

Prevalence of Birth Defects in the Vicinity of Hongyanhe Nuclear Power Plant Before Its Normal Operation, from 1996 to 2009

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Abstract- The study was to determine the prevalence, types and epidemiologic patterns of birth defects in the vicinity of Hongyanhe nuclear power plant from 1996 to 2009. Hongyanhe nuclear power plant is the first nuclear power plant in northeast China and the first one receiving central government approval to build four units at the same time.

We used the database of the Liaoning Birth Defects Monitoring Network to investigate birth outcomes for infants with defects from 1996 to 2009, in Wafangdian. The infant must have been born in there with a birth diagnosed within 7 days after delivery, and the mothers living in Wafangdian for more than one year were enrolled.

During 1996 to 2009, a total of 783 birth defects were identified among 95,632 births, which yielded a prevalence of 81.88 per 10,000 births. The highest prevalences of birth defects was observed in 2007 (128.98 per 10,000 births), and the lowest one was in 1996 (42.24 per 10,000 births). There was an upward trend detected in the time span. The major types of birth defects in our study were: congenital heart disease, hydrocephalus, cleft lip and cleft palate, polydactyly, spina bifida and cleft lip. All of the prevalences were lower than the national prevalence and other studies. The major types of birth defects in our study are similar with the types of national. The prevalences of NTDs and trisomy 21 thought to be caused by ionizing radiation are lower than other studies of China.

To our knowledge, few studies about prevalence of birth defects have the large intervals of time, from 1996 to 2009 in northeast China.

Keywords- Nuclear Power Plant; Birth Defects; Prevalence

I. INTRODUCTION

Birth defects are significant abnormalities of appearance, structure, or function that are present at birth. China is a high prevalence country of birth defects. There were an estimated 800,000 to 1 200,000 births with birth defects each year, with a prevalence rate in births of 4% to 6%. Birth defects are the leading cause of lifelong disability and require costly medical care. The economic, emotional and social impacts on families affected are enormous and can be grossly underestimated [1]. Most birth defects are believed to be caused by a complex mix of factors including genetics, environment, and behaviors, though many birth defects have no known cause [2, 3]. About 10% of the birth defects are caused due to environmental factors, which can be classified into 3 broad categories namely: chemical, biological and physical. Ionizing radiation is widely known to cause adverse health effects in animal experiments and humans, including the unborn infant [4-6].

Wafangdian country occupies 3,793.5 square kilometers, with a total population of 1,020,000 in the seaside of the Bohai Sea. Hongyanhe nuclear power plant is located in Donggang town of Wafangdian country, Liaoning province. Donggang town is a distinct place for establishing nuclear power plant. There is open land, stable geological structure, few people and buildings, and surrounded on three sides by Bohai Sea. Hongyanhe nuclear power plant is the first nuclear power plant in northeast China and the first one receiving central government approval to build four units at the same time. Commercial operation is planned for 2012-2014.

The observed data in the survey was obtained through the Liaoning Birth Defects Monitoring Network, which is a critical component of public health strategies to collect meaningful data on infants with birth and reduce the occurrence and impact of birth defects [11, 12]. The study was to determine the prevalence, types and epidemiologic patterns.

II. METHODS

A. Data Collection

The areas covered in the basic survey included 32 towns in Wafangdian. We used the database of the Liaoning Birth Defects Monitoring Network to investigate birth outcomes for infants with defects from 1996 to 2009. The reason of choosing the time interval was the monitoring of birth defects since 1996, in Wafangdian. There were only six member hospitals which

could deliver births in Wafangdian. In the six hospitals, every neonate (live and stillbirths greater than or equal to 28 weeks' gestation) was immediately examined after birth by trained doctors to screen for birth defects. The types of birth defect were classified using ICD-9 standard of diagnosis. The infant must have been born in member hospitals with a birth diagnosed within 7 days after delivery, and the mothers living in Wafangdian for more than one year were enrolled.

B. Data Quality Management

The healthcare workers of diagnosis, data collection, and data checking were trained. Each member hospital had the special departments and healthcare workers for data collection, checking, and confirming to ensure high quality data. Data on birth defects were collected using standardized questionnaires and were checked by professionals responsible for data quality. If incomplete, inconsistent and uncertain information were identified, the questionnaire was returned to healthcare workers and verified. Strict measures were in the place to ensure confidentiality of data and anonymity of extracted data for analysis.

C. Statistical Analysis

Prevalence was expressed as the number of birth defects per 10,000 births. Residential areas were categorized into six zones by each 10 kilometers according to the distance to Hongyanhe nuclear power plant. Neural tube defects (NTDs) are birth defects of the brain and spinal cord. The neural tube defects contain spina bifida, anencephaly, and encephalocele. The data were analyzed using SPSS version 16.0. Chi-square tests were performed to determine any association between distances and years. Linear chi-square tests were used to detect trends in prevalence. The statistically significant level was set at $P < 0.05$.

D. Ethical Issues

This study was approved by the Ethics Committee of China Medical University. Care was taken to ensure that requirements for the protection of personal data were fully complied. Identifying information was not included in the study.

III. RESULTS

During 1996 to 2009, a total of 783 birth defects were identified among 95,632 births, which yielded a prevalence of 81.88 per 10,000 births. Further description of prevalence of birth defects is shown in Table 1.

TABLE 1 THE PREVALENCE OF BIRTH DEFECTS (PER 10,000) IN WAFANGDIAN, 1996-2009

Year	0~10 km		10~20 km		20~30 km		30~40 km		40~50 km		50~60 km		χ^2
	N	prevalence	N	prevalence	N	prevalence	N	prevalence	N	prevalence	N	prevalence	
1996	1	66.67	1	37.88	5	30.67	4	29.09	21	58.28	2	19.47	4.79
1997	0	0	3	107.53	6	43.76	11	83.71	28	79.23	6	63.42	3.57
1998	0	0	1	36.36	6	46.01	6	50.29	38	104.54	3	34.36	10.55
1999	0	0	1	46.87	11	88.42	10	87.57	32	108.44	2	24.72	6.72
2000	3	288.46	2	102.04	4	35.00	7	60.14	41	124.54	2	24.21	18.52*
2001	0	0	0	0	9	78.19	10	78.25	34	106.62	4	49.50	5.81
2002	1	80.65	2	89.29	2	15.75	9	71.88	28	87.55	1	12.55	11.38*
2003	1	92.01	1	59.74	6	64.47	9	82.92	23	92.65	6	87.66	1.13
2004	1	100.03	1	60.42	6	67.73	8	86.52	24	92.28	7	99.55	0.94
2005	0	0	0	0	5	51.02	9	82.11	34	119.84	12	148.70	9.26
2006	0	0	1	37.88	12	113.31	17	157.12	20	72.89	8	110.50	8.28
2007	4	500.00	2	89.29	18	129.87	18	146.82	37	107.90	15	145.49	10.73
2008	1	104.17	3	102.39	11	83.02	7	58.68	27	71.09	14	148.78	6.44
2009	0	0	2	61.92	5	32.57	7	60.66	27	73.81	16	175.05	16.94*
χ^2	32.34*	-	6.46	-	30.11*	-	22.89*	-	18.86	-	44.56*	-	-

* Statistically significant difference between different years or different zones

A. The Times Trends

The highest prevalence of birth defects was observed in 2007 (128.98 per 10,000 births), and the lowest one was in 1996 (42.24 per 10,000 births). There was statistically significant variation in annual prevalence of birth defects ($\chi^2=46.94$, $P < 0.05$). Furthermore, an upward trend was detected using linear chi-square test ($\chi^2=14.82$, $P < 0.05$). Further description of prevalence of birth defects is shown in Fig. 1.

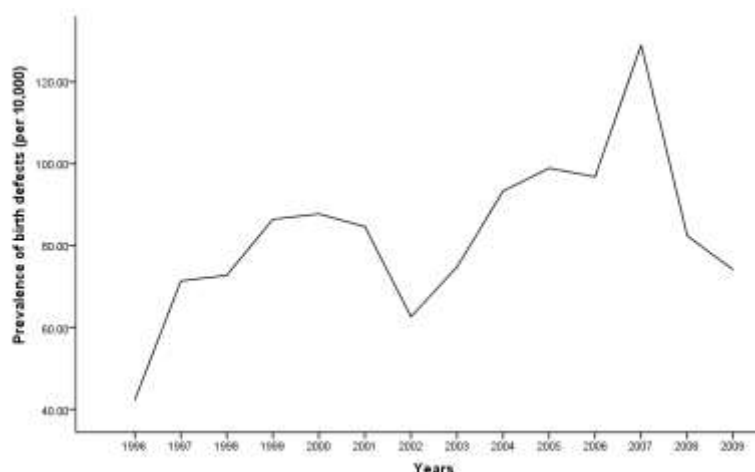


Fig. 1 The time trends in prevalence of birth defects in Wafangdian, 1996-2009

B. The Distances Trend

The distance from the nuclear power plant was divided into 6 zones by each 10 kilometers. The highest prevalence of birth defects was observed in the zone of 40-50 km (92.06 per 10,000 births), and the lowest one was in the zone of 10-20 km (60.38 per 10,000 births). There was statistically significant variation in prevalence of birth defects between different zones ($\chi^2=15.35$, $P<0.05$). Furthermore, an upward trend was detected using linear chi-square test ($\chi^2=9.27$, $P<0.05$).

C. The Major Birth Defects

The top six types of birth defects were: congenital heart disease (CHD) 18.40 per 10,000 births (176/95,632), hydrocephalus 7.53 per 10,000 births (72/95,632), cleft lip and cleft palate 7.32 per 10,000 births (70/95,632), polydactyly 4.29 per 10,000 births (41/95,632), spina bifida 4.18 per 10,000 births (40/95,632), and cleft lip 4.18 per 10,000 births (40/95,632). The prevalence of NTDs was 6.69 per 10,000 births (64/95,632). The prevalence of trisomy 21 was 0.73 per 10,000 births (7/95,632).

Further description of prevalence of birth defects is shown in Fig. 2.

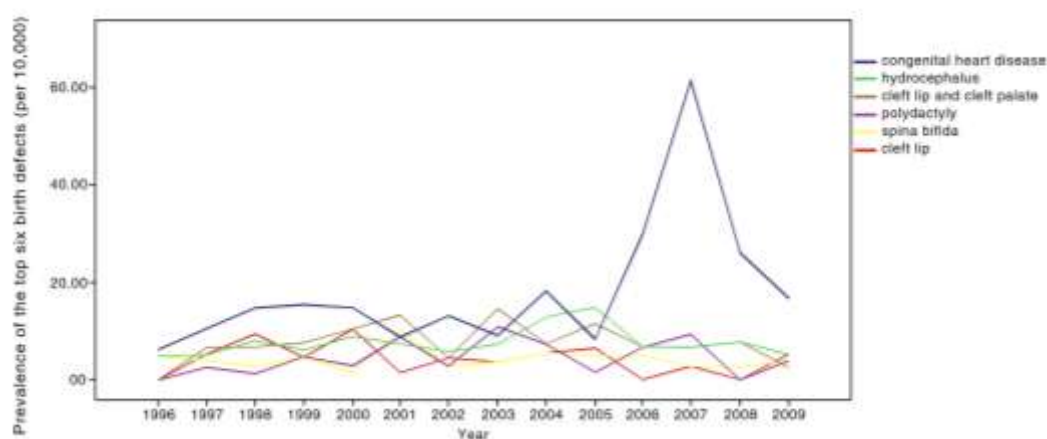


Fig. 2 The time trends in prevalence of the top six of birth defects in Wafangdian, 1996-2009

D. The Time Trend in Different Zones and the Distances Trend in Different Years

There was statistically significant different prevalence of birth defects between different zones in 2000 ($\chi^2=18.52$, $P<0.05$), 2002 ($\chi^2=11.38$, $P<0.05$), and 2009 ($\chi^2=16.94$, $P<0.05$). A significant difference in prevalence of birth defects was also observed between different years in the zones: 0~10 km ($\chi^2=32.34$, $P<0.05$), 20~30 km ($\chi^2=30.11$, $P<0.05$), 30~40 km ($\chi^2=22.89$, $P<0.05$), and 50~60 km ($\chi^2=44.56$, $P<0.05$).

IV. DISCUSSION

We found the prevalence of birth defects was 81.88 per 10,000 births during 1996 to 2009. This result showed a lower prevalence compared to other studies in China, even comparing the highest prevalence year in 2007. Pei LJ et al. reported that the prevalence of birth defects was 172.5 per 10,000 births which were registered in the Birth Defects Surveillance System of

China between February 2004 and March 2006 [13]. In Gansu province, a base-line survey showed that the incidence of birth defects was 154 per 10,000 births from 1 June to 1 December 2001 [11]. In the study by Liu B et al. in Shenyang, the prevalence of birth defects was 98 per 10,000 births during 2002 to 2004. National Office for Maternal and Child Health Surveillance announced that the national prevalence of birth defects was 145.43 per 10,000 births in 2009. A potential explanation for this inconsistency is that the time span was longer than previous studies. The national prevalence showed an increasing trend in birth defects. The average prevalence of long time span would be lower than recent years. It is also possible that Wafangdian is an ecological livable country, which has the rich seafood and fresh air, in the seaside of the Bohai Sea. Women exposed to air pollution during pregnancy are more likely to give birth to defects.

Among the time trend of birth defects, the highest prevalence of birth defects was observed in 2007 (128.98 per 10,000 births), and the lowest one was in 1996 (42.24 per 10,000 births). In our study, all of the prevalences were lower than the national prevalence reported by National Office for Maternal and Child Health Surveillance during 1996 to 2009. An upward trend was detected in our study. This is most like the result of report on women and children's health development in China that was created by Ministry of Health, People's Republic of China in August, 2011. This report showed that according to nation-wide hospital surveillance data for birth defects (surveillance period is from 28-week pregnancy to 7 days after delivery), the incidence of birth defects is on the increase, from 87.7/10,000 in 1996 to 149.9/10,000 in 2010, up by 70.9% [14]. We believe this could be explained by a perception that the air pollution has become more and more serious and the ionizing radiation from computers, mobile phone, microwave oven and television has become more and more widespread. It is also possible that the ability of Birth Defects Monitoring Network has been enhanced.

Among the distances trend of birth defects, the highest prevalence of birth defects was observed in the zone of 40-50 km (92.06 per 10,000 births), the lowest one was in the zone of 10-20 km (60.38 per 10,000 births) and an upward trend was detected. Hongyanhe nuclear power plant locates in Donggang town which is rural area of Wafangdian country. The most urban area locates in the zone of 40-50 km. we found a higher prevalence in urban areas compared with rural areas. The reason of the difference may be there are differences in education, economic level, high risk factors exposure, lifestyle, and health care between people who live in urban and rural areas in China [15-18]. With the urbanization process, a few urban areas have to endure crowded traffic, rapid pace of life and polluted environment, which are considered the risk factors of birth defects.

The major types of birth defects in our study were: hydrocephalus, cleft lip and cleft palate, polydactyly, spina bifida and cleft lip. The result is similar with other studies [13, 14]. The NTDs and trisomy 21 are the most common disorders thought to be caused by ionizing radiation [4]. The prevalences of NTDs and trisomy 21 are 6.69 per 10,000 births (64/95,632) and 0.73 per 10,000 births (7/95,632), respectively, which are lower than those in other studies of China [11, 13, 19].

Congenital heart disease is a most common type of birth defects (18.40 per 10,000 births, 76/95,632), which is consistent with the prevalence in other studies [19-21]. There was a rapid growth in 2006 and 2007. The prevalence of 2007 was the 9.2 times that of 2005. A potential explanation is that the strategy of pre-marital check-ups was changed. Congenital heart disease is associated with several risk factors and can be used as a basis to develop preventive interventions. The rate of pre-marital check-ups declined to 1.17% in 2004 from 95.48% in 2003 because the government announced that compulsory pre-marital check-ups was cancelled, but encouraged check-ups paid by themselves. In 2007, the rate of pre-marital check-ups was increasing to 80.58% because it became free. The prevalence of congenital heart disease in our study is consistent with the rate of pre-marital check-ups in Wafangdian.

The study has certain limitations. Firstly, because of the long time span, we can not acquire the information of pregnancy risks, such as maternal age at birth, maternal medication in pregnancy, maternal alcohol/drug addiction, maternal diagnostic X-ray exposure and so on. Most birth defects are believed to be caused by a complex mix of factors including genetics, environment, and behaviors, though many birth defects have no known cause. Those factors should be considered comprehensively on estimating the change of the numbers and types of birth defects in Hongyanhe nuclear power plant. Secondly, the data on birth defects in our study were obtained from hospital-based birth defects surveillance, but the hospital delivery prevalence of pregnant women in some rural areas is relatively low. In addition, the methods for surveillance and prenatal diagnosis have impacts on the prevalence of birth defects. This may be the reason for an upward trend of birth defects detected.

V. CONCLUSION

To our knowledge, few studies about prevalence of birth defects have the large intervals of time, from 1996 to 2009 in northeast China. There was an upward time trend of birth defects. All of the prevalences were lower than the national prevalence and other studies. The major types of birth defects in our study are similar with the national types. The prevalences of NTDs and trisomy 21 thought to be caused by ionizing radiation are lower than those in other studies of China.

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