The human sex odds at birth in France: a preliminary geo-spatial-temporal approach in the vicinity of two selected nuclear facilities Centre de Stockage (CdS) de l'Aube and Institut Laue-Langevin (ILL) in Grenoble

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Workshop: Simulation in den Umwelt- und Geowissenschaften, 10. bis 12. April 2013, Leipzig, Germany
Content

- Background and Motivation
- Data and Statistical Methods
- Results
  - TBL Gorleben, Germany
  - CdS l’Aube, France
  - ILL Grenoble, France
- Conclusion
- Outlook
Background and Motivation  Nuclear Bomb Tests

Cumulative Emissions of Radio Nuclides – Increasing Pollution of the Biosphere

The "Baker" explosion, part of Operation Crossroads, a nuclear weapon test by the United States military at Bikini Atoll, Micronesia, on 25 July 1946" (WIKIPEDIA, visited 11/4/2011)
Background and Motivation  Chernobyl

Cumulative Emissions of Radio Nuclides – Increasing Pollution of the Biosphere

Aerial view of the damaged core on May 3, 1986
(WIKIPEDIA, visited 11/4/2011)

Fallout  Southwest Europe < Rest of Europe
Background and Motivation  Fukushima

Cumulative Emissions of Radio Nuclides – Increasing Pollution of the Biosphere
Background and Motivation  NF/NPP – Emissions $^{3}$H $^{14}$C

Cumulative Emissions of Radio Nuclides – Increasing Pollution of the Biosphere

154 m „vent stack“ „Abluftkamin“ – NPP Neckarwestheim
Background and Motivation  Radiation induced genetic effects

Muller discovered X-ray mutagenesis in 1927

In 1946 Muller was awarded the Nobel Prize in Physiology or Medicine, "for the discovery that mutations can be induced by X-rays"

Pauling
1954 Nobel Prize in Chemistry
1962 Nobel Peace Prize

In 1958, Pauling and his wife presented the United Nations with the petition signed by more than 11,000 scientists calling for an end to nuclear-weapon testing

Neel

“Ionizing radiation can and undoubtedly does produce lethal mutations associated with the X chromosome, and under the simplest of circumstances these mutations may lead to an altered sex ratio among progeny born subsequent to exposure” (1966)
**Background and Motivation  Radiation and Sex Ratio or Sex Odds**

- **Sex Ratio (SR)** is the pertinent term for the number of newborn boys divided by the number of newborn girls
  
  \[ \text{SR} = \frac{\text{boys}}{\text{girls}} = \frac{m}{f} \]

- The **male probability**
  
  \[ p_{\text{male}} = \frac{\text{boys}}{\text{girls} + \text{boys}} = \frac{m}{m+f} \]

  leads to the more appropriate **Sex Odds (SO)**
  
  \[ \text{SO} = \frac{p_{\text{male}}}{1 - p_{\text{male}}} = \frac{\text{boys}}{\text{girls}} = \text{SR} \]

- Comparing two **SO** leads to the obvious and natural measure **Sex Odds Ratio**
  
  \[ \text{SOR} = \frac{\text{SO}_{\text{exposed}}}{\text{SO}_{\text{nonexposed}}} \]

- The inconvenient term "**Sex Ratio Ratio**" is avoided (in German: Geschlechtsverhältnisverhältnis vs. Geschlechtschancenverhältnis)
Background and Motivation  Radiation and Sex Ratio or Sex Odds

**Genetic theory for the human sex odds at birth**

**Irradiated parents and offspring gender sex odds**

- Fathers only $\Rightarrow$ sex odds $\uparrow$
- Mothers only $\Rightarrow$ sex odds $\downarrow$
- Both parents $\Rightarrow$ ???


Background and Motivation  Chernobyl: Sex Odds in Europe

Fig. 2. Male birth proportions for the Czech Republic, Denmark, Finland, Germany, Hungary, Norway, Poland, and Sweden combined (CDFGHNPS) and for Bavaria, the former GDR, and West Berlin combined (BGW) from 1982 to 1992 including jump-models in logistic regression (solid lines).

Background and Motivation  Chernobyl: Sex Odds in Europe

Criterion     Value       DF     Value/DF     Pr > ChiSq  
Deviance      56.92       54       1.054         0.367  
Pearson       56.92       54       1.054         0.367  

Analysis of Maximum Likelihood Estimates

Parameter  Estimate  Standard  Wald   Pr > ChiSq  
           Error     Error   Chi-Square   Pr > ChiSq  
Intrcpt    0.0533    0.000401      17635.6787        <.0001  
tu         -0.00224    0.000251         79.5937        <.0001  
te         -0.00247    0.000543         20.7330        <.0001  
d87        0.00200    0.000523         14.5855        0.0001  
t87        0.00419    0.000689         36.8871        <.0001  
dt2000     -0.00474     0.00121         15.4755        <.0001  
dusa       -0.00423    0.000451         88.1824        <.0001  

Pearson Residuals for global synoptic model
Background and Motivation  Chernobyl: Sex Odds in Germany

Analytical ecological level study

**multi-group** fallout (proxy for collective dose) in Bavaria+GDR

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Background and Motivation

Chernobyl: Sex Odds in Germany

Analytical ecological level study

Multi-group fallout (proxy for collective dose) in Bavaria+GDR

- OR/(mSv/a) 1.0380
- 95%-CI [1.0126, 1.0640]
- p-value 0.0031

As learned from the Atomic Bomb Tests and from Chernobyl, the human secondary sex odds (SO) at birth (male:female) is a simple and sensitive genetic health indicator. As childhood cancer is elevated near nuclear power plants, we looked after the sex odds at the municipality level in Germany and Switzerland and found increased sex odds within 35 km circular discs around nuclear facilities (NF):


Is the human sex odds at birth distorted in the vicinity of nuclear facilities (NF)? A preliminary geo-spatial-temporal approach, EnviroInfo 2010, Proceedings of the, 24th International Conference on Informatics for Environmental Protection, Cologne / Bonn, Germany

Scherb H, Voigt K.

Scherb H, Voigt K.

Is the human sex odds at birth distorted in the vicinity of nuclear facilities in France?
**Data and Statistical Methods**

**Live Births by Gender in Municipalities**

Municipality level birth data from Germany and Switzerland (data as of 6/2012)

German data not yet complete because of federal structure and German reunification in 1990

<table>
<thead>
<tr>
<th>Deviation Code</th>
<th>Bundesland</th>
<th>Period available</th>
<th>Deviation in year/period</th>
<th>Deviation size (births)</th>
<th>Births total</th>
<th>male</th>
<th>female</th>
<th>SO</th>
<th>Ln SO</th>
<th>Var</th>
<th>SE</th>
<th>2*SE</th>
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<th>SE</th>
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<td>2000;2002-2004 total ca. 7</td>
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<td>NRW</td>
<td>1970 - 2010</td>
<td>1971 total ca. 3</td>
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<td>5444572</td>
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<td>SH</td>
<td>1981 - 2010</td>
<td>1983;1993;2003 total ca. 10</td>
<td>768937</td>
<td>394762</td>
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<td>1991 - 2009</td>
<td>1991;2002-2004 total ca. 10</td>
<td>317125</td>
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<td>median 11</td>
<td>Bremen</td>
<td>1970 - 2010</td>
<td>1970 - 2010 ca. 6 per anno</td>
<td>403173</td>
<td>207920</td>
<td>195253</td>
<td>1.0649</td>
<td>0.0629</td>
<td>9.931E-06</td>
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<tr>
<td>large 4</td>
<td>NRW</td>
<td>1957 - 1969</td>
<td>1957-1967 up to 400 per anno</td>
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<th>Var</th>
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<th>2*SE</th>
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<td>33420738</td>
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<td>16259193</td>
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<td>0.0540</td>
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</table>

519,226 non-zero observations effective municipality-years
Municipalities, Nuclear Facilities (NF, xx), and the Study Region
Data and Statistical Methods  France convenient – centralist country

Source: Etat civil INSEE [producteur], Centre Maurice Halbwachs (CMH) [diffuseur]
Logistic regression is used for modeling, predicting, estimating, or testing of determinants of the outcome of a binomial variable, e.g. boys among newborn children.

**Sample SAS code for performing logistic regression:**

### Rayleigh function

*Comment: m=male, f=female;

data nlin; set nlin;
x=km;
so=m/f;
z=log(so);
var=1/m+1/f;
w=1/var;
run;

proc nlin data=nlin;
parms a=.00 b=.05 c=20;
model z = a + b*(x/c)*exp(-((x/c)**2-1)/2);
der.a=1;
der.b=(x/c)*exp(-(x/c)**2-1)/2;
der.c= -b*(x/c**2)*exp(-(x/c)**2-1/2) + b*(x**3/c**4)*exp(-(x/c)**2-1)/2;
_weight_=w;
run;

### Simple jump function

*Comment: m=male, f=female;

data a; set a;
d35=0;
if km < 35 then d35=1;
run;

proc logistic data=a;
model m/(m+f) = d35/scale=d;
run;
Results **TBL Gorleben, CdS l’Aube, and ILL Grenoble**

- **Transportbehälterlager (TBL) Gorleben, Germany**
  Gorleben is a radioactive waste disposal site, currently used as an intermediate storage facility planned to serve as a future deep final repository for waste from nuclear reactors.

- **Centre de stockage (CdS) de l'Aube, France**
  Disposal facility for intermediate and low level short lived waste. Disposal of waste resulting from processing of the spent fuel ???

- **ILL Grenoble, France**
  The Institut Laue–Langevin, founded in 1967 and honouring the physicists Max von Laue and Paul Langevin, provides one of the most intense neutron sources in the world.
### Results

Local data for Gorleben, l’Aube, and ILL Grenoble

<table>
<thead>
<tr>
<th>Year</th>
<th>Total Male</th>
<th>Total Female</th>
<th>Total Male</th>
<th>Total Female</th>
<th>Total Male</th>
<th>Total Female</th>
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<td>686 552</td>
<td>25407</td>
<td>13044</td>
<td>25391</td>
<td>12969</td>
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<td>691 557</td>
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<td>13039</td>
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<td>1970</td>
<td>. . . .</td>
<td>701 562</td>
<td>25742</td>
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<td>1971</td>
<td>. . . .</td>
<td>711 567</td>
<td>25942</td>
<td>13039</td>
<td>25703</td>
<td>12967</td>
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Births within 30 km from the TBL Gorleben

Births within 30 km from the CdS de l’Aube

Births within 80 km from the ILL Grenoble

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**Live Births (LB): Sex Odds (SO)**

**30 km from TBL Gorleben; jump 1998 SOR 1.148; p-value = 0.0011**

**30 km from CdS de l’Aube; jump 2000 SOR 1.178; p-value < 0.0001**
Results  Local absolute births for l’Aube – synoptic Poisson model

30 km  CdS de l’Aube; synoptic Poisson model with 3.4 % overdispersion and $p$-value 0.4145

- Female births
- Male births
- Fem mod reduced

Deficit: 394 girls, $p$-value < 0.0001
Results  Specificity of the effect (analysis not yet available for France)

- Preliminary analysis, German data not yet complete, see p. 15
- Paneling of Germany by 70 x 70 km² squares (≈ 40 km radius circular discs)
- 1st Castor to Gorleben in 1995
- Testing the uniform one-sided null hypotheses in all 70 x 70 km² squares: “No Sex Odds upward jump from 1996 onward”

Conclusions:

Gorleben is unique in Germany with a one-sided p-value of 0.0012 < 0.0020

Next to Gorleben is Ellweiler (p=0.0121), which is a “closed” nuclear processing and storage site with possible radioactive releases in January 1995: damage of coverings and erosion of the waste dump after strong rainfall in January 1995.
Results  **Spatial-temporal analyses: Transportbehälterlager Gorleben**

Spatial-temporal trend of the live births sex odds ratio in 10 km distance categories around the TBL Gorleben (CP=1998)

![Graph showing the spatial-temporal trend of the live births sex odds ratio](image)
Results  Spatial-temporal analyses: Centre de Stockage de l’Aube

Spatial-temporal trend of the live births sex odds ratio in 10 km distance categories around the CdS de l’Aube (CP=2000)

SOR from 2000 to 2007 vs. from 1992 to 1999; F-test p-value = 0.0156
Results  Spatial-temporal analyses: CdS + TBL combined

Combined spatial-temporal trend of the live births sex odds ratio in 10 km distance categories around the CdS de l’Aube (CP=2000) and the TBL Gorleben (CP=1998)

\[
\text{SOR 8 years after CP vs. 8 years before CP; F-test } p\text{-value} = 0.0023
\]
Results  Spatial-temporal analyses: control region Bure

Control region Bure, rock laboratory for studying long-time HAW disposal techniques, first boring in 1994
Results  **Spatial-temporal analyses: control region Bure**

Control region **Bure**, rock laboratory for studying long-time HAW disposal techniques, first boring in 1994, no significant “after-vs.-before–effect”

**SOR from 1994 to 2007 vs. from 1968 to 1993; F-test p-value = 0.2708**

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**HelmholtzZentrum münchen**
German Research Center for Environmental Health
Spatial-temporal analyses: ILL Grenoble

Spatial trend of the live births sex odds in 10 km distance categories around the Institut Laue-Langevin (ILL) at Grenoble 1968 - 2007

Rayleigh function for SO around ILL Grenoble; F-test p-value = 0.0482

Distance from the ILL Grenoble [km]; 10 km ring categories
Results  Spatial-temporal analyses: ILL Grenoble

Spatial trend of the live births sex odds in 1 km distance categories around the Institut Laue-Langevin (ILL) at Grenoble 1968 - 2007
Results  Possible consequences

- Within 30 km from l’Aube or Gorleben there is a theoretical **deficit of 720 girls** in the combined period∗region up to 8 years from 2000 onward (l’Aube) and from 1998 onward (Gorleben), respectively.

- Within 80 km from the ILL Grenoble there is a theoretical **deficit of 2994 girls** from 1968 to 2007 compared to the remainder of France.

- Under the somewhat speculative assumption of a sex odds of 3:10 among the “missing children”, we obtain approximately twice the figures for missing girls as missing children, i.e. ≈ **1400 and 6000 missing children** for l’Aube/Gorleben and ILL Grenoble, respectively; see our publications.
Conclusion

- “Low-dose” ionizing radiation increases the secondary sex odds in humans. The preliminary long term sex odds ratio is in the range of 1.01 to 1.02 per mSv/year.

- Our results clearly disprove the prevailing believe (e.g. by UNSCEAR) that radiation-induced genetic effects have yet to be detected in human populations.

- For fundamental criticism concerning the basis of radiation safety standards see The Lesvos Declaration, 6 May 2009

  or the book

  Fukushima and Health: What to Expect (Documents of the ECRR)

- The culprit of the many effects observed and reported may be incorporated radionuclides inadequately assessed by the radiological sciences
Outlook (own research)

- Continuation of Studies concerning low dose ionizing radiation and Sex Odds
- Germany (old Bundesländer – former GDR)
- France (large number of nuclear facilities not yet considered)
- Next publications: Nuclear Facilities international, Sex Odds in Cuba
  storage sites like Jülich, Ahaus, Lubmin, etc. in Germany
- Collaboration with other scientific disciplines, e.g. Genetics
Outlook (general)

- Important data on underestimated environmental and health topics are partly available
- However, often there is no (optimal) utilization of the existing data bases
- Thus, greater input from mathematics, statistics, and computer science is urgently needed to scrutinize those data
- To achieve this goal, the full spectrum of different data analysis approaches should be considered and applied appropriately
- Improved interdisciplinary skills are needed at all stages of environmental health research
The human sex odds at birth in France in the vicinity of two selected nuclear facilities

Thank you for your attention

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