

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

**Hagen Scherb and Kristina Voigt**

Institute of Biomathematics and Biometry

**All-Russian scientific-practical conference with foreign participation: "Roentgen-radiological technologies and radiation medicine in treatment – solving liquidation problems of man-made disasters" – on account of the 25<sup>th</sup> anniversary of the Chernobyl accident, Moscow, February 15<sup>th</sup> - 16<sup>th</sup>, 2011**

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- Increased thyroid cancer, stillbirths, birth defects, and infant deaths after Chernobyl
- Increased sex odds (SO) after the atomic bomb tests globally
- Increased sex odds (SO) after Chernobyl in Europe
- Increased sex odds (SO) near nuclear facilities (NF)

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# Motivation

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- **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

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## ➤ Data

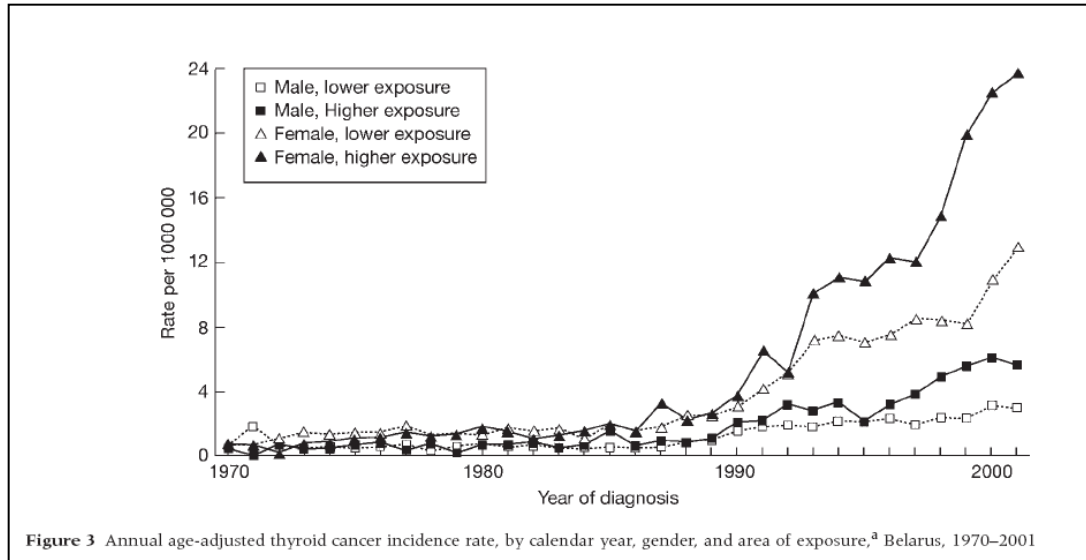
- Official national or regional annual or monthly statistics on live births, stillbirths, perinatal mortality, and infant deaths
- Published congenital malformation data (e.g., Down syndrome, cleft lip and palate)
- Congenital malformation registry data (e.g. Bavaria, Germany, 1984 - 1991)
- Cancer registry data (e.g. Czech Republic)

## ➤ Statistical Methods

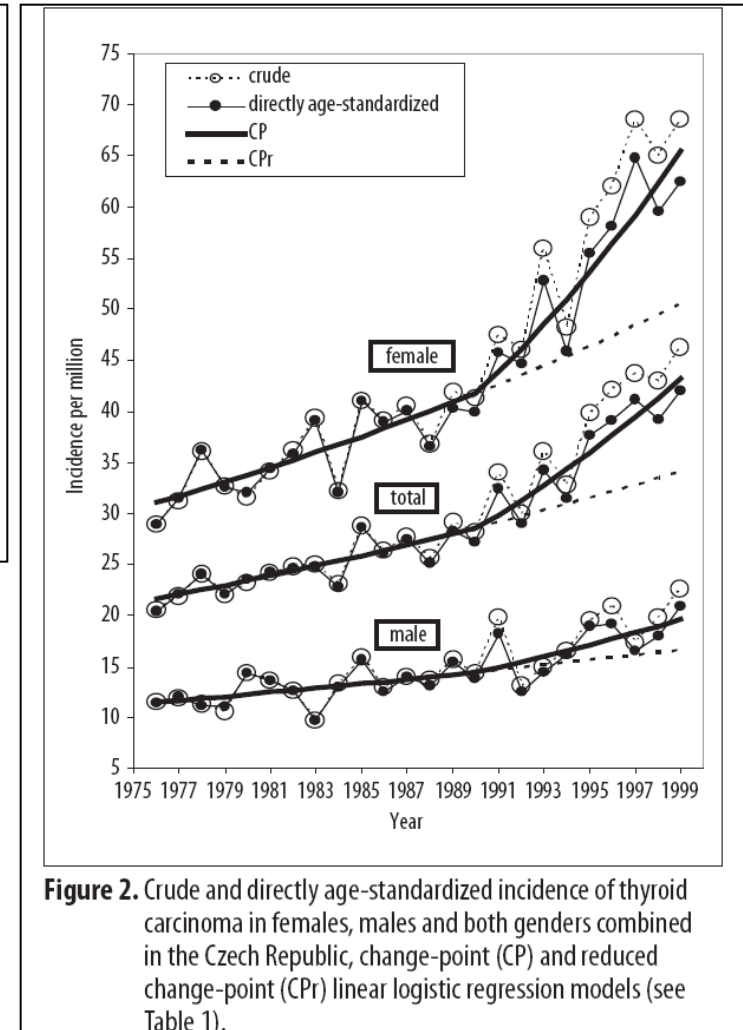
- Logistic model – example:  $\log \text{ odds } (\pi_x) = \text{intercept} + \alpha * d5(x)$
- Spatial-temporal trend models with dummy-coding and spatial-temporal interactions

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

## Mahoney MC et al. 2004



## Mürbeth S et al. 2004



# Results: Stillbirths in Europe

Scherb H et al. 1999

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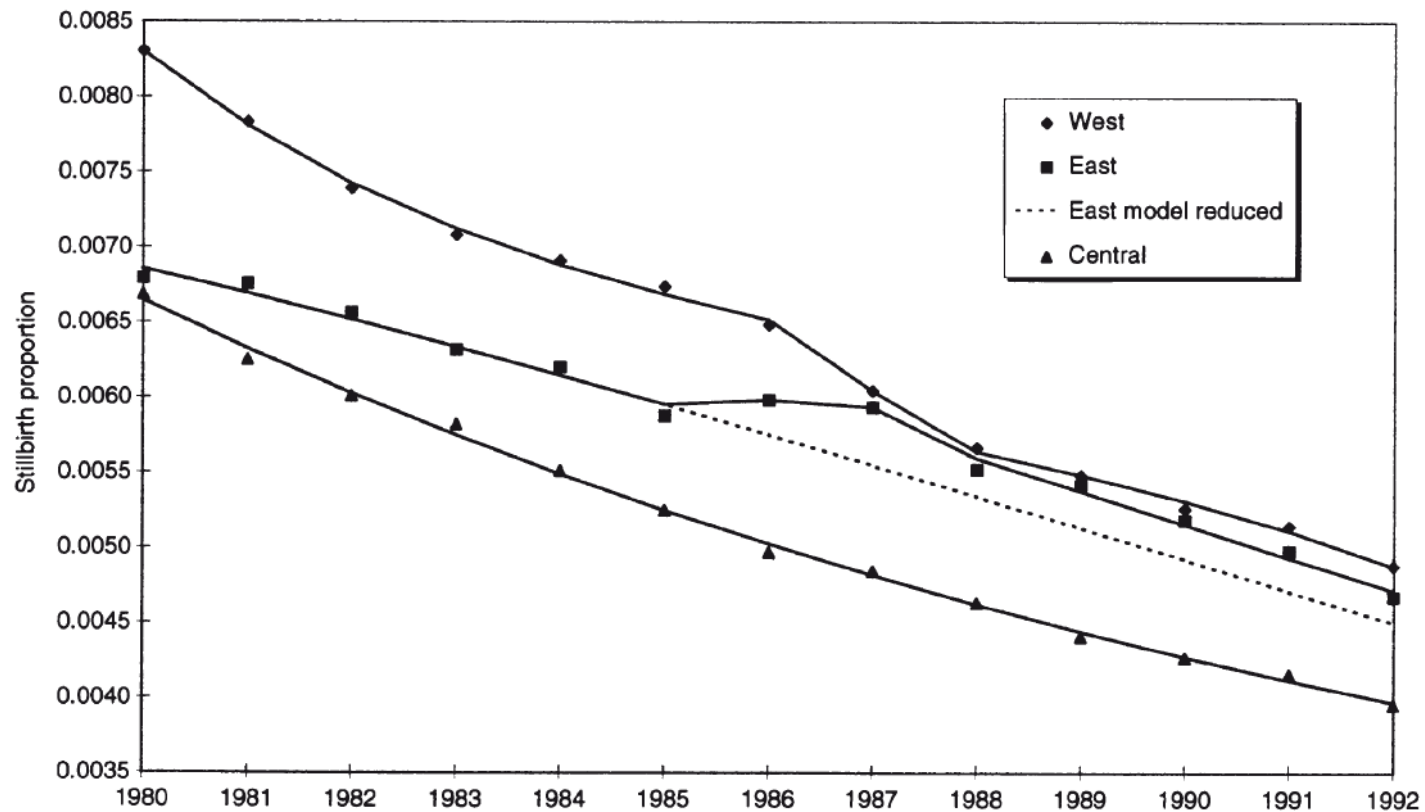
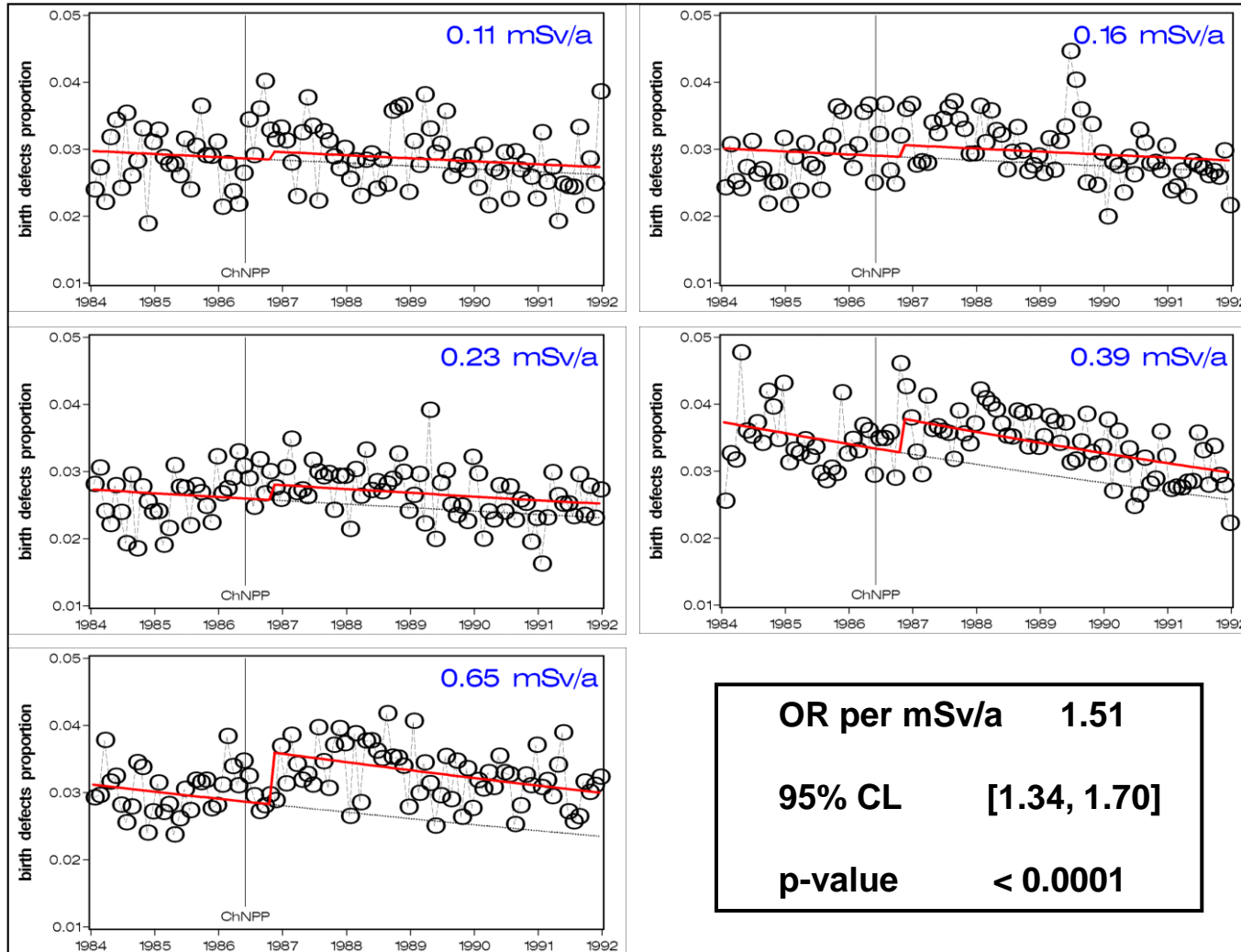


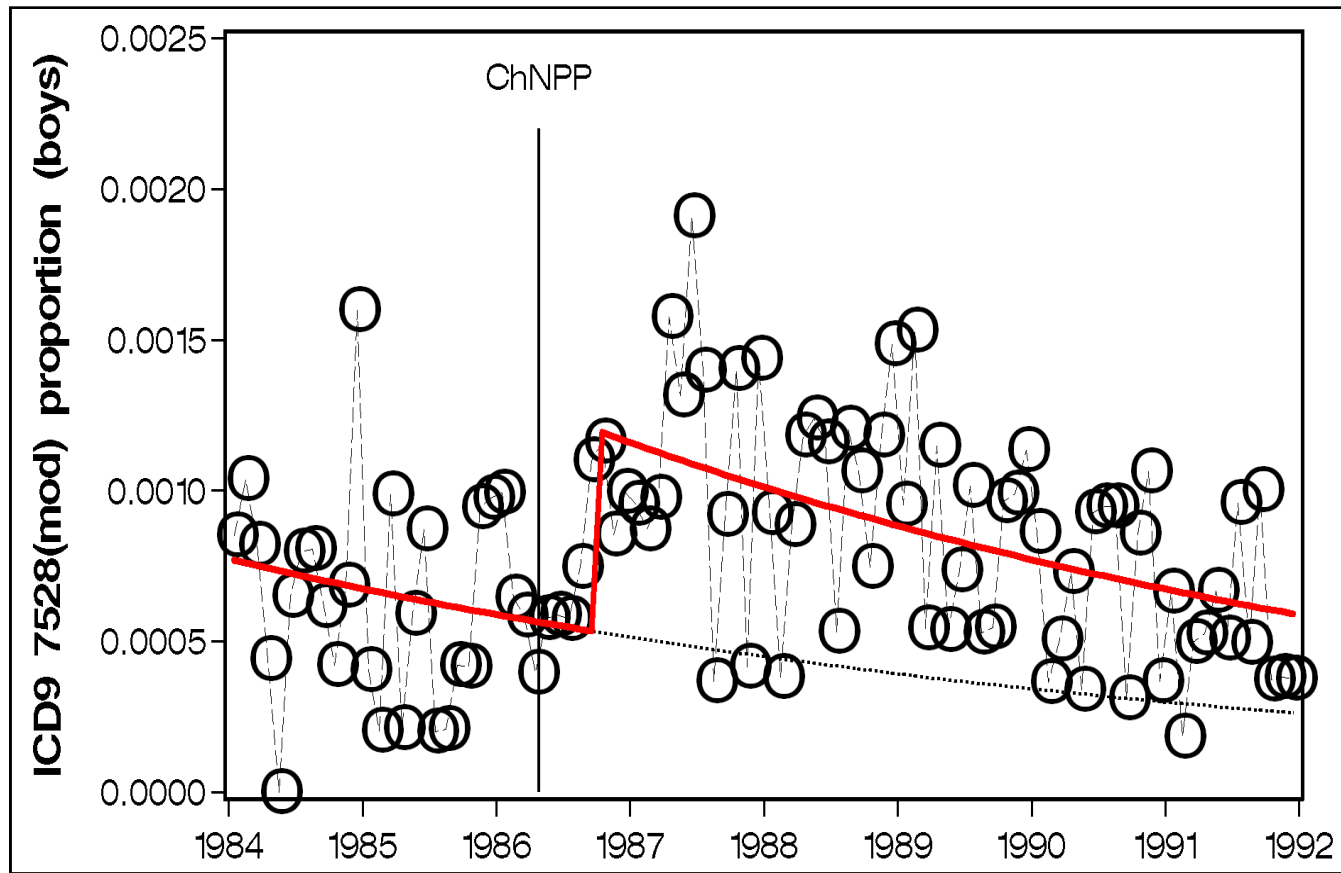
Figure 2 European stillbirth proportions 1980–1992 and synoptic linear logistic regression model according to data in Table 2 and model information in Table 6

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

## Scherb and Weigelt 2003



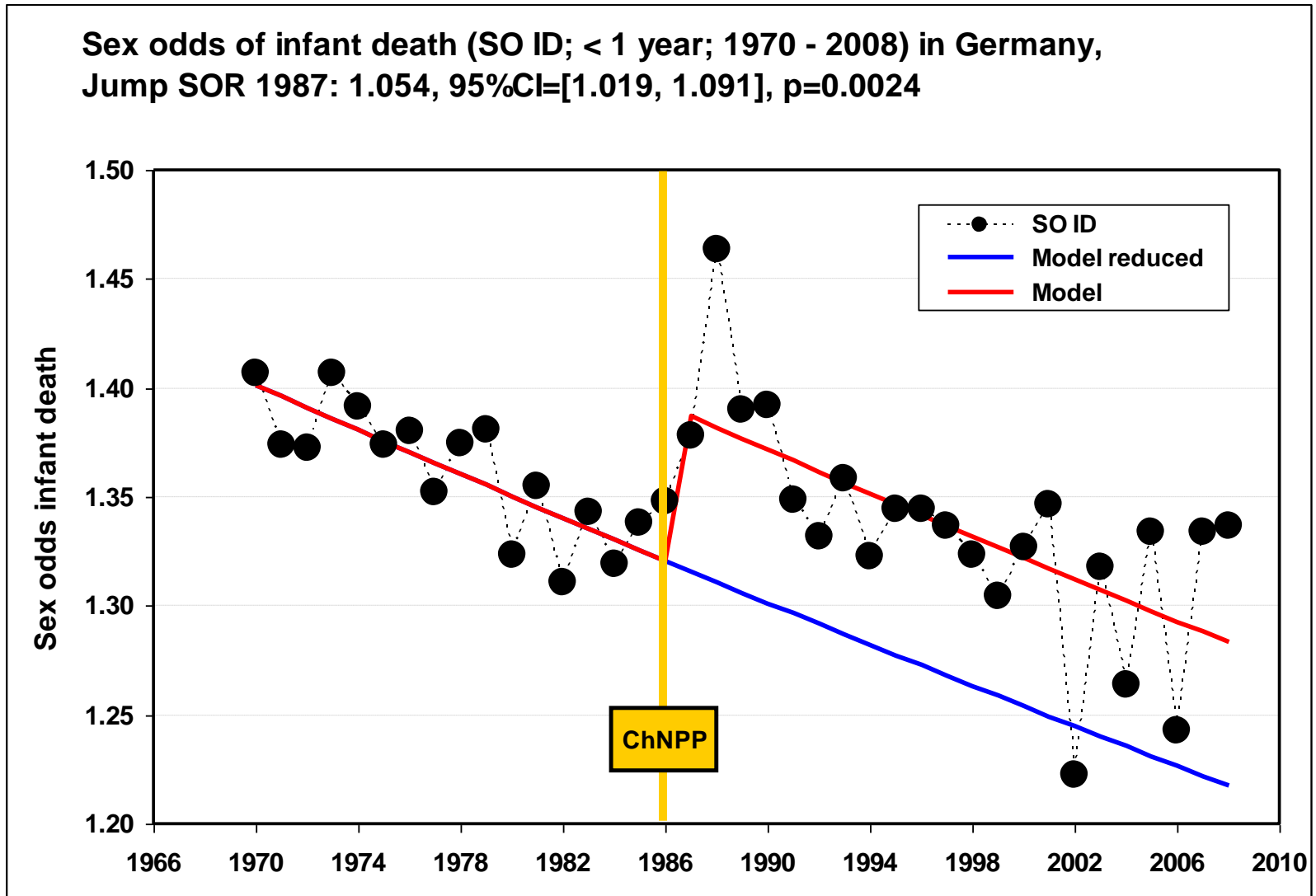
# Results: Male sexual organ defects in Bavaria, Germany, 1984 – 1991



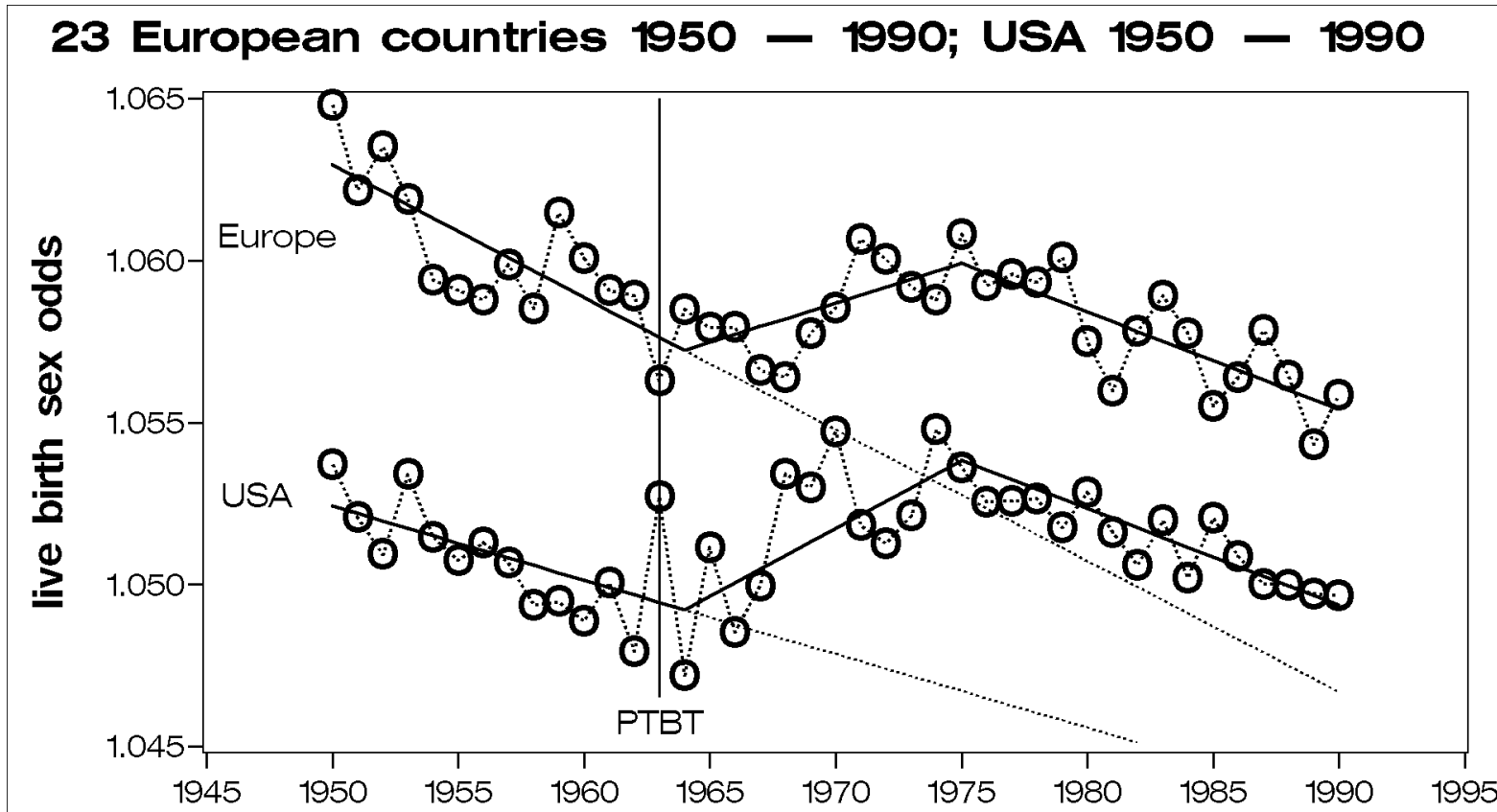
odds ratio (OR) for jump in October 1986: OR = 2.26, 95% CL [1.58, 3.23], p-value < 0.0001



# Results: Infant death in Germany, 1970 – 2008



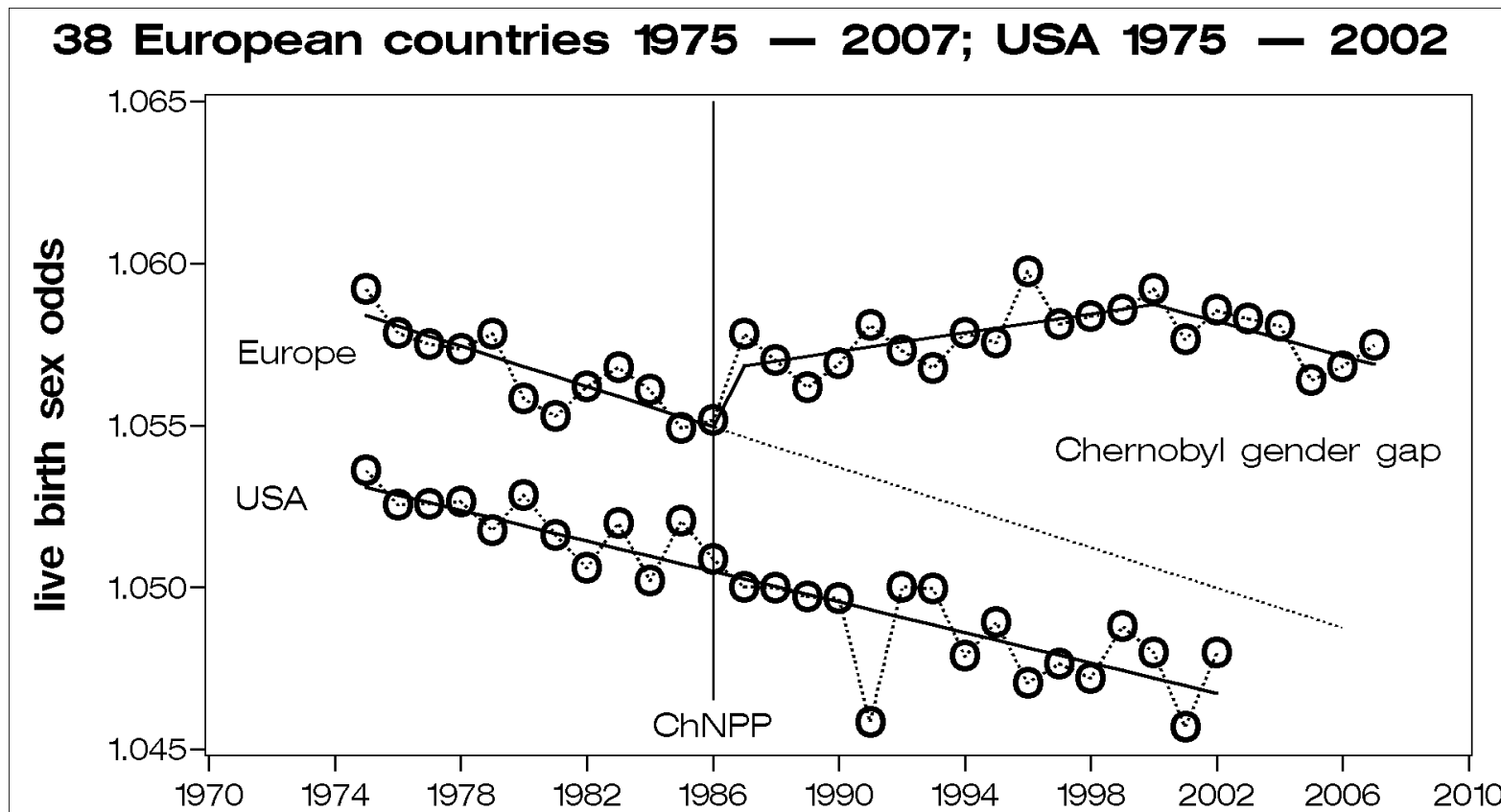
# Results: Increased sex odds (SO) after the atomic bomb tests globally



**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, submitted to ESPR, Environmental Science and Pollution Research**

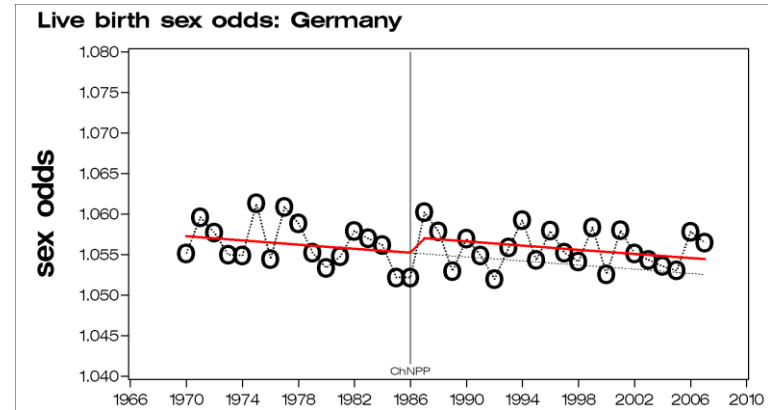
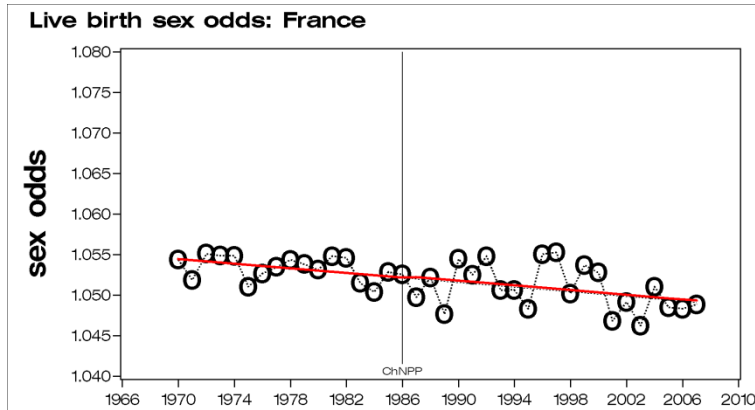
**PTBT: Partial Test Ban Treaty**

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

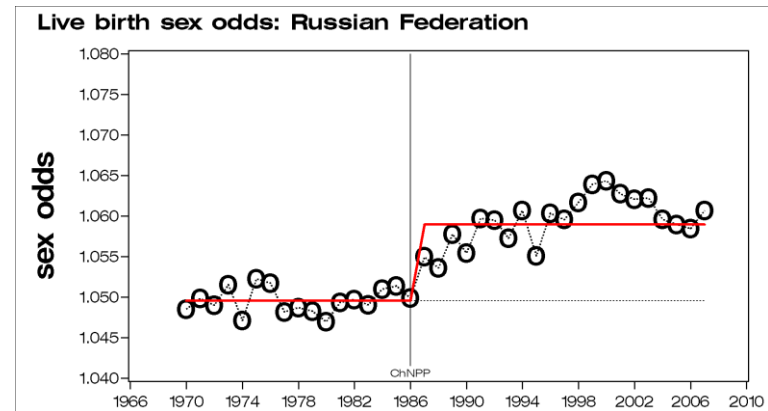
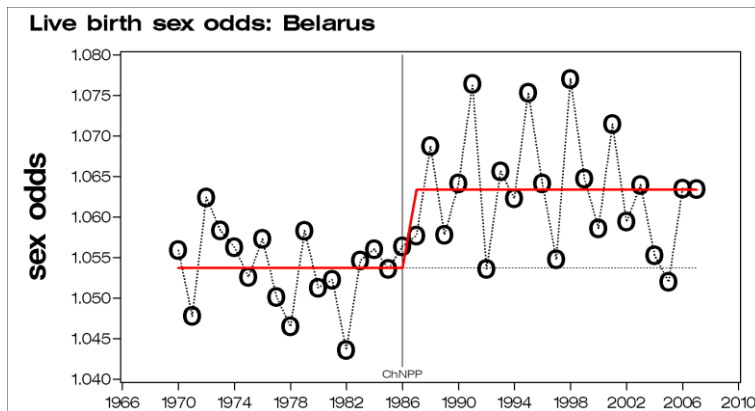


# Results: Increased sex odds (SO) after Chernobyl in Europe

## Less exposed countries: France and Germany

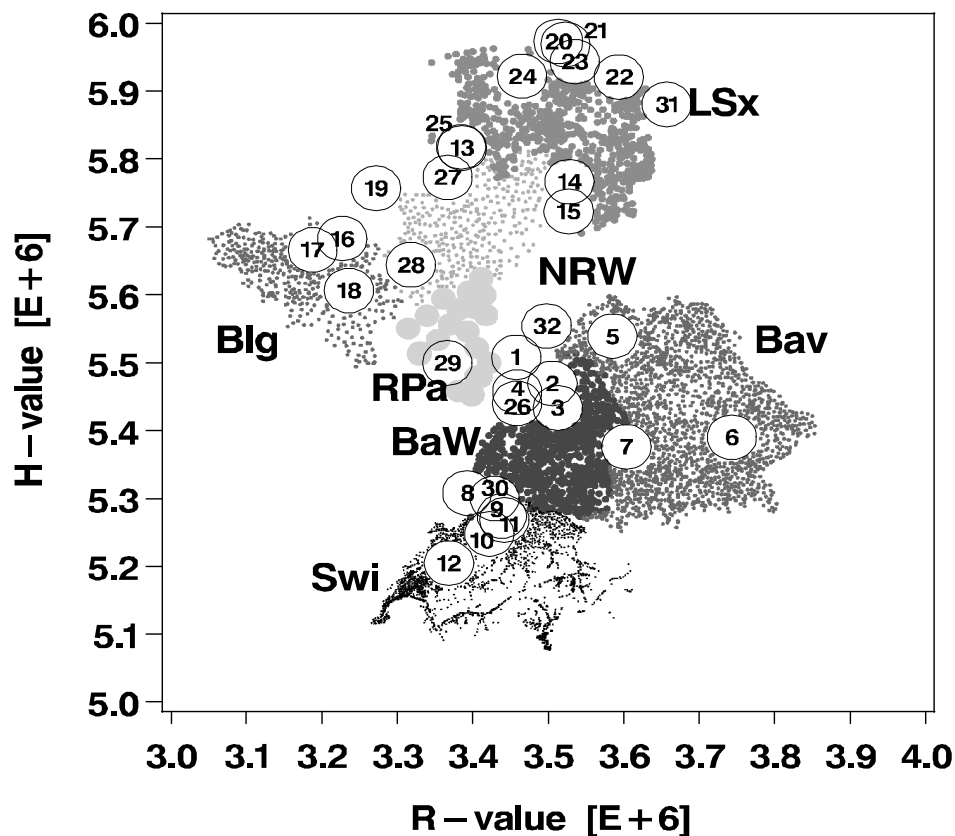


## Highly exposed countries: Belarus and Russian Federation



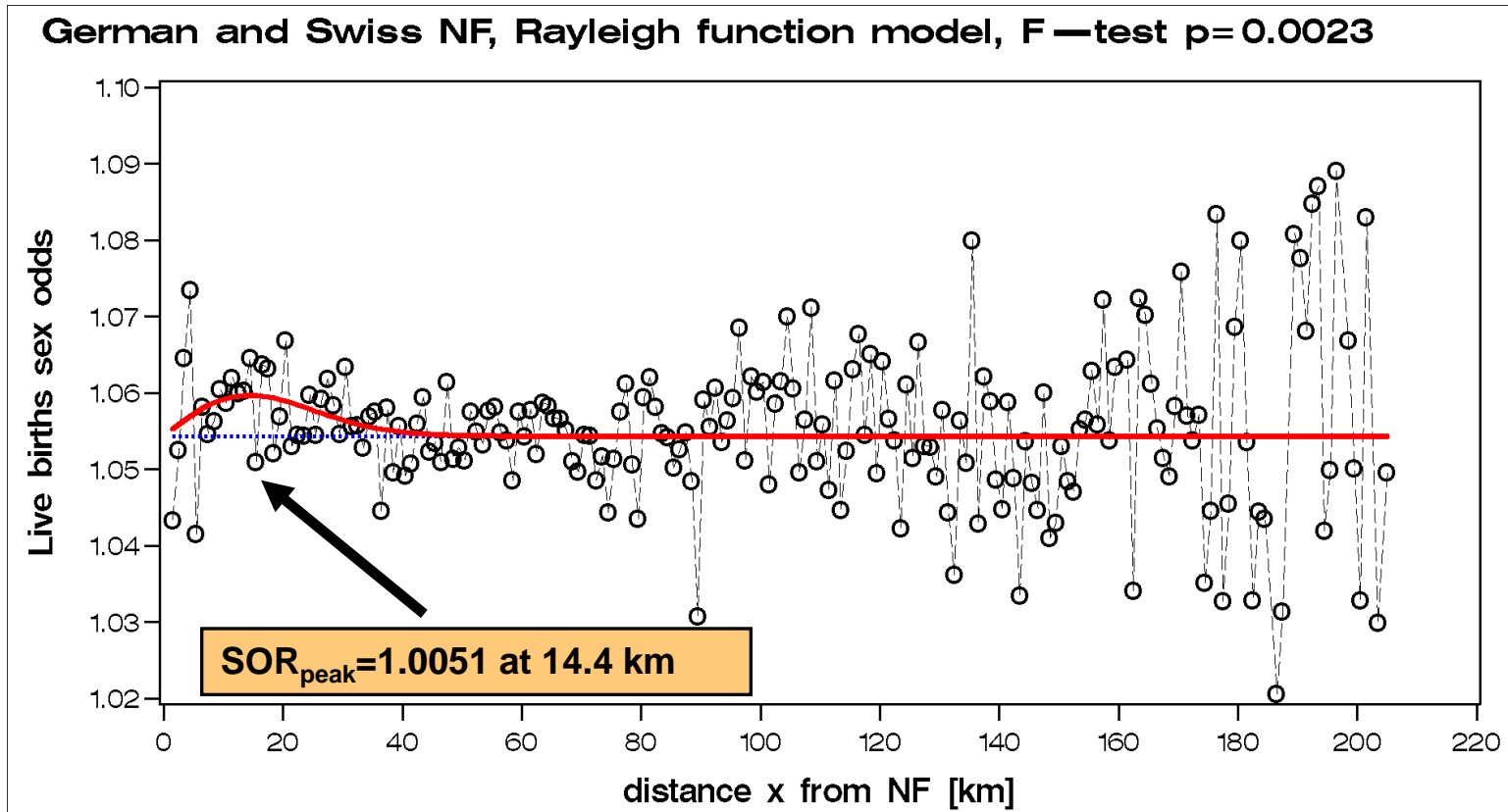
# Results: SO near nuclear facilities, Germany and Switzerland

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



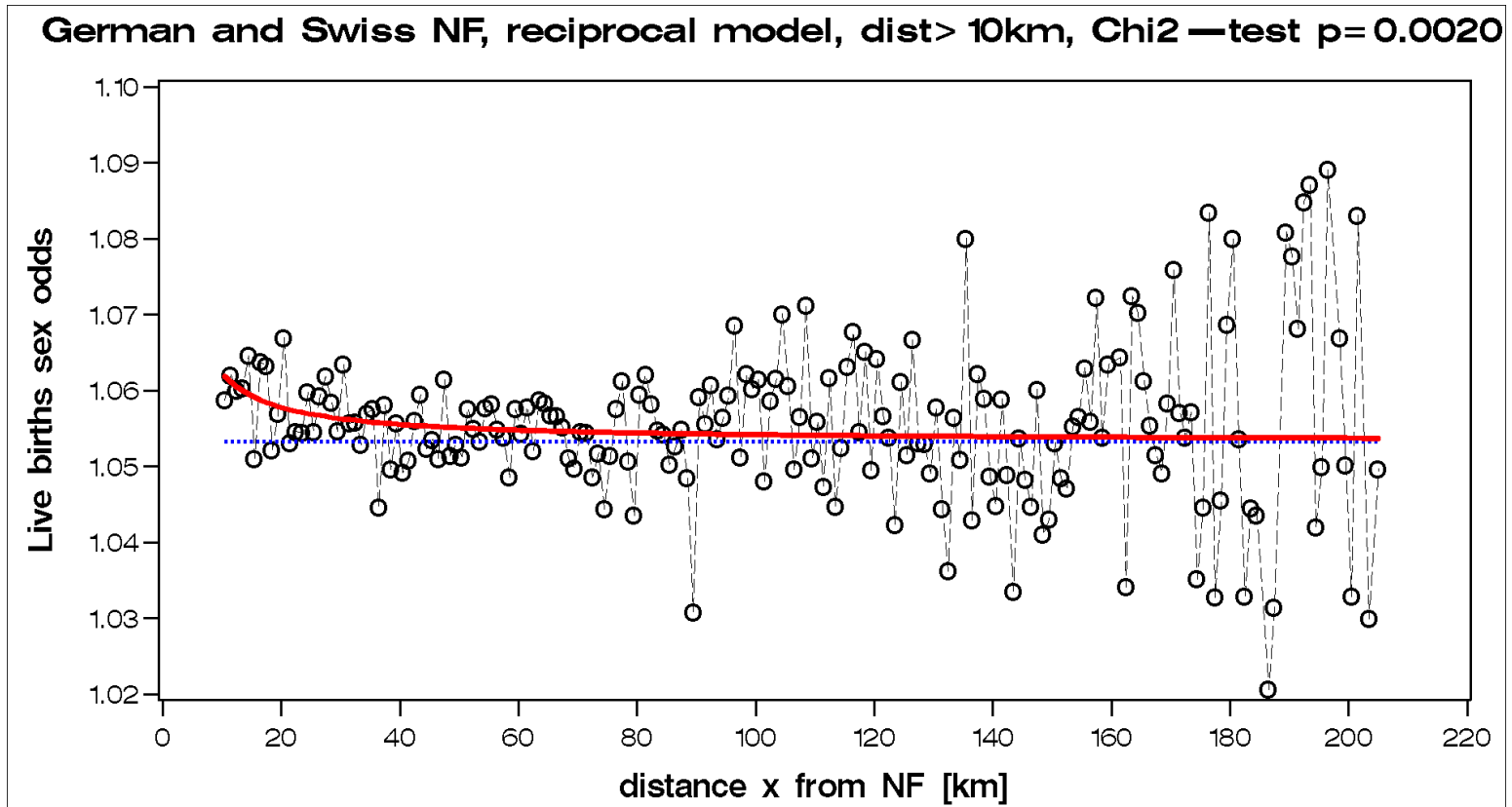
Region	• • • BaW	• • • Bav	• • • Blg	• • • LSx
	• • • NRW	• • • RPa	• • • Swi	○ ○ ○ xx

# 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 study, but here it works only when data are restricted to distances greater than 10 km**

[Kusmierz, Voigt, Scherb 2010](#)

Improved paper submitted to [ESPR](#)

# Conclusion

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- **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

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- **Important data on underestimated environmental and health topics are partly available**
- **However, often there is no (optimum) 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

**Dr. Hagen Scherb and Dr. Kristina Voigt**

Institute of Biomathematics and Biometry, Helmholtz Zentrum München –

[German Research Center for Environmental Health](#)

Ingolstaedter Landstr. 1, D-85764 Neuherberg, Germany

[scherb@helmholtz-muenchen.de](mailto:scherb@helmholtz-muenchen.de)