EFFECTS OF LOW-DOSE IONIZING RADIATION AMONG THE EMPLOYEES AT THE KAIGA GENERATING STATION: A CROSS-SECTIONAL STUDY

Tata Memorial Centre

Tata Memorial Hospital
Dr. E. Borges Marg, Parel
Mumbai - 400 012

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A Report
Prepared
Under the Consultancy Service Contract of NPCIL
with
Tata Memorial Centre
by
The Epidemiological Studies Cell
Tata Memorial Hospital
Mumbai

December 2000

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PREFACE

In January 1992, the Nuclear Power Corporation of India Ltd. (NPCIL) entered into a Consultancy Service Contract (No.CSC-92-1-TMC) with the Tata Memorial Centre (TMC) to carry out epidemiological studies in the employees and their families. The aim of the study was to investigate whether any health hazards were associated with exposure, if any, to low-dose ionizing radiation. The contract was to undertake the studies at 6 power stations or project sites. These were located at Tarapur, Maharashtra; Rawatbhata, Rajasthan; Kalpakam, Tamilnadu; Narora, Uttar Pradesh; Kakrapar, Gujarat and Kaiga, Karnataka.

NPCIL set up a Corporate Committee for Epidemiological Studies (COCES). The first meeting of COCES was held on 6th April 1992. Two additional committees were also constituted viz. Senior Technical Advisory Group (STAG) and Planning and Implementation Supervisory Committee for Epidemiological Studies (PISCES), and their functions and terms of references were laid down. Member-Secretary PISCES was designated to be officer incharge of Epidemiological Surveys. These committees met periodically. In the initial phase of the study, several issues were debated and decisions taken regarding the target population, the controls, the types of health indicators to be studied, the instrument for data collection and several technical issues.

Tarapur Atomic Power Station was the first site selected for the survey, because of its proximity to Tata Memorial Hospital (TMH), which allowed enumerators, statistician and doctors from TMH to visit the site regularly to carry out the work. This was followed by Kakrapar Atomic Power Station. Besides these two power stations, the data at other power stations were collected by the local

academic/medical Institutes as per the guidelines provided by TMH and the data transported to the Epidemiological Studies Cell at TMH for processing and analysis.

Todate four reports of surveys carried out at Atomic Power Stations located at Tarapur, Kakrapar, Rawatbhata and Narora have been generated. The present report covers the data collected at Kaiga Generating Station. The Department of Community Medicine, Kasturba Medical College, Manipal, was responsible for collection of data at the Kaiga Generating Station.

One of the important results yielded by all these surveys carried out upto now, at various power stations, is that there is no increase in the prevalence of malignancies in the radiation workers as compared to non-radiation workers. At Kaiga Generating Station, understandably no cancer cases were seen as the employee group was small and largely (80%) below the age of 40. The project has provided useful indicators and generated reliable baseline data for carrying out further work.

The Tata Memorial Centre has been privileged to undertake this research project to address a problem which is not only scientifically important but also socially relevant. This report, I am sure, will be of interest to a wide range of readers from epidemiologists, scientists, physicians as well as physicists concerned with these issues.

- Dr.K.A.Dinshaw
Director, TMC

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SUMMARY:

The potential effect of ionizing radiation on human population has been a concern to the scientific community and to the public at large, for a long time. The Nuclear Power Corporation of India Limited (NPCIL) recognised the need for more precise information on the biological effects of low dose radiation on human population. In response to this concern, NPCIL awarded a Consultancy Service Contract to the Tata Memorial Centre (TMC) Mumbai, to carry out epidemiological studies in radiation occupational workers and their families at various power station/project sites. At Tarapur and Kakrapar Power Stations TMC undertook the survey. The surveys at other sites have been conducted by local academic/medical institutions as per the procedures standardised by TMC, and the data are transported for processing and analysis to its Epidemiological Studies Cell especially set up for the purpose.

The present document reports the results of the cross-sectional survey carried out at Kaiga Generating Station during the year 1998 by the Department of Community Medicine, Kasturba Medical College, Manipal, and covers 1553 employees, 1162 spouses of employees and 1343 offspring of employees. The prevalence of malignancies in these three groups has been studied and the prevalence of congenital anomalies in the offspring of employees has also been reported on.

The primary interest was to study prevalence of malignancies in the study group, in particular to see if the prevalence was higher in radiation workers as compared to that in non-radiation workers. There were, however, no cases of cancer reported in all the three groups studied i.e. the employees, their spouses and their offspring. This was not surprising since the study groups were small, all being less than 1600 individuals. Furthermore, incidence of cancer is known to increase with age, while in the present study 80% of the employees and their spouses were below 40 years of age. Secondly working personnel and their families are usually healthier than the general population.

There were 6 cases of congenital anomalies (major and minor) among 1343 offspring of employees, giving a prevalence of 0.45% (0.45% in males and 0.44% in females). The prevalence of congenital anomalies in a comparable cross-section of the population was not available with which the present data could be compared. However, an earlier exhaustive study at a large maternity hospital in Mumbai, had reported the prevalence of congenital anomalies in the new born, on clinical examination only, to be 1.4% (Master-Notani et al, 1968). None of the anomalies, in the present study, occurred in the offspring of radiation workers.

Finally, the study population at Kaiga is quite small and the cohort is also young and no cancers were observed. However, the information collected will help augment the base when analysis of pooled data, from all power stations, is undertaken.

EFFECTS OF LOW-DOSE IONIZING RADIATION AMONG THE EMPLOYEES AT THE KAIGA GENERATING STATION : A CROSS-SECTIONAL STUDY

1. INTRODUCTION

The potential effect of ionizing radiation on human population has been a concern to the scientific community and the public at large, for a long time. The Nuclear Power Corporation of India Limited (NPCIL) recognized the need for more precise information on the biological effects of low dose radiation on human population. In response to this concern the NPCIL initiated an epidemiological survey in the employees and their families at its various sites and awarded a Consultancy Service Contract to Tata Memorial Centre (TMC), Mumbai. NPCIL also constituted various committees (composition given in Appendix G); one was the Corporate Committee for Epidemiological Studies (COCES) for ensuring suitable organizational arrangements and budgetary deployment. The other two committees were Senior Technical Advisory Group (STAG) to give guidelines on the conduct of the study and review the reports prepared by the other committee viz. Planning and Implementation Supervisory Committee for Epidemiological Studies (PISCES), which actually planned detailed methodology of carrying out the epidemiological survey. TMC conducted the survey at 2 sites viz. Tarapur DAE Centre and Kakrapar Atomic Power Station. For surveys at other stations, TMC provides guidelines regarding the format for data collection, the questionnaire, and the software for data entry. This data is then transferred to TMC for processing and analysis at its Epidemiological Studies Cell especially set up for the purpose.

This report deals with data collected at Kaiga Generating Station (KGS), Kaiga. Both the units of KGS were under construction and became operational by December 1999.

2. OBJECTIVES

The general aim of the project was to conduct health survey in employees and their families residing with them and assess morbidity due to various diseases and evaluate the impact, if any, of low-dose radiation.

Specific aims, for this report, are to compute morbidity (prevalence) of cancer and compare with suitable controls; for 3 groups viz. the employee group, their spouses and their offspring. Additionally, for the offspring group prevalence of congenital anomalies is also to be studied.

3. OPERATIONAL METHODOLOGY

Department of Community Medicine, Kasturba Medical College (KMC), Manipal, conducted the survey at Kaiga Generating Station during the year 1998. The survey involved filling a questionnaire with respect to demographic and medical data and other relevant details as well as undertaking medical examination.

3.1 Questionnaire

A detailed questionnaire was designed for collection of information on demographic characteristics and medical and health history and radiation exposure history. Besides, data were also obtained on lifestyle factors like tobacco use,

alcohol consumption, dietary intake and other occupational exposures. This was necessary, since environmental/lifestyle factors determine a large fraction of cancer rates. Thus, the confounding/modifying effects of these factors could be taken into account, if required. Occupational history including the type of occupational radiation exposure and period of exposure prior to and after joining the power station was obtained. Radiation exposure history, occupational as well as medical exposures were noted. Medical history giving details of past and/or present illness, if any, and details of clinical examinations, reproductive history, congenital anomalies, if any, among offspring, were also recorded.

The questionnaire was field-tested earlier at Tarapur DAE Centre, and was used in the present survey also.

3.2 Field Survey, Data Collection and Processing

The employees and their families were invited by the local authorities of Kaiga Generating Station (KGS) to participate in the survey and to come to the hospital of Kaiga Generating Station, where clinical investigations were conducted and data collected. For this survey, a team of doctors from Kasturba Medical College, Manipal, visited the hospital at Kaiga. Doctors have examined each and every participant as they presented themselves and filled the proforma. The investigations that were carried out included testing of complete blood count (C.B.C.), chest x-ray and cytology investigations.

Following criteria were set for carrying out these investigations :-

1. All adults above the age of 40 years and smokers 35 years and above had to undergo a chest x-ray.

2. All females above the age of 35 years had to undergo pap-smear test.
3. All children had to undergo blood test (C.B.C.).
4. Adults had to undergo blood test (C.B.C.), only if it was not done for the past one year.

The database was created from the completed proformas, with the software installed at Kasturba Medical College by the Epidemiological Studies Cell. The floppies containing the database were then transported to this cell for processing and analysis.

4. POPULATION COVERAGE

This report is based on information on 1553 employees, 1162 spouses of employees and 1343 offspring of employees i.e. a total of 4058 individuals as seen in Table 1. Of these 2546 members were individually examined and interviewed.

Table 1 : Population Covered i.e. Employees, their Spouses and Offspring (1998)

Groups	Covered in the Survey			Information obtained from the medical records of KGS Hospital			Total
	Males	Females	Total	Males	Females	Total	
Employees	911	53	964	547	42	589(38%)	1553(100%
Spouses	5	788	793	43	326	369(32%)	1162(100%
Offspring	382	407	789	284	270	554(41%)	1343(100%
Total			2546(63%)			1512(37%)	4058(100%

The information on health status with respect to malignancies and congenital

anomalies in the offspring, if any, in the group of 1512 individuals that was not examined, was obtained by reviewing the medical records maintained at the hospital of Kaiga Generating Station. Cancer and congenital anomalies are serious enough conditions to be brought to the notice of the doctor and also recorded and hence there is little likelihood of missing any case.

5. HEALTH OUTCOMES FOR STUDY

The basic study design was cross-sectional type with no follow-up. It was simply a one time survey so that only prevalence of various conditions could be assessed. Neither the incidence nor mortality were studied. The health outcomes reported on here are

1. Malignant disease in three groups viz. employees, their spouses and their offspring,
2. Congenital anomalies in the offspring.

Members of the surveyed group were given a thorough medical check-up. However for the purposes of this report only the above two conditions have been considered.

6. SELECTION OF COMPARISON GROUP

Several options were available for selection of controls for the three groups viz., the employees, their spouses and offspring that were to be surveyed. One was to have internal comparison group i.e. compare radiation workers with non-radiation workers of the power station. The other was to have external comparison

group such as the general population. A third suggestion made by the STAG/PISCES committee members was to obtain comparison group from Bhabha Atomic Research Centre (BARC), Mumbai, employees and their family members. Each of these groups carries both useful and restrictive elements.

6.1 Comparison Group for Evaluating Cancer Prevalence in Employees

General population groups are not ideal in studies evaluating occupational exposures, because workers are usually healthier than the general population (the healthy worker effect) - healthier people are more likely to get jobs and continue at work. Hence the workers are generally expected to experience lower risks for cancer and for other diseases than the general population. Furthermore, there are no cancer prevalence data available for the general population and prevalence estimated from available incidence rates by a fixed multiplier (1.5, 2 or 3) as an estimate of average duration, would not be strictly proper.

The second alternative of comparing with BARC (Mumbai) employees and their families, may also be questionable because in the perception of the lay public, these employees also come under the umbrella of radiation workers.

The better alternative is to have an internal comparison group i.e. compare prevalence of cancer among those exposed to radiation with those who were not exposed, within the same study group.

As for Kaiga Generating Station, there were no malignancies reported in the employees and the question of comparison therefore does not arise.

6.2 Comparison Group for Evaluating Cancer Prevalence in Spouses and Offspring of Employees

Similarly no prevalent cancer cases were reported for the spouses and offspring of employees and hence further discussion regarding the comparison groups utilised, is not relevant, for this power station.

6.3 Controls For Congenital Anomalies in Offspring of Employees

It has not been possible to obtain the prevalence of congenital anomalies in a comparable cross-section of the population independent of radiation-occupational groups. The only data available from the country deals with prevalence of congenital anomalies in the new born (Master-Notani et al;1968, Agarwal et al;1991) and hence are not comparable with the present data. We have compared the prevalence of congenital anomalies in the offspring of employees of Kaiga Generating Station with those of BARC (Mumbai) employees. Internal comparison i.e. comparing offspring of radiation workers versus those of non-radiation workers though of limited value, could not be undertaken because no congenital anomalies were observed in the offspring of radiation workers.

7. RADIATION EXPOSURE : DEFINITION AND MEASUREMENT

The details of annual radiation dose received by employees was provided by Kaiga Generating Station. An employee who has been given a TLD number for measuring radiation exposure is defined for the purposes of this study as a radiation worker. The radiation exposure to an employee at a nuclear installation can either be external and/or internal and is mainly due to gamma and beta radiations.

External exposure is caused due to radioactive source external to the body and is measured by means of personal dosimeters. These dosimeters can either be thermoluminescent dosimeters or film badge type dosimeters. For day-to-day dose management direct reading type dosimeters are also employed. For special applications, some other types of dosimetry devices are used.

Internal exposure is caused by radioactive materials entering the human body through inhalation, ingestion and injection. This type of exposure is monitored by bioassay and whole body counting techniques.

The external radiation exposure received by an employee is controlled by suitable adjustment of distance, time and shielding, while the internal exposure is controlled by protective equipment and clothing.

The dose received by the personnel is controlled and is kept well below the stipulated exposure limits recommended by International Commission on Radiological Protection (ICRP) and Atomic Energy Regulatory Board (AERB), from time to time.

The distribution of cumulative radiation dose in mSv (external cum internal), received by workers is given in Appendix A. In fact the workers had received this dose at other power stations before joining Kaiga Generating Station which became operational in 1999. The cumulative dose of an employee is measured by adding annual doses from initial employment upto end-1998, when the survey ended. The mean cumulative radiation dose per worker was 19.36 mSv in males.

Furthermore, not a single annual radiation dose exceeded 250 mSv, which is considered to be a radiation incident of medical significance for the United States population (Fry,1980). Infact, almost all the annual radiation doses for 325 radiation workers were below 50 mSv; except two employees who received annual doses of 62.5 mSv and 126.8 mSv.

8. CHARACTERIZATION OF EMPLOYEE POPULATION : UNIVARIATE DESCRIPTION

Table 2 describes the age and sex distribution of the radiation and non-radiation workers. It is seen that most of the employees are below 40 years of age. The 5-year age group distribution is given in appendix B Table 1.

Table 2 : Age Distribution of Employees of KGS by Radiation Status(1998)

	Males		Females	
Age	Radiation Workers No.(%)	Non-Radiation Workers No.(%)	Radiation Workers No.(%)	Non-Radiation Workers No.(%)
Upto 39	305(94)	887(78)	0	82(86)
40 - 49	10(3)	162(14)	0	12(13)
50+	10(3)	84(8)	0	1(1)
Total	325(100)	1133(100)	0	95(100)

For age distribution by 5-year age interval see appendix B.

Table 3 : Profile of Male Employees of KGS by Radiation Status (1998)

Group	Radiation Workers		Non-Radiation Workers		Total	
	No.	%	No.	%	No.	%
• **Marital Status**	**(n=185)**		**(n=726)**		**(n=911)**	
Unmarried	145	78	151	21	296	33
Married	40	22	572	79	612	67
Widowed/Divorced/ Separated	-	-	3	0.4	3	-
• **Education**	**(n=185)**		**(n=726)**		**(n=911)**	
Upto primary	1	0.5	13	2	14	2
Middle (V-VII std)	-	-	26	3	26	3
Secondary and Technical after SSC (VII-XII Std)	155	84	514	71	669	73
Undergraduate and above	29	16	173	24	202	22
• **Community**	**(n=325)**		**(n=1133)**		**(n=1458)**	
Hindu	297	91	992	88	1289	89
Muslims	9	3	49	4	58	4
Christians	15	5	77	7	92	6
Others	4	1	13	1	17	1
• **Habits**	**(n=325)**		**(n=1133)**		**(n=1458)**	
No habit	288	89	902	80	1190	81
Chewers only	6	2	48	4	54	4
Smokers only	20	6	93	8	113	8
Alcohol consumers only	3	1	44	4	47	3
Combination of Habits	8	2	45	4	53	4
Snuff	0	-	1	-	1	-
• **Cadre of Work**	**(n=321)**		**(n=866)**		**(n=1187)**	
Administration	1	-	100	12	101	8
Scientific	122	38	293	34	415	35
Technical	195	61	299	34	494	42
Security	3	1	55	6	58	5
Labour	0	-	119	14	119	10

Besides age and sex, it is also relevant to compare the profile of the radiation and non-radiation workers with respect to other characteristics. This information was available for 964 (911 males and 53 females) interviewed employees. For two characteristics viz. community and habits additional self-reported information was available from 589 non-interviewed employees (547 males and 42 females) and has been incorporated in Table 3. The distribution of various characteristics is shown for male employees only (Table 3), because there were very few female employees. The radiation and non-radiation workers were found to be similar with respect to community distribution (almost 90% belonged, as expected, to the majority community), educational level (almost 73% had studied upto secondary level or above) and aiso the habit pattern (over 80% had no habit). The radiation and non-radiation workers were different with respect to marital status which was not surprising, since radiation workers were much younger (82% below 30) compared to non-radiation workers (28% below 30). Expectedly, there was a higher proportion of administrative staff and lower proportion of scientific/technical staff in the group of non-radiation workers compared to radiation workers.

9. STATISTICAL METHODS

This is a cross-sectional survey with no follow-up, so that only the prevalence of conditions of interest can be studied. The primary interest is to study the prevalence of malignancies, particularly in the radiation workers and compare with that in adequate control groups of non-radiation workers, after controlling for environmental/life style factors, which determine a large fraction of cancer rates of a population (Higginson and Muir, 1979; Doll and Peto, 1981).

As mentioned earlier, there were no prevalent cancer cases in the groups studied. The other outcome of interest was congenital anomalies in the offspring of the employees. The observed (O) number of anomalies was compared with the expected (E) number arrived at from the corresponding control group, after adjusting for age and sex differences. The observed number of cases is considered to follow a Poisson distribution with mean E and under the null hypothesis, the ratio O/E is unity. The confidence intervals were read from the tables prepared by Bailar and Ederer for the ratio of an observed value of a Poisson variable to its expectation. The ratio O/E with 95% confidence intervals are exhibited in the relevant tables.

10. OBSERVATIONS AND DISCUSSION

The core question of the study concerns whether the employees of the Nuclear Power Plants, if exposed to low doses of ionizing radiation, are at higher risk for any disease condition; in particular cancer. The query is also extended to the family members i.e. their spouses and offspring. The interest is focused on cancer induction, since it is considered to be the most important long-term somatic effect of radiation exposure. However, it is not possible to distinguish between malignancies caused by ionizing radiation from those caused by other factors. There is no radiation specific tumor pathobiology. In general, only the frequency of an already prevalent tumor is expected to be elevated by radiation exposure. The age-adjusted incidence rate of cancer of different sites reported from 6 population based Indian registries is attached in Appendix D, for reference (ICMR, Biennial Report, 1992).

10.1 Cancer Prevalence

This survey is a cross-sectional type. Neither benign nor malignant conditions were observed in all the 3 groups: the employees, the spouses and the offspring of employees.

This is not a surprising observation as all the 3 groups studied were small, comprising less than 1600 individuals. Furthermore, cancer is known to increase with age, while above 80% of employees of KGS and their spouses were below 40 years of age. The offspring group was also very small, 1343 in number, of whom 1091 were 14 years of age and under.

10.2 Prevalence of Congenital Anomalies in the Offspring

Among the somatic effects of radiation, other than cancer, developmental effects in the unborn child are of great concern. Exposure to high doses of radiation can cause death, anomaly, growth retardation and functional impairment depending on the fetal stage at which exposures occur.

Several abnormalities have been reported in humans after in-utero irradiation. The commonly reported ones are microcephaly, often combined with mental retardation, some central nervous system defects and growth retardation.

Because of large environmental and genetic variables encountered in human populations, it is very difficult to measure any effect that might be produced by low-dose radiation, on the developing fetus.

Table 4 : Prevalence of Congenital Anomalies (Major and Minor) in Offspring of Employees of KGS (1998)

Offspring of		Males	Females	Total
Radiation Workers	No.	28	28	56
	Cases(%)	0	0	0
Non-Radiation Workers	No.	638	649	1287
	Cases(%)	3(0.47)	3(0.46)	6(0.47)
Total	No.	666	677	1343
	Cases(%)	3(0.45)	3(0.44)	6(0.45)

Table 4 gives the number of congenital anomalies both major and minor observed in the offspring of the employees with details of anomalies given in Table 5. The information on anomalies that might have occurred in the stillborn fetuses or in neonatal deaths was not available.

Table 5: List of Prevalent Congenital Anomalies(Major and Minor) in Offspring of Employees of KGS (1998)

	Males		Females		Total
CONG.ANOMALIES (ICD 9TH :740-759)	No.(age)	(Parent/employee Radiation Status)	No.(age)	(Parent/employee Radiation Status)	
1.Digestive System (749-751)					
Cleft Palate	1(8)	NR	1(14)	NR	2
2.Musculo-Skeletal System (754-756)					
Bent Rt. Foot	1(2)	NR	-		1
3.Cardiovascular System (745-747)					
Cong. Heart Disease	-		1(1)	NR	1
4.Anomalies of Eyes (743)					
*Squint (378)	1(6)	NR	1(6)	NR	2
TOTAL	3(0.45%)		3(0.44%)		6(0.45%)
Total Number of Offspring	666		677		1343

* These anomalies fall outside the range of ICD-9th 740-759
R : Radiation Worker, NR : Non-Radiation Worker

There are certain anomalies, indicated in Table 5 which fall outside the range of anomalies classified as congenital by the International Classification of Diseases (ICD) codes; 740 to 759. For the time being we have considered all the observed anomalies for analysis.

Total number of congenital anomalies (major and minor) recorded were 6 in number, of which 3 were in male offspring and 3 in female offspring; giving an overall prevalence of 0.45%. The prevalence of congenital anomalies in a comparable cross-section of the population is not available with which the present data could be compared. However, it has been compared with the prevalence in offspring of BARC (Mumbai) employees, shown in Table 6. The detailed description of anomalies in the offspring of BARC employees is given in Appendix C, Table 5. No significant difference in the prevalence of congenital anomalies in the 2 groups was observed [Males: O=3, E=3.62, O/E=0.83, 95% CI=0.17-2.42; Females: O=3, E=2.92, O/E=1.03, 95% CI=0.21-3.00].

Table 6 : Prevalence of Congenital Anomalies in Offspring of Employees of BARC, Mumbai (1994)

	Males	Females	Total
No. of Offspring	14,446	12,645	27,091
No. of Congenital Anomalies	55	42	97
Prevalence (%)	0.38	0.33	0.36

Internal comparison of congenital anomalies in offspring of radiation workers with that of non-radiation workers of KGS can not be undertaken. The reason being, as seen from table 4, that there are no congenital anomalies

observed in both male and female offspring of radiation workers to compare with that of non-radiation workers.

Questions of classificatory nature, nonetheless, still remain to be answered. Whether one should include anomalies falling outside the ICD range. Overall, the prevalence of congenital anomalies seen in the offspring of employees is only 0.45% (0.45% in males and 0.44% in females). An earlier exhaustive study at a large maternity hospital catering to the Mumbai population, has reported the prevalence of congenital anomalies in the new born on clinical examination only, to be 1.4% (Master-Notani et al, 1968).

11. CONCLUSION

This survey was carried out among the employees of the Kaiga Generating Station and their spouses and offspring. The study end points were prevalence of malignancies in the above 3 groups as well as prevalence of congenital anomalies in the offspring, to be compared with suitable controls. Prevalence, no doubt, is not such a desirable study-end-point for evaluating etiological associations, and a cohort follow-up study would be the method of choice. Nonetheless, cross-sectional surveys do provide important indicators.

In the present survey, it was of interest to study if prevalence of malignancies in radiation workers was different from that in non-radiation workers. However no malignancies were observed in any employee. This was not surprising because, besides the 'healthy worker' effect, the employee group was very small, less than

1600 individuals. Furthermore, cancer is a disease of old age, while over 80% of employees were below 40 years of age.

Similarly, there were no malignancies seen in the spouses and offspring of employees as well. Again, both these groups were small, less than 1600 individuals. More than 80% of spouses also, expectedly, were below 40 years of age.

As regards congenital anomalies in the offspring of employees, the prevalence in a comparable cross-section of the population was not available with which the data of the present survey could be compared. Furthermore all the congenital anomalies were reported in the offspring of non-radiation workers only. The annual exposure of 2 mSv is a dose limit set by AERB/ICRP for a pregnant employee. However, the question of in-utero work-related exposure also did not arise as there were no female radiation workers in this survey. The prevalence of congenital anomalies in the offspring in the present survey was only 0.45% which did not seem to be high. An earlier exhaustive study at a large maternity hospital catering to the Mumbai population, has reported the prevalence of congenital anomalies in the new born on clinical examination only, to be 1.4% (Master-Notani et al, 1968).

The cumulative dose distribution in the radiation workers provided by KGS has been shown in Appendix A. Most of the radiation workers do not receive any significant dose. Even the dose received is generally kept well within the upper-bound of annual dose stipulated by ICRP/AERB and is thus not likely to cause any health effects. The mean cumulative radiation dose per worker is 19.4 ± 1.9 mSv for males and there were no female radiation workers.

Undoubtedly, the study group is small and therefore no definitive conclusion can be drawn. Nonetheless, these numbers would help augment the base, when the analysis is done on the data pooled across all power stations.

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APPENDIX A

Radiation Exposure Data of Kaiga Generating Station Employees.

DOSE DISTRIBUTION OF KAIGA GENERATING STATION EMPLOYEES

Table 1: Cumulative Radiation Dose in mSv from Initial Employment upto December 1998
of Kaiga Radiation Workers, by Age and Sex

A) MALES

Exposure (in mSv)	No.of Persons in Different Age Groups 18-	30-	40-	50+	Total	%
0-	5	0	1	0	6	1.8
1-	158	9	0	0	167	51.4
10-	58	10	1	3	72	22.2
20-	45	10	0	3	58	17.8
50-	1	5	2	1	9	2.8
100-	0	3	5	3	11	3.4
200-	0	1	1	0	2	0.6
Total	220	30	9	9	325	100.0

Mean Cumulative Radiation dose per worker =19.36 ± 1.86 mSv

B) FEMALES

There were no female radiation workers

APPENDIX B

Kaiga Study Population Distribution By Age, Sex And Radiation Status

APPENDIX B

Table 1: Distribution by Age,Sex and Radiation status of Kaiga Study Population (1998)

A] Employees :

	Age										
Sex											
Radiation status	<20	20-	25-	30-	35-	40-	45-	50-	55-	60+	Total
Males											
Radiation Workers	0	115	152	27	11	2	8	5	5	0	325
Non-Radiation Workers	7	99	218	354	209	87	75	54	30	0	1133
Total	7	214	370	381	220	89	83	59	35	0	1458
Females											
Radiation Workers	0	0	0	0	0	0	0	0	0	0	0
Non-Radiation Workers	0	10	29	32	11	5	7	1	0	0	95
Total	0	10	29	32	11	5	7	1	0	0	95

B] Spouses of Employees :

	Age										
Sex	15-	20-	25-	30-	35-	40-	45-	50-	55-	60+	Total
Males	0	0	4	20	14	7	1	1	1	0	48
Females	49	228	363	215	122	79	41	16	1	0	1114
Total	49	228	367	235	136	86	42	17	2	0	1162

C] Offspring of Employees :
i) Offspring of Radiation Workers

	Age							
Sex	0-4	5-9	10-14	15-19	20-24	25-29	30-	Total
Males	12	7	2	1	2	4	0	28
Females	13	5	2	4	3	1	0	28
Total	25	12	4	5	5	5	0	56

ii) Offspring of Non-Radiation Workers

	Age							
Sex	0-4	5-9	10-14	15-19	20-24	25-29	30-	Total
Males	217	180	124	64	39	14	0	638
Females	227	195	107	57	46	13	4	649
Total	444	375	231	121	85	27	4	1287

APPENDIX C

BARC (Mumbai) Data

Table 1: Distribution of BARC(Mumbai) study population by Age, Sex and Radiation Status (1994).

A] Employees :

Sex / Radiation status	Age <20	20-	25-	30-	35-	40-	45-	50-	55-	60+	Total
Males											
Radiation Workers	0	6	58	214	288	325	519	573	417	16	2416
Non.Radiation Workers	9	497	1826	2204	1896	1787	1926	2011	1479	101	13736
Total	9	503	1884	2418	2184	2112	2445	2584	1896	117	16152
Females											
Radiation Workers	0	0	12	19	13	20	20	21	8	1	114
Non.Radiation Workers	2	163	616	522	268	328	333	243	110	5	2590
Total	2	163	628	541	281	348	353	264	118	6	2704

B] Spouses of Employees :

Sex	Age 15-	20-	25-	30-	35-	40-	45-	50-	55-	60+	Total
Males	0	3	48	139	142	141	166	168	145	95	1047
Females	70	851	2135	2196	1992	2443	2287	1142	169	13	13298
Total	70	854	2183	2335	2134	2584	2453	1310	314	108	14345

C] Offspring of Employees :

Sex / Radiation status	Age <1	1-4	5-9	10-14	15-19	20-24	25+	Total
Males								
Rad.Workers' Offspring	24	171	324	430	552	546	200	2247
Non-Rad. Workers' Offspring	313	1649	2293	2281	2462	2188	1013	12199
Total	337	1820	2617	2711	3014	2734	1213	14446
Females								
Rad.Workers' Offspring	33	174	324	385	474	441	131	1962
Non-Rad. Workers' Offspring	299	1578	2210	2075	2163	1717	641	10683
Total	332	1752	2534	2460	2637	2158	772	12645

Table 2: Prevalent Cases of Cancer in Employees of BARC(Mumbai) by Age, Sex, Radiation status and Site (ICD 9th), 1994

A] Radiation Workers (Males) :

		AGE GROUPS										
ICD 9TH	SITE	<20	20-	25-	30-	35-	40-	45-	50-	55-	60+	Total
152	SMALL INTESTINE								1			1
154	COLON								1	2		3
162	LUNG							1	1			2
202	NON.HODGKIN'S LYMPHOMA								1			1
205	LEUKEMIA MYELOID							1				1
TOTAL		0	0	0	0	0	0	2	4	2	0	8

B] Radiation Workers (Females) :

		AGE GROUPS										
ICD 9TH	SITE	<20	20-	25-	30-	35-	40-	45-	50-	55-	60+	Tota
180	CERVIX							1				1
202	NON.HODGKIN'S LYMPHOMA							1				1
TOTAL		0	0	0	0	0	0	2	0	0	0	2

C] Non-Radiation Workers (Males) :

		AGE GROUPS										
ICD 9TH	SITE	<20	20-	25-	30-	35-	40-	45-	50-	55-	60+	Tota
143	ALVEOLUS		1									1
145	PALATE								1			1
150	ESOPHAGUS						1					1
151	STOMACH						1		3	2		6
154	RECTUM							1				1
155	LIVER									1		1
157	PANCREAS							1		1		2
160	ETHMOID						1	1				2
161	LARYNX								1			1
162	LUNG								2			2
162	TRACHEA					1						1
170	BONE							1				1
171	CONNECTIVE TISSUE							1				1
172	MELANOMA						1					1
185	PROSTATE					1						1
188	BLADDER							2		1		3
189	URETER							1		1		2
191	BRAIN								1			1
193	THYROID						2		1			3
195	ILL DEFINED SITES				1				1			2
201	HODGKIN'S LYMPHOMA		1									1
202	OTHER LYMPHOMA								1	1		2
204	LEUKEMIA LYMPHOID				1					1		2
205	LEUKEMIA MYELOID						1					1
TOTAL		0	2	0	2	2	7	8	11	8	0	40

D] Non-Radiation Workers (Females) :

		AGE GROUPS										
ICD 9TH	SITE	<20	20-	25-	30-	35-	40-	45-	50-	55-	60+	Tota
174	BREAST						2	1	1	1		5
183	OVARY					1						1
TOTAL						1	2	1	1	1		6

Table 3: Prevalent cases of cancer in Spouses of Employees of BARC(Mumbai) by age,sex and site (ICD 9th), 1994

A) MALES

		AGE GROUPS										
ICD 9TH	SITE	<20	20-	25-	30-	35-	40-	45-	50-	55-	60+	Tota
191	BRAIN				1							1
TOTAL					1							1

B) FEMALES

		AGE GROUPS										
ICD 9TH	SITE	<20	20-	25-	30-	35-	40-	45-	50-	55-	60+	Total
151	STOMACH							1				1
153	COLON				1	1	1					3
154	RECTUM					1				1		2
162	LUNG						1					1
171	CONNECTIVE/ SOFT TISSUE					1						1
174	BREAST				2	3	6	11	7	1		30
179	UTERUS					1			1			2
180	CERVIX						1			1		2
183	OVARY						2	2	1			5
184	VAGINA						1					1
191	BRAIN				1							1
193	THYROID						1	1	1			3
205	LEUKEMIA MYELOID			1	1							2
TOTAL		0	0	1	5	7	13	15	10	3	0	54

Table 4: Prevalent Cases of Cancer in Offspring of Employees of BARC(Mumbai)+ by Age,Sex and Site (ICD 9th), 1994

A) MALES

		AGE GROUPS						
ICD 9TH	SITE	<5	5-	10-	15-	20-	25-	Tota
								1
171	CONNECTIVE/ SOFT TISSUE				1	1		2
173	SKIN OTHER			1				1
186	TESTIS				1			1
191	BRAIN		1	1				2
202	NON.HODGKIN'S LYMPHOMA						1	1
205	LEUKEMIA MYELOID				1			1
	TOTAL	0	1	2	3	1	1	8

B) FEMALES

		AGE GROUPS						
ICD 9TH	SITE	<5	5-	10-	15-	20-	25-	Tota
								1
191	BRAIN						1	1
	TOTAL	0	0	0	0	0	1	1

+Note: All cases were in offspring of the Non-Radiation Workers.

APPENDIX C

Table 5: CONGENITAL ANOMALIES OBSERVED IN OFFSPRING OF EMPLOYEES OF BARC(Mumba (1994)

CONG.ANOMALIES (ICD 9TH : 740-759)	Males No.(Age)(Parent/Employee's Rad.Status)	Females No.(Age)(Parent/Employee's Rad. Status)	Total
1.Central Nervous System (740-742)			
Microcephalus	1(12) (NR)	3(2,7,14) (NR,NR,R)	4
Hydrocephalus	5(1,2,5,14,15)(NR,NR,NR,NR,NR)	1(8) (NR)	6
Meningomyelocele	1(4) (NR)	2(4,15) (NR,NR)	3
total	7	6	13
2.Cardio-Vascular System (745-747)			
Pulm.Valvotomy	1(1) (NR)	-	1
Atrial Septal Defect(ASD)	6(2,2,4,6,16,19) (NR,NR,NR,NR,NR,NR)	11(1,2,4,46,12,15,20,29,22,25) (NR,NR,NR,NR,NR,NR,NR,NR,R,R)	17
Ventricular Septal Defect(VSD)	9(1,9,12,12,17,18,24,27,20) (NR,NR,NR,NR,NR,NR,NR,NR,R)	7(1,2,5,19,8,12,17) (NR,NR,NR,NR,R,R,R)	16
ASD + VSD	1(11) (NR)	-	1
Fallot's Tetrology	3(3,14,16) (NR,NR,NR)	-	3
Cong.Heart	5(3,4,13,20,4)(NR,NR,NR,NR,R)	2(10,10) (NR,NR)	7
Patent Ductus Arteriosus	3(8,13,16) (NR,NR,NR)	3(0,6,18) (NR,NR,NR)	6
total	28	23	51
3.Musculo-skeletal System (754-756)			
Talipes	2(3,26) (NR,NR)	-	2
Talipes equinovarus	1(9) (NR)	-	1
Polydactyly	-	1(4) (NR)	1
total	3	1	4
4.Digestive System (749-751)			
Cleft Lip + Palate	1(1) (NR)	2(21,26) (NR,NR)	3
Cleft Palate	1(8) (NR)	4(3,5,7,7) (NR,NR,NR,R)	5
total	2	6	8
5.Genito-Urinary System (752-753)			
Hypospadias	1(19) (NR)	-	1
Undescended Testis	1(20) (NR)	-	1
Cong.Hydronephrosis	-	1(4) (NR)	1
total	2	1	3
6.Syndrome			
Down's Syndrome (758)	10(2,3,7,8,10,14,18,19,20,21) (NR,NR,NR,NR,NR,NR,NR,NR,NR,R)	3(11,20,2) (NR,NR,R)	13
7.Hereditary Condition			
*Thalassemia (282)	3(1,8,10) (NR,NR,NR)	2(11,26) (NR,NR)	5
Total	55(0.4%)	42(0.3%)	97(0.4
Total no. of offspring	14446	12645	27091

* This anomaly falls outside the range of ICD-9th 740-759

APPENDIX D

Annual Age-Adjusted Cancer Incidence Rate Per 100,000 Population From 6 Population-Based Indian Registries, 1989

APPENDIX D

Table :Annual Age-Adjusted (World Population) Cancer Incidence Rate per 100,000 persons, India. **Males; 1989**

		REGISTRY					
ICD9th	**SITE**	**BANGALORE**	**BOMBAY**	**MADRAS**	**DELHI**	**BHOPAL**	**BARSHI**
140	LIP	0.4	0.3	0.6	0.5	0.2	0.0
141	TONGUE	4.7	6.5	5.3	7.7	13.2	2.1
142	SALIVARY GLAND	0.8	0.4	0.4	0.8	0.5	0.5
143	GUM	0.6	1.5	0.9	1.1	1.3	1.4
144	FLOOR OF MOUTH	0.3	0.6	0.1	0.2	1.0	0.0
145	OTHER MOUTH	2.1	3.7	6.3	2.4	8.1	2.0
146	OROPHARYNX	1.9	3.2	1.9	3.2	3.8	0.0
147	NASOPHARYNX	0.6	0.6	0.6	0.6	0.0	0.0
148	*HYPOPHARYNX*	*5.9*	*8.2*	*6.5*	*2.3*	*8.4*	*3.5*
149	PHARYNX	0.2	1.8	1.0	0.6	2.3	1.3
150	OESOPHAGUS	9.4	11.5	10.2	6.4	7.7	6.7
151	STOMACH	9.5	7.0	16.5	3.4	3.7	1.2
152	SMALL INTESTINE	0.0	0.5	0.1	0.2	0.0	0.0
153	COLON	2.7	4.0	2.0	2.0	1.4	2.0
154	RECTUM	4.3	3.9	4.5	3.0	5.5	4.0
155	LIVER	3.2	3.5	1.9	2.2	2.1	2.6
156	GALLBLADDER	0.5	1.6	0.3	1.9	2.6	0.0
157	PANCREAS	1.7	2.5	1.4	2.3	2.4	0.0
158	RETROPERITONEUM	0.9	0.3	0.1	0.3	0.0	2.1
159	OTHER DIGESTIVE	0.8	0.7	0.0	0.6	0.0	0.0
160	NASAL CAVITY	0.3	1.4	0.6	0.5	1.6	0.0
161	LARYNX	4.1	8.8	5.5	8.6	2.9	1.3
162	LUNG	8.6	14.6	11.1	11.9	14.1	2.0
163	PLEURA	0.6	0.2	0.2	0.2	0.4	0.0
164	THYMUS	0.1	0.1	0.2	0.1	0.0	0.0
165	OTHER RESPIRATORY	0.0	0.0	0.0	0.0	0.0	0.0
170	BONE	1.3	0.8	0.9	1.2	0.6	0.0
171	CONNECTIVE TISSUE	0.6	1.5	1.0	1.5	0.8	1.0
172	SKIN MELANOMA	0.1	0.3	0.3	0.2	0.0	0.0
173	SKIN OTHER	2.0	1.3	2.2	1.4	0.7	2.7
175	BREAST MALE	0.2	0.3	0.7	0.7	0.0	0.0
185	PROSTATE	7.1	6.9	3.6	6.3	5.6	1.9
186	TESTIS	0.6	0.9	1.1	0.7	0.1	0.8
187	PENIS	1.8	1.6	2.8	1.7	0.6	5.1
188	URINARY BLADDER	2.7	4.2	3.8	5.6	0.6	0.8
189	KIDNEY	1.1	1.4	0.9	1.8	0.7	0.4
190	EYE	0.2	0.4	0.3	0.2	0.2	0.0
191	BRAIN	3.8	3.0	1.8	3.4	3.2	0.0
192	NERVOUS SYSTEM	0.2	0.1	0.0	0.1	0.0	0.0
193	THYROID	0.9	0.7	0.9	0.8	0.3	0.5
194	OTHER ENDOCRINE	0.1	0.2	0.1	0.3	0.0	0.0
195	ILL DEFINED	1.1	0.3	0.9	1.8	0.0	0.7
196	SECONDARY LYMPH	1.9	3.5	2.0	0.0	1.3	1.9
197	SECONDARY RESPI	1.7	2.6	3.3	0.4	2.8	1.4
198	SECONDARY OTHER	0.7	1.5	0.9	0.1	0.7	0.0
199	PRIM UNKNOWM	9.0	1.1	3.3	11.6	0.0	2.1
200	LYMPHOSARCOMA	0.4	1.3	0.6	0.0	0.0	0.7
201	HODGKINS	2.4	1.2	1.7	1.6	1.5	1.0
202	OTHER LYMPHOID	2.7	2.7	3.3	5.1	0.5	1.2
203	MULTIPLE MYELOMA	0.6	1.3	0.5	2.7	0.3	0.0
204	LEUKEMIA LYMPHOID	1.6	1.6	1.5	2.5	1.5	0.8
205	LEUKEMIA MYELOID	2.3	1.9	1.4	2.5	0.7	1.9
206	LEUKEMI MONOCYTIC	0.1	0.0	0.2	0.0	0.0	0.0
207	LEUKEMIA OTHER	0.0	0.2	0.0	0.0	0.0	0.0
208	*LEUK UNSPECIFIED*	*0.7*	*0.3*	*0.3*	*1.3*	*0.2*	*0.0*
	ALL SITES	112.2	130.4	118.5	118.8	106.2	57.6

APPENDIX D

Table :Annual Age-Adjusted (World Population) Cancer Incidence Rate per 100,000 persons, India. **Females; 198**

		Registry					
ICD9TH	SITE	BANGALORE	BOMBAY	MADRAS	DELHI	BHOPAL	BARSHI
140	LIP	0.1	0.2	0.3	0.3	0.0	0.0
141	TONGUE	1.0	1.9	2.1	1.3	1.4	0.0
142	SALIVARY GLAND	0.5	0.3	0.2	0.5	0.0	0.0
143	GUM	2.8	1.0	1.5	1.1	1.5	0.0
144	FLOOR OF MOUTH	0.4	0.1	0.2	0.0	0.0	0.0
145	OTHER MOUTH	7.9	2.8	6.5	1.4	5.3	0.6
146	OROPHARYNX	0.5	0.6	0.4	1.0	0.5	0.0
147	NASOPHARYNX	0.4	0.2	0.3	0.2	0.5	0.0
148	HYPOPHARYNX	1.2	1.5	2.7	0.6	0.8	0.5
149	PHARYNX	0.1	0.9	0.5	0.0	0.4	0.0
150	OESOPHAGUS	10.2	8.2	7.7	4.6	5.2	1.4
151	STOMACH	4.3	3.4	7.1	2.4	1.1	1.3
152	SMALL INTESTINE	0.0	0.3	0.0	0.2	0.0	0.0
153	COLON	2.3	2.4	0.8	2.0	2.1	0.5
154	RECTUM	2.2	2.6	2.6	1.8	0.0	1.7
155	LIVER	1.0	1.8	0.6	1.1	1.1	0.0
156	GALLBLADDER	0.8	2.3	0.6	6.6	5.2	0.0
157	PANCREAS	1.0	1.8	0.7	1.3	0.8	0.6
158	RETROPERITONEUM	0.5	0.6	0.1	0.3	0.0	0.0
159	OTHER DIGESTIVE	0.5	0.5	0.0	0.3	0.0	0.0
160	NASAL CAVITY	0.4	1.0	0.8	0.4	0.4	0.0
161	LARYNX	0.7	1.3	0.3	1.8	0.5	0.0
162	LUNG	1.6	3.7	1.7	2.2	3.2	0.0
163	PLEURA	0.5	0.2	0.0	0.2	0.5	0.0
164	THYMUS	0.1	0.1	0.0	0.0	0.0	0.0
165	OTHER RESPIRATORY	0.0	0.0	0.0	0.0	0.0	0.0
170	BONE	0.9	0.7	0.6	1.2	1.1	2.4
171	CONNECTIVE TISSUE	0.3	0.9	0.7	1.7	0.5	0.6
172	SKIN MELANOMA	0.1	0.3	0.2	0.2	0.0	0.0
173	SKIN OTHER	1.6	1.2	0.7	1.6	0.7	2.3
174	BREAST FEMALE	22.3	26.1	24.6	28.3	21.9	6.8
179	UTERINE	0.6	1.5	0.4	1.2	0.5	0.0
180	CERVIX UTERI	26.4	19.4	43.5	30.1	24.3	26.2
181	PLACENTA	0.0	0.1	0.2	0.2	0.3	0.0
182	BODY UTERUS	2.0	2.2	1.9	2.5	4.2	0.0
183	OVARY	4.7	7.0	6.0	8.7	6.2	0.9
184	VAGINA	1.4	1.7	2.0	1.5	0.5	1.3
188	URINARY BLADDER	0.8	1.3	1.1	1.0	0.0	0.0
189	KIDNEY	0.4	0.8	0.7	1.4	0.0	0.0
190	EYE	0.0	0.2	0.6	0.4	0.0	0.0
191	BRAIN	1.7	2.2	0.8	2.6	1.6	0.0
192	NERVOUS SYSTEM	0.0	0.1	0.0	0.1	0.0	0.0
193	THYROID	3.2	2.0	1.1	2.2	2.1	0.0
194	OTHER ENDOCRINE	0.1	0.1	0.1	0.1	0.0	0.0
195	ILL DEFINED	0.7	0.5	0.4	1.5	0.0	1.3
196	SECONDARY LYMPH	0.6	1.3	0.6	0.0	0.2	0.7
197	SECONDARY RESPI	0.8	1.9	2.4	0.5	2.2	0.0
198	SECONDARY OTHER	0.5	1.2	0.5	0.0	1.0	0.0
199	PRIM UNKNOWN	7.4	0.7	3.8	12.1	0.0	1.1
200	LYMPHOSARCOMA	0.2	0.9	0.3	0.0	0.0	0.6
201	HODGKINS	0.7	0.7	0.7	1.0	0.2	0.0
202	OTHER LYMPHOID	1.9	2.1	1.5	2.4	0.5	1.4
203	MULTIPLE MYELOMA	0.7	0.6	0.2	2.1	0.5	0.0
204	LEUKEMIA LYMPHOID	0.6	1.1	0.5	1.4	0.6	0.0
205	LEUKEMIA MYELOID	2.0	1.3	0.9	2.0	0.5	0.0
206	LEUKEMIA MONOCYTIC	0.0	0.0	0.2	0.1		0.0
207	LEUKEMIA OTHER	0.0	0.1	0.0	0.0	0.0	0.0
208	LEUK UNSPECIFIED	0.9	0.4	0.2	1.1	0.0	0.0
	ALL SITES	124.7	120.4	135.0	140.7	100.1	52.2

APPENDIX E

Glossary Of Terms Used

APPENDIX F

Abbreviations

GLOSSARY OF TERMS USED

Cross-Sectional Study	:	One of the observational analytical epidemiological methods to examine relationship between disease and other variables of interest as they exist in a defined population at a particular time. (The other two well-known methods in this category are Cohort studies and Case-Control studies).
Incidence Rate	:	The rate of occurrence of a disease within a specified period; expressed as number of cases per unit of population per unit of time. In particular, cancer incidence rate is conventionally expressed per 100,000 population, per year.
Ionizing Radiation	:	Any electromagnetic or particulate radiation capable of producing ions, directly or indirectly, in its passage through matter.
Morbidity	:	1. The condition of being diseased. 2. The incidence, or prevalence, of illness in a group.
Mortality Rate	:	Is analogous to incidence rate but refers to the occurrence of death rather than the occurrence of disease and is expressed as number of deaths per unit of population per unit of time.
Prevalence	:	The number of cases of a disease in existence at a given time per unit of population.
Relative Risk	:	Expression of risk due to exposure, as a ratio of the risk among the exposed to that among those not exposed.
Sievert (Sv)	:	SI unit of radiation dose equivalent. It is equal to absorbed dose in Gray, times a quality factor, times other modifying factors.
TLD	:	Thermoluminescent Dosimeter.

ABBREVIATIONS

AERB	:	Atomic Energy Regulatory Board
BARC	:	Bhabha Atomic Research Centre, Mumbai
COCES	:	Corporate Committee for the Epidemiological Studies (Constituted by NPCIL)
DAE	:	Department of Atomic Energy
ICRP	:	International Commission on Radiological Protection
NPCIL	:	Nuclear Power Corporation of India Limited
PISCES	:	Planning and Implementation Supervisory Committee for Epidemiological Studies (Constituted by NPCIL)
STAG	:	Senior Technical Advisory Group (Constituted by NPCIL)
TMC	:	Tata Memorial Centre, Mumbai
TMH	:	Tata Memorial Hospital, Mumbai

APPENDIX G

Composition of Committees (COCES, STAG, PISCES)

APPENDIX

COMPOSITION OF COMMITTEES

CORPORATE COMMITTEE FOR THE EPIDEMIOLOGICAL STUDIES (COCES) (1992-)

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   Dr.Y.S.R.Prasad
   M.D., NPCIL
   Mr. S.L. Kati
   Mr. S.K. Chattarjee
   Mr. Y.S.R.Prasad
2. ED (F), NPCIL - Member
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   Mr. R.C. Joshi
   Mr. S.B. Kulkarni
3. ED (O), NPCIL - Member
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   Mr. C.H. Surendar
   Mr. B.K. Bhasin
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   Dr. V. Venkat Raj
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   Dr. P.B. Desai
   Dr. K.A. Dinshaw
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   Dr. P.C. Kesavan
   Dr.(Mrs) A.M. Samuel
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   Mr. M.L. Mittra
9. Director (Health & Safety), NPCIL - Member Secretary
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   Mr. G.R. Srinivasan
   Mr. B.K.Bhasin
   Mr. S. Krishnan, ED(CPHSE)
   Mr. M. Das, Chief Engineer
10. Director, TMH - Member
    Dr. R.S. Rao
    Dr. K.A. Dinshaw
11. Director, CRI - Member
    Dr. M.G. Deo
    Dr. A.N. Bhisey

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3. Mr. K. Muthuswamy, CAO, TMC
4. Mr. G.V. Nadkarni, Consultant E&PA, NPCIL
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11. Dr.P.K.Sinha, Medical Supdt, KAPS Hospital, Kakrapar.
12. Mr. M.R.Sachdev, Health Physicist, NPCIL
13. Dr. S.K. Dave, Dy.Director, NIOH

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    Health Physics Group, NPCIL - Member Secretary

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6. Dr. M.Yunus, Professor & Chairman, Dept. of Community Medicine, J.N.Medical College, Aligarh.
7. Mr. M.R.Sachdev, Health Physics Group, NPCIL
8. Mr. B.K.Bhasin, SD, TAPS
9. SD, RAPS
10. SD, KAPS
11. SD, NAPS
12. SD, MAPS
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15. Dr.M. Nagarajan, Medical Supdt, DAE Hospital, Kalpakkam
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17. Dr.P.K.Sinha, Medical Supdt., KAPS Hospital, Kakarapar
18. Dr.K.R.Lele, TMH
20. Mr. A.C.R. Subba Reddy, Maintenance Supdt., Kaiga

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3. Dr. A. Seshan, BARC Hospital, Mumbai - Member
4. Dr. K.S.V.Nambi, Head, EAD,BARC,Mumbai - Member
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6. Mr. S.D.Talole, TMH - Member

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