Self-Reported Morbidities among Tribal workers Residing adjacent the Turamdih Uranium Mine and Mill in Jharkhand, India.

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Abstract
The study was conducted among 411 main workers of tribal communities, aged 15-59 years, residing surrounding hazardous uranium tailing pond of Turamdih Uranium mine in Jharkhand, India. The survey was conducted between January and June 2016. The objective of the study was to explore the differential morbidities among mineworkers and non-mineworkers and the association of the morbidity with various socio-demographic factors. Chi-square test, and binary logistic regression were used for data analysis. The results indicate that the prevalence of digestive problems, skin diseases, cancerous diseases, and urinary dysfunction was significantly higher among the Uranium mine-workers than the non-mineworkers. The main workers living within a range of 2 km from the tailing pond being more likely to suffer digestive problems (OR=1.57; 95% CI, 0.94–2.60) and respiratory illnesses (OR=1.89; 95% CI, 1.06–3.37) than those living further away. The findings have important program and policy implications related to safety measures, nuclear regulation acts, and resettlement of tribal victims.

Keywords: uranium mining, radiation, mineworkers, morbidities, tailing pond, distance

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Introduction

In view of alternate sources of efficient energy generation, Uranium has gained enormous global importance driven by its medical, military and civil applications, albeit with potential safety and environmental legacies.(1) In India, Uranium Corporation of India (UCIL), founded in 1967 under the Department of Atomic Energy, is responsible for the mining and milling of uranium ore. Jaduguda in the East Singhbhum district of Jharkhand is the first uranium mine and mill (processing plant) of India, which started its operations in 1967. Jharkhand accounted for 30% (50,978 metric tonnes) of the total Uranium (U_3O_8) reserves (1,71,672 metric tonnes) in India as on 30 June 2011. Three states namely, Andhra Pradesh, Jharkhand, and Meghalaya, hold more than 90% of the country's uranium resources. (2)

Keeping in view the nation's endeavour to expand nuclear energy infrastructure (20,000

MWe by 2020 from the present capacity of 2770 MWe), new uranium mines are being opened by UCIL in several parts of the country including in the Singhbhum Thrust Belt of Jharkhand.(3) In this context, a new uranium mine and mill was commissioned in 2003 at Turamdih, 24 km west of Jaduguda and 5 km south of the Tatanagar railway station. The Turamdih Processing Plant has been set up to treat the ore from the Turamdih, Banduharang, and Mohuldih mines.(4)

Uranium mining and environment

Uranium, a highly radioactive element, is extracted from both underground and open-pit mines. Alkali and acid washes isolate the uranium, to yield the more refined and uranium rich ore called ***yellowcake***. The remaining 80% to 99.6% of the processed ore, which may be in the form of solid or liquid effluents, is referred to as ***tailings*** and is stored or dumped in ***tailings ponds*** or containment fields to prevent wind and water erosion.(5)

An epidemiologic study was conducted among 5,801 radiation workers of Rocketdyne/Atomics International to ascertain organ specific doses from lifetime exposure and intake of radionuclides including isotopes of uranium, plutonium, americium, calcium, cesium, cerium, zirconium, thorium, polonium, promethium, iodine, zinc, strontium, and hydrogen (tritium). (6) Traces of these decay metals and harmful radiations from uranium mining activities contaminate adjacent water resources, soil, air, and agricultural products and expose the human beings to the risk of fatal consequences.(7) Considering the public health risk of uranium mining, the Portuguese government approved a study of old uranium mines and tailing ponds to monitor the quality of underground water and soil with the purpose of evaluating the health risks. (8) The results of the study revealed higher radionuclide concentrations in some agricultural fields due to surface runoff and mixture of tailings materials with soils. Water from wells and small fountains were found to be the main sources of exposure for the local human populations. Transport of radioactive dust by wind and emission of radon from the tailings were also identified as additional pathways.(9–11)

Uranium mining and human health

Several studies have found a statistically significant correlation between exposure to radon, uranium, and decay elements of uranium and health complications like bronchial and lung cancer, leukaemia and other blood diseases, cancers of the bone marrow, lung, stomach, liver, intestine, gall bladder, skin, and kidney, psychological disorders, and birth defects. (12,13)

Several studies done among the Navajo uranium mineworkers of the United States have demonstrated the prevalence of a broad spectrum of morbidities including lung cancer, respiratory illnesses, tuberculosis, digestive dysfunction, and other cancerous diseases among the mineworkers. The studies have also established these diseases to be the cause of death of around 800 workers between 1960 and 1990. (14–17) Workers occupationally exposed to uranium appear to be at increased risk of fatal diseases from neoplasms of the lung and the larynx and the lymphatic and haematopoietic tissue.(18) Morbidities among workers and teenagers in the heavily uranium decay contaminated territories of Ukraine increased fourfold between 1987 and 2004.(19)
Systematic literature review searched on the PubMed and the Scopus databases provide evidence of increased lung cancer risk and mortalities among uranium-processing workers. (20,21) Studies conducted in villages surrounding the Jaduguda uranium mine and mill too have documented the severe health consequences suffered by the native tribal people, including premature deaths.(22)

We performed a statistical analysis to determine the association between mortalities as well as prevalent morbidities among mineworkers, aged 15-59 years, in the study area and their occupational exposure and various socio-demographic factors. In so doing, we aimed to answer the following three questions:

1) Is there a difference in the prevalence of various morbidities between uranium mineworkers (high exposure group) and non-uranium mineworkers (low exposure group) in the study area?

2) Does the occupational exposure have a dose-response relationship and a significant effect on prevalent morbidities?

3) To what extent do the distance of residence from the tailing pond and the different sources of drinking water in the Turamdih uranium mining area determine the association with self-reported morbidities among workers aged 15 -59 years?

Methods and materials

The survey was conducted between January and June 2016 at UCIL, Turamdih Mine and Mill area, located north-west of the Jaduguda mine in Jamshedpur city of Jharkhand, India. (Fig. 1) The study population belongs to Ho and Santhal communities (Schedule Tribes, Constitution of India.). They have a low level of education, live in poor socioeconomic conditions and follow unique customs and culture.

The tailing pond for dumping hazardous nuclear wastes at Turamdih was taken as the central point, and 31 villages within the range of 5 km of the pond were identified to be at risk of exposure to radiation. Based on the proportion of the tribal population and the female literacy rate, 411 households from 10 villages were selected for the study using the Probability Proportion to Size (PPS) sampling method. Inclusion criteria of the respondents from each household were – one economically active mineworker aged 15-59 years residing for at least five years in the study area. The total population in the age group 15-59 years was 1291, constituting approximately 60% of the total sample population.

Figure 1: Location Map of the Study Area

To identify the morbidity pattern in the study area, the study asked the respondents, "Have you suffered one or more illnesses, diseases, symptoms, and health problems in the last one year?" The respondents were given open opportunities to name the illnesses or diseases and describe their symptoms. The age and sex of the victims and the frequency and duration of each health issue were listed and coded. The study was conducted using an interviewer-administered questionnaire in the native language of the respondents using local, commonly understood terms. The languages used in the survey were Hindi and Santhali.

The events of death and the different types of morbidities were counted based on self-reporting by the interviewees, and no efforts were made to verify the events. In the tribal areas of India, where data on morbidity and mortality are mostly unavailable or weak, these self-reported responses of the tribal interviewees living adjacent to a uranium mine and mill provide a unique opportunity to examine the morbidity scenario as well as the determining factors associated with it. Morbidities among mineworkers aged 15-59 years, like digestive problems, respiratory illnesses, urinary dysfunction, cancerous diseases, and skin diseases, were taken as the outcome variables in the study. Occupation, distance of residence, main source of drinking water, age, household density, religion, education, etc. were taken as the independent variables. 'Sex' was excluded from the list of predictor variables as more than 90% of the respondent workers were male. The analysis emphasized on the pattern of differential morbidities among miners (high exposure group) and non-miners (low exposure group) and the relationship of the morbidities with the proximity of the house to the tailing pond (the major source of radioactive radiation), main sources of drinking water, and other socio-demographic factors.

Figure 2. Conceptual Framework: Uranium mining, environment and human health relationship

Data were analysed using Statistical Package for Social Sciences (SPSS) version 20.0. Chi-square test was used to evaluate the association between mortality as well as various types of morbidities among respondent workers with occupational exposure and socio-demographic factors. Association between factors was considered statistically significant at $p < 0.05$.

We used logistic regression to estimate unadjusted and adjusted effects of occupational exposure, closeness/distance of houses to/from the tailing pond (up to 2 km relative to more than 2 km) and household's major source of drinking water (unimproved sources relative to improved sources) on the prevalent morbidities and other household environmental and socioeconomic variables mentioned above as controls. Results were presented in the form of odds ratios (ORs) with 95 confidence intervals (95 CI). The logistic regression models were estimated using the IBM SPSS Statistics, version 20, and the Arc GIS 10.1 statistical software package.

We tested for the likelihood of multi-collinearity between the predictor variables before carrying out the multivariate models. We found a high degree of co-linearity between the distance of houses from the tailing pond and the distance of houses from the mill (uranium processing unit) and mining field. Therefore, We removed 'distance of houses from the mill and mining field' as a variable before carrying out the multivariate models. In the correlation matrix of predictor variables, we kept only those variables that had pairwise Pearson correlation coefficient values < 0.4 to ensure that multi-collinearity was not a problem.

Results

Profile of the respondent workers

Among the respondent workers, around 40% were below 35 years of age and only 9% were females. More than half of the respondent workers were residing less than 2 km away from the hazardous tailing pond and the uranium-processing unit. Forty-four per cent respondent workers were using hand pump/borewell as the main source of drinking water. More than 80% of the respondent workers did not have the toilet facility on their premises and were using solid unclean fuels for cooking food.

A little less than 50% of all the respondents were illiterate and almost two-thirds of the respondent workers had a poor standard of living. Almost 86% of all the respondents consumed alcohol (made of rotten boiled rice and called 'Hadia' in the local language) more than once a week. Other socioeconomic characteristics and the distribution of the respondent workers have been defined in Table 1.

Table 1: Socioeconomic characteristics of worker respondents (N=411) aged between 15 and 59 years.

Prevalence of various types of morbidities among respondent workers in the study area

Several studies have found a statistically significant correlation between several human health complications and the exposure to radon, uranium, and decay elements of uranium. In this context, the present study collected information on the illnesses, disease patterns, health problems, and symptoms of health problems in the study population in the one year preceding the survey based on the respondents' self-reported morbidities. More than 30 types of health problems were recorded among the respondent workers (including mineworkers and non-mineworkers) in the Turamdih uranium mining area. A person could have one, two or more diseases/health problems.

The survey found that digestion-related health problems like indigestion, bloating, stomach pain, nausea, pancreas dysfunction, vomiting and diarrhea were very common, and, that almost one in four persons suffered from them. This was followed by respiratory infections like pneumonia, lung infection, chest pain, and tuberculosis (TB). Cancer, kidney and urinary dysfunction, itching, redness of the skin, spots on the skin, and swelling were found to be major health consequences among the tribal people of the Turamdih uranium mining area. The study also found a high prevalence of vector-borne diseases like malaria, chikungunya, dengue, etc. (Table 2)

The prevailing illnesses, diseases, and symptoms were grouped into seven morbidity categories for further investigation. Digestive problems (22.9%) were the leading morbidities among the tribal communities residing in the areas surrounding the

Turamdih Uranium mine and mill, followed by respiratory infections (17.5%) and other diseases (15.3%). Vector-borne diseases and other diseases like malaria, chikungunya, dengue, jaundice, sinus infections, etc. were also highly prevalent (15.3%) among the respondent workers. (Table 2)

Table 2: Prevalence of various types of morbidities and differences among respondent workers *(N=411)* in the Turamdih uranium mining area, 2016.

The study aimed also to examine the differential morbidities between mineworkers (n_m = 195) and non-mineworkers (n_n = 216) in the study area and to determine the demographic and socioeconomic factors associated with these morbidities. The mineworkers represented the high exposure group to the radioactive radiation due uranium mining activities, whereas the non-mineworkers represented the low exposure group.

Prevalence of differential morbidities among mineworkers and non-mineworkers

Table 2 shows that at around 30%, the prevalence of digestive problems was much higher among the Uranium mineworkers compared to the non-mineworkers, among whom it was only 17%. These differences were significant ($\chi 2$ =9.935, df(1), p= 0.002). One out of five mineworkers was suffering from skin diseases (redness or spots on the skin, itching, and swelling), whereas only 7% of the non-mineworkers had such symptoms. These differences were highly significant ($\chi 2$ =13.103, df(1), $p \leq 0.001$). The prevalence of urinary dysfunction, including kidney stone, kidney failure, and gallbladder infections (6.7%) and of cancer disease (6.2%) was also significantly higher among mineworkers than among non-mineworkers (2.8% and 1.9%).

Effects of occupational exposure on selected morbidities

Table 3 shows the estimated effects of the type of occupational activities and selected demographic and socioeconomic variables on the prevalence of digestive problems, respiratory illnesses, urinary dysfunction, skin diseases, and cancer among the sampled mineworkers in alternative models. Model 1 in Table 3 shows that the unadjusted odds of suffering from digestive problems (OR = 1.89; 95% CI, 1.18–3.01), cancerous diseases (OR = 3.48; 95% CI, 1.10-10.96), and skin diseases (OR = 3.03; 95% CI, 1.63–5.63) were much higher among the mineworkers than among the non-mineworkers. The prevalence of respiratory illnesses and urinary dysfunction was also more likely among the mineworkers compared with the non- mineworkers of UCIL, Turamdih area; however the result was insignificant.

Controlling for exposure to the demographic and socioeconomic variables in Model 2 (Table 3) increased the effect of radioactive radiation from uranium mining activities on the prevalence of skin diseases and digestive problems marginally. By contrast, the effect of radiation on the prevalence of cancerous diseases (OR = 4.47; 95% CI, 1.52 – 17.96) and urinary dysfunction (OR = 2.48; 95% CI, 0.90 – 6.85) among mineworkers increased significantly. The effect of radiation on the prevalence of respiratory illnesses reduced somewhat when demographic and socioeconomic variables were controlled in Model 2, and it remained insignificant.

Table 3: Unadjusted and adjusted effects (OR, 95% CI) of occupational characteristics and other predictors on selected morbidities in the last one year.

Effects of the control variables on the selected morbidities

Model 2 in Table 3 discusses the adjusted effects of the control variables on the selected morbidities. With other variables controlled, age had a positive effect on the prevalence of respiratory illnesses, with workers aged 35 and above having a significantly higher prevalence of respiratory illnesses (OR = 1.85; 95% CI, 1.04 – 3.30) than workers aged below 35 years. Distance of residence from the tailing pond had a significant effect on the prevalence of digestive problems and respiratory illnesses such that workers living within 2 km of the tailing pond were more likely to suffer digestive problems (OR = 1.57; 95% CI, 0.94 – 2.60) and respiratory illnesses (OR = 1.89; 95% CI, 1.06 – 3.37). The main source of drinking water too had a significant effect on the prevalence of digestive problems, with workers using hand pumps being two times more likely (OR = 2.07; 95% CI, 1.15 – 3.71) and those using other unimproved sources (e.g. well, river, pond, rainwater, and streams) being more than two times more likely (OR = 2.63; 95% CI, 1.29 – 5.38) to suffer digestive problems than those using piped water supply and mobile water tank for drinking water.

As far as the household environment is concerned, respondent workers living in relatively less dense houses (fewer than 3 persons per room) were significantly less likely to suffer from cancerous diseases (OR = 0.12; 95% CI, 0.03 - 0.45) and urinary dysfunction (0.37; 95% CI, 0.14 – 1.01) than respondent workers living in high-density houses. Unexpectedly, the result shows that respiratory illnesses were higher among respondent workers living in low density houses. The findings of the study also revealed that respondent workers of the *Sarna* community had a significantly higher susceptibility to respiratory illnesses (OR = 2.90, 95% CI, 1.68 – 5.02) and cancerous diseases (OR = 3.34; 95% CI, 1.10 – 10.17) than those of the Hindu and other communities. Other socioeconomic variables like education of respondents had no significant effect on any type of morbidities.

Discussion

The purpose of this study was to document disease patterns and health problems and their determinants in the study area and to differentiate the risk between high exposure group (mineworkers of UCIL, Turamdih) and low exposure group (non-miners). Another objective of this study was to assess the differential level of morbidities between mineworkers and non-mineworkers and the association of the morbidities with socio-demographic factors. The findings of the study indicate that the prevalence of digestive problems, skin diseases, cancerous diseases, and urinary dysfunction was significantly higher among the mineworkers of UCIL, Turamdih than among the non-mineworkers. The findings of the study are in conformity with those of (23–25) Mapel et al., 1997; Jones BA, 2014; Tirmarche et al., 2004, who have established differential health risks related to lung and liver cancer, digestive problems, respiratory disorders, and urinary dysfunction among uranium mineworkers and non-mineworkers.

Being poor, unskilled and less educated (mostly illiterate), as well as having a strong attachment to their native land, indigenous language and culture, the tribal people displaced by UCIL were forced to resettle in the region of the tailing pond and uranium processing unit. Unaware of the inherent risks of uranium mining, the natives had no clue as to the hazardous environmental impact of living in close proximity to the mining area, nor the knowledge to deal effectively with the unknown situation. For example, the Turamdih workers have low addiction to cigarette/bidi/tobacco smoking; consequently, when they developed chest pain, lung cancer or other respiratory problems, they could rule out smoking as a cause. As the findings of the study established, proximity of residence to the uranium tailing pond was significantly related to the risk of respiratory illnesses and digestive problems.

Another finding of the study suggests that proximity of residence to the uranium mine, mill and tailing pond has a significant effect on the morbidities. Workers residing up to 2 km of the tailing pond or the uranium mill were more likely to suffer digestive, respiratory, cancerous and skin diseases and to die prematurely than those living more than 2 km away from the tailing pond or the uranium processing unit. The findings resonate with several previous studies conducted in the surroundings of uranium mining (open-cast/underground) and nuclear plants across the world.(26–30) When asked for the "reason to reside in close proximity to the uranium mine and mill", one of the respondents, Ghasia Ho (46 years) stated, "*After displacement by the UCIL Authority, a small, one-room house was provided to each household without considering the number of household members. No electricity, separate kitchen, bathroom, and drinking water were provided. The house was also far from our working place. Therefore, we were compelled to resettle close to the UCIL, Turamdih Mine and Mill.*

The main source of drinking water was also found to have a statistically significant effect on workers' (15-59 years) morbidities irrespective of their occupational orientation. The study makes it evident that respondent workers using hand pump/borewell, well (covered/uncovered), river, pond, canal, and rainwater as sources of drinking water had three to four times more risk of dying prematurely than those using a piped water supply or a mobile water tank as the main sources of drinking water in their households. The findings conforms to the previous studies that suggest that the radioactive element of decayed uranium from the tailing pond seeps into the ground water, surface water, and aquifers through porous land structure and soil, making the water contaminated.(7,31,32) Previous studies on uranium mining areas have also reported groundwater samples to have uranium concentration above the drinking water standard level of 30 ppb set by the USEPA. (33)

The tailing pond at UCIL, Turamdih, receives uranium ore wastage and effluents from the processing mill. The tailings have too little of the uranium to be of use; but the uranium is still radioactive and may contain toxic heavy metals that seep and penetrate into the ground water. As *Laxman Diggi, a native of the Nandup village adjacent to UCIL, Turamdih, states, "During the monsoon season, the tailing pond is often inundated and overflows. The contaminated water from the tailing pond spreads into our cultivable lands, pond, and houses."* Therefore, the drinking water from the surface runoff or the underground sources becomes severely contaminated with the lethal radiation, causing slow, unbearable suffering to and premature deaths of the poor native tribal people. An earlier study done in the UCIL, Jaduguda mining region (24 km away from UCIL, Turamdih) also offered evidence of high concentrations of ^{238}U, ^{232}Th, ^{40}K in the soil and the drinking water, posing a significant radiological threat to the native tribal population. (34)

Limitations of the study

A cross-sectional study cannot determine causal relationships between variables. Since the respondents were tribal people – mostly illiterate and unaware of health problems – the study is prone to reporting bias; in most cases, respondent workers tend to under-report their problems.

Conclusion

These findings contribute to the thin empirical literature on uranium mining and the associated loss of life, health consequences, environmental justice, and public health in developing countries. The Government of India is increasing its strength and coverage in uranium mining and the nuclear energy sector rapidly. This makes it important that the health and safety of the workers of the uranium mines (underground and open-pit) and the residents of the nearby areas be protected.

The findings of the study have important program and policy implications related to safe drinking water, environmental impact assessment, safety measures, nuclear regulation acts, and compensation to and resettlement of tribal families. Based on the findings of the study, the authors have following recommendations to make:

- Check urban residential expansion towards the uranium mining area,
- Resettle the poor tribal families away (at least 5 km) from the uranium mining areas,
- Establish a water treatment plant and supply safe drinking water to the local people living in the surroundings of the tailing pond, mines or mills,
- Monitor the tailing pond and the nearby water bodies to ensure that the radioactive elements do not penetrate into the groundwater,

- ❖ Provide compensation and jobs to the victim families to ensure sustained livelihood, health and education,

- ❖ Bring all the existing uranium mines and mills under the international nuclear safety guidelines, and

- ❖ Educate the local people on the health hazards of radiation and develop a program to create awareness on hygiene and security measures.

Ethics approval and consent to participate:

The "Student Research Ethical Committee" (SREC) at the International Institute for Population Sciences, Mumbai, approved the study. Since the study was undertaken in a tribal dominated area, informed consent of the respective tribal community heads was obtained before administering the survey. Individual respondents' consent was taken before the interviews, and freedom of withdrawal anytime from the study was assured. The purpose of the survey was explained to the community as a whole and to the individuals before conducting the survey, and the participants were assured that the information collected from them would be used for academic research purposes only.

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Figure 1: Location Map of the Study Area

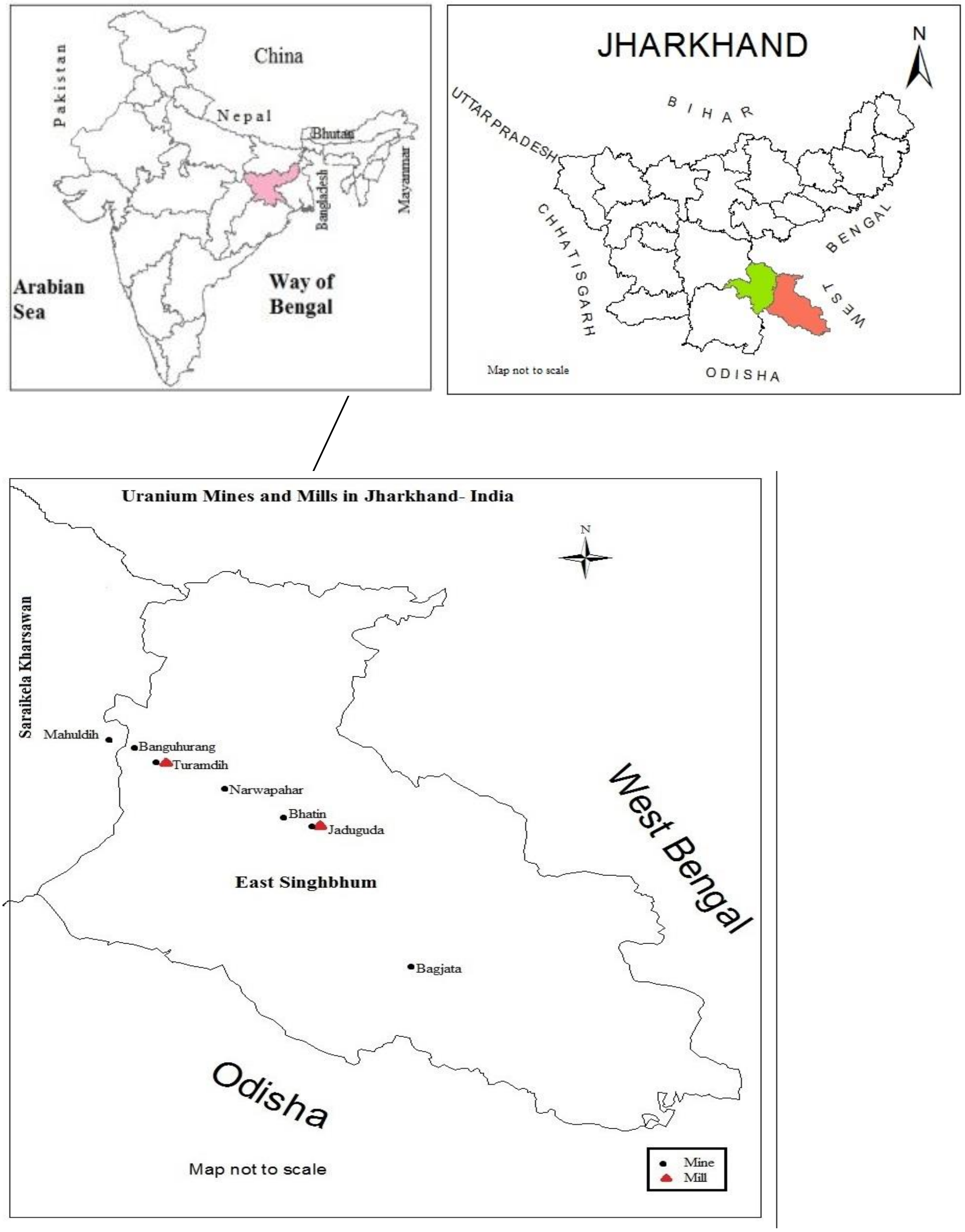
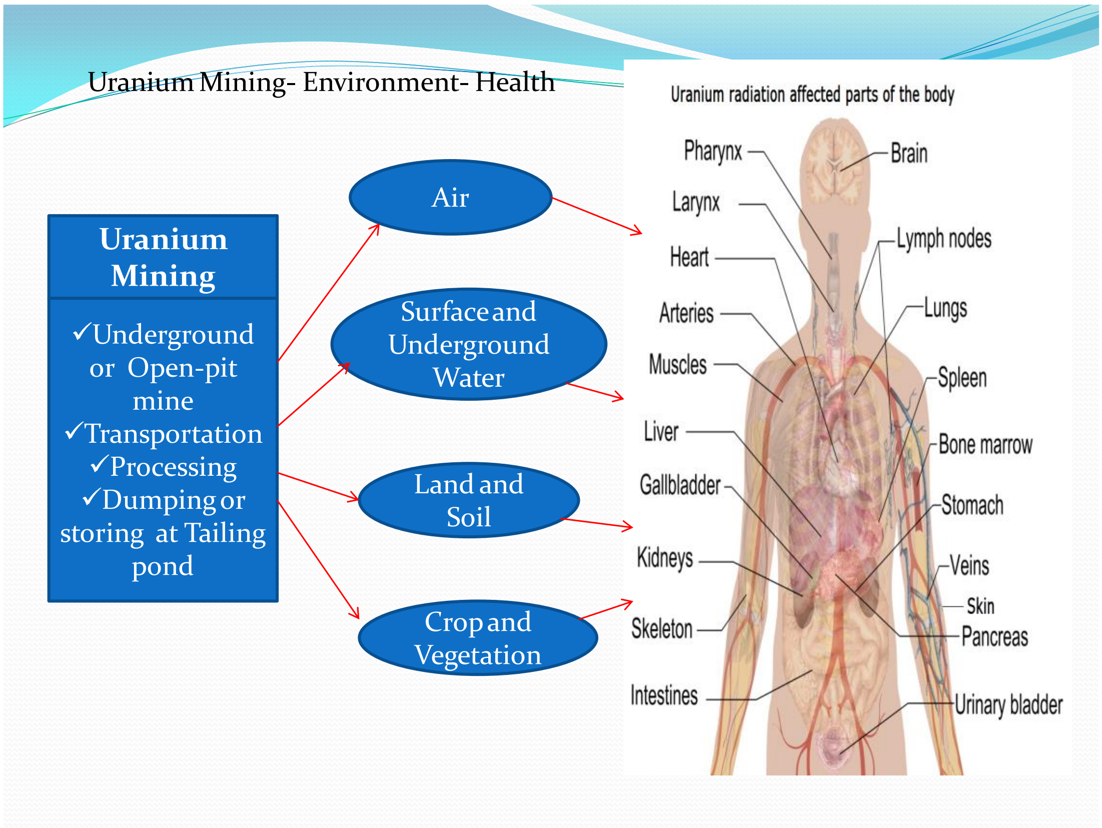


Figure 2. Conceptual Framework: Uranium mining, environment and human health relationship



This Conceptual framework describes how various activities of Uranium mining affect elements of environment that consequently distresses the human health. (Kumar, Ashwani. 2017)

Table 1: Socio-economic characteristics of respondent workers (N=411) aged between 15 and 59 years.

Background Characteristics		Respondents aged (15 - 59)				
		Mine-workers		Non Mine-workers		Total Workers
		n	n%	n	n%	
Workers Age	Below 35	73	44.0%	93	56.0%	166
	35 and above	122	49.8%	123	50.2%	245
Distance from tailing pond	More than 2Km	88	45.8%	104	54.2%	192
	Upto 2Km	107	48.9%	112	51.1%	219
Source of drinking water	Piped/Mobile water tank supply	77	46.1%	90	53.9%	167
	Own/community Hand-pump	89	49.2%	92	50.8%	181
	Others@	29	46.0%	34	54.0%	63
Distance from Processing Unit	More than 2Km	93	47.7%	102	52.3%	195
	Upto 2Km	102	47.2%	114	52.8%	216
No. of persons per room	3 or more	54	35.5%	98	64.5%	152
	less than 3	141	54.4%	118	45.6%	259
Sub-caste	Santhal	54	45.4%	65	54.6%	119
	Ho & others	141	48.3%	151	51.7%	292
Religion	Hindu & others	135	49.3%	139	50.7%	274
	Sarna	60	43.8%	77	56.2%	137
Standard of living#	Poor	103	37.7%	170	62.3%	273
	Non-poor	92	66.7%	46	33.3%	138
HH Head Education level	Illiterate	78	41.1%	112	58.9%	190
	Primary/Middle	83	51.6%	78	48.4%	161
	High School & Above	34	56.7%	26	43.3%	60

@Other sources of drinking water: river, pond, canal, stream, and rainwater
Standard of living (SLI) index is calculated by adding the scores assigned to the durable goods in the household as following: 4 for a car or tractor; 3 each for a moped/scooter/motorcycle, telephone, refrigerator, or color television; 2 each for a bicycle, electric fan, radio/transistor; and 1 each for a mattress, pressure cooker, chair, cot/bed, table, or clock/watch. Index scores range from 0–5 for low SLI, 6–15 for medium SLI, to 16–42 for high SLI.; Further, medium and high SLI group into 'non-poor' and low SLI households into 'poor'

Table 2: Prevalence of various types of morbidities and differences among respondent workers (N=411) in the Turamdih uranium mining area, 2016.

Morbidity Categories	Diseases/Symptoms/Illnesss	Prevalence (%)			Pearson χ2 value
		Mine Workers	Non-Mine Workers	Total	
Digestive problems	Stomach pain, Pancrease disfunction, Vomiting, Dirrhoea	29.74	16.67	22.87	(9.935, df(1), p= 0.002)
Respiratory illness	Pneumonia, Lung infection, Chest pain, Tuberculosis	20.00	15.28	17.52	(1.158, df(1), p= 0.209)
Urinary diseases	Kidney Stone, Kidney failure, Gallbladder stone, Gallbladder infections	6.67	2.78	4.62	(3.515, df(1), p= 0.061)
Cancer	Lung cancer, Leukaemia, Skin cancer, Abdomen cancer, Bone-marrow cancer	6.15	1.85	3.89	(5.069, df(1), p=0.024)
Skin Diseases	Itching, Redness/spot on skin, Swelling	19.49	7.41	13.14	(13.103, df(1), p= 0.001)
Other Diseases	Nausea, Hail fall, Sinus infection, Anaemia, Fever	15.38	15.28	15.33	(0.001, df(1), p= 0.976)

Table 5. 1 Unadjusted and adjusted effect (OR, 95% CI) of occupational characteristics and other predictors on selected morbidities in the last one year.

	Digestion Problems		Respiratory Illnesses	
Background Variables	**Model 1**	**Model 2**	**Model 1**	**Model 2**
Occupation				
Non mine Worker®				
Mine Worker	1.89***(1.18 – 3.01)	1.94**(1.18 – 3.18)	1.39(0.83 – 2.31)	1.22(0.71 – 2.12)
Age				
Below 35®				
35 and above		1.15(0.70 – 1.89)		1.85**(1.04 – 3.30)
Distance from tailing pond				
More than 2 Kms®				
Upto 2 Kms		1.57*(0.94 – 2.60)		1.89**(1.06 – 3.37)
Main Source of drinking water				
Piped/Mobile water tank®				
Hand-pump (Own/community)		2.07**(1.15-3.71)		1.73*(0.93-3.22)
Others#		2.63**(1.29-5.38)		0.79(0.32-1.96)
Household density				
3 or more per room®				
Less than 3 per room		0.79(0.48 – 1.39)		1.71*(0.94 – 3.12)
Religion				
Hindu and others®				
Sarna		1.38(0.84 – 2.27)		2.90***(1.68 – 5.02)
Education				
Illiterate®				
Literate		1.23(0.75 – 2.01)		1.25(0.72 – 2.16)

Continue…

Background Variables	Urinary Dysfunction Model 1	Urinary Dysfunction Model 2	Cancerous Disease Model 1	Cancerous Disease Model 2	Skin Disease Model 1	Skin Disease Model 2
Occupation						
Non mine Worker®						
Mine Worker	1.96(0.76 – 5.08)	2.48*(0.90-6.85)	3.48**(1.10 – 10.96)	4.47**(1.26 – 16.06)	3.03***(1.62 – 5.63)	3.35***(1.75 – 6.41)
Age						
Below 35®						
35 and above		1.15(0.43-3.08)		2.10(0.60 – 7.32)		1.49(0.79 – 2.80)
Distance from tailing pond						
More than 2 Kms®						
Upto 2 Kms		1.60(0.59-4.32)		0.86(0.27 – 2.71)		0.83(0.44 – 1.57)
Main Source of drinking water						
Piped/Mobile water tank®						
Hand-pump (Own/community)		1.93(0.60-6.23)		3.57(0.70 - 18.09)		1.13(0.57 - 2.25)
Others#		1.48(0.32-6.77)		0.71(0.06 - 8.65)		0.64(0.27 - 1.76)
Household density						
3 or more per room®						
Less than 3 per room		0.37*(0.14-1.01)		0.12***(0.03 – 0.45)		0.68(0.36 – 1.27)
Religion						
Hindu and others®						
Sarna		1.28(0.48-3.39)		2.70*(0.85 – 8.55)		1.33(0.71 – 2.46)
Education						
Illiterate®						
Literate		0.77(0.30 – 2.00)		3.05(0.78 – 11.90)		0.81(0.44 – 1.49)

® Reference Category; ***p≤ 0.01; **p≤0.05; *p≤0.1

#River, canal, pond, rainwater, and streams