

# Overview on data sources for modeling epidemiological effects of environmental pollution

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## **Abstract:**

We focus on German population based data, which are routinely available in German statistical databases for the evaluation of the human sex odds at birth in the vicinity of nuclear facilities as well as around chemical sites. In this respect we have to distinguish between the statistical offices of the German states (Bundesländer) and the Federal statistical office of the FRG (Federal Republic of Germany). A specific difficulty arising from the German reunification in 1991 concerns data availability and data formats from the former GDR (German Democratic Republic). These offices collect data on birth statistics which are the basis of our research on the effects of environmental pollutants on the development of the human sex odds at birth. The beginning of data collection as well as the date since when the data are available in electronic format differs a lot. We also collected birth statistics data in Switzerland and France. We use the geocoding system Gauss-Krueger (GK), which is suitable for European countries. Furthermore, EUROSTAT and WHO population based health data are looked upon. We list possible data sources for enhanced investigations on epidemiological effects, and we consider bio-physical plausibility. Some initial effort has been put into the finding of data e.g. in Japan and in other countries.

**Keywords:** *statistical data sources, environmental pollution, ionizing radiation, chemical pollution, geoinformatics.*

## **1 INTRODUCTION**

Epidemiological effects of environmental pollution can be modeled in many different ways. An important indicator is the human sex ratio at birth. Sex ratio is the ratio of males to females in a population. In this iEMSs Conference 2012 three contributions are presented concerning this important indicator. One by Voigt et al. concerning the differences in human sex odds around chemical plants/parks, the second one by Scherb et al. treating the changes in sex odds around nuclear facilities, and this paper treating the data sources/statistical databases which are exploited. We put the focus on the changes in the human sex odds in our recently performed studies. The ratio of male to female offspring at birth may be a simple and non-invasive way to monitor the reproductive health of a population. Except in societies where selective abortion skews the sex ratio (SR), approximately 105 boys are born for every 100 girls. The authors concluded from a large retrospective cohort study that the sex ratio at birth is remarkably constant [Ein-Mor et al., 2010]. This has also been stated in a study carried out from 1950-1994 in 29 countries worldwide [Parazzini et al., 1998]. The authors found out that in most European

countries the proportion of male live born was approximately constant during the study period. Other factors, e.g. smoking [Beratis et al., 2008], maternal diet [Rosenfeld and Roberts 2004], and mother's occupation [Ruckstuhl et al., 2010], etc. may have an influence on the sex odds also. However, in these studies only a few thousands of births were examined restricting the explanatory power a lot. A variety of sex odds studies has been published indicating that several environmental as well as social factors can influence the human sex odds at birth. The influence of chemical exposure is widely studied. The references are given in Voigt et al., this issue. In a systematic review of 100 studies, Terrell et al. [2011] examined whether environmental or occupational hazards alter the sex ratio at birth. In general, the 100 studies examined in that review addressed small numbers of births. Terrell et al. looked at 15 studies on the effect of ionizing radiation. The studies were classified into the effects of the treatment for childhood cancer and on the effects of occupational ionizing radiation. The number of exposed births ranged from 84 to 39502, which are small numbers entailing low statistical power. Only few research initiatives are published on the influence of ionizing radiation on the human sex odds. In recent studies [Kusmierz et al., 2010], [Scherb and Voigt, 2011], and [Scherb and Voigt, 2012], the effect of ionizing radiation on the alteration of sex odds in the vicinity of German nuclear facilities was investigated. Within 35 to 50 km distance from nuclear facilities, the sex odds increase significantly in the range of 0.30% to 0.40% during nuclear facility operating time. In this issue further evidence on the increase of the human sex odds in the in the surrounding of the TBL Gorleben (Transportbehälterlager: nuclear waste shipping casks storage) in Lower Saxony, Germany is given [Scherb et al., this issue]. A screening approach addresses the sex odds in the vicinity of 10 chemical sites in Germany. For first results see Voigt et al. [this issue]. For the evaluation of human sex odds data a sound statistical basis is of vital importance. We started our research with the evaluation of the German data sources. In the following section we will list some of these sources and explain the difficulties in the data collection.

## 2 GERMAN DATA SOURCES FOR BIRTH STATISTICS

### 2.1 Special situation in Germany

The situation in Germany (East Germany/West Germany) till 1990 enhances the difficulties in data collection and data validation. Before 1990, Germany was divided in the western Federal Republic (FRG) and the eastern Democratic Republic (GDR). The FRG consisted of 10 states (Bundesländer) and West Berlin. The GDR consisted of 14 counties (Bezirke) and East Berlin.

**Table 1.** Statistical offices in Germany

		Office since	Data since	online	Web page of statistical office
01	Schleswig-Holstein		1981		<a href="http://www.statistik-nord.de">www.statistik-nord.de</a>
02	Hamburg		1972		<a href="http://www.statistik-nord.de">www.statistik-nord.de</a>
03	Niedersachsen		1971	x	<a href="http://www.lskn.niedersachsen.de">www.lskn.niedersachsen.de</a>
04	Bremen		1970	x	<a href="http://www.statistik.bremen.de">www.statistik.bremen.de</a>
05	Nordrhein-Westfalen		1957	x	<a href="http://www.it.nrw.de">www.it.nrw.de</a>
06	Hessen		1975		<a href="http://www.statistik-hessen.de">www.statistik-hessen.de</a>
07	Rheinland-Pfalz		1972		<a href="http://www.statistik.rlp.de">www.statistik.rlp.de</a>
08	Baden-Württemberg		1975	x	<a href="http://www.statistik-bw.de">www.statistik-bw.de</a>
09	Bayern		1972	x	<a href="http://www.statistik.bayern.de">www.statistik.bayern.de</a>
10	Saarland		1975		<a href="http://www.saarland.de/statistik.htm">www.saarland.de/statistik.htm</a>
11	Berlin		1946		<a href="http://www.statistik-berlin-brandenburg.de">www.statistik-berlin-brandenburg.de</a>
12	Brandenburg	1990	1991		<a href="http://www.statistik-berlin-brandenburg.de">www.statistik-berlin-brandenburg.de</a>
13	Mecklenburg-Vorpommern	1990	1990	x	<a href="http://www.statistik-mv.de">www.statistik-mv.de</a>
14	Sachsen	1990	1980	x	<a href="http://www.statistik.sachsen.de">www.statistik.sachsen.de</a>
15	Sachsen-Anhalt	1990	1991		<a href="http://www.statistik.sachsen-anhalt.de">www.statistik.sachsen-anhalt.de</a>
16	Thüringen	1990	1980		<a href="http://www.statistik.thueringen.de">www.statistik.thueringen.de</a>

After the German Reunification 5 new states were founded and the two parts of Berlin formed the new state of Berlin. In Table 1 the German statistical offices are listed together with the year since when they offer official birth statistics. Additionally, the German Federal Statistical Office (Statistisches Bundesamt Deutschland) offers a valuable data source for birth statistics since 2010 under the URL <http://www.destatis.de/>.

## **2.2 Geo-spatial background and requirements**

The geographic coordinates given in the Gauss–Krueger coordinate system are used. The Gauss–Krueger coordinate system is a special transverse Mercator map projection used in Germany, Austria and Finland rather than the UTM-system but similar to this. The central meridians of the Gauss–Krueger zones are only 3° apart, as opposed to 6° in UTM. A transverse Mercator map projection approximates the reference ellipsoid by a cylinder sector, which perimeter smoothes the central meridian of the mapped zone some depth below the reference surface, so the elliptical cylinder intersects the ellipsoid. The transverse Mercator map projection provides a nearly conformal mapping of earth's surface in smaller regions, so distances can simply be computed by using the Euclidean distance from the numerical differences of the coordinate components with very small errors. Before and after the German reunification, the lowest administrative levels (NUTS-3-regions) split into districts, which are either cities or management associations from municipalities. The smallest statistical units information is published for, the community, may be rather different in size, e.g., the large metropolises Berlin, Frankfurt, Munich, are single municipalities, and the smallest municipalities have fewer than 10 residents. The data provided by the statistical offices for the states can sometimes be downloaded from the internet. For other states, fees must be paid for the data. The states of Schleswig-Holstein and Hamburg, and of Brandenburg and Berlin each have a joint National Institute of Statistics, respectively. From 2008, birth data can be downloaded free of charge via the Internet from the "regional database" at the German Federal Statistical Office DESTATIS for all communities under the URL <https://www.regionalstatistik.de>.

## **2.3 Challenges in data handling**

Regional restructurings continuously merge communities, consequently decreasing their numbers and increasing their areas. Therefore, for each year the respective territorial status of the individual communities must be taken into account. The geographic coordinates of municipalities were taken from a data CD (GN250) of the Federal Agency for Cartography and Geodesy (BKG). This system prioritizes places where people live in contrast to balance points of the geometrical municipality areas. As yet, we have mainly used the numbers of live births by sex at the municipality level. Further interesting epidemiological indicators are stillbirths and infant death by gender, and also cause of death and age at death. Small-scale statistical analyses, for legal reasons, are not easily possible. Data access is restricted for very small sizes close to the individual case for reasons of data privacy. Since infant mortality and stillbirths are on the order of half a percent of all births, 10 cases are expected in 2000 births, which in turn necessitates 200,000 inhabitants per year. Therefore, stillbirths and infant deaths are published at the county level in general, which is too coarse for our analyses. One possible solution would be to have the data processed by the research data centers of the German state. In this case, researchers provide their methods and obtain the results without direct access to the original data. However, this procedure is rather costly: Per year and trait the research data centers charge 250 Euros, resulting in 20,000 Euros for certain 40-year statistics. So far, only data from the western German states have been evaluated, and effects in the vicinity of nuclear plants of the former GDR were not investigated. Basically, however, figures are available for municipalities from East Germany from 1979 onward. After the German

reunification, the data sets of the 'Central Administration of Statistics (SZS)' of the GDR passed over to the Federal Archives (BArch). Individual digital archive objects exist including birth date, TGS code of mothers' residences, possible infant death and stillbirth, as well as further detailed medical information. These anonymous data may be obtained from the Federal Archives. Since those data are stored on magnetic tapes, rare ( $\approx E-4$ ) technical problems are likely to be encountered reading them. However, possible reading errors may be corrected using figures from the GDR statistical yearbooks as check sums. In conclusion, it seems possible that in the near future we obtain a complete picture of the births at the community level for the whole of Germany from the early 1980s to the present.

### **3 DATA SOURCES FOR BIRTH STATISTICS OF OTHER EUROPEAN COUNTRIES**

#### **3.1 Switzerland**

From the Swiss Federal Statistical Office, the number of births by gender and municipality since 1969 is available. Also, a list of geographical coordinates of the municipalities may be obtained. The Helvetian Swisstopo uses a special oblique cylindrical Mercator projection with an inclined cylinder axis (also called "Swiss Grid"), based on a projection starting from the 1841 Bessel ellipsoid and using a fundamental point in Berne. For distance computations over different systems it is necessary to transform coordinates into the same system. For the transformations, online calculators provided by the national geodetic authorities were used. For longer distances (more than some arc degrees) Euclidian distance from cylindrical coordinates causes increasing errors. Therefore, longer distances were computed using spherical trigonometry or, for higher precision, nautical programs.

#### **3.2 France**

We requested and received the official birth statistics for the French communes from 1968 till 2007 from the Centre Maurice Halbwachs – ADISP, Paris, France. These data also remain to be analysed.

#### **3.3 Adequate data situation in some European countries**

Ascertaining data from France, Germany, and Switzerland provides insight in genetic effects near numerous nuclear facilities including nuclear power plants in three highly populated countries in central Europe. High statistical power is guaranteed by this comprehensive approach.

### **4 ASIAN COUNTRIES**

#### **4.1 Different situation**

It goes without saying that it is more difficult to receive official birth statistics from other countries. Another aspect is that in several Asian countries sex selective abortions are practised. A variety of publications concerning this topic is around. Hesketh and Xing [2006] stated that the tradition of son preference, however, has distorted these natural sex ratios in large parts of Asia and North Africa. This son preference is manifest in sex-selective abortion and in discrimination in care practices for girls, both of which lead to higher female mortality. Differential gender mortality has been a documented problem for decades and led to reports in the early 1990s of 100 million "missing women" across the developing world. Since that time, improved health care and conditions for women have resulted in

reductions in female mortality, but these advances have now been offset by a huge increase in the use of sex-selective abortion, which became available in the mid-1980s. Largely as a result of this practice, there are now an estimated 80 million missing females in India and China alone. For China Zhu et al. [2009] analysed approximately 5 million people, which mean 1 % of the population at the time of the study. In 2005 males under the age of 20 exceeded females by more than 32 million in China, and more than 1.1 million excess births of boys occurred. China will see very high and steadily worsening sex ratios in the reproductive age group over the next two decades.

#### 4.2 Asia: Example Japan

Davis et al. [2008] were examining the sex ratio in the USA and in Japan. In Japan the birth statistics from 1970 – 1999 were looked upon. Sex ratio at birth has declined significantly in Japan. The male proportion of fetal death has increased overall in Japan. The authors hypothesize that the decline in sex ratio in Japan may be caused partly by prenatal exposure to metalloestrogens and other endocrine-disrupting chemicals at a critical stage of prenatal development.

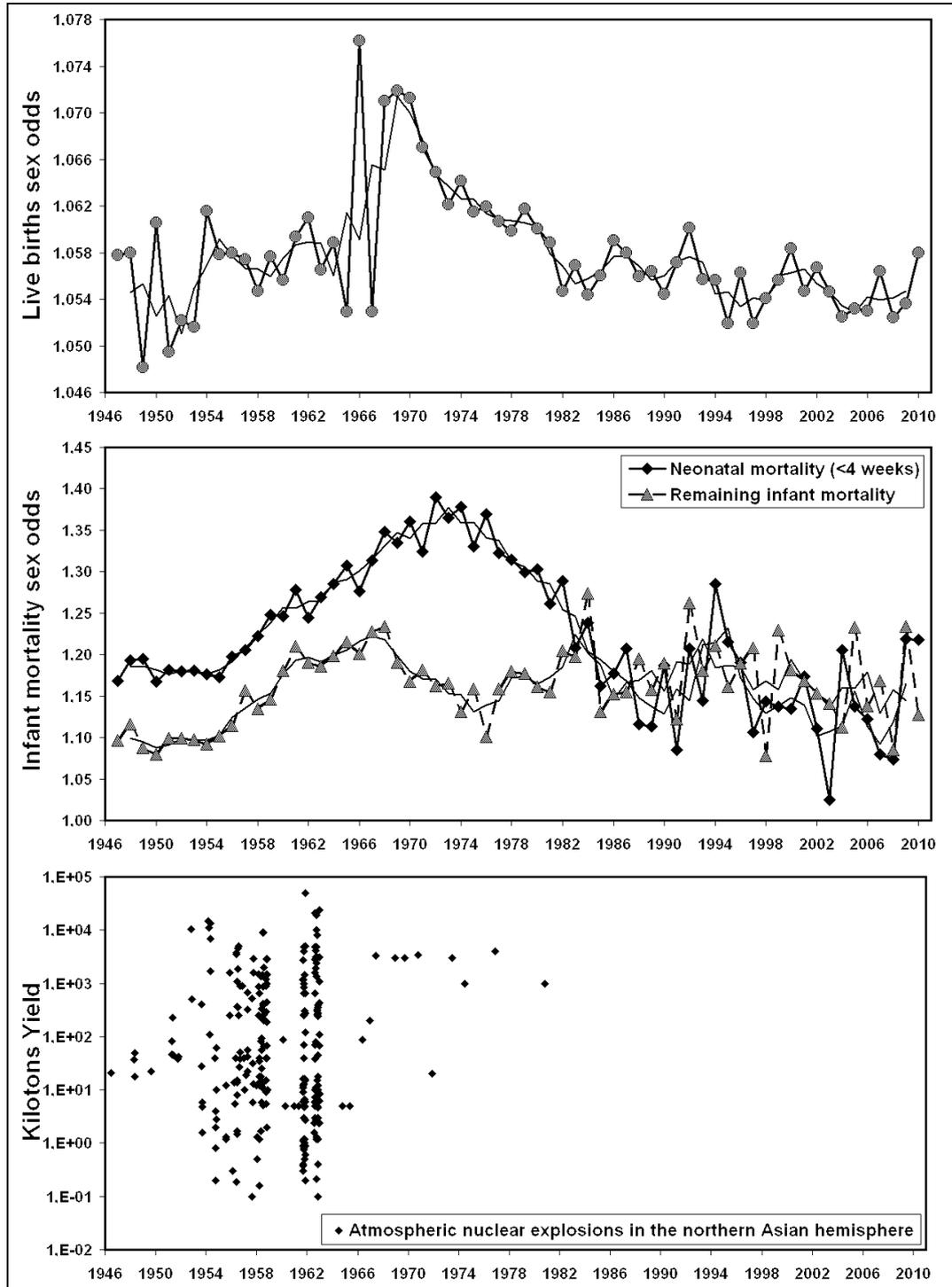
We now want to take an initial look at the sex odds at birth in Japan before the accident in Fukushima from our experience with sex odds studies [Scherb and Voigt, 2012]. The data from 1946 till 2010 are looked upon in Figure 1. The data are available under: <http://www.mhlw.go.jp/english/database/db-hw/vs01.html>. The figures 1965-1967 may be artificially distorted by superstitious reasons with respect to the 'hinoeuma year'. Figure 1 is divided in three parts: Live births sex odds, infant death sex odds, and atomic bomb yield in kilotons (by the USSR and China, and from the Enewetak Atoll) from 1946 to 2010.

In Germany we found a jump in the sex ratio of infant mortality (less than one year of age) after Chernobyl. At the district level in Bavaria and the former German Democratic Republic we found a significant association between the measured soil contamination with <sup>137</sup>Cs and the sex odds with an SOR per mSv/a of 1.015.

A similar effect can be observed in Japan: sex ratios in live births and infant deaths are increasing synchronously with the atmospheric nuclear weapons tests. Japan is situated at 35°N 136°E, approximately in the middle of the United States Nuclear Test Site Enewetak Atoll (11.5°N 162.3°E), the former USSR Semipalatinsk Nuclear Test Site (50.1°N 78.7°E), and the Chinese Lop Nur Nuclear Weapons Test Base (40.2°N 90.6°E). The USA performed atmospheric bomb tests at Enewetak 1948-1958, USSR at Semipalatinsk Test Site 1949-1962, and despite the Partial Test Ban Treaty from 1963, People's Republic of China tested atomic bombs at Lop Nur 1964-1980. Due to meteorological basics, nuclear fallout is restricted to the hemisphere where the tests took place. So, nuclear explosions within the southern hemisphere should not contribute to fallout in Japan, but the above mentioned northern hemisphere tests do. Possibly the USSR tests at the Novaya Zemlya Test Site as well as the Kyshtym disaster in 1957 may have contributed to radioactive pollution in Japan rather than the French bomb tests in Northern Africa and the US tests inside continental America due to greater distances.

Synchronously with the multiple bomb tests in the Asian and Pacific regions (see bottom graphic in Figure1), the neonatal mortality sex odds increases to a summit in 1970ies. During the maximum period 1968-1982, the infant mortality sex odds of children aged more than 4 weeks and less than 1 year decreases. This suggests the following guess: Ionizing radiation causes prenatal losses of children with a gender bias - females are stronger affected than males. Nevertheless the surviving males are injured, too, and subsequently they bear a higher mortal risk. With increasing doses, their life expectancy may decrease. The result is a reduction of the number of males outliving the fourth week, observed by decreasing mortality sex odds in the age range between 4 weeks and 1 year. The Japanese statistics

provides figures of infants deceased within 4 weeks and 1 year of their life. The difference yields the number of children who died aged more than 4 weeks and less than 1 year. We can see that with the onset of the Chinese nuclear bomb testing the live birth as well as the deceased newborns' sex odds increase (see top and center graphics in Figure 1).



**Figure 1.** Live Births and Infant Death Sex Odds in Japan and atomic bomb test yield in the northern Asian hemisphere (1946-2010)

## 5 CONCLUSIONS AND OUTLOOK

Human sex ratio at birth, conventionally expressed by the number of male live births per female live births, is about 1.05 - 1.06 and remarkably constant [Ein-Mor et al, 2011]. The sex ratio is unique among the genetic indicators. Its uniqueness arises from the fact that maternal exposure is expected to produce an effect different from paternal exposure. When investigating changes in the sex ratio, a number of determinants of this trait have to be taken into account. However, when undisturbed, the birth sex ratio is constant. Ionizing radiation is the only reproductive hazard known causing men to father an excess of sons. Conversely, irradiated mothers, so the theory goes, would give birth to an increased proportion of girls. Therefore, in analogy to ionizing radiation, one may anticipate eventual changes in the overall sex ratio after local or global releases of genotoxic pollutants in case the presumed disturbances of the sex ratio were not completely balanced between to the two genders of exposed parents.

Both, increases and decreases in the human sex odds provide an indication that there is an impact of man-made facilities on the human genome. Further background concerning this issue is given by Sperling et al. [2012].

We are of the strong opinion that we have to extend our work to other data sets. We are planning to evaluate the complete German data set including the new German states. Furthermore, we will evaluate the human sex odds at birth around the nuclear facilities in France. We are also planning to take a closer look at the forthcoming birth statistics in Japan after Fukushima, if and when available.

In conclusion, time trend analyses and spatial-temporal analyses of official birth or infant death statistics most clearly reveal disturbances of the sex ratios after the injection of radioactive materials into the biosphere. These results add evidence to many related recent findings in the fields of radiation epidemiology and radiation biology and cast doubt on the official assessment of the so-called 'low-level' ionizing radiation by pertinent national and international institutions. The effects we observed are probably a consequence of doses well below 1 additional mSv/a per individual in the overall mean globally. The legal limiting value of 1 mSv/a holding for the general population in many countries may be put in perspective.

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