (to month of birth), study region
  (N=4,735 controls)

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Epidemiological Study on Childhood Cancer in the Vicinity of Nuclear Power Plants (KiKK-Study), 2003 – 2007

Relevant periods of operation

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Tabelle 3.14: Fälle und Kontrollen nach Abstandskategorien
(Abstand Wohnung zum nächstgelegenen Kernkraftwerk)
Diagnose 1980-2003, alle Erkrankungen

<table>
<thead>
<tr>
<th>Abstand</th>
<th>Fälle absolut</th>
<th>Fälle %</th>
<th>Kontrollen absolut</th>
<th>Kontrollen %</th>
</tr>
</thead>
<tbody>
<tr>
<td>unter 5km</td>
<td>77</td>
<td>4,8</td>
<td>148</td>
<td>3,1</td>
</tr>
<tr>
<td>5km bis unter 10km</td>
<td>158</td>
<td>9,9</td>
<td>464</td>
<td>9,8</td>
</tr>
<tr>
<td>10km bis unter 20km</td>
<td>523</td>
<td>32,9</td>
<td>1.589</td>
<td>33,6</td>
</tr>
<tr>
<td>20km bis unter 30km</td>
<td>403</td>
<td>25,3</td>
<td>1.181</td>
<td>24,9</td>
</tr>
<tr>
<td>30km bis unter 40km</td>
<td>225</td>
<td>14,1</td>
<td>726</td>
<td>15,3</td>
</tr>
<tr>
<td>40km bis unter 50km</td>
<td>137</td>
<td>8,6</td>
<td>371</td>
<td>7,8</td>
</tr>
<tr>
<td>Ab 50km</td>
<td>69</td>
<td>4,3</td>
<td>256</td>
<td>5,4</td>
</tr>
<tr>
<td>Gesamt</td>
<td>1.592</td>
<td>100,0</td>
<td>4.735</td>
<td>100,0</td>
</tr>
</tbody>
</table>

Tabelle 3.16: Geschätzte Odds Ratios (OR) für ausgewählte Abstände
(abgeleitet aus der Regressions-Kurve aus Modell (6), Tabelle 3.15)

<table>
<thead>
<tr>
<th>Vergleichskategorie: Außerhalb der Studienregion (Abstandsmaß = 0 per Definition)</th>
<th>OR</th>
<th>Untere eins. 95%-Konfidenzgrenze</th>
</tr>
</thead>
<tbody>
<tr>
<td>5km</td>
<td>1,27</td>
<td>1,10</td>
</tr>
<tr>
<td>10km</td>
<td>1,13</td>
<td>1,05</td>
</tr>
<tr>
<td>20km</td>
<td>1,06</td>
<td>1,02</td>
</tr>
<tr>
<td>30km</td>
<td>1,04</td>
<td>1,02</td>
</tr>
<tr>
<td>40km</td>
<td>1,03</td>
<td>1,01</td>
</tr>
<tr>
<td>50km</td>
<td>1,02</td>
<td>1,01</td>
</tr>
</tbody>
</table>
Epidemiological Study on Childhood Cancer in the Vicinity of Nuclear Power Plants (KiKK-Study), 2003 – 2007

• exposure: individual distance of the residence to nearest study NPP (chimney position) at the day of 1st Dx (cases), on corresponding reference date (controls)

• Statistical approach: a priori model: Conditional logistic regression model with

\[ \log(OR(r)) = \beta r^{-1} \quad ; \quad r = \text{radius} [\text{km}] \]

<table>
<thead>
<tr>
<th>Diagnostic group</th>
<th>$\beta$</th>
<th>Lower 95%-CL</th>
<th>Cases ($N$)</th>
<th>Controls ($N$)</th>
</tr>
</thead>
<tbody>
<tr>
<td>All leukaemias</td>
<td>1.75</td>
<td>0.65</td>
<td>593</td>
<td>1766</td>
</tr>
<tr>
<td>Acute lymphoid leukaemias</td>
<td>1.63</td>
<td>0.39</td>
<td>512</td>
<td>1523</td>
</tr>
<tr>
<td>Acute non-lymphocytic leukaemias</td>
<td>1.99</td>
<td>$-0.41$</td>
<td>75</td>
<td>225</td>
</tr>
</tbody>
</table>

$\beta$, regression coefficient; 95%-CL, one-sided 95% confidence limit.
Figure 2:
Estimated dose response curve for leukaemia (upper curve) based on conditional logistic regression model (593 cases, 1766 matched controls, distance axis cut off at 50 km).
Lower curve: estimated lower one sided 95% confidence band.
Dotted lines: categorical results for inner 5- and 10-km zone.
Sensitivity analysis

• Exclusion of communities, who did not provide controls and/or controls’ addresses (16%)
• Restriction to controls, whose addresses at time of 1st Dx of index case could be manually checked (45%)
• repeating analysis with one NPP site left out (for all sites)
→ Biases small, if any.

Check for confounding

<table>
<thead>
<tr>
<th>Block</th>
<th>Vergleichs-intervall</th>
<th>Geschätzter Regressionsparameter</th>
<th>Fälle</th>
<th>Kontrollen</th>
<th>Bewertung</th>
</tr>
</thead>
<tbody>
<tr>
<td>1 Soziale Schicht</td>
<td>[-0,81; 1,93]</td>
<td>0,50</td>
<td>251</td>
<td>487</td>
<td>Kein CIE</td>
</tr>
<tr>
<td>2 (Zusätzliche) Strahlenexposition</td>
<td>[-0,81; 1,93]</td>
<td>0,87</td>
<td>251</td>
<td>487</td>
<td>Kein CIE</td>
</tr>
<tr>
<td>3 Andere i.d. Lit. disk. Risikofaktoren *)</td>
<td>[-0,81; 1,93]</td>
<td>0,61</td>
<td>251</td>
<td>487</td>
<td>Kein CIE</td>
</tr>
<tr>
<td>4 Immunologische Situation des Kindes</td>
<td>[-0,81; 1,93]</td>
<td>0,51</td>
<td>251</td>
<td>487</td>
<td>Kein CIE</td>
</tr>
<tr>
<td>5 Sonstiges</td>
<td>[-0,81; 1,93]</td>
<td>0,05</td>
<td>251</td>
<td>487</td>
<td>Kein CIE</td>
</tr>
</tbody>
</table>

*) incl. ambient pesticide exposure; X-ray exposure (child, mother; diagn., therap.); fertility treatment, infections, medical drugs during pregnancy; hair dye; etc.
Population mixing? Net migration in NPP regions with respect to year of 1st. criticality

- Brokdorf
- Brunsbüttel
- Stade
- Krümmel
- Unterweser
- Lingen/Emsland
- Grohnde
- Würgassen

Net migration
1st criticality
End of operation/end of study period
Conclusions of the KiKK-Study

- Statistically significant association between the distance of the home to the nearest NPP at the time of diagnosis and the risk of developing cancer (predominantly leukaemia) before the 5th birthday.
- Age group and disease entities plausible (under radiation hypothesis)
- Strong dose-response relation with distance
- Consistent with previous observations in Germany and other countries
- Association consistent over time, not due to effect of specific site, no evidence for systematic bias due to non-compliance, missing addresses etc.
- No evidence for relevant confounding due to any other known risk factor for childhood cancer
“…The result was not to be expected under current radiation-epidemiological knowledge. Considering that there is no evidence of relevant accidents and that possible confounders could not be identified, the observed positive distance trend remains unexplained.”

Kaatsch P. et al.: Leukaemia in young children living in the vicinity of German nuclear power plants. Int. J. Cancer: 1220, p.725

“… This observation is (...) unexpected given the observed levels of radiation “
…We cannot exclude the possibility that the effect is the result of uncontrolled confounding or pure chance.”

Conclusions of the KiKK-Study (national)

„… based on current radiobiologic and –epidemiologic knowledge, the ionising radiation emitted from German NPP in normal operation can not be interpreted as a cause on fundamental grounds. Whether confounding, selection, or chance play a role in the observed distance trend cannot be conclusively established with this study.

(Translation: W.Hoffmann)
Maria Blettner (former Chair of the German Radiation Protection Committee): “If you are hiking, X-ray your teeth or fly by plane you have a higher nuclear radiation risk than you have living near a nuclear power plant.” p.3461

“increased incidence of leukemia is either due to chance or due to other causes”

“It is possible that unknown cofounder are involved or it could be due to pure chance.” p.3461
The inconceivable / incomprehensible cloud

A study finds higher risks for childhood cancers in the vicinity of nuclear power plants in Germany.

The emotional debate demonstrates confusion.
Federal Office for Radiation Protection under suspicion.

Authors of the study: government agency has BIASED results IDEOLOGICALLY.

Minister for Environment, Nature Conservation and Nuclear Safety initiates to double-check the study

Calculations wrong

It could be also coincidence
Discussion – further spotlights

Experts disagree about risks...

…Controversial because of conflicting interests...

....Unreliable because of ambiguous interpretations...

We must not panic.

If they don`t want to find anything.

NPP study: Health professionals demand for consequences
Childhood Leukemia and Cancers Near German Nuclear Reactors:
Significance, Context, and Ramifications of Recent Studies

RUDI H. NUSSBAUM

A government-sponsored study of childhood cancer in the vicinity of German nuclear power plants (German acronym KiKK) found that children < 5 years living < 5 km from plant exhaust stacks had twice the rate of leukemia compared to those living > 10 km away. Of these plants with similar populations, no statistically significant increased risk was found (relative risk [RR] 0.97; 95% confidence interval [CI], 0.87–1.08). Nevertheless,

DISSONANCE BETWEEN ASSUMPTIONS AND EVIDENCE

Radiation risk models (magnitude? Parameters? Linearity?...)
Methodologic problems (e.g. Life Span Study)
Heterogenous radiation sensitivity (age, sex, ...)
Highly variable local conditions
Complex composition of reactor emissions
Diversity of human uptake
Biologic action of incorporated radionuclides

• A small coolant leak in Reactor 2 of the Three Mile Island nuclear power plant near Harrisburg, Pa., led to a partial meltdown of the fuel assembly

• It was the sort of accident that the designers and engineers (…) had not foreseen, and it took (…) days until the situation was under control

OR incidence (median exposure quartile 4 vs. quartile 1; logistic regression)

0,1 1 10 100
0-14 0-24 0-14 0-24

OR mortality (median exposure quartile 4 vs. quartile 1; logistic regression)

0,1 1 10 100
0-14 0-24 0-14 0-24

# adjusted for sex, age (5 yr intervals), population density, median income of study tracts

“The association we found between exposure to background radiation and childhood cancer would not be predicted on the basis of current radiobiology…… In view of lower prior probability of detecting excess cancer, it may be that chance or some unknown bias explain the result….” p. 551
Wing et al. performed a reanalysis of the TMI cancer incidence study by Hatch et al.

Rather than absolute doses to TMI area residents, Wing et al. used relative units (ratios) based on the doses assumed by the Hatch study.

"... cancer incidence ... increased more following the TMI accident in areas estimated to have been in the pathway of the radioactive plumes than in other areas ... Causal interpretation is further strengthened by the observation that ... higher and lower dose study tracts are all within 10 miles of the source and differ in exposure only as a function of weather conditions at the time of the accident." (Wing et al., 1997, pp. 56-57)
Epidemiologic Correspondence (I)

Wing et al. find positive associations of accident dose with all cancer, lung cancer, and adult leukemia. There are no new findings here, only a new interpretation..., we suspect, because of a change in the zeitgeist.”

Hatch M. et al., 1997 EHP 105 (1)

“...Hatch at al.’s study (3) appeared constrained by circular reasoning. Hatch et al. assumed that the maximum radiation dose was “very low”, an average of approximately 0.1 mSv, with 1 mSv would result in an increase in cancer of less than a half percent´.(..). Consequently, after observing that the cancer rates rose with estimated accident doses, they conclude that this association might be evidence of stress among the exposed, rather than effect of radiation from the TMI accident (5), which was their primary hypothesis”

(Wing, s. et al., 1997 Environmental Health Perspect 105 (3)
“…we have a situation manufactured from misconceptions, misinterpretations, mistaken logic and simple error.” “…published response to the brouhaha. “
“Our conclusion do differ: we saw no convincing evidence that cancer incidence was a consequence of the nuclear accident…”
(Susser, M. et al., 1997 Environmental Health Perspect 105: p.53)

“…some of the people exposed to the fallout from the accident showed signs of acute radiation damage.”
“This analysis shows that cancer incidence,.., increased more following the TMI accident in areas estimated to have been in the pathway of radioactive plumes than other areas.”
“However, we do believe that the study design by Susser an his colleagues has yielded results that demand serious attention…and our reevaluation constitutes more than “brouhaha”.”
(Wing, s. et al., 1997 Environmental Health Perspect 105: 53pp.)
Thyroid cancer in children in Belarus after Chernobyl

“IAEA's 1991 assessment of the health consequences of the Chernobyl accident found no health disorders that could be attributed directly to radiation, ruling out reports of widespread illnesses. What the investigators did find was substantial negative psychological consequences and stress-related illnesses attributed to uncertainty and fear extending beyond contaminated villages and towns.”

Rojas- Burke, J. The Journal of Nuclear Medicine Vol.33. 11, 1992

“...the only realistic explanation for the increase in the frequency of thyroid cancer is that it is a direct consequence of the accident at Chernobyl”


“There is a little doubt that the number of children reported to have thyroid cancer increased dramatically in radiation-contaminated areas,…and in Belarus in 1990 (ref.2)"

“…we do not know how many of the recorded cases were dedicated as a result of medical screening and how many cases clinically manifested themselves.”
*Shigematsu, &Thiessen, J.W. Nature 1992 359, 681*

“…. urgent need for research to establish beyond doubt the origin of the reported increases…”
“…concerted support from the international community is needed to clarify the nature of this epidemic…”
Thyroid cancer in children in Belarus after Chernobyl

“This study documents marked increases in the incidence of thyroid cancer among residents of both “higher Exposure” areas within in the Republic of Belarus.”

“…it appears likely that (…) radioiodine (…) served as a cancer-initiating event.”


Table 3  Rate ratios by sex and age at diagnosis for thyroid cancer incidence rates per 100 000 among residents of ‘lower exposure’ areas in Belarus, 1980–1999

<table>
<thead>
<tr>
<th>Year of diagnosis</th>
<th>Males</th>
<th></th>
<th></th>
<th></th>
<th></th>
<th>Females</th>
<th></th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>$n^b$</td>
<td>Rate</td>
<td>RR$^c$</td>
<td>(95% CI)</td>
<td></td>
<td>$n$</td>
<td>Rate</td>
<td>RR</td>
<td>(95% CI)</td>
</tr>
<tr>
<td>1980–1986</td>
<td>2</td>
<td>0.09</td>
<td>1.00</td>
<td>–</td>
<td></td>
<td>5</td>
<td>0.20</td>
<td>1.00</td>
<td>–</td>
</tr>
<tr>
<td>1992–1995</td>
<td>75</td>
<td>22.96</td>
<td>255.75</td>
<td>(1041.59, 62.80)</td>
<td></td>
<td>117</td>
<td>37.06</td>
<td>183.52</td>
<td>(74.98, 449.16)</td>
</tr>
<tr>
<td>1996–2001</td>
<td>38</td>
<td>13.00</td>
<td>144.80</td>
<td>(243.03, 86.28)</td>
<td></td>
<td>55</td>
<td>19.63</td>
<td>97.21</td>
<td>(59.75, 158.15)</td>
</tr>
</tbody>
</table>

Annual incidence of thyroid carcinoma among children, adolescents, and adults in Belarus

(Cardis et al. 2006, modified)
Summary, recommendation, and a word of caution…

The issue of cancer around nuclear installations
.... is addressed with increasingly adequate study designs
.... will continue to create debate
.... will possibly change our understanding of low level radiation risk
.... has probably more impact on nuclear politics than on public health

Methodologically, it
.... touches on various areas of epidemiologic methods, and probably more so on epidemiologic reasoning
.... should be studied, analysed, interpreted, and communicated with the unbiased, (self-)critical, internal and external validity-driven, a priori hypothesis-oriented scientific approach of epidemiology