Chapter 8
Summary, Conclusions and Policy Suggestions

The main objective of the study was to analyze the cost of illness borne by the local community and factory workers in coastal Kerala who are affected by radiation induced pollution. The study also tried to find out the factors affecting the willingness to pay for health insurance by the local community. The review of studies on radiation and health in coastal Kerala clearly showed that this area is abundant in radioactive minerals like ilmenite and monazite from which compounds like thorium can be extracted. The review has also shown that the health effects due to radiation have been high in the coastal areas of Kerala. Within coastal Kerala, Karunagapally panchayat was selected for the current study, as the problem of radiation-induced pollution was more acute there. The population residing very near the mining sites and factories and the factory workers in the study area provided an excellent sample and was ideally suited for the conduct of the present study on the economic costs of radiation-induced pollution. Both Secondary and Primary data was collected for the study. Secondary data was used to analyze the health effects of radiation induced pollution in the study area based on data from earlier studies. Primary data for this study was collected by a household survey using a structured questionnaire covering 300 households from two wards in Chavara panchayat in Karunagapally taluk of Kollam district. A control group of 100 households was selected from Perayam panchayat in Kollam taluk, which is free from radiation problem and with the same socio economic characteristics of the study group. From the two factories, i.e. India Rare Earths Limited and Kerala Minerals and Metals Limited, 100 workers including 65 temporary and 35 permanent workers were selected.
Valuation survey was undertaken along with the socio economic and morbidity survey to find out the factors affecting the willingness to pay for health insurance by the households affected by radiation induced pollution. The Cost of Illness approach was used to analyze the health costs of the study and control group households and workers in the factories. The factors affecting the willingness to pay for health insurance by the local community was analyzed using the Logistic regression model. The major findings of the study can be summarized as follows.

8.1 Findings of the Study

8.1.1 Secondary Data Analysis on Radiation and Health Effects

The review of studies on radiation and health in the global as well as in the Kerala context highlighted that radiation can cause adverse health effects like specific types of cancer and other illnesses. As a background to the economic analysis of radiation induced pollution in coastal Kerala, secondary data on the health effects of radiation-induced pollution was analyzed. The major findings can be summarized as follows.

- The radiation levels, both the Median and Maximum radiation levels are higher in the coastal grama panchayats of Chavara, Neendakara, and Alappad in Karunagapally taluk panchayat. Certain households in the coastal panchayats reported radiation levels as high as 70 mGy/year (milli gray per year), which was 10 times higher than the normal value.

- The cancer incidence rates also showed that the coastal panchayats have the highest incidence of cancer among both males and females.
• The incidence of radiation induced cancers like lung and liver cancer, leukaemia and brain cancer among all population and thyroid cancer among females were very high in this taluk, which are higher than any other cities of India. One of the striking aspects is that the smoking habits and use of tobacco is not highly prevalent in this taluk. So the high incidence of cancer in this taluk cannot be attributed to smoking and tobacco use. It is quite significant to note that liver cancer among males and thyroid cancer among females had the highest prevalence in this taluk and these could be caused mainly due to radiation.

• It was noted that the radiation-induced cancers are more prevalent among the age groups of less than 55 years when compared to more than 55 years. Of the males who were affected by leukaemia, 81 per cent belonged to the age group of less than 55 years. This pattern was also seen in the case of brain cancer (90 per cent) and bone cancer (66 per cent). It was also seen that the thyroid cancer among females was significantly prevalent (75 per cent) among the young age group of 0 – 55 years. This pattern was also seen in the case of leukaemia, where 57 per cent of the females belonged to the young age group.

• Data collected on the death of workers who were working during the period 1970-1984 in the Indian Rare Earths factory showed that such workers died at very young age and had long years of service in the factories at their age at death. The diseases that caused their death were mainly radiation-induced cancers like
stomach cancer, leukaemia, and liver cancer. The average age at death for the IRE workers who died of cancer was 49.

- There were studies that tried to estimate the prevalence and incidence of other radiation induced illnesses like Down's syndrome and swellings in thyroid gland. It showed that Karunagapally taluk had abnormally high incidence of Down's syndrome among the population. In the case of swellings in thyroid gland, the prevalence was high in both study and control group. However, latest reports concluded that the control group selected for the study also had high radiation levels and therefore the results obtained could be wrong.

8.1.2 Socio-Economic Profile of the Study and Control group Households and Workers

The Socio economic and demographic profile of the respondents who were the eldest earning members of the household and other members of the households in the study group and control group was analysed as a background for the economic analysis of radiation-induced pollution. It was seen from the analysis that the socio economic and demographic profiles were similar for the study and control group households except in the case of health expenditure incurred. The housing and living conditions, personal habits and the income and family expenditure pattern were similar for both groups. In the case of workers, there were disparities in the wages, bonus and family income of the permanent and temporary workers. However, the overall demographic and social profile of the temporary and permanent workers was similar. The analysis of the socio economic and demographic profile clearly pointed to the fact that the households of the study and
control group as well as the permanent and temporary workers could be compared in order to find out the cost of illness due to radiation-induced pollution.

8.1.3 Cost of Illness borne by the Local Community

The objective of our study was to find out the cost of illness borne by the local community affected by radiation-induced pollution by comparing it with a control group, which was not affected by radiation-induced pollution. The following were the major findings of the analysis.

- There was no significant difference in the prevalence of non-radiation diseases between the study and control group households. While 93.3 per cent of the households reported non-radiation-induced illnesses in the study group, 98 per cent reported the same in the control group. The most severe radiation induced illness, viz., cancer was reported by 7.6 per cent of the households of the study group whereas among the control group households only one such case of cancer was reported. Swelling in thyroid gland and Down's syndrome that are caused by radiation-induced pollution were more prevalent among the study group as compared to the control group. The prevalence of respiratory ailments like oesinophilia and asthma, stomach ailments and skin allergy also was more prevalent among the study group households. Of the total 300 sample households, 7 per cent of the study group reported uterus problems for women including cases of uterus cancer, whereas only one per cent among control group reported such illnesses. The proportion of households reporting radiation-induced illnesses was high among the study group (74.7 per cent) as against only 39 per cent in the
study group. Liver cancer and leukaemia were highly prevalent among the male members of the households whereas stomach cancer and thyroid cancer were prevalent more among the females. The swelling in thyroid gland was found to be predominant among the girls and women of the households whereas Down’s syndrome was prevalent among the children only.

- The overall average number of days lost per year due to all the non-radiation illnesses was more (40 days) for the control group households as compared to the study group households (26 days). The details of the amount of money lost due to loss of workdays by the earning members in the past one-year for such illnesses also showed that the control group households lost more money as wages. In effect the control group of households had the additional loss of money of Rs.1002 per year by not working for 14 days when compared to the study group households. In the case of radiation induced illnesses the workdays lost were mainly due to cancer, Down’s syndrome of children, oesinophilia, eye problem, stomach ailments, and skin allergy. It could be seen that on an average, 78 days per year was lost due to loss of job due to cancer in the study group as against 35 days in the control group. The earning members of the study group lost an average of Rs.7400 per year due to loss of job from cancer as against Rs.4500 in the control group. Workdays and wages were also lost due to other diseases like Down’s syndrome, oesinophilia, asthma and stomach ailments among the study group households as compared to the control group households. The difference between the workdays and wages lost by the earning members in the study and
control group households were 11 days per year and Rs. 2284 per year respectively, which was found to be statistically significant.

- The households in the study and control group mainly depended on allopathic treatment for their outpatient and inpatient care. It could be seen that majority of the households go for private outpatient care among the study and control groups (66.67 and 78 per cent respectively). While 35.67 per cent of the households in the study group went to government hospital for outpatient care, in the case of control group households this proportion was 40 per cent. The study group households also visited the private doctor more often than the control group of households (21.67 and 17 per cent respectively). It could also be seen that while 48.3 per cent of the households among the study group depended on private hospitals for inpatient care, this proportion was 41 per cent for the control group households. However, only 17.7 per cent of the households in the study group depended on government hospitals for inpatient care while for the control group this proportion was 19 per cent.

- The Median expenditure for the study group of households for government outpatient care was Rs.2850 per year as compared to Rs.2400 per year for the control group. The difference in the expenditure on government hospital outpatient care was not statistically significant for any of the income groups between the two categories of households. However, it was found that there was a statistically significant difference between the study and control group households among the poorest income group in the case of private hospital outpatient
expenditure. The average private hospital outpatient expenditure was Rs.5375 among the poorest 25 per cent of the study group as against Rs.3718 in the control group. The Mean and Median expenditure for the study group households seeking private hospital outpatient care were Rs.5702 and Rs.4650 per year respectively as compared to Rs.4267 and Rs.3900 in the control group. The difference between this expenditure of the two groups was also statistically significant. The study group households incurred an additional expenditure of Rs.750 per household per year as compared to the control group. This was mainly due to the fact that the study group households were affected by chronic radiation induced illnesses, for which the treatment is costly. These observations indicated that the study group households spent more on private hospital outpatient care as compared to the control group households.

- The Median expenditure per year for the government hospital inpatient care was Rs.7250 for the study group households as against Rs.5400 for the control group. The difference in the amount of expenditure between the study and control groups was statistically significant. While the poorest income group in the study group spent Rs.13,598 per year for private inpatient care; the corresponding figure for the control group was Rs.7258. The Median expenditure of the private inpatient care was as high as Rs.9600 per year as compared to Rs.8300 per year in the control group of households and the difference was statistically significant. This high amount of money spent for private hospital inpatient care was due to the fact that the study group households had to undergo treatment for the radiation induced illnesses, which were highly prevalent among this group. The total cost of
illness referred to the sum of outpatient and inpatient expenditure for the allopathic system of treatment as well as the expenditure incurred for Ayurveda and Homeopathic systems of treatment. The burden was mainly on the poorest income group in the study group with an average expenditure of Rs.18,727 per year, as against Rs.8,294 per year among the same income groups for the control group. The Median expenditure of total cost of illness among the study group households was Rs.13,425 per year and it was Rs.9,000 per year in the control group.

- The monthly health expenditure also differed significantly between the study and control group households, especially for the poorest income quartile. While the average health expenditure per month was Rs.619 for the poorest income group in the study group, it was Rs.403 rupees in the control group. It was seen that the proportion of health expenditure to total family expenditure was more than 30 per cent for 12 per cent of the study group households whereas only one per cent of the control group households reported such proportion of health expenditure. This shows that the proportion of the health expenditure to total family expenditure was significantly higher for the households of the study group as compared to the control group households. An analysis of the sources of meeting health expenditure among the study and control group households revealed that while 58 per cent of the study group households relied on money lenders for meeting their health expenditure, 78 per cent of the households in the control group met from the salary. The analysis also revealed that 70.1 per cent of the indebted households among the study group attributed their high health expenditure as the
In the present study discriminant analysis was applied to differentiate and discriminate between the study and control group households on the basis of a single variable, which is a linear combination of significant variables found in the univariate analysis, and used to predict the group membership. This also helps in determining the relative importance of the variables for differentiating between the two groups. In the model for the current study, the stepwise discriminant analysis was done. The analysis showed that number of persons having radiation induced illnesses, total cost of illness and total workdays lost were the significant variables in the model. When the absolute values of unstandardised coefficients were ranked from the largest to the smallest, number of persons having radiation-induced illnesses in a household had rank one. When the coefficients were standardized to adjust for the unequal means and standard deviation of the independent variable, the coefficient for number of persons having radiation induced illnesses in a household (Standardized Coefficients) was still the largest. This clearly showed that the number of persons having radiation-induced illnesses in the household was the most important differentiating variable between the study and control groups. The analysis also showed that 65.8 percent of the cases
were correctly classified. Wilk’s Lambda was obtained as 0.82 and chi-square value was 44.65 for 3 degrees of freedom which were found to be highly significant $P < 0.0001$. If high-risk households could be identified, special monetary support and health care needs could be demanded either from the government agencies or non-government agency so as to compensate for the economic loss to the families residing in the radiation induced pollution area.

8.1.4 Cost of Illness borne by the Workers

The cost of illness borne by the permanent and temporary workers in the Indian Rare Earths and Kerala Minerals and Metals Factories were also analyzed. The following were the main findings of the analysis.

- There was no significant difference between permanent and temporary workers in respect of prevalence of non-radiation Illnesses and radiation-induced illnesses. Only one worker in each group reported Cancer. The workers who reported cancer were normally given voluntary retirement which partly explains why no difference was observed between permanent and temporary workers in respect of prevalence of radiation-induced illness.

- The details of the workdays and wages lost by the workers due to non-radiation induced illnesses showed that the maximum number of days of work and wages lost were due to back pain and heart diseases. Respiratory problem due to oesinophilia accounted for the maximum loss of workdays and wages. The temporary workers lost 31 workdays and lost wages of Rs.6300 per year due to
respiratory illnesses caused by oesinophilia and asthma, while the permanent workers lost 18 days and wages of Rs.4500 per year due to this disease condition. There was a statistically significant difference in the wages and workdays lost due to this disease between the temporary and permanent workers.

- It was seen that a majority among both the permanent and temporary workers go to private hospitals for outpatient care (74 and 78.4 per cent respectively). The proportion of workers who went to the government hospital outpatient care was comparatively low (less than 10 per cent) among both types of workers. It was also seen that both permanent and temporary workers depended on private hospitals rather than government hospitals for inpatient care. Apart from the better quality of health care provided by the private hospitals, the factories had made arrangements with such hospitals for the treatment of their workers and insisted that reimbursement benefits from factories were to be availed only through such hospitals.

- The analysis also revealed that both permanent and temporary workers accessed the private hospital for outpatient care. Nearly 32.3 per cent of both groups of workers spent from Rs.3000 to Rs.4500 per year as outpatient care in private hospitals. While, 17.1 per cent of the permanent workers spent more than Rs.4500 a year, only 13.8 per cent for the temporary workers spent the same amount. The factories had made arrangement with a few private hospitals near the factories for the treatment for the illnesses of workers and only workers getting treatment in these hospitals were eligible for reimbursement benefits. These benefits were high
for the permanent workers as compared to the temporary workers, and hence it was an incentive for the permanent workers to spend on private outpatient care. Moreover, the income levels of the permanent workers were high and they could afford more sophisticated lab tests and costly medicines unlike the temporary workers. This was the reason for the higher median expenditure of Rs.3650 per year reported by the permanent workers as compared to the temporary workers, who reported a median expenditure of Rs.3100 per year. The difference between the private hospital outpatient expenditure for both groups of workers was statistically significant. It was seen that 17 per cent of both groups of workers spent between Rs.5000 to Rs.10,000 per year for private hospital inpatient care. It was noted that 6 per cent of the temporary workers spent more than Rs.10,000 per year for the private inpatient care. The Median expenditure was Rs.5300 for the permanent workers and Rs.5700 for the temporary workers. This higher expenditure for the temporary workers was mainly due to the occurrence of higher frequency of radiation and non-radiation induced illnesses among the temporary workers and hence they had to spend more time in private hospitals, which accounted for their high private inpatient expenditure.

- The total cost of illness was less than Rs.5000 for 62 per cent of the permanent workers as against 54 per cent among the temporary workers. However, it was noted that while only 14 per cent of the permanent workers spent Rs.10,000 per year, 24 per cent of the temporary workers spent the same amount. This difference was due to the high frequency of radiation-induced illnesses occurring among the temporary workers.
The Total cost of illness borne by the workers after adjusting for reimbursement benefits showed some interesting pattern. It was noted that 74 per cent of the permanent workers had to pay less than Rs.2500 per year as total cost of illness after adjusting reimbursement benefits. Whereas 23.1 per cent of the temporary workers had to pay more than Rs.5000 per year as total cost of illness while there were no permanent worker paying a similar amount. This was mainly because the temporary workers had limited reimbursement benefits and with their high frequency of illness they incurred more health expenditure. The permanent workers preferred the private hospitals as they provided better quality of health care facilities along with the reimbursement benefits from the factory for most of the treatments availed.

The permanent and temporary workers had some interesting perceptions about their job, factory and radiation. The temporary workers felt that they were discriminated from the permanent workers in terms of wages, bonus, reimbursement benefits and safety precautions. While 60 per cent of the permanent workers felt that they were vulnerable to radiation-induced illnesses in the future due to the nature of their work, this proportion was very high i.e. 88 per cent for the temporary workers.
8.1.5 Willingness to Pay for Health Insurance by the local community affected by radiation induced pollution.

Considering that the local community suffered due to radiation-induced pollution, health insurance was thought of as a viable solution to prevent their indebtedness. Hence, it was important to see what factors affected their willingness to pay for health insurance. This was also an alternative and direct way to supplement the cost of illness approach to find out the burden of the households affected by radiation induced pollution. The analysis was based on the contingent valuation method done during the primary survey. A logistic regression model was used to analyze the factors affecting the willingness to pay for the health insurance. The dependent variable, the Willingness to Pay (WTP) for health Insurance was classified as Yes/No response and the probability of a Yes/No answer was modelled as a Logistic function. The demographic, economic and social variables, which significantly influenced the cost of illness related to health were included in the analysis. Other variables that were logical and important were also included in the multivariate analysis.

- It was noted that the respondents who were less than 40 years old were highly willing to pay for health insurance. The Odds Ratio of age of the respondent indicates that there is 2.98 times more chance of willingness to pay by respondents who were less than 40 years old as compared to the respondents who were more than 40 years. The younger respondents were inclined to pay more for the health insurance due to the benefits attached to the health insurance scheme. The younger respondents were more enthusiastic to bring about a significant
change so as to solve their financial problems by reducing health expenditure due to radiation-induced illnesses.

- The income variable that was represented by the total income of the households was also found to be highly significant. This was quite obvious and theoretically true that the ability to pay is an important factor in deciding about the willingness to pay. Thus, it convincingly showed that households with higher income had a positive and significant attitude for the willingness to pay. It was found that the odds ratio of high-income group for willingness to pay was 1.25, which indicated that households with high income had 25 per cent more chance of paying for health insurance than the low-income group.

- The prevalence of radiation induced illness positively and significantly influences the willingness to pay for health insurance. This was mainly due to the fact that the chronic radiation induced illnesses take more time for treatment (e.g. cancer), which lead to more health expenditure. Health insurance, therefore, would be a major source of support for such households.

- The Total cost of illness was a significant factor, which positively influenced the willingness to pay for health insurance among the local community. These households incurred more health expenditure and were in need of more support to reduce their burden of illness. It was found that such group of households who had high cost of illness had 58 per cent more chance of willingness to pay for health insurance when compared to households without such high cost of illness.
• It was also noted that the families with indebtedness especially due to high health expenditure were significantly accepting the scheme of willingness to pay for health insurance. These households had 1.61 times more chance of willingness to pay for health insurance. These households were burdened with indebtedness due to the radiation-induced diseases and a health insurance scheme would definitely reduce their burden and get faster and better access to health care facilities.

• The family size of the households also significantly affected the willingness to pay for health insurance. The households with large family size had a 33 percent more chance of paying for health insurance as compared to household with less family size. The expectation of getting benefits from the health insurance was more among larger families as compared to the smaller families.

• Households already having other types of insurance like life insurance schemes also did not have any significant impact on the willingness to pay for health insurance. This could be mainly because schemes like the life insurance are not meant to provide support to cover financial burden in times of need.

The analysis of the willingness to pay for health insurance confirmed that the local community who are affected by radiation induced pollution were more willing to pay for health insurance, as it would reduce their indebtedness. This, therefore, supports the argument that the health insurance scheme would provide good family support to the local community suffering from radiation-induced
pollution and it will improve the quality for health care services, provides better and fast access to health care facilities and reduces the financial burden of the local community.

8.2 Conclusion

This study mainly attempted to analyze the cost of illness borne by the local community and workers affected by radiation-induced pollution. A detailed review of the health effects of radiation in the global context revealed that specific cancer, genetic illnesses and other ailments could be caused by radiation. There was, however, very few studies in the global and Indian context that looked into the economic analysis of radiation induced pollution. The analysis of the secondary data highlighted the high prevalence of radiation levels and radiation-induced diseases in coastal Kerala. The analysis of the households in the study and control group households showed that the study group was adversely affected by the radiation-induced illnesses. The loss of workdays and wages and the cost of illness for the treatment in the private and government out patient and inpatient care were significantly higher for the study group as compared to the control group. The indebtedness among the study group households were mainly due to the radiation induced illnesses. The Discriminant analysis showed that the study and control group could be differentiated with respect to the following variables, viz.; persons having radiation induced illnesses, total cost of illness and total workdays lost. There was only one worker in both among permanent or temporary workers who had cancer and this was mainly due to the policy of the factories to give voluntary retirement to those workers with chronic illness. The total cost of illness borne by the workers after deducting the reimbursement benefits showed that the temporary workers had significantly higher financial burden.
than the permanent workers. The temporary workers felt that they were discriminated in
the factories vis-a-vis the permanent workers in the factories in terms of wages, bonus.
leave benefits and reimbursement benefits. The analysis of the willingness to pay for
health insurance using a logistic regression model revealed that factors like younger age
of the respondent, larger family size, family income, cost of illness, prevalence of
radiation induced illnesses and level of indebtedness significantly influenced the
willingness to pay for health insurance by the local community affected by radiation
induced pollution.

8.3 Policy Suggestions
The present study showed that the local fishing community in the study area is affected
by radiation induced pollution and the burden of radiation induced illnesses are so high
for them and that there is an urgent requirement for government intervention in this
matter to reduce their dreadful health consequences for which they themselves are not
responsible. There is a need for a detailed scientific epidemiological study by an
independent authority of the households of the local community and workers of the study
area so as to understand the health effects of radiation. Such a study would give reliable
and accurate information to carry out the economic valuation of the health effects on the
population of this area due to radiation-induced pollution. It should be brought to the
notice of the government that there is a strong need to provide adequate health care
facilities to the people of the area affected by radiation-induced pollution. As the most
significant impact of radiation is seen in terms of prevalence of cancer in the area, more
cancer detection centres and hospitals should be established by the government free of
cost for the prevention and control of cancer in the local fishing community. The
temporary workers who do most of the hazardous jobs, which are prone to radiation in the factories, should be paid higher wages, bonus and reimbursement benefits to compensate the higher risk involved in their work in the factory. The safety precautions for such workers also have to be ensured so that the accidents and radiation induced illnesses could be minimised. There should be a monitoring agency in the government to verify the efficiency of the pollution abatement mechanisms in the factory. In the case of Australia\textsuperscript{1}, where there is mining of radioactive mineral sands and is the largest producer of such compounds, the temporary workers are paid higher wages and bonus than the permanent workers in factories since they do not get work regularly. In Australia, there is a radiation officer in the factory to measure the radiation levels, and the government in turn monitors the radiation levels and assessment of health condition of workers are made every six months. The factories in the study area are also responsible for the welfare of the local community. Apart from the health care facilities provided to the local population, they are also responsible for providing compensation to those people who are affected by radiation-induced illnesses. A health insurance or similar support schemes by Government or other developmental agencies would be helpful to the local community suffering from radiation-induced illnesses. These schemes would improve the quality of life of the people and their accessibility to better health care facilities thereby reducing their financial burden significantly. In Australia, the government provides the license to do mining and processing of radioactive mineral sands only if they are satisfied with the rehabilitation measures provided to protect the health of the local community. The

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\textsuperscript{1} The observations made on Australia are based on the researcher's visit to the Australian Mineral sands factories to look into the environmental and health effects of radiation induced pollution in Australia.
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mining will start only if the departments of environment and health and the radiation safety department give approval for the project. Such rehabilitation and radiation safety measures taken in the beginning of a project would reduce health hazards to the local community significantly and these could be followed in India too when it is decided to do further mining of radioactive mineral sands. The safety and rehabilitation measures taken by the Australian Government in their mining sites can be adopted in India also so that health hazards of radiation induced illnesses can be avoided or minimized to a maximum extent.