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Investigations on the health effects of human population residing in the high-level natural radiation areas in Kerala in the southwest coast of India

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Abstract. Monitoring of newborns at birth for clinically and cytogenetically observable malformations as well as a comprehensive Health Audit Survey are being carried out in the high-level natural radiation (HLNR) area of Kerala, a southwest state of India. A total of 92,689 newborns were monitored from August 1995 to June 2004 and overall incidence of stillbirths and malformations was 0.51% and 2.03%. Multiple logistic regression analyses of congenital malformation and stillbirths do not suggest any correlation with the radiation levels. Health Audit Survey was carried out in three Panchayats, and the pattern of both birth defects and late onset diseases was similar. The karyotype analysis of 23,844 cord blood samples was carried out. The overall incidence of constitutional karyotype anomalies was 4.86±0.45 per 1000. © 2004 Published by Elsevier B.V.

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1. Introduction

Investigations on the health effects of high-level natural radiation (HLNR) on human population are being carried out in the densely populated monazite bearing HLNR area of Kerala, a southwest state of India on the Arabian coast. The average per capita dose received by the population in the 55-km-long and 0.5-km-wide belt is about four times the normal background radiation level, and the dose rate varies from 1.0 to 45.0 mGy/year [1,2]. The details of the HLNR area and methodology of studies being carried out by the Department of Atomic Energy, Government of India are described elsewhere [3–5]. As part of the programme, hospital-based monitoring of newborns at birth for clinically observable malformations, cytogenetic analysis and a comprehensive house-to-house Health Audit Survey are being carried out. The prevalence of various end-points studied are compared between HLNR and Normal Level Natural Radiation (NLNR) areas as well as at different background dose levels and forms the subject matter of this paper.

2. Materials and methods

The newborns from four government hospitals in the HLNR and NLNR areas were clinically screened for identifiable malformation at birth by trained doctors. Cord blood samples were used for lymphocyte microculture technique, and Giemsa stained/G-banded slides were analysed for karyotype anomalies. The detailed methodology of these studies are described elsewhere [3–5]. The mean radiation dose at the area of residence of the couples is used for dose–response analysis and classification of HLNR (>1.5 mGy/year) and NLNR (≤ 1.5 mGy/year) areas. The house-to-house Health Audit Survey was conducted in collaboration with the departments of Health and Social welfare, Government of Kerala. The basic data collection was carried out by Anganwadi Workers, having good rapport and routine interaction with the population. They were trained to elicit information on sociodemography, life style, reproductive history of married women, congenital malformation/late onset chronic diseases, etc. and record it in the precoded proforma.

3. Results

A total of 92,689 (60,544 from HLNRA; 32,145 from NLNRA) newborns (91,368 singletons, 648 twins; seven triplets, one quadruplet) were monitored for malformations from August 1995 to June 2004. About 85% of mothers was in the age group of 20–29 years at the time of delivery. The overall incidence of stillbirths was 0.51% and that of malformations was 2.03%, the system involved being musculoskeletal (29%) followed by genitourinary (18%), ear (10%), gastrointestinal (8%), cardiovascular (7%), central nervous (6%) and others (22)%. Multiple logistic regression analyses of malformation and stillbirths showed dependence on maternal age, gravida status, ethnicity, gender of the baby and consanguinity but do not suggest any correlation with radiation levels (Table 1). The frequency of Down syndrome also were similar in HLNR (7.3/10,000) and NLNR (5.9/10,000) areas ($P>0.2$), with an overall incidence of 1 in 1471. The relatively lower incidence of stillbirths, malformations, DS and lower birthweight

Table 1
Multiple logistic regression analysis of congenital malformations and stillbirth

Characteristic	No. of newborns	%	Malformed no.	F[a]	OR[b]	95% CI	Stillbirth no.	F[a]	OR[b]	95% CI
Maternal Age										
15–19	6075	06.6	104	17.1	1.00		39	6.4	1.00	
20–21	14,556	15.7	295	20.3	1.23	0.98–1.54	62	4.3	0.66*	0.44–0.98
22–23	21,335	23.0	413	19.4	1.20	0.96–1.50	82	3.8	0.57*	0.38–0.85
24–25	19,999	21.6	392	19.6	1.24	0.99–1.56	106	5.3	0.76	0.51–1.12
26–27	13,984	15.0	273	19.5	1.25	0.98–1.59	81	5.8	0.81	0.53–1.22
28–29	8593	09.3	182	21.2	1.37*	1.06–1.78	40	4.7	0.62	0.39–1.00
≥30	8138	08.8	210	25.8	1.68*	1.30–2.17	60	7.4	0.93	0.59–1.46
Gravida										
1	42,197	45.5	864	20.5	1.00		193	04.6	1.00	
2	42,184	45.5	841	19.9	0.92	0.83–1.02	198	04.7	1.04	0.83–1.29
3	7207	07.8	132	18.3	0.80*	0.66–0.98	61	08.5	1.78*	1.30–2.45
≥4	1092	01.2	32	29.3	1.21	0.83–1.75	18	16.5	3.24*	1.93–5.43
Gender										
Male	47,492	51.2	1166	24.6	1.00		266	5.6	1.00	
Female	45,188	48.8	703	15.6	0.63*	0.57–0.69	204	4.5	0.81*	0.67–0.97
Consanguinity										
Absent	90,552	97.7	1809	20.00	1.00		447	04.9	1.00	
Present	2128	02.3	60	28.2	1.43*	1.10–1.85	23	10.8	2.04*	1.34–3.12
Ethnicity										
Nair	14,688	15.9	267	18.2	1.00		60	4.1	1.00	
Ezhava	20,588	22.2	442	21.5	1.18*	1.01–1.38	100	4.9	1.20	0.87–1.65
Viswakarma	4729	05.1	96	20.3	1.11	0.88–1.41	21	4.4	1.05	0.64–1.75
Other Hindu	21,880	23.6	453	20.7	1.15	0.98–1.34	133	6.1	1.44*	1.06–1.96
Christian	11,790	12.7	226	19.2	1.06	0.89–1.27	58	4.9	1.19	0.82–1.71
Muslim	19,005	20.5	385	20.3	1.16	0.99–1.37	98	5.2	1.18	0.84–1.64
Radiation dose (mGy/year)										
≤1.50	32,144	34.7	678	21.1	1.00		163	5.1	1.00	
1.51–3.00	51,778	55.9	1023	19.8	0.94	0.85–1.03	272	5.3	1.04	0.86–1.27
3.01–6.00	5507	05.9	107	19.4	0.92	0.75–1.13	18	3.3	0.64	0.39–1.05
≥6.01	3251	03.5	61	18.8	0.89	0.68–1.17	17	5.2	0.97	0.58–1.62
Total	92,680	100.0	1869	20.2			470	05.1		

[a] F—Frequency/1000 newborns.

[b] Odds ratio. Coefficients obtained from logistic regression analysis, including all variables indicated in the model as a categorical variable. Reference category is indicated with an OR of 1.00. Nine intersex cases not included in analysis.

* Significant at 5% level.

(<2500 g, 8.2% among live singleton newborns) is commensurate with the younger maternal age [6].

Health Audit Survey has been conducted in three Panchayats (99 Anganwadies, about 23,000 households) in the study area, and the data are being processed. Percentage of individuals reported to have congenital malformation and late onset chronic diseases (arthritis, asthma, blindness, cataract, deafness, diabetes, dumbness, epilepsy, heart disease, hypertension, hypotension, leukemia, other cancers, neurological disorders, psychiatric disoders, thyroid diseases, vitiligo, etc.) in different age groups based on 10,800 households of 46 Anganwadies is depicted in Fig. 1. Although the pattern of

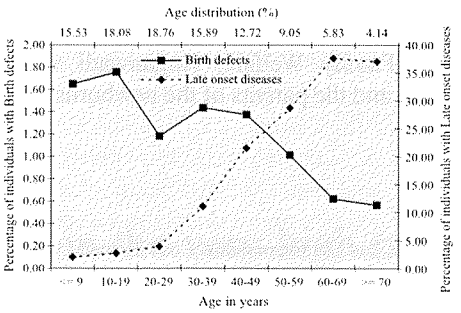

Fig. 1. Age-specific prevalence of birth defects and late onset diseases.

background radiation levels vary widely in the three Panchayats, the pattern of both birth defects and late onset diseases was similar in the three Panchayats.

The karyotype analysis of 23,844 (8004 from NLNRA and 15,840 from HLNRA) cord blood samples was carried out. The overall incidence of karyotype anomalies was 4.86±0.45 per 1000 (4.80±0.55 in HLNR area and 5.00±0.79 in NLNR area) and is comparable with published figures [7]. Both structural and numerical chromosomal anomalies were comparable between HLNR and NLNR areas and did not seem to be associated with the background dose levels. Numerical anomalies were slightly higher among males (2.76±0.47 vs. 2.34±0.45), whereas structural aberrations were higher among females (1.71±0.37 v/s 2.95±0.51).

4. Discussion

Screening newborns for congenital malformation is a practical approach to assess transmission of genetic damage, if any, caused by chronic exposure to HLNR. The studies carried out do not suggest an increase of any of the end-points in HLNR area so far. The natural radiation dose rates of the area may not be high enough to induce genetic damage to be measured/discerned by screening congenital malformations. Apart from the multifactorial origin of congenital malformations, the intricacies of dominant and recessive mutations which could have occurred in the past generation(s) and the uncertainties involved in the dose estimation owing to mobility of the population and differential dose exposure profile of parents make matters more complex. The studies are being expanded to assess the impact of HLNR on chronic diseases through the Health Audit Survey. This will make it possible to gauge the impact of HLNR on some selected disease conditions as the etiopathogenesis of diseases are not similar and the pathway of other mutagens and radiation may also be different.

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