2. Data and Statistical Methods

This study is based on official (in German "amtlich"), gender specific annual live births statistics gathered and compiled from national or regional statistics offices in Belgium, Switzerland, and the following states of Germany: Baden-Württemberg, Bavaria, Lower Saxony, North Rhine-Westphalia, and Rhineland-Palatinate. For these countries or regions, the first author was able to compile the data from freely available internet data bases containing official demographic data, and through assistance by statistical authorities. In Table 1 we list the time periods available and the total live births by gender in those 7 countries and regions. All in all, 316 360 municipality- or district-years have been ascertained with 22.6 million live births and an overall sex odds of 1.0546. Table 2 lists the possibly relevant NF in or adjacent to the study regions by operational time periods and NF type.

2.1 Geo-spatial considerations

For the computation of distances in the German epidemiological study on childhood cancer in the vicinity of nuclear power plants (Spix et al. 2008), geographic coordinates given in the Gauss–Krüger coordinate system are used. The Gauss–Krüger 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–Krüger 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. The Helvetian Swisstopo uses a special oblique cylindrical Mercator projection with an inclined cylinder axis (also called "Swiss Grid"), based on a double 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, higher distances were computed using spherical trigonometry or, for higher precision, nautical programs. Figure 2 displays the study regions, the position of all municipalities, and the position of the possibly relevant NF, in or adjacent to the single regions, using uniform (H, R) coordinates.

Table 1: Available gender specific birth statistics by study region.

Region	data available	male births	female births	sex odds
Baden-Württemberg	1975 - 2008	1 795 839	1 702 372	1.0549
Bavaria	1972 - 2008	2 241 831	2 125 162	1.0549
Belgium	1989 - 2007	1 141 451	1 088 579	1.0486
Lower Saxonia	1971 - 2008	1 470 778	1 392 783	1.0560
North Rhine-Westphalia	1980 - 2008	2 584 664	2 449 001	1.0554
Rhineland-Palatinate	1970 - 2008	754 120	714 496	1.0555
Switzerland	1969 - 2008	1 633 929	1 548 471	1.0552
Combined		**11 622 612**	**11 020 864**	**1.0546**

Table 2: Nuclear facilities (NF) in the study region; gender specific births and sex odds ratio through operational periods within 35 km distance from the NF; Pressurized Water Reactor (PWR), Boiling Water Reactor (BWR), Nuclear Storage Site (NSS), Nuclear Fuel Elements (NFE), and Uranium Mining (UM); * NF not considered because of low Belgium sex odds or low spatial-temporal coverage (s. Table 1).

No. (s. Fig. 2)	NF	Type	In operation since/to	Live births < 35 km during NF operation, lagged for gestation		Sex odds ratio vs. last row of this Table	p-value (Chi^2)	hold one NF out p-value (Chi^2), compare to **
				male	female			
1	Biblis	PWR	1975 -	223 648	211 753	1.0017	0.5804	0.0007
2	Obrigheim	PWR	1969 - 2005	164 321	155 447	1.0026	0.4733	0.0010
3	Neckarwestheim	PWR	1976 -	380 463	360 212	1.0017	0.4640	0.0005
4	Philipsburg	BWR/PWR	1980 -	333 967	314 761	1.0063	0.0133	0.0019
5	Grafenreihnfeld	PWR	1981 -	95 714	90 722	1.0006	0.8957	0.0007
6	Isar I und II	BWR/PWR	1977 -	67 059	63 341	1.0041	0.4627	0.0011
7	Gundremmingen	BWR	1966 -	142 702	135 276	1.0005	0.8986	0.0006
8	Fessenheim	PWR	1977 -	99 148	93 694	1.0036	0.4290	0.0012
9	Beznau I und II	PWR	1969 -	337 335	317 880	1.0065	0.0106	0.0031
10	Goesgen	PWR	1979 -	220 979	208 604	1.0047	0.1308	0.0005
11	Leibstadt	BWR	1984 -	143 467	135 293	1.0057	0.1354	0.0008
12	Muehleberg	BWR	1971 -	218 795	207 560	0.9998	0.9387	0.0004
13	Emsland	PWR	1988 -	55 502	52 301	1.0065	0.2915	0.0011
14	Grohnde	PWR	1984 -	84 739	80 308	1.0008	0.8791	0.0009
15	Wuergassen	BWR	1972 - 1994	34 453	32 643	1.0010	0.8960	0.0010
16	BR*	PWR	1962 - 1987	5 332	5 288	0.9563	-	-
17	Doel*	PWR	1974 -	392 512	375 500	0.9914	-	-
18	Tihange*	PWR	1975 -	122 594	117 476	0.9897	-	-
19	Dodewa*	BWR	1968 - 1997	5 926	5 710	0.9843	-	-
20	Brunsbuettel	BWR	1977 -	21 085	20 003	0.9997	0.9779	0.0010
21	Brokdorf	PWR	1986 -	15 505	14 769	0.9957	0.7073	0.0009
22	Kruemmel	BWR	1984 -	35 882	33 745	1.0085	0.2662	0.0012
23	Stade	PWR	1975-2003	43 456	40 771	1.0109	0.1174	0.0021
24	Unterweser	PWR	1979 -	86 010	81 341	1.0029	0.5608	0.0010
25	Lingen	BWR	1968 - 1977	19 372	18 400	0.9985	0.8862	0.0007
26	Karlsruhe	BWR	1966 - 1991	149 269	140 584	1.0070	0.0624	0.0007
27	Ahaus	NSS	2000 -	26 427	24 866	1.0080	0.3701	0.0009
28	Juelich	NSS	2000 -	75 735	71 688	1.0020	0.7076	0.0008
29	Ellweiler	UM	1969 -	31 361	29 450	1.0100	0.2225	0.0013
30	Menzenschwand	UM	1969 -	132 037	124 574	1.0052	0.1892	0.0012
31	Gorleben	NSS	2000 -	1 753	1 573	1.0570	0.1108	0.0010
32	Hanau/Kahl	NFE	1969 -	54 772	51 343	1.0118	0.0577	0.0021
	German states and Switzerland < 35 km from NF			**2 532 471**	**2 393 556**	**1.0035**	**** 0.0008**	
	German states and Switzerland > 35 km from NF			**7 948 690**	**7 538 729**	**1.0000**	**1.0000**	

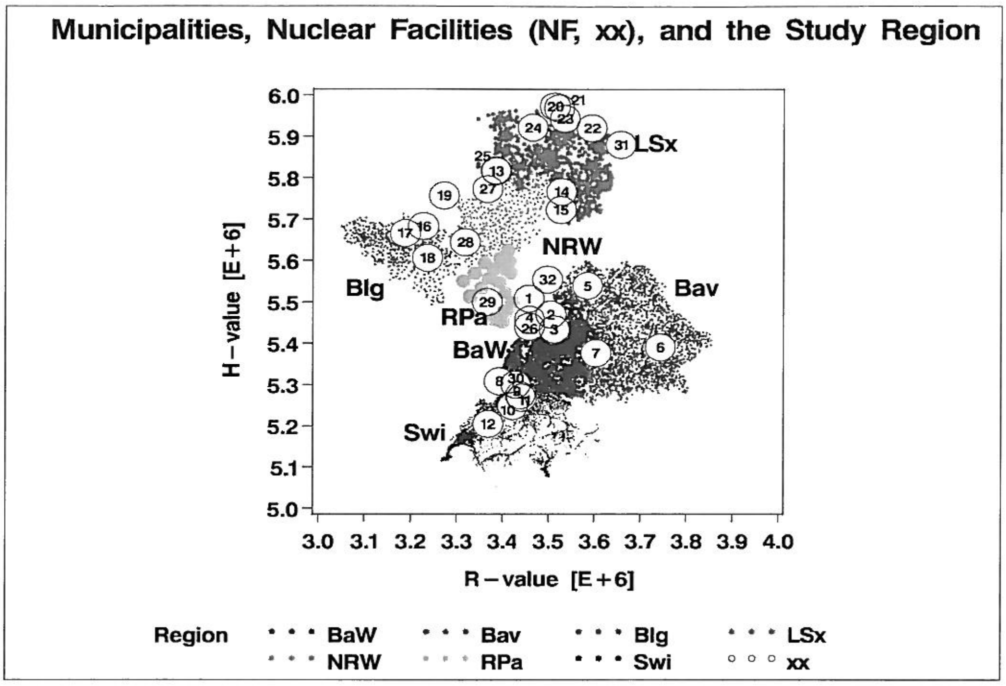

Figure 2: Belgium (Blg), Switzerland (Swi), Baden-Württemberg (BaW), Bavaria (Bav), Lower Saxony (LSx), North Rhine-Westphalia (NRW), and Rhineland-Palatinate (RPa), NF (xx) within surrounding 35 km circles, see Table 2.

2.2 Distributional assumptions and regression techniques

To investigate whether there are significant spatial trends depending on the distance from NF, we applied linear logistic regression (Scherb and Weigelt 2003). To allow for changing sex odds trends (slopes) with distance from NF, one may use various possible distance laws, the simplest one being a jump model for the 5 km disc around NF. We used dummy coding for distances and for time periods as well. For example, the dummy variable for the distance from NF below 5 km is defined as d5(x) = 1 for x < 5 km and d5(x) = 0 for x ≥ 5 km (x = distance [km]). The simple logistic model for a constant distance trend and a downward or upward jump beyond 5 km has the following form (LB: live birth, π_x : Binomial probability parameter at distance x):

$$\text{Boys}_x \sim \text{Binomial}(\text{LB}_x, \pi_x)$$

$$\text{log odds}(\pi_x) = \text{intercept} + \alpha * \text{d5}(x)$$

The data in this study were processed with Microsoft Excel 2003. For statistical analyses, we used R 2.11.1, MATHEMATICA 5.0, and mostly SAS 9.1 (SAS Institute Inc: SAS/STAT User's Guide, Version 9.1. Cary NC: SAS Institute Inc; 2003).

2.3 Statistical power considerations

Recently, it has been hypothesized that the overall background radiation may perhaps be responsible for approximately 20% of all childhood leukemia cases in Great Britain. (Little et al. 2009; Wakeford et al.