HelmholtzZentrum münchen
German Research Center for Environmental Health

Detrimental Genetic Effects of Ionizing Radiation across Europe after the Chernobyl Accident

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Motivation

- Detrimental genetic effects in exposed human populations have been considered and investigated ever since the discovery of the mutagenic properties of X-rays
- Man made ionizing radiation poses an ongoing increasing environmental and human risk underestimated and not yet fully understood
- The most important public health criteria available for studying those effects in man are
  - cancer
  - birth defects
  - stillbirths
  - neonatal deaths, infant deaths
  - human birth sex odds
- The Chernobyl accident resulted in the exposure of a large number of people to ionizing radiation and created a new situation for epidemiology

Data & Statistical Methods

- **Data**
  - **Official national or regional annual or monthly statistics on live births, stillbirths, perinatal mortality, and infant deaths**
  - **Published congenital malformation data (e.g., Down syndrome, cleft lip and palate)**
  - **Congenital malformation registry data (e.g. Bavaria, Germany, 1984 - 1991)**
  - **Cancer registry data (e.g. Czech Republic)**
- **Statistical Methods**
  - **Logistic model – example:** $\log \text{ odds}(\pi_x) = \text{intercept} + \alpha * \text{d5(x)}$
  - **Spatial-temporal trend models with dummy-coding and spatial-temporal interactions**

Results: Thyroid cancer in adults in Belarus and the Czech Republic

Mahoney MC et al. 2004

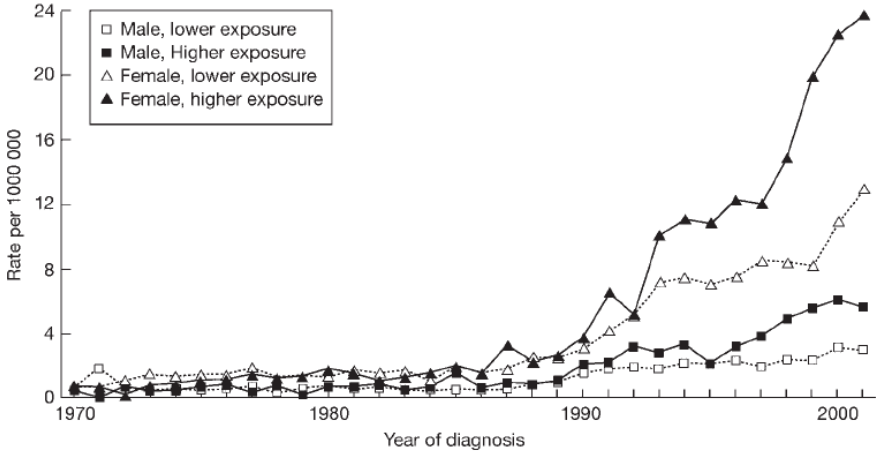


Figure 3 Annual age-adjusted thyroid cancer incidence rate, by calendar year, gender, and area of exposure,[a] Belarus, 1970–2001

Mürbeth S et al. 2004

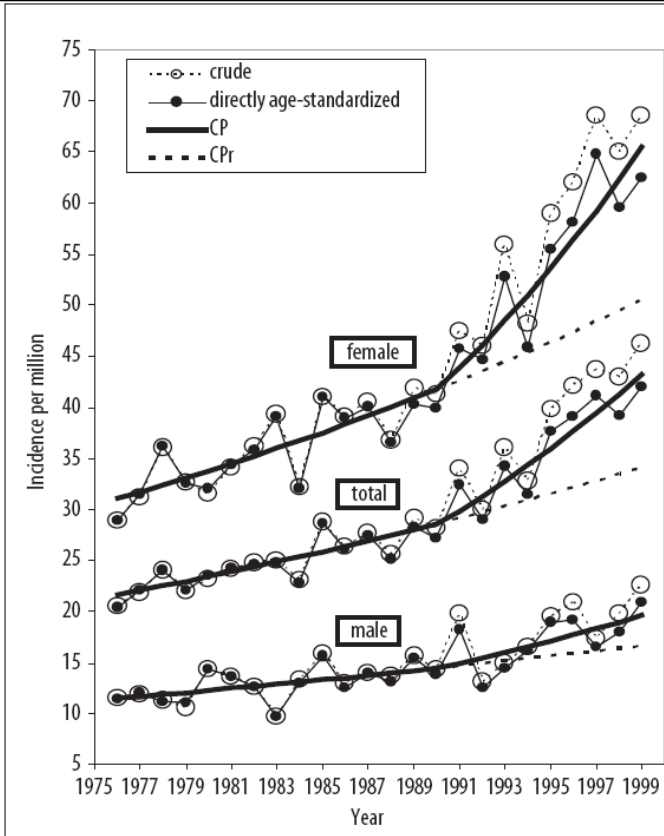


Figure 2. Crude and directly age-standardized incidence of thyroid carcinoma in females, males and both genders combined in the Czech Republic, change-point (CP) and reduced change-point (CPr) linear logistic regression models (see Table 1).

Results: Stillbirths in Europe

Scherb H et al. 1999

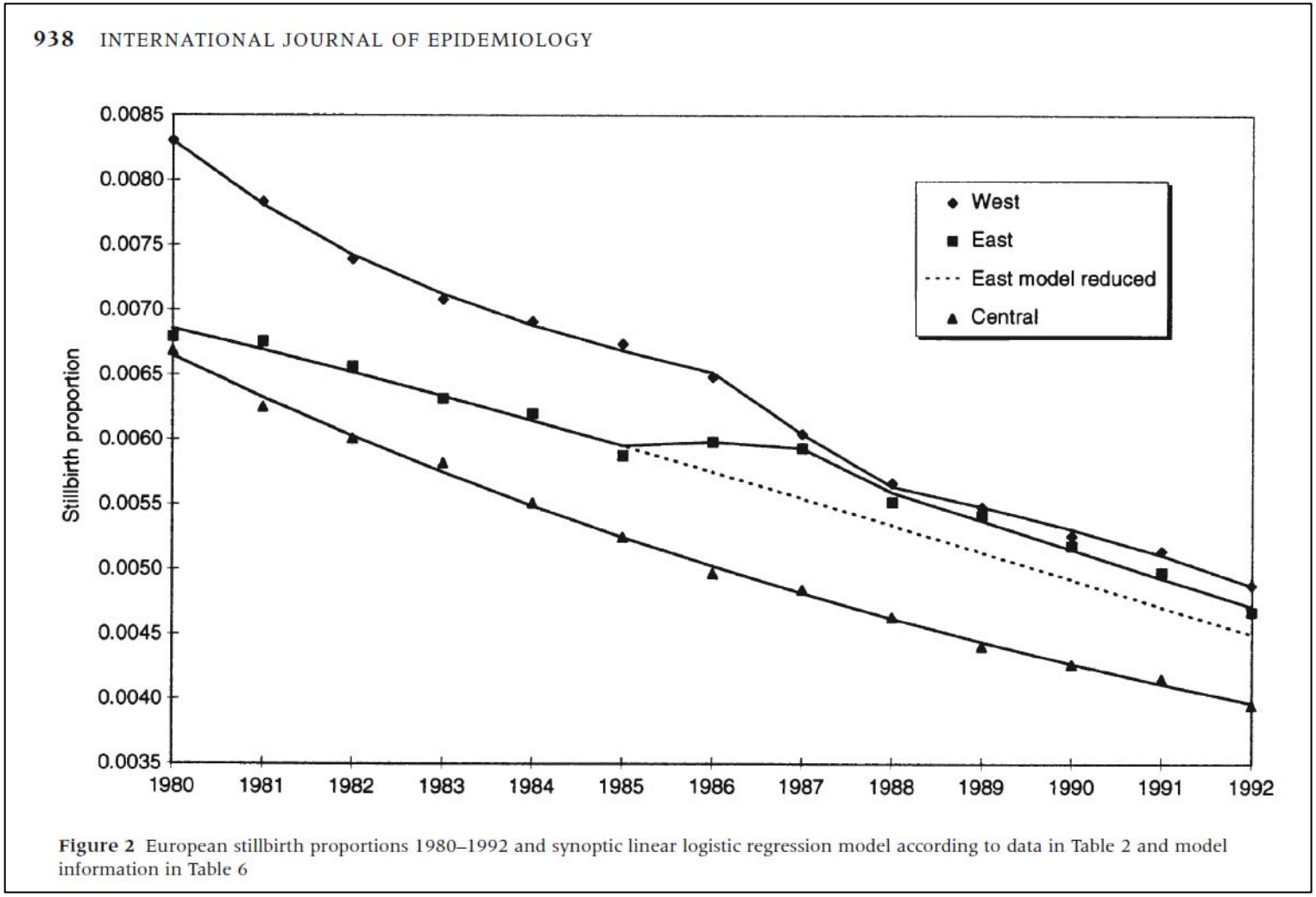
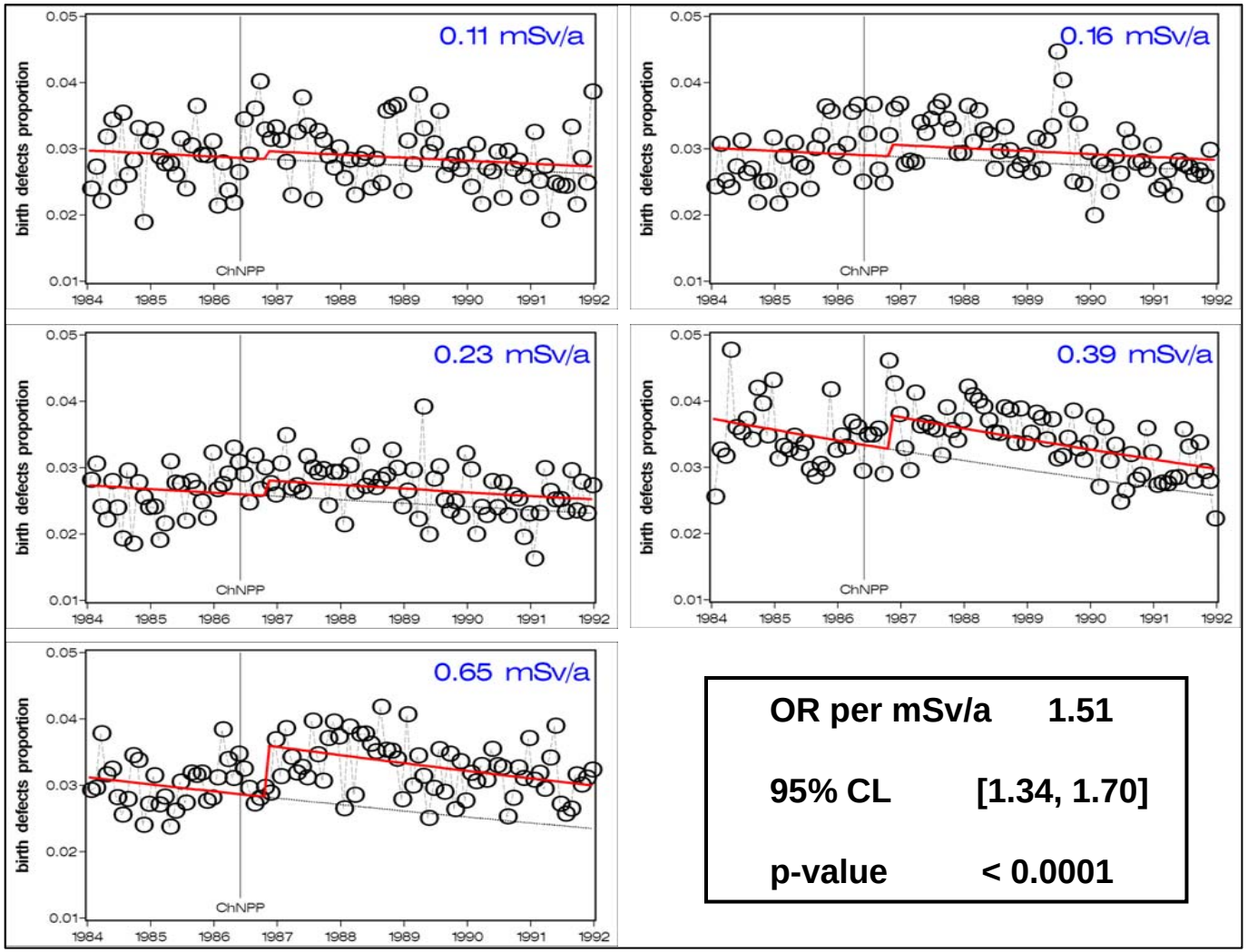


Figure 2 European stillbirth proportions 1980–1992 and synoptic linear logistic regression model according to data in Table 2 and model information in Table 6

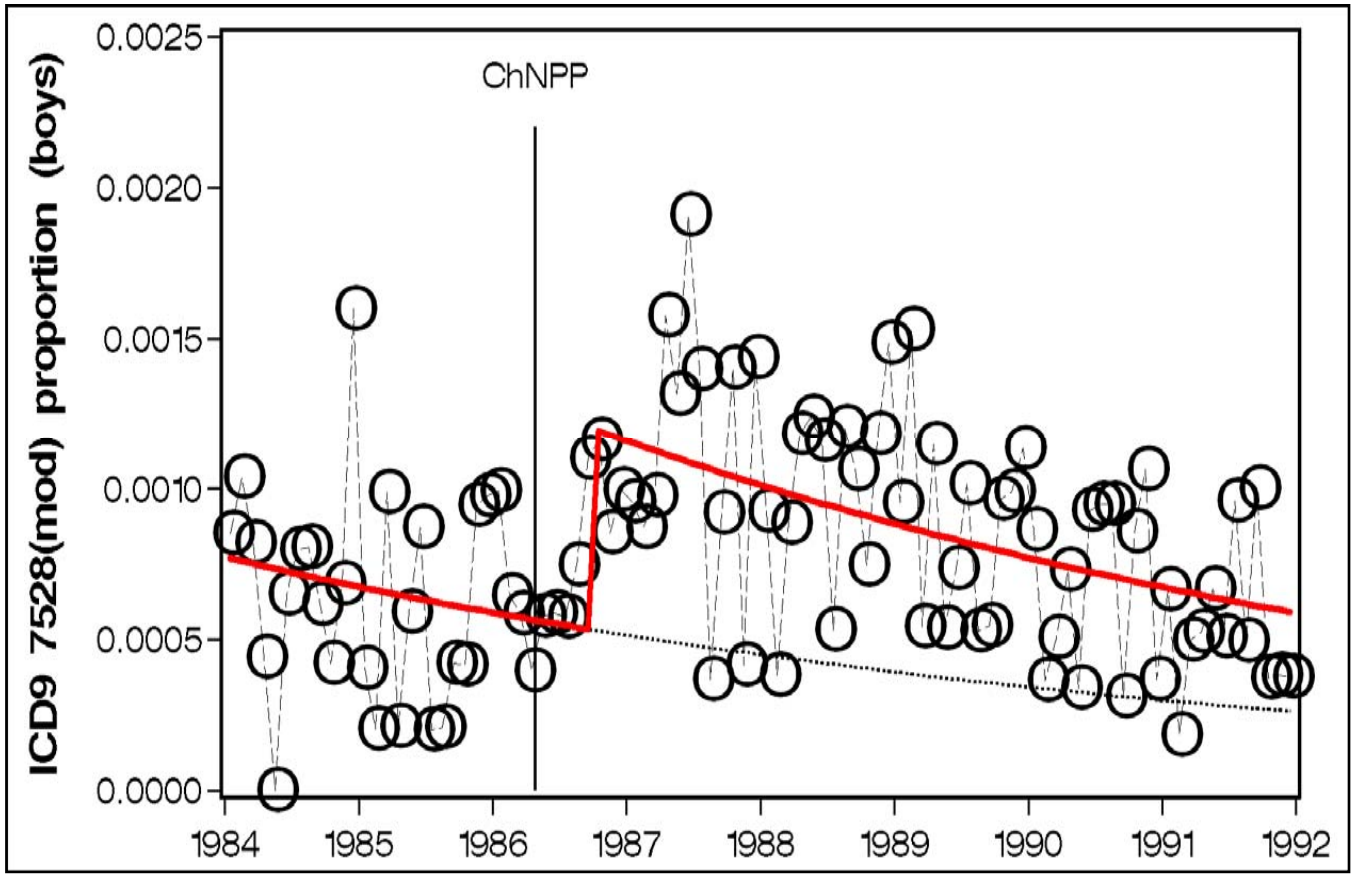
Results: Birth defects in Bavaria, Germany, 1984 – 1991

Scherb and Weigelt 2003



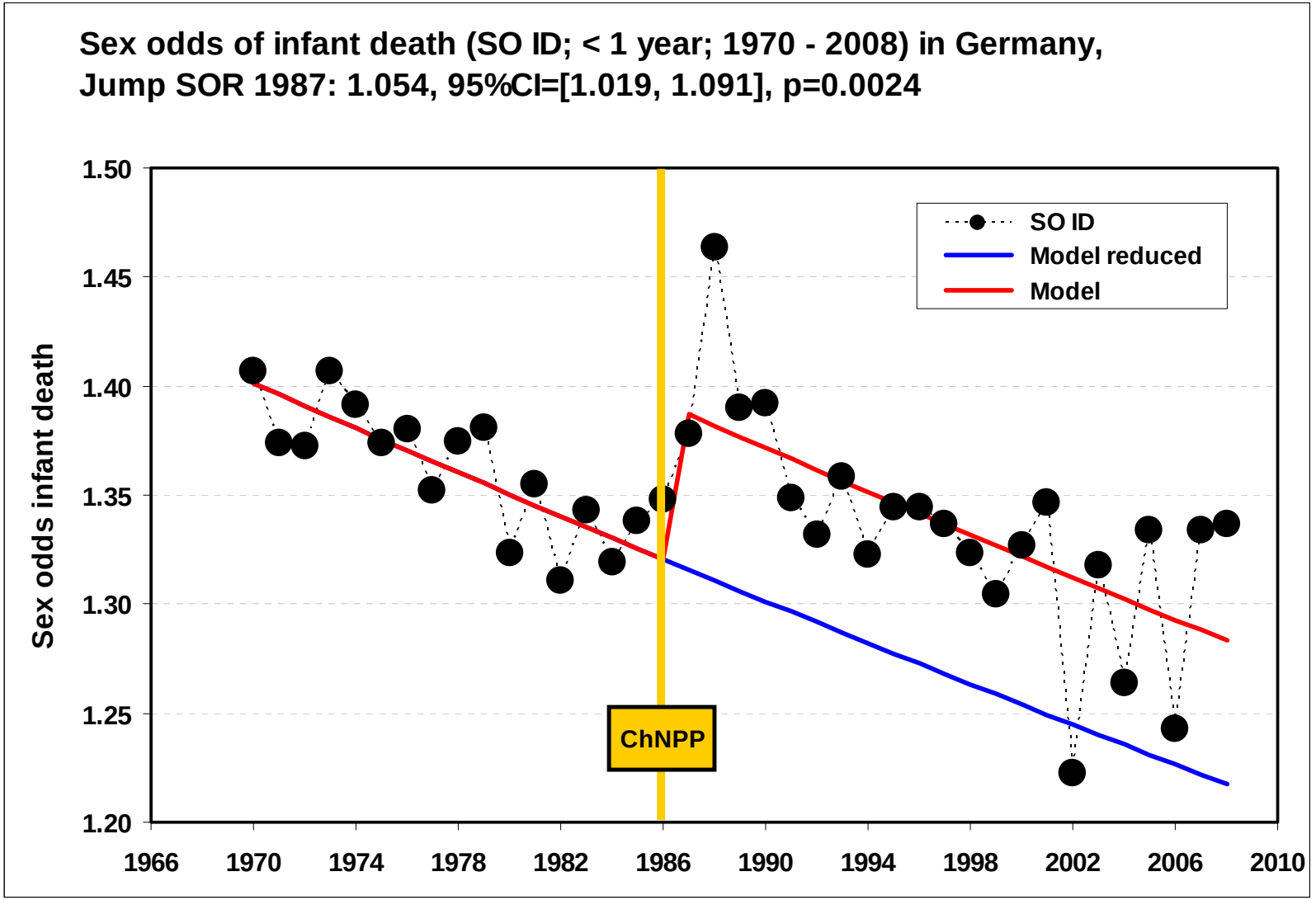
OR per mSv/a	**1.51**
95% CL	**[1.34, 1.70]**
p-value	**< 0.0001**

Results: Male sexual organ defects in Bavaria, Germany, 1984 – 1991

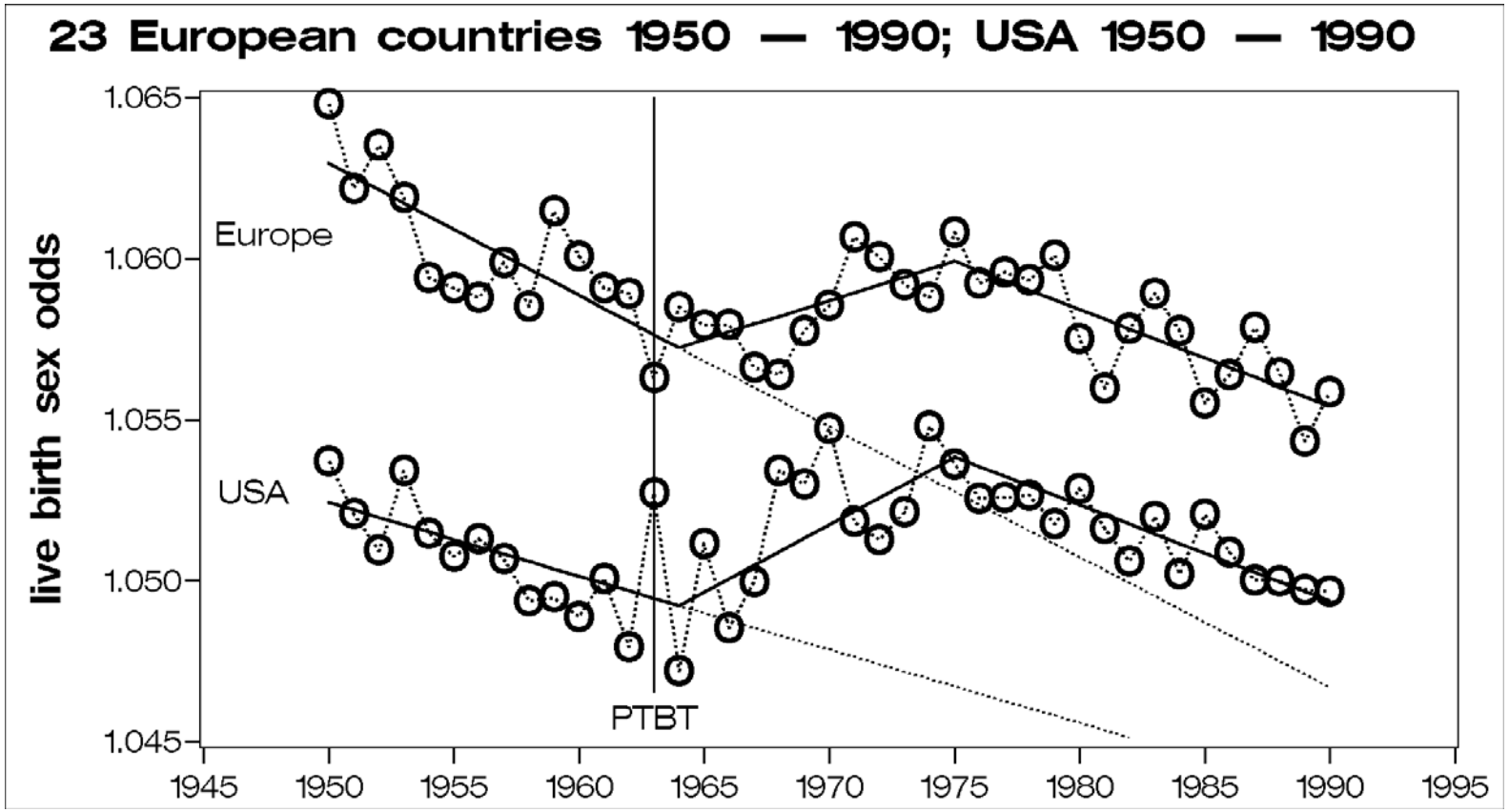


odds ratio (OR) for jump in October 1986: OR = 2.26, 95% CL [1.58, 3.23], p-value < 0.0001

Results: Infant death in Germany, 1970 – 2008



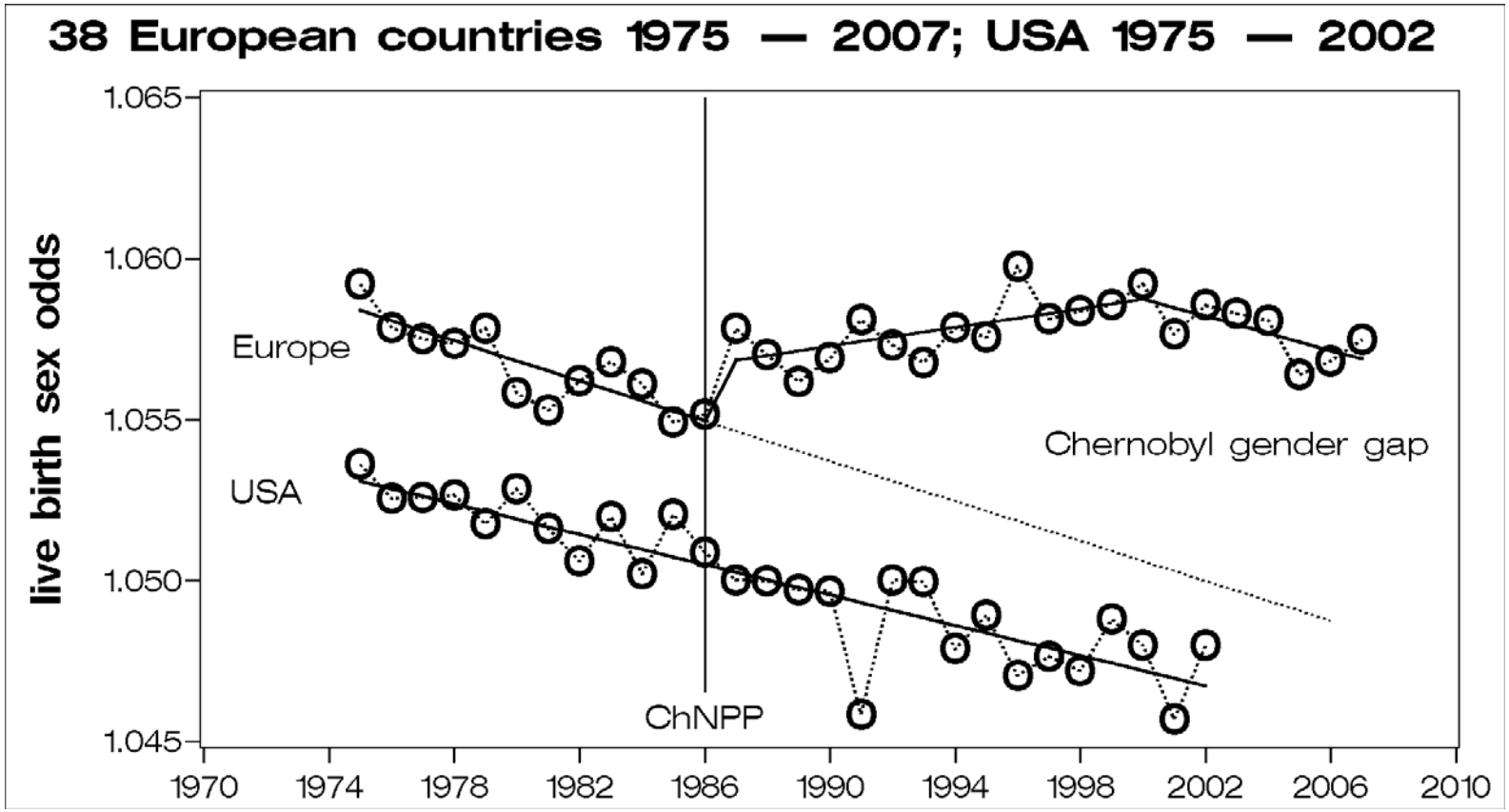
Results: Increased sex odds (SO) after the atomic bomb tests globally



Trends of the live birth sex odds (male/female) in Europe and in the USA, 1950 to 1990 (Martuzzi et al. 2001; Mathews and Hamilton 2005), Synoptic reanalysis: http://www.ncbi.nlm.nih.gov/pubmed/21336635

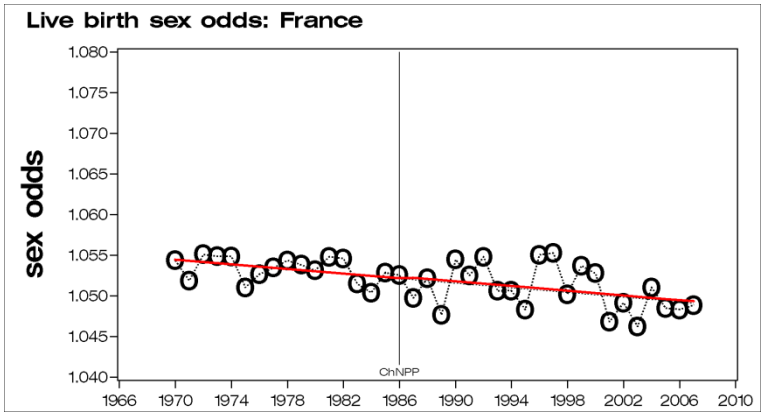
PTBT: Partial Test Ban Treaty

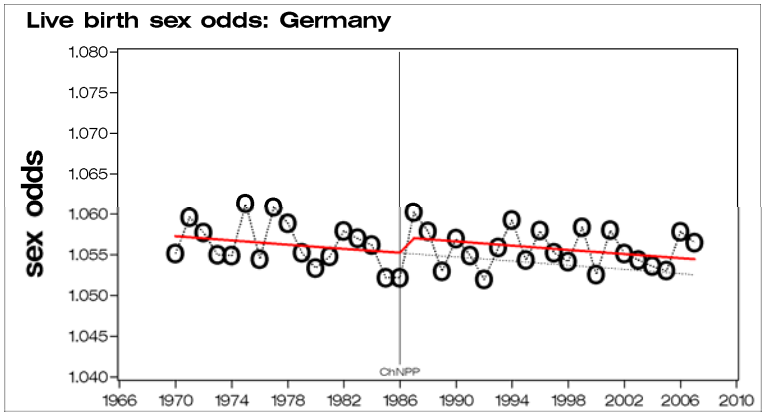
Results: Increased sex odds (SO) after Chernobyl in Europe



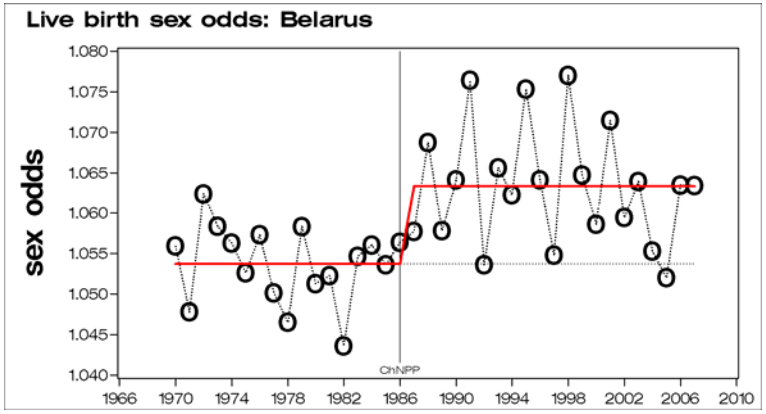
Results: Increased sex odds (SO) after Chernobyl in Europe

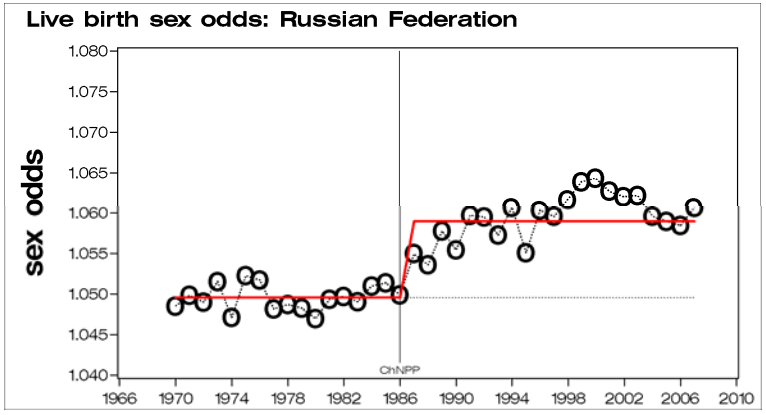
Less exposed countries: France and Germany





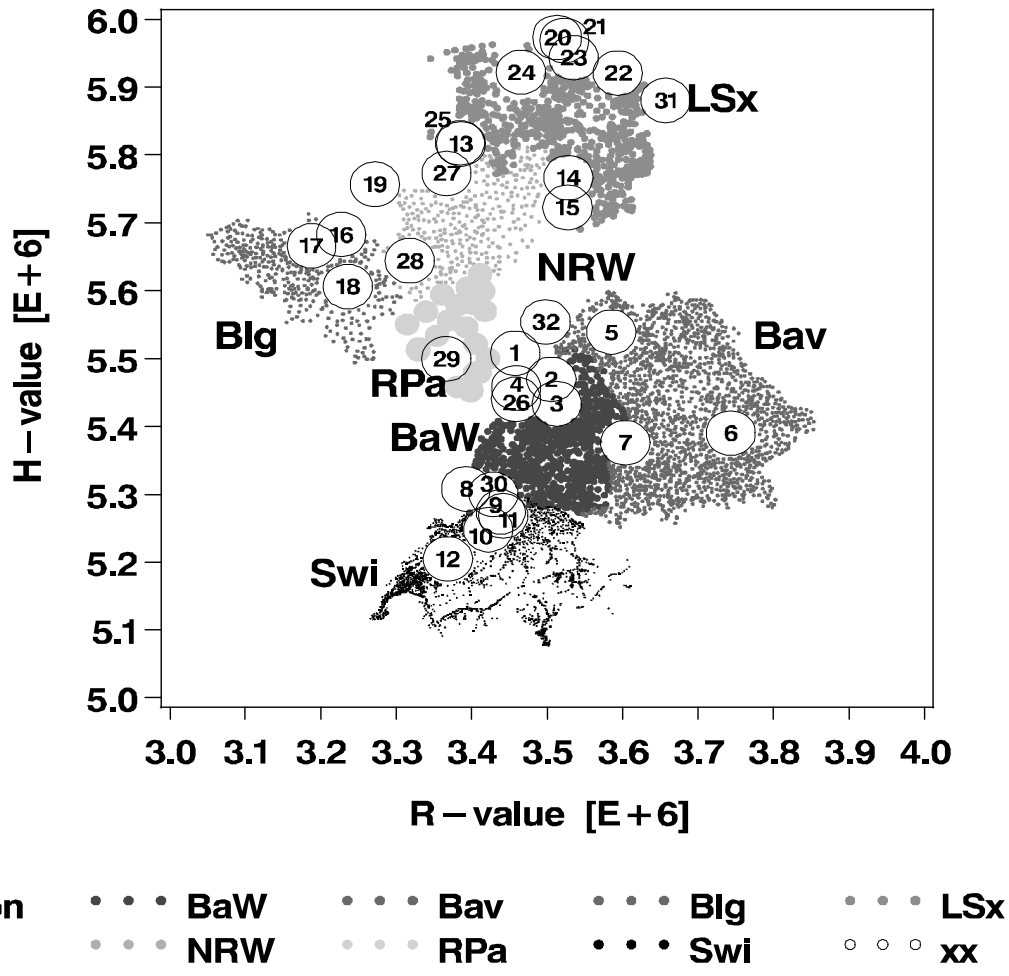
Highly exposed countries: Belarus and Russian Federation



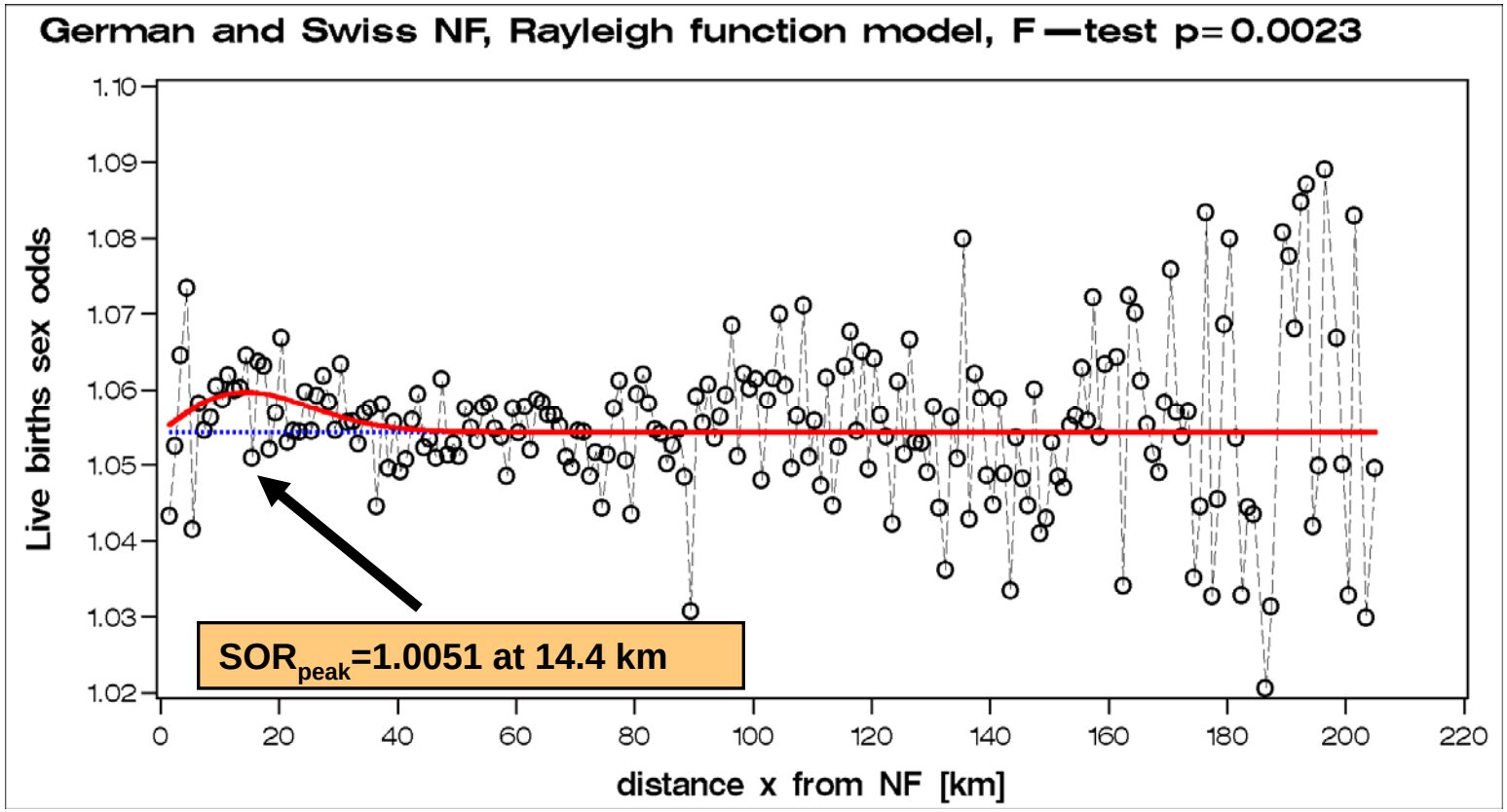


Results: SO near nuclear facilities, Germany and Switzerland

Municipalities, Nuclear Facilities (NF, xx), and the Study Region

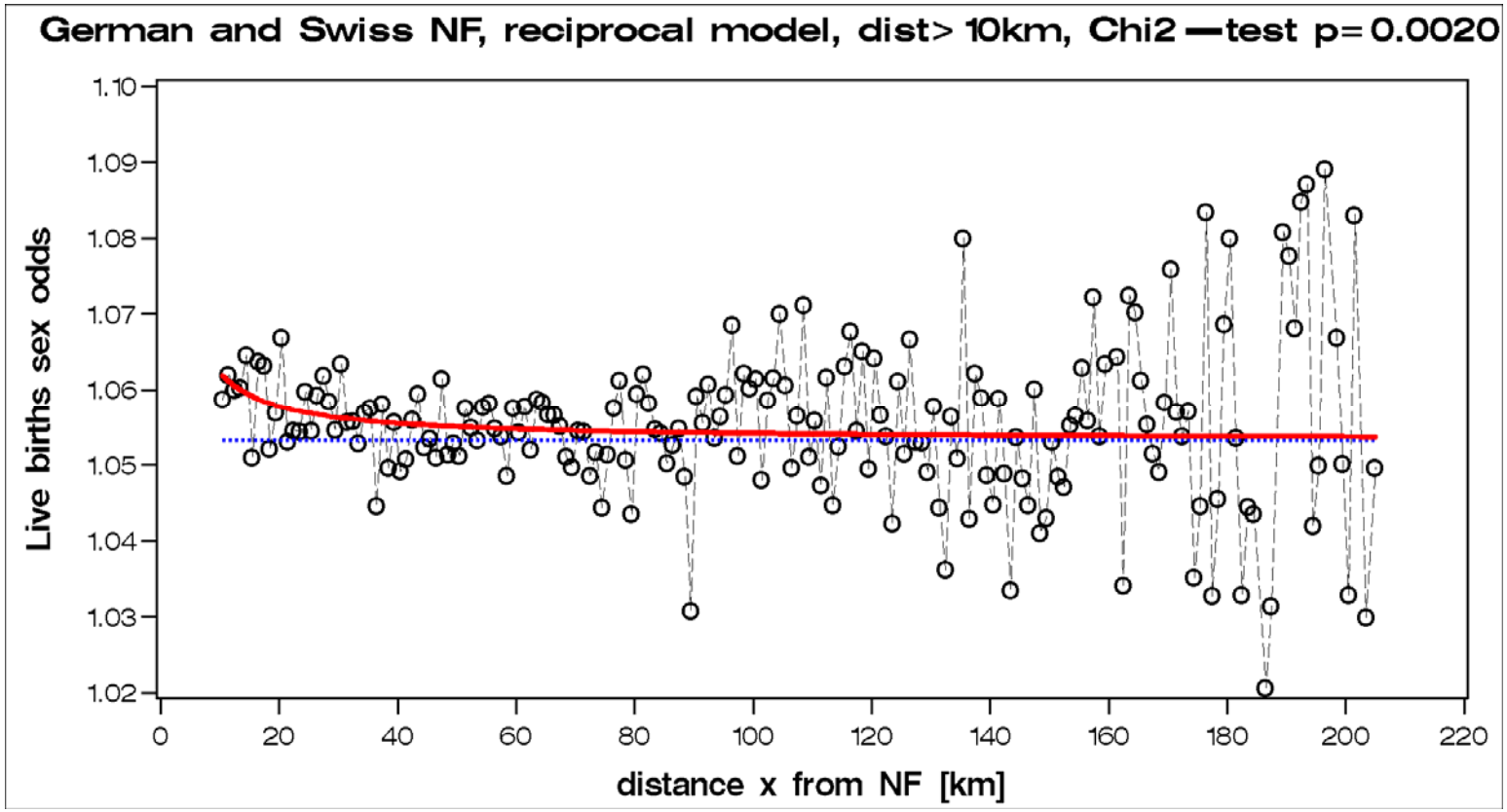


Results: Increased sex odds near nuclear facilities (NF)



In probability theory and statistics, the Rayleigh distribution is a continuous probability distribution. As an example of how it arises, the wind speed will have a Rayleigh distribution if the components of the two-dimensional wind velocity vector are uncorrelated and normally distributed with equal variance. The distribution is named after Lord Rayleigh. (WIKIPEDIA)

Results: Increased sex odds near nuclear facilities (NF)



A reciprocal distance law (1/r) was applied in the KiKK (Germany) study, but here it works only when data are restricted to distances greater than 10 km

Kusmierz R, Voigt K, Scherb H 2010 Improved paper ESPR

Conclusion

- **Low-dose ionizing radiation increases**
  - **thyroid cancer in adults**
  - **congenital malformations**
  - **stillbirths**
  - **infant deaths**
  - **secondary sex odds in humans**

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

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

Outlook

- 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 mathematicians and statisticians 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

Thank you for your attention

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