HEALTH EFFECTS OF THE TOXIC GAS LEAK FROM THE UNION CARBIDE METHYL ISOCYANATE PLANT IN BHOPAL

TECHNICAL REPORT

ON

POPULATION BASED LONG TERM EPIDEMIOLOGICAL STUDIES PART II (1996-2010)

2013

CENTRE FOR REHABILITATION STUDIES
GOVERNMENT OF MADHYA PRADESH
&
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FOREWORD

This second technical report on Population Based Long term Epidemiological studies for the duration 1996-2010 marks the successful completion of twenty five years of scientific data collection by the staff of National Institute for Research in Environmental Health (previously with Centre for Rehabilitation Studies).The first phase of data collection was carried out during 1985-1994 which was previously published in the form of first technical report.

During 25 years of its operation, the study has collected enormous data through periodic surveys of the community. The detailed methodology, results and conclusions are explained in this report. It gives me great pleasure to note that lot of efforts have been made by the staff of the study team in collection and analysis of data to bring out the report in this final form.

The objective of the initial set up at Bhopal after the industrial accident and environmental disaster in December 1984 was to develop a scientific, rational and therapeutic approach to help the MIC affected individuals.

This technical report consolidates the outcome of the second phase of the long-term follow-up of this cohort study. The report may have immense importance in terms of understanding the evolution of late effects of MIC exposure.

I hope that the publication of this technical report would be taken as another achievement by this team and would serve as a baseline for next phase of research programme of National Institute for Research in Environmental Health (NIREH), an institute created to eventually become a centre of excellence and also emerge as a National Institute to head the research in environmental health.

(V.M Katoch)

Preface

On the night of 2nd/3rd December 1984, world's worst industrial accident took place at the pesticide plant owned by an American Multinational, the Union Carbide Corporation at Bhopal, Madhya Pradesh, India. Approximately, 40 tons of highly toxic liquid Methyl Isocyanate (MIC) stored in tank 610 suddenly escaped in a gaseous form into the atmosphere following entry of water into the tank. This occurred around midnight when the ambient temperature was below 10º Celsius. The tank burst out emitting a thick cloud of deadly fumes. The gases spilled over houses, streets situated in areas inhabited by approximately, 500,000 people. A large number of deaths, estimated to be about 2500, occurred in the exposed population.

Ironically, despite the existence of the Union Carbide, pesticide manufacturing plant since 1969, at the time of the disaster no information on the toxicity of MIC was or could be provided by the Union Carbide management, nor were there any contingency plans for disaster management. Immediate observations on the dead (post mortem) and the pattern of morbidity amongst the survivors indicated that although lung and eyes seemed the main target organs, multiorgan involvement in the survivors was also to be expected. Certain pertinent questions were raised in this regard. How long will the effects last? What permanent disabilities are likely to be expected? What is the future of for these victims and of their off springs?

Dr. V. Ramalingaswamy, the then Director General and Dr. S. Sriramachari, the then Additional D.G. of the Indian Council of Medical Research (ICMR), New Delhi, initiated the entire research set up at Bhopal, They visualized the far reaching impact of the toxic gas(es) on various organ systems. Within a month of the disaster, in January 1985, the ICMR geared up its resources to undertake the gigantic task of identifying the toxic gaseous products and study their effects on human health. The facilities available for research at Bhopal were limited both in terms of manpower and equipment. Therefore, the task to create technical know-how and research infrastructural facilities at Bhopal was undertaken. A number of eminent scientists from all over the country were drawn to contribute in this endeavor. Twenty main research projects on various aspects of the gas injury ranging from epidemiology to molecular biology were initiated. ICMR established Bhopal Gas Disaster Research Centre (BGDRC) at Gandhi Medical College to coordinate research activities.

Further, in addition to several ICMR institutes, many prominent medical research institutions spread over the country extended timely help and co-operation.

Of the various projects initiated, a core project on epidemiological aspects of toxic gas exposure was undertaken. A cohort of 80,021 persons residing in 36 municipal wards of Bhopal, exposed with toxic gas was registered. Another cohort of 15,931 persons was also registered from an area where history and symptoms due to the gas exposure were not reported. Five Community Health Clinics were set up in the exposed areas and one in the control area.

This became a core project from which samples for other specific studies were taken and linkages between these studies were established. The field teams collected morbidity and mortality data through home visits.

The first Technical Report on "Population based Long-term Epidemiological Study (1985-1994)" was published which reveal that those exposed to toxic gas for a long period, after the exposure, continued to suffer from multisystem involvement like respiratory, ophthalmic and gastrointestinal disorders.

The details of methodology, result and conclusions of the project on "Population Based Long Term Epidemiological Studies on the Health Effects of Bhopal Toxic Gas Exposure 1996-2010)" are presented here in the form of a Technical Report.

Prof. Manoj Pandey
Director Incharge, NIREH

Acknowledgements

The project on “Population Based Long Term Epidemiological Studies on the Health Effects of Bhopal Toxic Gas Exposure” has been conducted for more than two decade and large numbers of scientists have contributed in these studies.

It is worthy to note the contribution made by Late Dr. V. Ramalingaswamy, and Prof. N.K. Ganguly Former Director General’s, ICMR. Late Dr. S. Sriramachari, Additional Director General and Dr. Usha K. Luthra, Former Additional Director General and Chief NCD, Late Dr. C.R. Ramchandran, Chief NCD, Late Dr. A.K. Prabhakar, NCD New Delhi, and eminent scientific community to the most valuable contribution made by Late Dr. S. N. Sharma, HOD, Deptt. of P.S.M, GMC and first Principal Investigator of the Project, Late Dr. M. P.Dwivedi, Former Director BGDRC,ICMR, Bhopal and Principal Investigator of this Project.

Thanks are due to Dr. V. M. Katoch, Director General, ICMR, Dr. Padam Singh Former Additional Director General, Dr. Bela Shah, Scientist-G, Head NCD, ICMR and Dr. Arvind Pandey, Director NIMS, Dr. D. K. Shukla, Scientist-F, ICMR, Dr. R. K. Gupta, Scientist-F and Dr. Atul Juneja, Scientist –D, NIMS, New Delhi and other Scientists of Indian Council Of Medical Research for technical guidance.

With gratitude, we extend our sincere thanks to members of Advisory Committee and Review Committee who have greatly contributed with their valuable time for guidance of this study. Our sincere gratitude is due to all the people who extended their cooperation and time for participation in this study over a protracted period of time.

The Report could be brought into proper shape, proper content was possible only because of extensive guidance and active cooperation made by Dr. Padam Singh, Dr. P. S. S. Sundar Rao, Dr. D. C. S. Reddy, Dr. V. K. Vijayan, Dr. H. R. Rajmohan, Dr. B. Mishra, Dr. J. S. Thakur, Dr. S.N. Dwivedi, Dr. S.K. Jain and Dr. R.C. Sharma.

I am also highly thankful to Mr. K.K. Dubey, Director, Kamla Nehru Hospital, and Deputy Secretary Gas Rahat, Bhopal whose guidance have been continuously encouraging to complete the task within time. I would like to extend my thanks to my colleagues Dr. Sushil Singh and Mrs. Moina Sharma, Dr. B. S. Panwar, Dr. K. K. Soni, Dr. U. M. Rao, Dr. R. Galgalekar and Mr. Sanjay Khare without their active contribution it could never been possible to shape this report in present form.

I would like to express my gratitude to all my colleagues of epidemiological study for their continuous efforts in collection of information from registered cohort I would also like to express my thanks to Mrs. Premalata Maheshwari, and Mrs. Gaurie Shrivastava, Research Assistants who were recently retired after making immense contribution to the study.

I must acknowledge the contribution of our three staff members, Dr. Om Prakash Tiwari, Assistant Research Officer (Computer), Mr. Sudeep Shrivastava, Research Assistant, and Mr. M. P Tiwari, Field Attendant whose untimely demise has caused severe loss in the research activities of the Centre.

I am also thankful to Mr. Sudhir Shrivastava, Mr. Krishnadas V. K., Mr. R. K. Varma, Mr.

Mohan Waldhurkar, Mrs. Anitha S. Pillai and Mr. C. S. Pillai, Mr. Sunil Sharma, Mr. Anand Kori, Mr. Rajendra Pandey, Mr. Mateen Khan, Mrs. Meena Chaturvedi, Mr. Vijay Singh and Mrs. Swapna Azhar for their continuous assistance in the preparation of this report.

At last, but not the least I express my heartfelt thanks to Secretary, Government of Madhya Pradesh, Bhopal Gas Tragedy Relief and Rehabilitation Department and Commissioner-cum-Director, Directorate of Gas Relief and Rehabilitation, Government of Madhya Pradesh, Bhopal for the continuous encouragement for carrying out epidemiological study smoothly. At the end I would humbly place my thanks to all the gas exposees for their continuous support.

Dr. N. Banerjee
Head, NIREH
Former Officer-in-charge.CRS

I. INTRODUCTION

a. Bhopal at a glance

Bhopal, the capital of the state of Madhya Pradesh is situated in the centre of India, at an altitude of 505 meter above sea level (Fig.1). The city is located at longitude 77º12' – 77º40' eastern and latitude 23º07' -23º94' northern. It covers a total area of 284 sq km. The new and old city taken together, the spread of Bhopal is East-West. The population of Bhopal was 672,000 in 1981. The city is administered by the Bhopal Municipal Corporation and for administrative purposes in 1984 the city was divided into 56 wards (Table-1). The density of population was 2355.2/sq.km.[1]

In this city of lake and hills, climate is moderate in all seasons. The coldest month is January with mean daily maximum temperature at about 25.7ºC, and the mean daily minimum at 10.4ºC. After February, the ambient temperature increases steadily till May which is usually the hottest month with mean daily maximum temperature at 40.7ºC and mean daily minimum temperature at 26.4º. The city receives its water supply from the upper lake and partly from Kolar dam. The average rain fall was 1234.4 mm for the years 1983-84. The literacy status of the people was 56.77 in 1981.[1]

The American Multinational Company, Union Carbide Corporation (UCC) set up a pesticide formulation plant in Bhopal in 1969. The Union Carbide Factory was constructed on a sixty seven acre plot on Berasia Road at the North-West end of Bhopal city. This was meant to mix and package pesticide imported from the USA from late 1977. Union Carbide India Limited (UCIL) started manufacturing Sevin at the Bhopal plant by using imported primary raw materials viz. Alpha Naphthol and Methyl-isocyanate (MIC) manufactured at the Union Carbide Plant in the USA and shipped in stainless steel containers to the Bhopal Factory. However, since early 1980, MIC was being manufactured at Bhopal Plant using the technical know-how and the basic design supplied by the Union Carbide Corporation (UCC), USA. The raw materials used to make MIC were Monomethylamine (MMA) and Phosgene. The latter was produced by reacting Carbon monoxide and chlorine. Carbon monoxide was produced by reaction of petroleum coke with oxygen.[1]

b. The Disaster

Ingress of about 512 liters of water in tank No E-610 containing about 42 tons of Methyl Isocyanate, initiated an exothermic reaction overpowering all existing safety systems and resultant products of reaction namely MIC 27-30 tones, Carbon dioxide- 1.25 tones, Ammonia 80- Kg, some amount of Methyl Chloride, Carbon tetrachloride, some alkylamines and cyanide started escaping through 33 meter high vent gas scrubber in to outside cold (10-12^{0}C) atmosphere and continued till the reaction stopped by itself around 3.00AM on 3rd December 1984[2]. And after going through thermal inversion the mixture of toxicants got condensed, settled down and started drifting in to surrounding communities along with the slow moving wind at speed of 10-12.km. per hour. Beside the above, uncertain amount of leftover of the 22 chemicals procured over periods of 15 year for making Sevin (cited above) too were lying unattended in

factory premises. Were likely to cause the environmental damage and damage to health of exposed human population and flora and fauna.

Toxic gas mixture spread rapidly into J. P. Nagar, Kazi camp, Chhola Road, Chandbad, New Kabad Khana, Sindhi Colony and Railway Colony. Most people were at home when the accident occurred. This mid night accident left people awestruck, confused, and panicked and these mental states led them to leave comparatively safety of their houses and running in to dark and often poorly lit streets, moving in different directions. Many a time, instead of running towards safe gas-free zones, they inadvertently walked into more concentrated toxic Gas pockets.

c. Immediate Mortalities and Morbidities

People first noticed irritation of eyes, rapidly developing into intense swelling and burning sensation and inability to keep them open. Simultaneously, people were violently coughing, unable to breathe and feeling suffocated. Many of the exposed persons experienced the smell and sensation like that of burning chilies in eyes. A large number of deaths occurred instantly at home, in streets and hospitals over the next 72 hours. Estimates placed the number of dead persons around 2,000 and dead cattle around 1,000.[3]

d. Autopsy Findings:

Autopsy studies were carried out by the Medico-Legal Institute and the Department of Pathology from the third day onwards i.e. about 72 hours. The ICMR team helped in carrying out autopsies from December 13-21, 1984 and subsequently the histopathological studies. Initial autopsy studies during the first four weeks revealed a characteristic “cherry red discoloration” of lung, the primary target organ alongside massive pulmonary edema, emphysema and haemorrhage, generalized visceral congestion, cerebral edema, ring haemorrhages and anoxic brain damage. Thus, most deaths had occurred due to asphyxia as a result of acute lung injury, chemical pneumonia or acute respiratory distress syndrome. Extensive pulmonary edema and exudative lesions were observed during subsequent autopsy studies carried out on victims succumbing one to four months post-exposure. Later studies from four months to one year and beyond revealed diffuse interstitial pulmonary fibrosis (DIPF)[4]

Besides these immediate losses of life a much larger number suffered with respiratory, ophthalmic, gastrointestinal and musculo-skeletal complaints.

Acute phase morbidities arbitrarily covered period of 0-1 month post exposure to toxic gas leak. Kamat et al., studied 78 patients during acute phase and found that 79% had respiratory symptoms and 74% had ophthalmic symptoms.[5] Mishra et al., reported that during the acute phase of the 544 patients examined in OPD 99% suffered with breathlessness, 95% with cough, 46% had choking and irritation, 25% had chest pain, 21% were listless, 16% suffered with hypersomnolence, 7% were brought in coma, 92% suffered with loss of appetite 52% had nausea and vomiting, 82 % had rhonchi and crepts 80% had tachypnoea, 54% had tachycardia and 2% had fever.[6] Kamat et al., found that 78% showed restrictive pulmonary impairment with reversible airflow obstruction, in 24% reduced oxygen uptake on exercise among 55% and raised levels of carboxyhaemoglobin, and methaemoglobin.[7] Among 500 Chest radiographs of

patients taken within 72 hours of gas disaster, 98% showed abnormalities of interstitial and alveolar lesions and destructive lesions of pre-existing lung diseases.[8] Hematological profile of 237 cases at 2 weeks post exposure revealed haemoglobin level of 14%, increased polymorphonuclear cells among 35%, lymphocytosis among 52%, 19% had eosinophillia in excess of 20%. At the time of the gas leak common complaints related to eyes were foreign body sensation, burning, excessive lacrimation, photophobia and blurring of the vision. On detail examination 60-70% had conjunctival and circumcorneal congestion with relatively little edema. A fair number of cases had superficial corneal ulcers, mainly involving central zone and inter-palpabral fissure.[9]

e. After math of disaster.

i. Acute phase

Arbitrarily relates to the first month of post exposure period. Men and women of all age groups flooded the hospitals within few hours of the gas disaster. Over 2000 hospital beds belonging to the Government and public sector were commissioned. Improvised camp hospitals were also set up for treating never ending stream of causalities.

Symptoms related to the respiratory tract consisted of choking, difficulty in breathing, pain in the chest and severe cough. Eye complaints were foreign body sensation, burning, excessive lacrimation, photophobia, intense pain and blurring of vision. With the prompt and appropriate treatment, majority of the patients responded well and became symptom free within few days.

ii. Sub-acute phase

Sub-acute phase was characterized by persistent morbidities among survivors of the acute phase. This period arbitrarily relates to 1-3 months post exposure.

iii. Chronic Phase

Chronic phase consisted of subject seeking medical assistance for the persistent symptoms or new symptoms related with respiratory, eye, gastrointestinal, neurological, muscular and mental health illnesses, disturbed sleep, severe loss of working capacity..This continued even after four years of gas disaster.

In vast majority of the exposed subjects, irrespective of the severity of exposure, symptoms of cough with or without expectoration, wheezing, chest pain, breathlessness; severe muscle weakness, body aches, epigastric pain, loss of appetite, visual disturbances, disturbed sleep, and severe loss of work capacity persisted even after 3 to 4 months after the disaster.

f. Centre for Rehabilitation Studies (CRS)

From April 1995, Centre for Rehabilitation Studies of Bhopal Gas Tragedy Relief & Rehabilitation Department, Government of Madhya Pradesh, reinitiated the study titled “Long-term Epidemiological Study” on the similar guidelines.

II. AIMS AND OBJECTIVES

The long term epidemiological study on health effects of the toxic gas exposure through community health clinic was started in mid January 1985. As the size of the exposed/affected population was very large, the statistical design of the studies required to register sufficient number of persons from the exposed areas to document the immediate and the long term effects of the toxic gas inhalation. For comparison a matching cohort from the unexposed/unaffected areas was also planned. Keeping these in view, the objectives of the Long term Epidemiological Studies were:-

i) To register cohorts in the affected and unaffected (control) areas of Bhopal.

ii) To collect baseline data on socio-economic and demographic profiles and to study changes over a period of time in context of the exposure to the toxic gas.

iii) To observe mortality and morbidity in the registered cohorts of population and to establish a relationship with the grades of exposure of the affected population.

iv) To identify sub-cohorts for in-depth epidemiological studies. Detailed information on demographic, socio-economic status and the base line data on the effects of gas exposure were recorded for preparing a comprehensive register of persons for undertaking detailed clinical and other studies.

v) To establish linkages between various studies and with the studies on the affected population outside the cohort.

For this purpose, a detailed health survey proforma was structured and the questionnaires (Annexure-I) were administered to the individuals by specially trained field workers. The objectives of the study were reviewed from time to time for mid-course corrections/modifications including changes in the periodicity of data collection.

Following modifications were done in 1987 :

i) To study the changes in socio-economic and demographic patterns of the study area through annual survey.

ii) To study mortality, socio-economic and demographic events occurring in the sample.

iii) To study point prevalence morbidity in the sample cohort along with six monthly morbidity survey.

iv) To establish linkage with clinical studies initiated by ICMR.

Again,1989 onwords the study was continued on total cohort.

III. Methodology

a. The Toxic Gas Exposed Areas and Population

From the 1971-81 base, the population of Bhopal was estimated and after allowing an annual growth rate of 7.4% on December 1984 it came to 832904 and 894538 in 1985. This population was living in 56 wards. On the basis of symptomatology revealed by Bhopal population following exposure, these 56 wards were further divided in to 36 gas affected and 20 not affected wards (Table -1). On the above basis Municipal Corporation of Bhopal, prepared a map outlining gas affected and non affected wards (Figure-1).

Fig:1. Bhopal -1984 with municipal wards and nos.

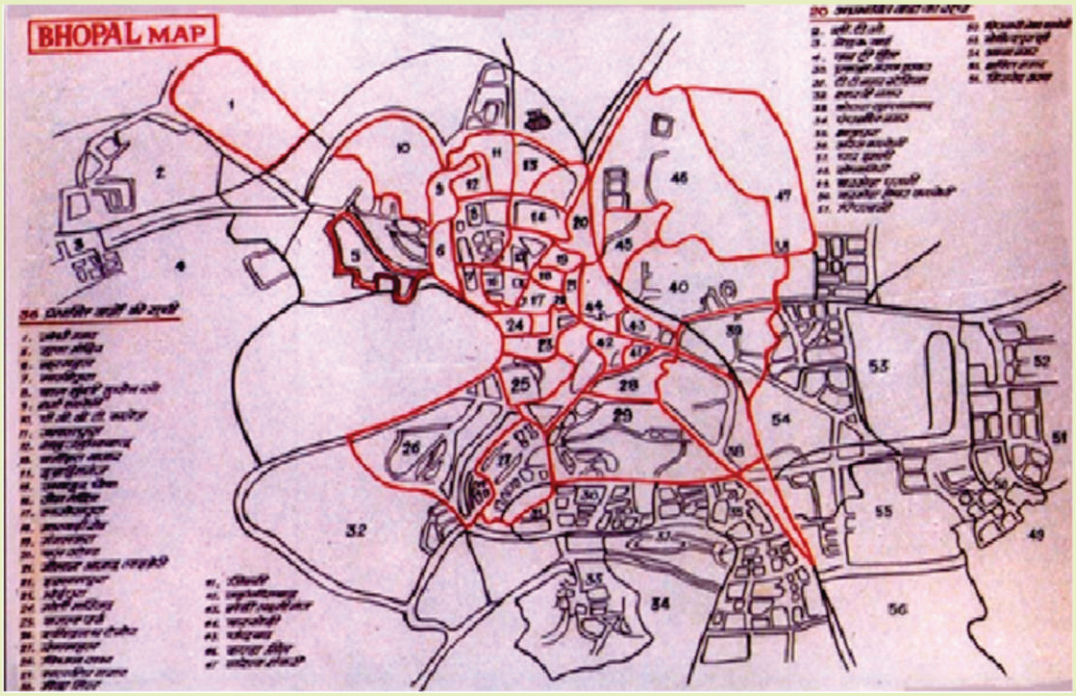


Table 1 : Bhopal -1984 Municipal wards with Severity of exposure

1.	Gandhi Nagar (m)	20	Bus stand (S)	39	A.N.Nagar(m)
2.	C.T.O.	21.	M. Azad Library (m)	40.	Aish Bag (m)
3.	Nehru Nagar	22.	Islampura(m)	41.	Jinsi(m)
4.	One Tree Hill	23.	Bhoipura(m)	42.	Jahangirabad(m)
5.	GufaMandir(m)	24.	Moti Masjid (m)	43	MandiLaxmiganj(m)
6.	Noor Mahal(m)	25.	Kamla Park (m)	44.	Berkheri(m)
7.	Malipura(m)	26.	R.TegoreBhawan(m)	45.	Chandbad(M)
8.	Bag Munshi Husain (M)	27.	Rang Mahal(m)	46.	Kapra Mill (M)
9.	Sharma Colony (m)	28.	VidhanSabha(m)	47.	NarelaShankri
10.	PGBT College (m)	29.	Malviya Nagar (m)	48.	SonaGiri
11.	Jamal Pura(M)	30.	PrakashPushkar	49.	BerkheraPathani
12.	Shajahanabad(m)	31.	T.T.Nagar	50.	BerkheraL.Colony
13.	Vergikrut Bazar (S)	32.	Shastri Nagar	51	Piplani
14	Ibrahimganj(M)/(m)	33	Kotra Sultanabad	52	PiplaniL.Colony
15	Jumerati(m)	34	Punchsheel Nagar	53	Govindpura
16	Jain Mandir(m)	35	Shahpura	54	Anna Nagar
17	Lakherapura(m)	36	Arera Colony	55	Shakti Nagar
18	Marwari Road (m)	37	Char Imli	56	Kaliyasote
19	Mangalwara(m)	38	Maida Mill (m)		

Legends: (S) Severely affected, (M) Moderately affected, (m) Mildly affected
Part of ward 14 Ibrahimganj/M/(m) comes under both moderate,Mildly affected areas

These affected areas on the basis of experienced mortality during 3rd to 6th December 1984 were further sub-categorized in to severe average death rate 22/1000 (range 20.2-23.8) covering a population of 32,476 (3.9%), moderate average death rate 1.33/1000 (range 0.5-3) covering a population of 71,917 (8.6%) and mild average death rate 0.2/1000 (range 0.1-0.4) covering a population of 416,869 (50.1%) respectively (Table-2).

Table – 2
Distribution of Population of Bhopal - Selection of Cohort Population

Areas Affected/ Exposed	Municipal Wards As per Bhopal Nagar Nigam	No.of Municipal Wards selected	Estimated Population for 1984 based on 1981 census	No.of Deaths (Dec.3-6, 1984) reported by Bhopal Nagar Nigam	Death Rates during 3 – 6 Dec. 1984 (Per Thousand)	Estimated Population for 1985 based on 1981 census	Cohort Pop'n during Aug.-Oct. 1985	Percentage of population covered from 1985 estimated population
Severely	13,20	2 (13,20)	32476	714	21.98	34879	26382	75.64
Moderately	8,11,14,45,46	5 (8,11,14,45, 46)	71917	96	1.33	77239	34964	45.27
Mildly	7,9,12,44 *11,5,6,10,15 16-17,18, 19,21 22,23,24,25,26 27,28,29,38,39, 40,41,42,43,47	4 (7,9,12,44)	64293	19	0.29	447717	18675	4.17
Total	36 (Pop'n 521262 1981 Census)	11	168686	829	5.0	559835	80021	14.29
Areas Unaffected/ Control	2,3,4,30,31,32,33, 34,35,36,37,48,49 ,50,51,52,53,54, 55,56	03 (36,54,55)	311642 (37.42%)	2		334703	15931	4.76
Grand Total		56	832904			894538	95952	10.73

b. Study Design

The objective of the epidemiological study was to determine both short-term and long-term health effects of the gas on the exposed population. Keeping this as the aim, a cohort approach was planned. Initially, as there was no sampling frame available on the list of exposed persons or the list of households living in the exposed area, a "cluster sample" approach was adopted for the study.

The study was planned initially to include 20,000 persons from each of the three exposed areas and an equal number from the control area. The figures presented in Table 3 are the number of persons enumerated in the 1985 survey.

For study purposes, the wards were further sub-classified into localities. The localities were selected at random and were included as clusters in the study. The severely exposed area included four localities, the moderately exposed area included six localities and the mildly exposed area included three localities. The unexposed area included three localities (Figure-1, Table- 3).

A major part of the exposed area close to UCIL, was slum locality with no house numbering and no information was available on the residents of these areas. Initially, during January 1985, "a house-listing operation" was carried out to list the households and also to provide an "identification number" for the purpose of long-term follow-up. A door–to-door survey was

carried out in the selected localities to list the households, and a tin plate with house number was affixed on each house. Along with this, a family folder was prepared which included the identification number of the household and the list of members residing in the household, with specific identification number for each individual. This folder was provided to each household for future reference and to ensure better linkages of data collected on a long-term basis through various projects. Each of the selected exposed and control areas ware covered in this operation. This activity was completed by March 1985. All the persons listed in the baseline survey formed the cohort for the long-term study.

In the early post-exposure period, it was planned to collect data on morbidity and mortality on a fortnightly basis. The fortnightly survey was initiated from April 1985.

A detailed epidemiological study was carried out during August-October 1985 to record the base line data on demographic, socio-economic characteristics of persons and the immediate morbidity and mortality in the three Gas exposed areas and in control area. The details of the number of persons enumerated in the study in the exposed and unexposed areas are given in Table-3.

Table 3
Distribution of Families and their Population (1985)
According to Area and Locality

Areas	Muncipal Ward Number	Locality Number	Name of the Locality Aug-Oct 85	Families Covered Aug-Oct85	Population Covered	Average Family Size
Severely Affected	13	01	J.P.Nagar	1724	8060	4.67
	13,20	02	Kazi Camp	1647	7829	4.75
	20	07	KanchiChhola	1147	4623	4.03
	20	08	Railway Colony	1106	5870	5.30
Total	Two	Four		5620	**26382**	4.69
Moderatel y Affected	11	03	TeelaJamalpura	990	5575	5.63
	08	04	Shahajahanabad	1185	6243	5.26
	14	05	Straw Product	1096	5292	4.82
	14	06	Ibrahimganj	1096	5486	5.00
	45	09	Station Bajaria	1420	7057	4.96
	46	10	Chandbad	1174	5311	4.52
Total	Five	Six		6961	**34964**	5.02
Mildly Affected	07,12,09,44	11	Noor Mahal	1467	7876	5.36
	07	12	HawaMahal	1119	5841	5.21
	07	13	Fatehgarh	951	4958	5.21
Total	Four	Three		3537	**18675**	5.27
Grand Total	Eleven	Thirteen		16122	80021	4.96
Control	54	14	Anna Nagar	1428	6091	4.26
	55	15	Vishwakarmanagar	1109	5026	4.53
	36	16	Habibganj	1112	4814	4.3
Total	Three	Three		3649	**15931**	4.36

During the period (August to October 1985), the collection of fortnightly morbidity and mortality data was discontinued because of detailed time bound base line survey. The system of fortnightly surveys was restarted from November 1985 and continued up to December 1986.

During January to March 1987, all households included in the survey were revisited to update the cohort registered to exclude the persons who had moved out and also to check on the deaths and births which occurred in the family after the survey carried out during August-October 1985.

The Project Advisory Committee took a decision to initiate six monthly surveys instead of fortnightly surveys, from May 1987. These surveys were planned on a sub sample from the main sample. The localities included in the severely affected areas were 1 and 7; in moderate 3, 5, 9 in mild 11, 13 and in the control area 14 and 16.

The updating of the cohort was carried out on annual basis in the six monthly surveys during November to May. This procedure was continued for four six monthly surveys i.e. up to November 1988. A further modification was made from November 1988 to include the total cohort instead of sub sample from the main cohort. The collection of information on morbidity and mortality and annual updating of cohort is being continued till date.

c. Operational Plan

The study team included both the medical and non-medical personnel. The non-medical personnel (Research Assistants – RA) were involved in the survey work of visiting each household for collection of information on vital events, morbidity and mortality and the medical personnel (Assistant Research Officers – ARO) for quality control purposes as well as for recording the cause of death.

One RA was allotted to cover one area. It was planned that each RA would visit his/her area and enquire and record all the information regarding morbidity, mortality and on pregnancy within the registered cohort since last visit. A detailed Proforma (Annexure- I) for recording the information on the immediate morbidity and mortality in the exposed and unexposed areas was developed. Information was collected from the “Head” or from “senior member” of the household. If any member was ill, his/her name, identification number and details of the morbidity and other information regarding hospitalization etc. were recorded. The morbidity data was collected on the basis of symptoms. A list of 40 symptoms (see Annexure-I) was provided to RA for recording the morbidity. Similarly, if any death had occurred in the household, the date, month, year of death along with cause of death were recorded. The International Classification of Diseases was followed for coding the cause of death. All these families were followed up by the ARO to verify and confirm the cause of death. A built-in mechanism was followed for checking the information generated by the RA.

The RA submitted, completed proforma on weekly basis to the statistical unit for scrutiny. The data received at the statistical unit were being scrutinized within a week. All the discrepancies observed were listed and the Proforma needing any correction were kept separately. A weekly meeting was arranged with the Principal Investigator along with RAs, AROs, computer and statistical staff to discuss the problems, if any, encountered in the study. All the proformas with any discrepancies were discussed and necessary corrections if needed were

carried out or the proformas requiring corrections at field level were returned. The data were manually analyzed and report was prepared and presented.

In addition to the "Statistical Unit", a separate unit named "Data Base Information System" was started. The Data Processing Unit in addition to providing support to epidemiological study was the main source for providing appropriate sample for other studies and for preparation of data files of these studies for analysis along with report preparations.

Six community health clinics were set up in the study area, which were managed by the AROs. These clinics were situated in both affected and in the unaffected areas. Five clinics were established in exposed and one in unexposed area. The objectives of these clinics were:

i) To develop rapport with the persons in the selected area.

ii) To provide primary health care including treatment of common ailments to the registered cohort and to maintain records.

iii) To refer cases for specialized investigations and treatment to referral hospitals.

iv) To collect and maintain additional information on morbidity pattern through the clinics.

v) To assist various investigating teams in identifying the requirements of exposed and unexposed persons.

vi) To assist in the maintenance of cohort for long-term study.

vii) To monitor health problems on the registered cohort.

d. Validation of the data

The Assistant Research Officer (Med.) was to check on 100% of the work carried out by RA's in their respective areas. The families with morbidity were visited by Assistant Research Officer (Med.) to verify the recording of the RA for the accuracy of morbidity data. All the families where death was recorded during the visit of RA were followed up by ARO to find out the cause of death. The International Classification of Disease was followed for coding the cause of death. 10% of the 'no morbid 'families reported by the Research Assistant was also to be verified by the Assistant Research Officer (Med.)

1. At the field level

a) The medical personnel verified hundred percent of the work carried out by RAs in the respective area.

b) The families with morbidity were visited by the medical personnel to verify the recording of the RA for the accuracy of morbidity data.

c) 10% of the families given as no morbid were also verified.

d) Field work by Principal Investigator

e) All the families where deaths and births and morbidity were reported by the RA during their field visit was 100 percent verified and the cause of death was noted down by the medical personnel following the code of International Classification of Disease.

2. At the pre-analysis level

a) Once the data were collected from the field it was submitted in the statistical division of the institute.

b) Here the data was thoroughly scrutinized for any discrepancy, lack of information, consistency.

c) If there was any discrepancy the data was returned to the field for necessary correction.

d) After the scrutiny the data was manually analyzed and further sent to the computer section.

3. At analysis level

a) After the data was received at computer section it was entered into computer for analysis.

b) The data was also rechecked for any duplication of information.

c) After going through this procedure the data was analyzed

The operational aspect and validation of the project continues to be carried out by 90% of the same staff which was present at the time of initiation of the project.

HIGHLIGHTS

Summary, Recommendations & Conclusions of Technical Report on Population Based Long Term, Epidemiological Studies 1985-94

1. It was concluded that the Bhopal Gas Disaster was the worst industrial accident of the world occurred on the night of 2nd& 3rd December 1984 in Bhopal.
2. It was estimated that of the total population of Bhopal over 800,000 and about 500,000 were exposed to the toxic gases, out of the total population nearly 160,000 lac people present within a radius of 3 Km. from the factory, were exposed presumably to higher concentration of gas and also perhaps for a longer period of time.
3. In the campus the number of deaths occurred and 85% of these deaths, occurred in the first three days.
4. Of the survivor populations large number suffered from multi-system morbidities, particularly the respiratory, ophthalmic and gastrointestinal systems.
5. With passage of time, the prevalence rates and intensity of clinical signs and symptoms gradually decreased. However, even after 5 years of the toxic gas exposure several thousand attended the hospital and clinics daily for seeking medical relief.
6. The Technical Report opined that the mortality and morbidity caused by the toxic gas(es) inhalation was a onetime acute injury to the respiratory track and the ophthalmic system and often healed with resolution of necrosis and fibrosis, but did not lead to progressive pulmonary or ophthalmic diseases leading to blindness.
7. People with pre-existing lung diseases (presumed at least 5% in any population) or smokers, after gas exposure would have suffered more than those who were healthy before the exposure.

Expert Epidemiological Group

During 25 years of its operation, the study gathered huge amount of data and it becomes a very difficult task to review data of about 44 visits visually and intellectually through single table. Hence it was decided to take the opinion of Expert Epidemiological Group which after deliberations advised to analyze the data under the following guidelines.

1. Analysis to be undertaken for 1986, 1991 and 1996 onwards on yearly basis. Reduction in morbidity over the time is to be highlighted in four areas in addition to present morbidity rates.
2. Comparison of age and sex distribution at aforesaid different points of follow- up to be attempted across all areas.
3. The morbidity pattern to be presented for system specific morbidity.
4. Morbidity analysis to be considered with present age of cohort.
5. The symptom wise analysis to be undertaken based on GI symptoms.
6. The study undertaken after 1986 to compare with 0-4 years of 1986, ten years hence to compare with 10-14 of 1986 and like- wise for other age groups.
7. The analysis also should take into consideration, migration of population providing the details of migration in the appendix.
8. Those individuals who were not symptomatic/not morbid at the time of event but became morbid at some point of time in later years to be explored for analysis.
9. Age specific mortality rate to be considered for the analysis taking into account the age at death.
10. Specific mortality analysis by taking into account age at death.
11. The consistent color quotes to be adopted in representing the mild, moderate and severe area data in graphs in all parts of the report.
12. The characteristics of the sample which was available for follow-up throughout during 1986-91 and 1996-2010 to be documented and compared with the total samples. Also the morbidity pattern of this sample to be analyzed separately.

e. Over view of the presentation

Data of the study has been presented under four headings namely cohort progression, demographic and socio-economic profile, mortality including pregnancy outcomes and morbidity profile.

i. Cohort progression-1985-2010

To recapitulate it is being mentioned that a cohort of 80,021 in affected and 15,931 in control area was assembled in 1985. Over the years since 1985 this cohort experienced population loss following various factors like population movement.

ii. Demographic and socio–economic profile

To understand the socio-economic variables like religion, education, occupation, smoking, use of alcohol, tobacco chewing habits, type of houses, nature of family, smoke outlet facilities, cattle-shed, latrine, kitchen, disposal of animal and human excreta, protection of food and dietary habits etc. were being collected. All these factors directly or indirectly presumed to have impact on morbidity pattern. Main socio-demographic variables for the year 1996, 2006 and 2010 have been presented.

iii. Mortality

The mortality rates for each calendar year from 1996 to 2010 are presented by age wise manner.

iv. Pregnancy outcome

The pregnancies and their outcome for calendar year up to 2010 are also presented. In Table -30.

v. Morbidity

As mentioned earlier, only the persons registered in the baseline cohort were included for analyzing the data on morbidity. The analysis was carried out as cross-sectional morbidity rates for the persons enumerated at each of the follow-up points of time. All the households contacted and the persons residing in the households were included for estimating the morbidity rates. The numerator included those who were morbid on the day of survey and the denominator included those who were enumerated and available as residents in the household on the day of survey. The details of morbidity by age and sex for each of the morbidity are presented in this report.

IV. OBSERVATIONS

At the outset it is very important to note that this long-term follow-up study is one of the rarest studies which continued over a long span of the time and still continuing till date, almost 27 years after the disaster. During this period, the study went through three administrative changes i.e. initially it was conducted through a project supervised by Indian Council of Medical Research till December 1994, then it was continued under Center for Rehabilitation Studies under Department of Bhopal Gas Tragedy and Rehabilitation Govt. of M.P. till 2011 and since then it again came to National Institute for Research in Environmental Health under Indian Council of Medical Research. It is natural for such long-term study to lose some part of the cohort due to various reasons like migration, deaths, non response etc.

Before making observations on collected data it would be pertinent to recapitulate the findings noted in earlier technical report of the project for the period 1985-1994. Observations mentioned below which have been taken verbatim from chapter VI: summary, recommendations and conclusions. [10]

i) Soon after the gas disaster, 36 wards having population of 521,262 (62.6%) were found to be exposed and affected, while 20 wards with a population of 311,642 (37.4%) were found to be unaffected by the gas.

ii) On the basis of average death rates in the exposed/affected areas, the latter were categorized into: severely exposed/affected average death rate of 22/1000, moderately exposed/affected area average death rate of 1.33/1000, and mildly exposed/affected with average death rate of 0.20/1000. The unexposed/unaffected area was categorized as the control area. In the text, these areas are often referred to simply as severe, moderate, mild and control area.

iii) Age and sex distribution of the population of "affected" as well as "control" areas were almost similar comparable to national population pyramid.

iv) A noteworthy feature was that the "death rates" were higher in the "exposed areas", than in the "control areas" throughout the ten years period of observations.

v) The "Gas exposure" particularly in the severely affected area showed higher mortality in the initial years, which gradually declined and nearly touched "local" or "national levels". Deaths in the exposed area were mainly due to respiratory disorders throughout the period of observations. Death rates were higher in the age group of 45 years and above.

vi) Another notable feature was the "pregnancy rate", which is generally associated with disasters in general. The rate was high till 1986 – 87 and gradually declined over a period of time. Likewise, by 1989 the "abortion rate" in the affected areas, which was initially 12%, declined to about 7.5%, as against 1.4% in the control area.

vii) General morbidity as well as that traceable to respiratory or ophthalmic morbidity, based on the symptomatology reported by the patients or the responsible family members, was observed to be consistently higher in affected areas as compared with the control areas. The "immediate" morbidity was about 95-97% for both pulmonary and ophthalmic involvement.

a. Cohort

In 1985 when study was conceived, acute effect of toxic gas release were studied on a cohort of 80,021(26,382, 34,964 and 18,675 from severely, moderately and mildly affected localities) along with a control population of 15,931. However, when study was actually started in 1986, a population of 19,260, 28,261 and 15,185 from severely, moderately and mildly affected area respectively and 13,526 from control area could be contacted for study. Of the actually available cohort of 62,706 from affected area and 13,526 from control area in 1986, only 5,658, 6,533 and 4,669 from severely, moderately and mildly affected area respectively (total-16,860) and 5,741 from control area were actually available for study in 2010.

Table-4
AGE WISE DISTRIBUTION OF COHORT(YEAR- 1986 -2010)

SEVERE AREA

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	1550	8.04	5610	29.12	9707	50.39	2050	10.64	343	1.78	19260
1991			2208	27.36	4597	56.96	952	11.80	313	3.88	8070
1996			1084	10.02	7404	68.46	1783	16.48	545	5.04	10816
2001				-	5054	73.30	1390	20.16	451	6.54	6895
2006					3242	41.17	1296	16.46	423	5.37	4961
2010					3278	57.94	1749	30.91	631	11.15	5658

MODERATE AREA

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	1940	6.86	8171	28.91	14372	0.90	3172	11.22	596	2.11	28261
1991			3208	24.39	7711	8.64	1743	13.25	488	3.71	13150
1996			1178	8.35	9799	69.45	2436	17.07	724	5.13	14137
2001					7100	72.51	1979	20.21	713	7.28	9792
2006					3736	64.06	1567	26.86	531	9.10	5834
2010					3811	58.35	1955	29.92	767	11.73	6533

MILD AREA

Years	0-4	%	05-14	%	15-44	%	45-64	%	65+	%	Total
1986	967	6.37	3873	25.50	8249	54.04	1688	11.11	408	2.70	15185
1991			1561	22.45	4166	59.93	929	13.36	296	4.26	6952
1996			752	7.89	6596	69.26	1652	17.34	527	5.53	9527
2001					4383	70.98	1351	21.88	442	7.16	6176
2006					2950	61.30	1426	29.62	438	9.10	4814
2010					2467	52.86	1643	35.19	559	11.97	4669

CONTROL AREA

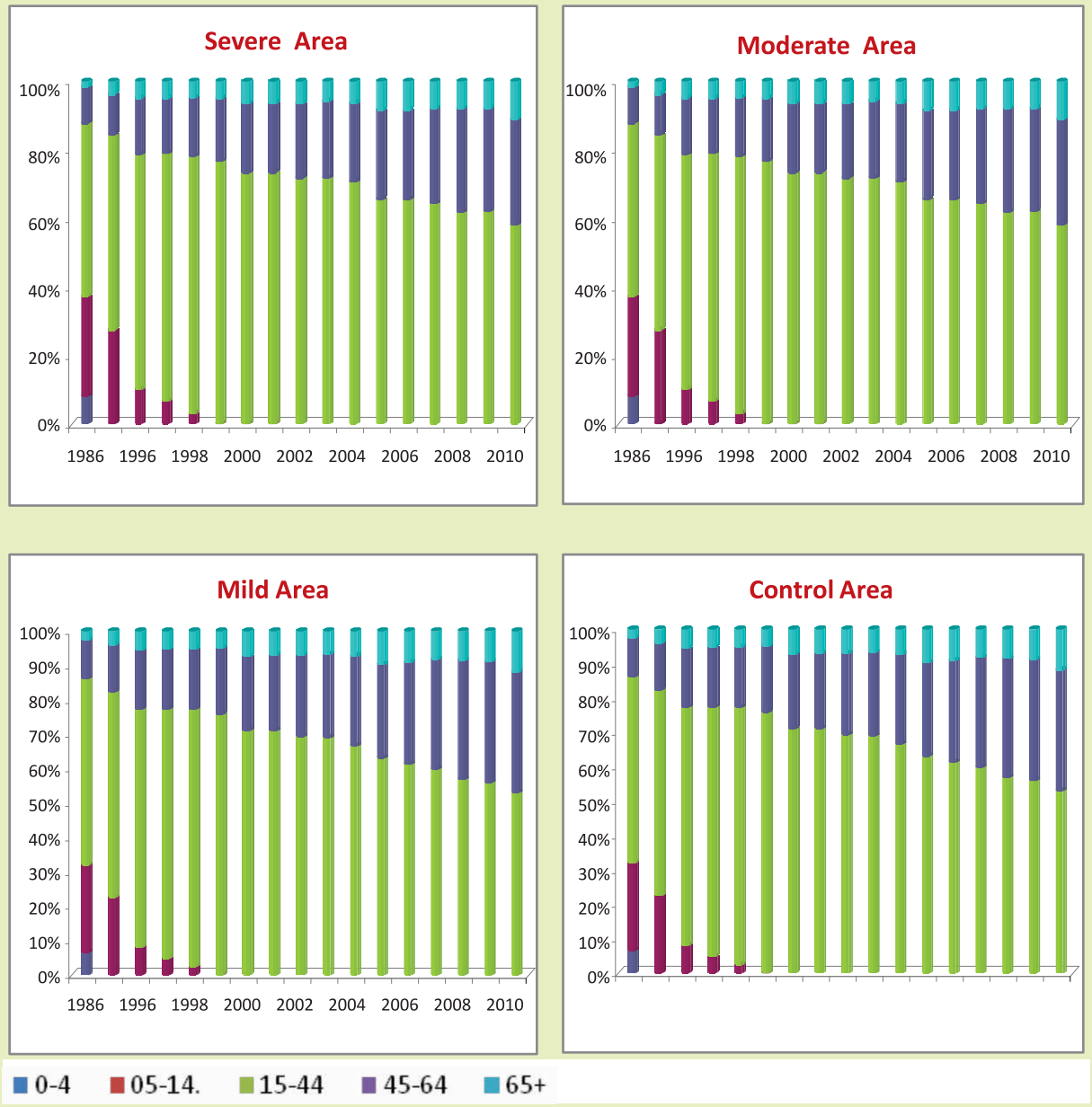
Years	0-4	%	05-14	%	15-44	%	45-64	%	65+	%	Total
1986	1032	7.63	4032	29.80	7092	52.43	1145	8.47	225	1.66	13526
1991			2128	26.90	4641	58.67	887	11.21	255	3.22	7911
1996			787	9.85	5602	70.11	1285	16.08	316	3.95	7990
2001					3706	72.20	1183	23.05	244	4.75	5133
2006					3344	62.66	1639	30.70	355	6.65	5338
2010					3182	55.42	2000	34.84	559	9.74	5741

For the details see table no 12 to 15 in Annexure

Table No. 4 gives the consolidated data on age wise distribution of cohort for period 1986 to 2010 for three affected areas and control area. Over the years as study progressed there was a natural shift in age groups with passage of time. By 1999 only three age groups i.e. 15-44, 45-64 and 65+ remained available for the follow- up in affected as well as control area, The details of which are presented in tables 12 to 15.

From the Table-4 and figure 2 it can be deduced that proportionate distribution of the population among the available age groups in all the areas fluctuates within the narrow range.

Figure : 2. Age wise distribution of cohort (1986-2010)



a-i. Sex wise distribution of cohort

Initial (1985) and mid- decadal analysis of the cohort in 2006 revealed that age and sex distribution of the affected and control population participated was similar from the angle of proportion of population in affected and control area in both sex in terms of percentage at three different points of times namely 1985, 2006, 2010. The details of the same have been represented in table 16 to 19 in Annexure.

Table 5
Sex wise distribution of the cohort Population over the years

	Severe	Moderate	Mild	control
Year	n/ (M%:F%)	n/ (M%:F%)	n/ (M%:F%)	n/ (M%:F%)
1985	26382/ (53.09:46.91)	34964/ (52.75:47.27)	18675/ (52.02:47.98)	15931/ (53.83:46.18)
2006	4961/ 49.9%:50.10%	5834/ 50.87:49.13%	4814/ 48.87%:51.13%	5338 51.70%:48.30%
2010	5658/ 49.78%:50.22%	6533/ 50.16%:49.84%	4669/ 49.19%:50.8%	5741/ 51.69%:48.31%

For the details see table no 16 to 19 in Annexure, n denotes total Numbers ,
M = Male, F= Female

b. Socio-Economic Profile

Religion:- During 1985, 73.92% Hindu Community represented in severely affected area whereas in 2010 only 47.50% have participated. Similarly in moderate area instead of 35.05% they have increased to 44.14% whereas in mild area from 40.08% it has come to 36.57%

Muslim Community represented 25.49% during 1985 whereas in 2010 they are in 52.15 percent in severely affected area. In moderate area, their participation was reduced from 62.5% to 52.85%. In mild area from 58.20% to 62.46% In control area it has dropped from 7.55% to 4.22%.

There is a cross reduction in the participation of other religions namely Christian, Sikh and others uniformly in affected and control area.

i. Education status: it was found that over the period of 1985-2010 educational status has increased in affected as well as control area. Proportion of illiterates has gone down (example in severe area from 60.85% to 22.71%) in all areas. Proportionately literacy has increased up to secondary level, while there is little change at collegiate and technical education level (Table no.- 20,20A).

ii. Socio-economic class and per capita income: it has been observed that between 1985 and 2010 there has been very significant improvement in per capita income in affected as well as control area 0.04% to 59.54%, in severe area, control area (Table no.-20 and 20A).

iii. Housing: In the year 1985 during base line survey it was observed that 71.79% in the severely exposed area have been living in Kachha House, while in year 2010 this proportion came down to 11.50%. Same pattern was observed in moderately and mildly exposed area as well. However, in control area in 1985 only 11.41% were living in pucca houses, this proportion increased to 35.19% in 2010.

IV. Tobacco Smoking: The study also tried to find out about the use of tobacco smoking, as it may be imparting confounding effect to respiratory morbidities and to cancers. It was found that over the period of 1985-2010 smoking was seen prevalent as 9.90 to 13.01% in affected area. The smoking habits appear to be increasing in affected area except in the severe area and the same is true for control area where it was increased from 6.62 to 13.98%.(Table no. 21) These finding are in agreement with the observations of the "Population Based Cancer Registry", which identified the higher rate of cancer in MIC affected area, was due to higher proportion of population consuming tobacco rather than due to the effect of MIC exposure per se.[11]

c. Mortalities

i. Annual Mortality

Mortality during post exposure acute phase (4th -31st December 1984) was very high i.e. 12.57/1000 for males and 11.6/1000 for females in severely affected area. The corresponding figures for moderate were 0.71and 0.56 and for mild 0.1 and 0.22. It was in sharp contrast to that observed in control area (0.35 and 0.41respectively).[12]

During 1985 to 1993 the annual mortality figures in severe area ranged between 7.4 -3.4 for males and 7.8-1.6 for females. For moderate area these figures ranged between 6.5-3.2 for males and 5.4-2.6 for females and in mild area 6.1-2.5 and 4.6-2.4 for females. In control area these figures ranged 3.9 and 1.9 in males and 4.2 and 1.9 in females. Generally a decreasing trend in death rate has been observed in all the areas. However, the death rates till 1993 and later were observed to be higher in affected area in comparison to control.[12]

Death rates observed between 1996 to 2010 bring out the fact that crude death rates were lower than the national crude death rates (2002 to 2009) (Table No. 6). However, death rates observed in 2010 reveal that except in severely affected area (5.48/1000) death rates were higher in mildly (8.25/1000), moderately (8.11/1000) and control area (6.1/1000) (Table 22). The reason being the higher ages representing more in the cohort follow-up and the respective age related issues irrespective of whether belong the affected area or control area. In fact during the year 2010, 90.91/1000 age specific mortality rate have been recorded in 85+ age group (Table. 27).

ii. Age specific Mortality

The mortally rates were very high during the acute phase. The mortality rate calculated for the period of 3rd to 6th December 1984 were 21.98 in severe, 1.33 in moderate and 0.29/1000 in mildly affected area. For period 4th -31st December 1984 these were 12.57/1000 for males and 11.6/1000 for females in severely affected area. Mortality rates showed a decreasing trend with passage of time throughout the study. In present study (1996-2010), mortality rates most of the times (2002-2009) less than the national crude death rate. Death rates observed between 2002-2009 bring out the fact that Mortality in all age groups has remained under national urban death rate for respective age groups in this respective year, except occasional and slight increase as mentioned in table no.6 and figure. no. 3.

Table-6
AGE SPECIFIC MORTALITY RATE DURING THE YEARS 2002 - 2009
AFFECTED AREAS

Years	2002		2003		2004		2005		2006		2007		2008		2009	
	National	CRS	National	CRS	National	CRS	National	CRS	National	CRS	National	CRS	National	CRS	National	CRS
0-4	10.3	0	10.2	0	10.1	0	10.3	0	17.7	0	9.6	0	9.1	0	8.7	0
05-9.	0.7	0	0.6	0	0.8	0	0.9	0	1.5	0	0.7	0	0.6	0	0.7	0
10-14.	0.7	0	0.8	0	0.6	0	0.7	0	1.0	0	0.6	0	0.6	0	0.5	0
15-19	1	0.83	1.3	**3.68**	1.2	0	1.3	0	1.6	0	1.0	0	1.1	0	1.0	0
20-24	1.5	2.45	1.3	0.89	1.3	0.66	1.6	1.41	2.1	0.65	1.5	1.29	1.7	**2.63**	1.2	
25-29	1.8	2.46	1.6	1.05	1.7	1.01	1.7	0.82	2.0	0.37	1.7	0.99	1.6	2.10	1.5	2.09
30-34	1.9	0.88	2.1	1.11	2.3	0.43	2.0	1.36	2.2	1.89	2.0	1.03	2.1	0.54	1.8	2.09
35-39	3.2	3.01	2.5	1.32	2.4	3.76	2.8	2.25	2.5	0.51	2.8	0.80	2.9	1.78	2.9	2.77
40-44	4.4	3.85	3.5	2.27	3.6	2.98	3.5	3.01	3.0	1.84	3.8	3.98	3.8	3.43	3.3	1.07
45-49	5.4	7.66	4.2	3.9	5.1	2.97	5.3	4.99	4.2	5.69	5.2	**6.27**	5.4	4.77	4.7	**5.16**
50-54	8.7	3.48	8.3	6.31	6.6	**13.35**	7.8	3.52	5.9	7.12	7.7	8.61	7.5	4.69	8.0	**9.38**
55-59	12.7	17.56	12.7	9.61	10.8	**15.07**	11.7	4.42	10.2	10.75	11.9	7.67	12.2	**15.60**	10.6	10.22
60-64	20.2	15.90	20.0	**26.56**	18.1	**21.05**	19.0	13.45	18.0	7.66	20.0	16.16	18.7	14.90	17.8	**28.70**
65-69	36.7	26.64	31.1	26.26	27.8	20.04	13.3	**32.68**	28.9	20.22	30.2	30.41	29.5	25.30	28.7	**38.40**
70-74	44.3	48.33	42.1	29.41	45.1	**48.78**	49.2	36.11	47.6	41.18	48.8	43.14	46.3	48.70	47.6	**58.6**
75-79	72.3	19.5	63.7	47.2	66.0	40.5	77.2	44.2	67.0	50.56	68.9	36.36	68.1	56.0	70.7	50.7
80-84	90.4	31.25	99.1	**112.36**	107.3	37.97	107.8	38.46	98.3	47.43	107.0	29.85	109.0	40.2	96.8	25.1
85+	178.5	18.87	154.9	43.48	183.8	51.47	176.9	17.05	188.6	28.41	198.7	37.31	186.2	20.1	177.0	36.6

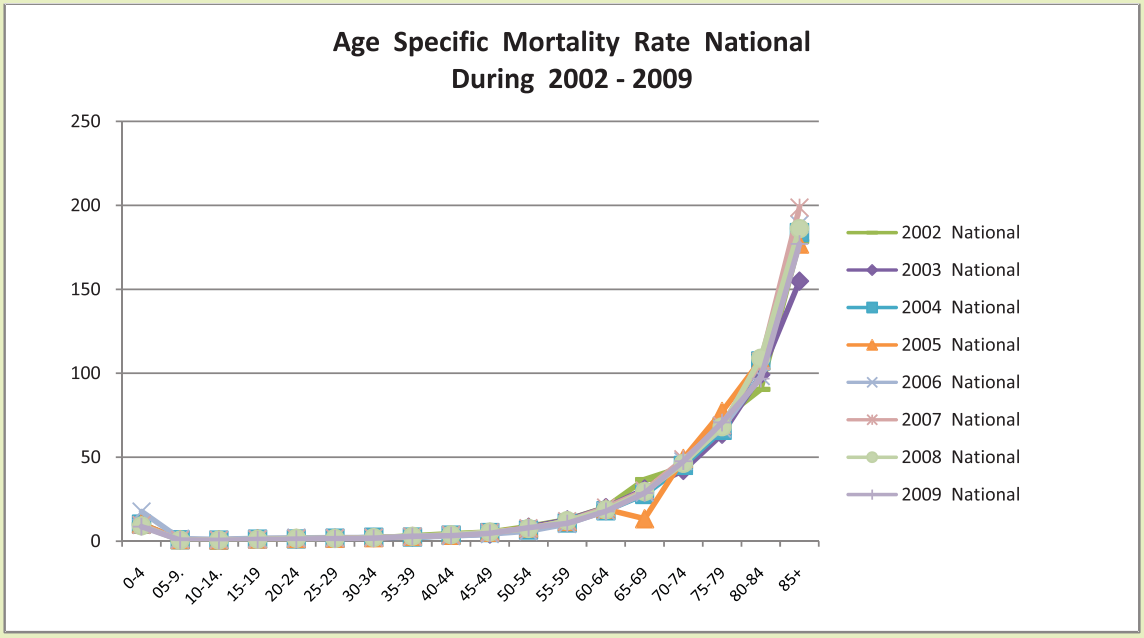
National indicates - National Urban Death rate
CRS indicates – Centre for Rehabilitation studies Data

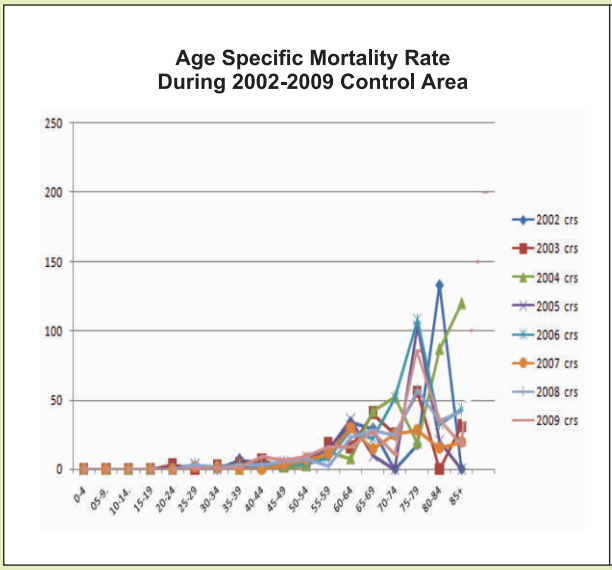
AGE SPECIFIC MORTALITY RATE DURING THE YEARS 2002 - 2009
CONTROL AREA

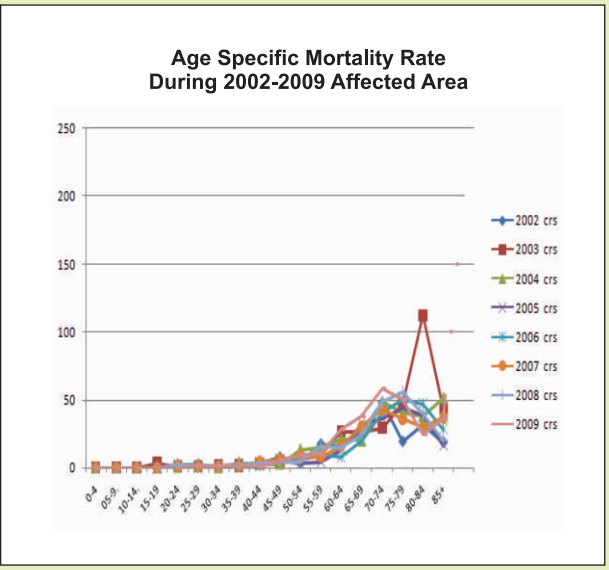
Years	2002		2003		2004		2005		2006		2007		2008		2009	
	National	CRS	National	CRS	National	CRS	National	CRS	National	CRS	National	CRS	National	CRS	National	CRS
0-4	10.3	0	10.2	0	10.1	0	10.3	0	17.7	0	9.6	0	9.1	0	8.7	0
05-9.	0.7	0	0.6	0	0.8	0	0.9	0	1.5	0	0.7	0	0.6	0	0.7	0
10-14.	0.7	0	0.8	0	0.6	0	0.7	0	1.0	0	0.6	0	0.6	0	0.5	0
15-19	1	0	1.3	0	1.2	0	1.3	0	1.6	0	1.0	0	1.1	0	1.0	0
20-24	1.5	0	1.3	3.27	1.3	0	1.6	1.72	2.1	-	1.5	-	1.7	-	1.2	-
25-29	1.8	0	1.6	0	1.7	2.51	1.7	2.88	2.0	2.99	1.7	1.88	1.6	3.69	1.5	0.91
30-34	1.9	0	2.1	2.06	2.3	2.04	2.0	0.0	2.2	1.46	2.0	1.18	2.1	1.22	1.8	0.98
35-39	3.2	7.16	2.5	4.12	2.4	0	2.8	2.68	2.5	3.86	2.8	-	2.9	3.45	2.9	1.63
40-44	4.4	4.2	3.5	6.76	3.6	1.66	3.5	2.28	3.0	1.83	3.8	-	3.8	3.59	3.3	9.65
45-49	5.4	4.5	4.2	2.05	5.1	2.04	5.3	4.61	4.2	3.29	5.2	3.29	5.4	5.63	4.7	6.75
50-54	8.7	6.54	8.3	2.62	6.6	2.79	7.8	8.33	5.9	4.32	7.7	7.21	7.5	7.30	8.0	9.22
55-59	12.7	9.26	12.7	18.35	10.8	12.99	11.7	14.23	10.2	8.43	11.9	11.05	12.2	2.46	10.6	16.63
60-64	20.2	33.9	20.0	15.8	18.1	7.69	19.0	36.1	18.0	28.30	20.0	29.91	18.7	23.15	17.8	15.87
65-69	36.7	29.41	31.1	40.54	27.8	41.67	13.3	9.9	28.9	22.73	30.2	14.39	29.5	28.17	28.7	27.03
70-74	44.3	0	42.1	25.64	45.1	52.63	49.2	0	47.6	51.28	48.8	25.32	46.3	24.39	47.6	11.5
75-79	72.3	17.86	63.7	55.56	66.0	19.2	77.2	103.45	67.0	108.11	68.9	28.57	68.1	57.1	70.7	85.7
80-84	90.4	133.33	99.1	0	107.3	86.96	107.8	20.41	98.3	32.26	107.0	15.63	109.0	35.1	96.8	35.7
85+	178.5	0	154.9	31.25	183.8	120	176.9	0	188.6	43.48	198.7	19.61	186.2	41.67	177.0	18.2

National indicates - National Urban Death rate
CRS indicates – Centre for Rehabilitation studies Data

Figure : 3. Age Specific Mortality Rate during 2002- 2009



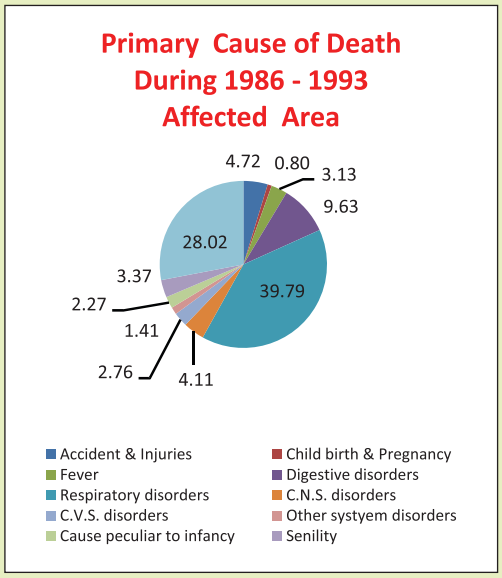


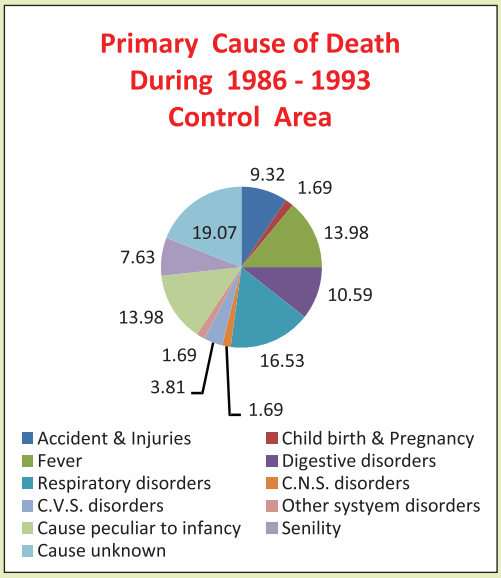


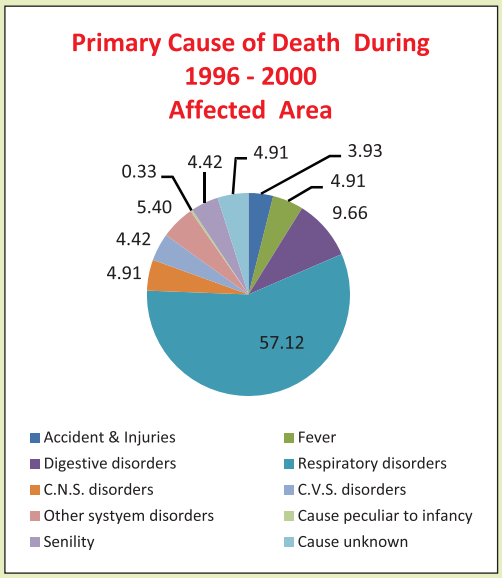
iii. Primary Cause of Death

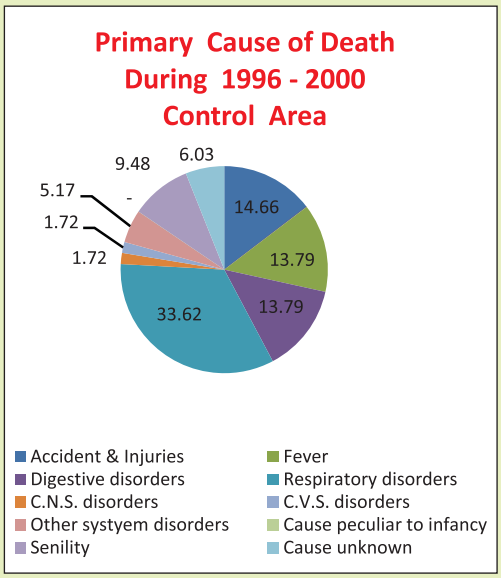
The information on causes of death was included since 1986: cause of death analysis is based on 3978 death records collected during 1986-2010. Between the periods of 1986 to 2010 most common cause of death was observed to be respiratory in affected area followed by digestive and cerebro-vascular disorders. In control area too respiratory disorders were the most common cause of death though with lesser frequency, followed by digestive disorders and fever (Table no 22-26).

Figure : 4. Primary Cause of Death during 1986-2010.

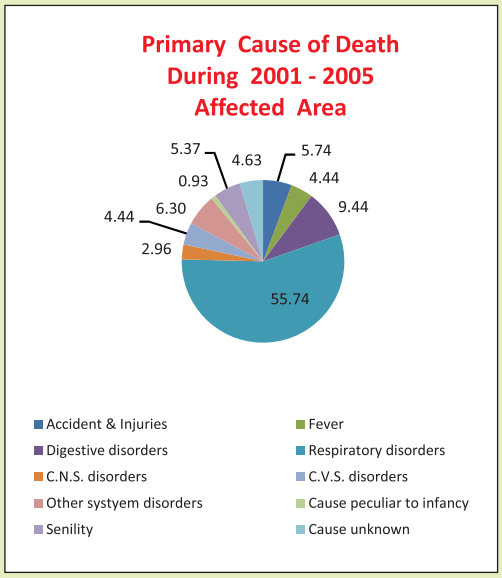


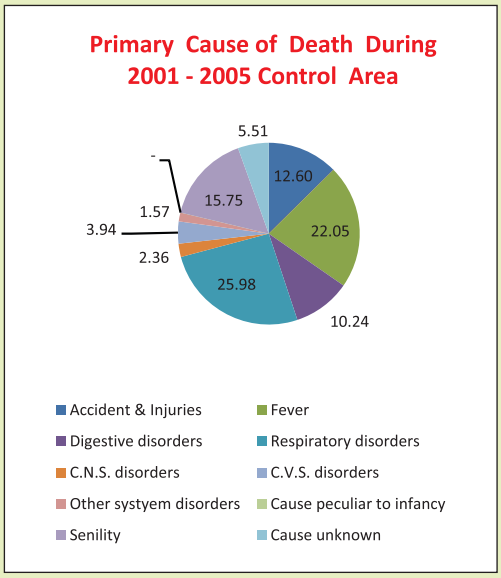


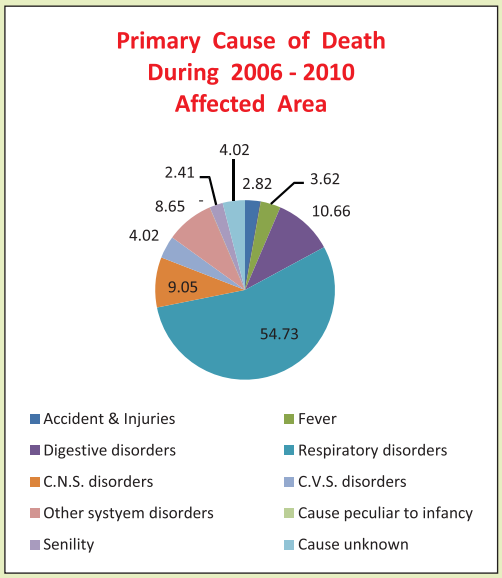


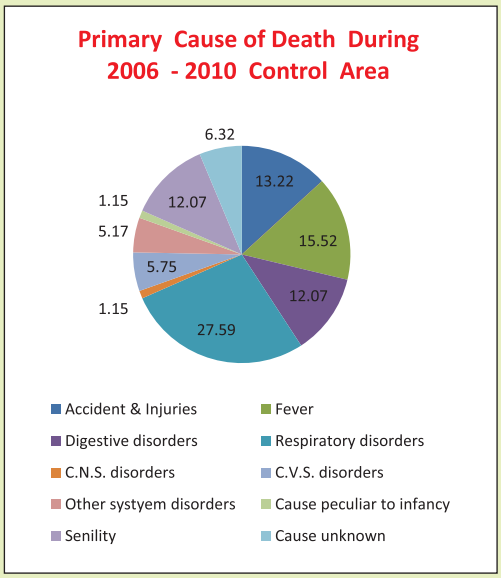


Cont.... Figure : 4.









iv. pregnancy outcome

During the initial survey carried out in Feb-March 1985, a separate "card" was adopted to collect the information on outcome of pregnancy. The pregnancy status of all married women in the age group 15-49 years along with the pregnancy outcome was also recorded during survey in August-October, 1985. Since January-December, 1986 a different format was introduced to collect detailed information on pregnancies through fortnightly visits of the families. From the year 1987 onward, these data were collected through six monthly follow-up of the families. It can be seen that immediately after the disaster, in the severely affected area, the abortion rate was 523 per 1000 (Table-36 in annexure Technical Report, 1985-1994).The abortion rate showed a decreasing trend from severely to mildly affected area. In the subsequent years there was a declining trend in the abortion rate in all the exposed area. In the control area abortion rate for December 1984 was 83 per 1000. No clear pattern was observed in the exposed area with regard to still birth rates.[18] From the year 1996 onward, these data were collected through six monthly follow-up of the families. The data for the year 1996-2010 is presented in Table 30 in annexure, however due to scarcity of data no clear pattern could be interpreted.

d. Morbidities

As mentioned earlier during the surveys information on morbidities were collected through a proforma enquiring about the forty symptoms. These symptoms were further re-grouped under the following systems:

Systems (morbidities) with their codes (Annexure –I):

1.	General Morbidities	-	Over all morbidities
2.	Respiratory	-	1, 2. 3, 4, 5, 28
2.	Ophthalmic	-	19, 20
3.	Gastrointestinal Tract	-	16, 17, 18, 22, 25, 31, 39
4.	Skin	-	23

i. Acute Stage Morbidities

During acute stage in all the three exposed areas 96-99% had both eyes and lung symptoms, while 74% suffered with gastrointestinal symptoms in severely exposed area, whereas in moderate and mild area it was 48% and 14% respectively. Morbidity related to skin was among 1.2% in exposed area. The control area had very low morbidity during the same period (Table 7-11).

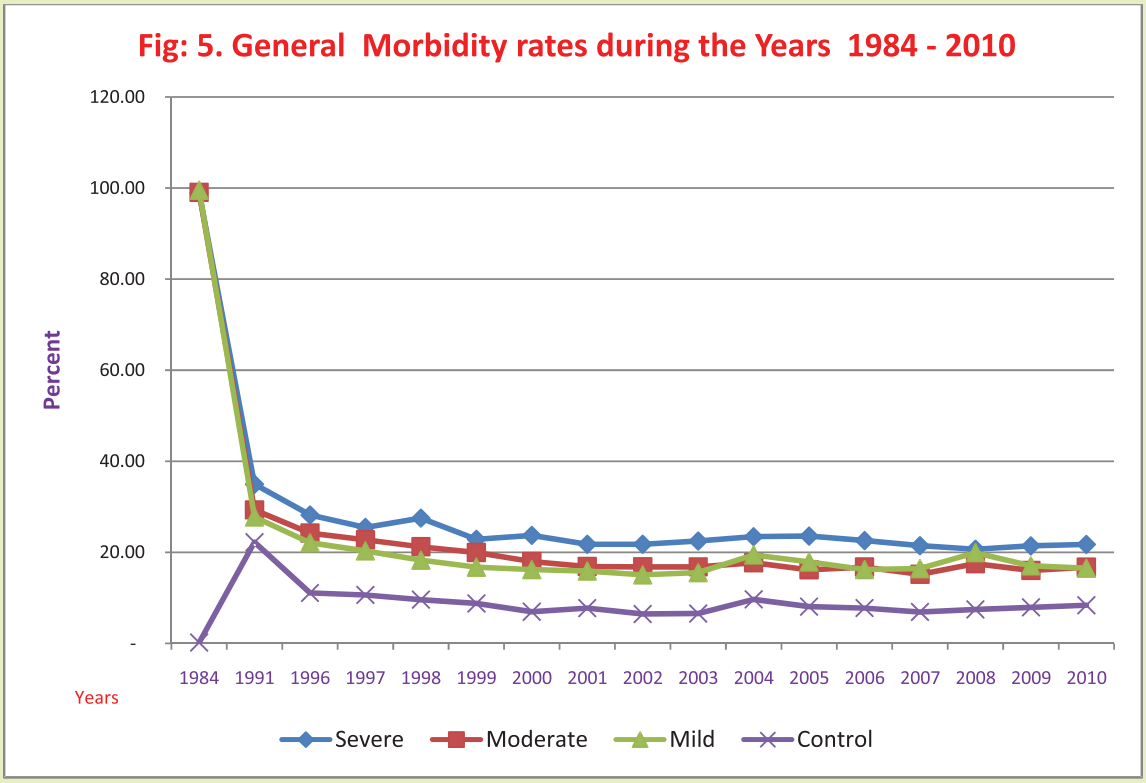
ii. General morbidities

Immediately after the disaster the morbidities were very high to the extent of 98.99%, 99.05% and 99.54% in severely, moderately and mildly affected area. Morbidity rate in all areas indicated three distinct trends indicating a low rate up to the survey during May 1988 to November 1988 later an increased trend up to survey in November 1990 to may 1991 and afterward a decrease. By six years post disaster in 1991 these morbidities came down to 34.94%, 25.88% and 27.77% in the same areas and showed further decline to 28.20%, 24.23% and 22.11% in respectively. There was further decline in all the areas. By 2001 general morbidities came down to 21.76%, 16.88% and 15.90% in severely moderately and mildly affected area. Since 2006, general morbidities have been seen fluctuating between 22.58% to 20.66% in severely affected area, 16.02% to 17.49% in moderately affected area and 16.22% to 19.93% in mildly affected area. However, these were higher than morbidities seen in control area which continued to fluctuate between 6.54% to 10.63% since 1997.

Table 7
General Morbidities (1984-2010)

AREA	SEVERE			MODERATE			MILD			CONTROL		
YEARS	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
	Cont.	Morbid		Cont.	Morbid		Cont.	Morbid		Cont.	Morbid	
1984	24994	24743	98.99	33442	33127	99.05	18208	18126	99.54	15616	27	0.17
1991	8070	2820	34.94	13150	3404	25.88	6952	1931	27.77	7911	1758	22.22
1996	10816	3050	28.20	14137	3426	24.23	9527	2106	22.11	7990	884	11.06
2001	6895	1500	21.76	9792	1653	16.88	6176	982	15.90	5133	397	7.74
2006	4961	1120	22.58	5834	978	16.76	4814	781	16.22	5338	414	7.76
2010	5658	1229	21.72	6533	1093	16.72	4669	772	16.53	5741	480	8.36

For details see Table no. 31 in annexure



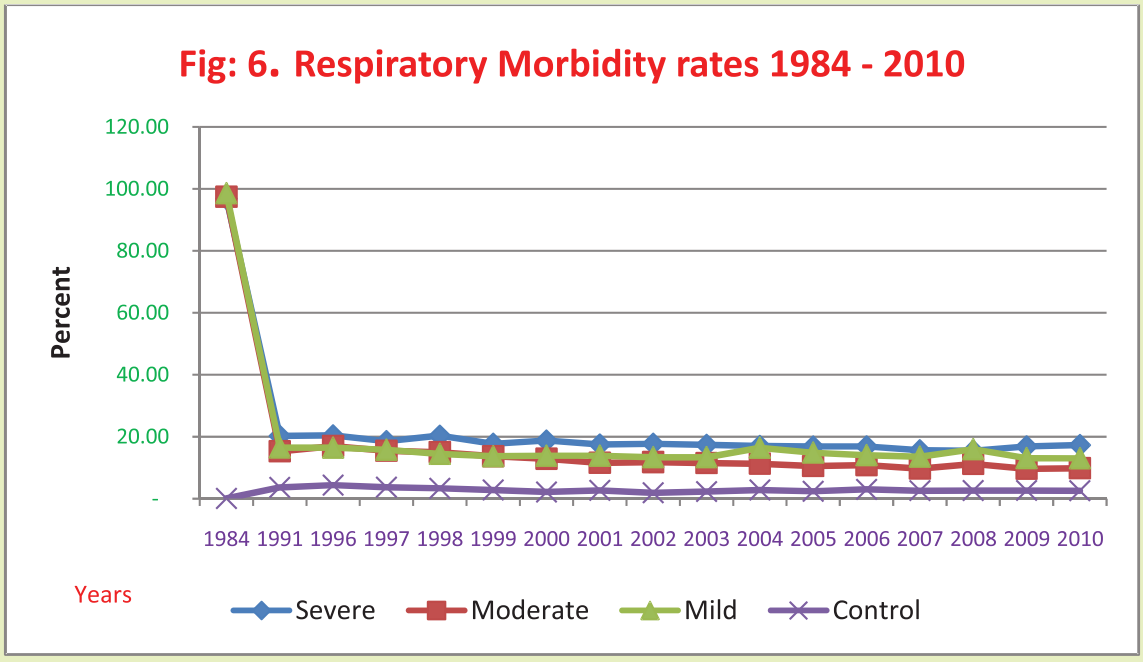
iii. Respiratory Morbidities

Table 8
Respiratory Morbidities (1986-2010)

AREA	SEVERE			MODERATE			MILD			CONTROL		
VISITS	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%
1984	24994	24213	96.87	33442	32802	97.45	18208	17958	98.62	15616	10	0.06
1991	8070	1632	20.23	13150	2012	15.30	6952	1147	16.49	7911	288	3.64
1996	10816	2207	20.41	14137	2402	16.99	9527	1568	16.46	7990	349	4.37
2001	6895	1202	17.43	9792	1133	11.57	6176	856	13.86	5133	136	2.65
2006	4961	835	16.83	5834	630	10.80	4814	675	14.02	5338	160	3.00
2010	5658	978	17.29	6533	641	9.81	4669	608	13.02	5741	147	2.56

For details see Table no. 32 in annexure

During acute stage 96.87% suffered with respiratory morbidities. In the severe area, the morbidity specific to lung for males was higher in all the follow-up periods compared to other two exposed and control area. Up to November 1988, there was no pattern in severe area, while in May 1991 there was an increase and later on a fall was noticed. The Respiratory morbidities came down from 96.87% in 1984 to 20.41%, 16.99%, and 16.46 % in severely, moderately, mildly affected area in comparison to 4.37% in control area. Since 1997, these morbidity rates are seen fluctuating between 20.31%-15.42% in severely, 15.43%-9.63% in moderately 16.41%-13.02% in mildly affected area. These respiratory morbidity rates remained high in all affected areas in comparison to control area (0.06%-4.37%) throughout 1984-2010.



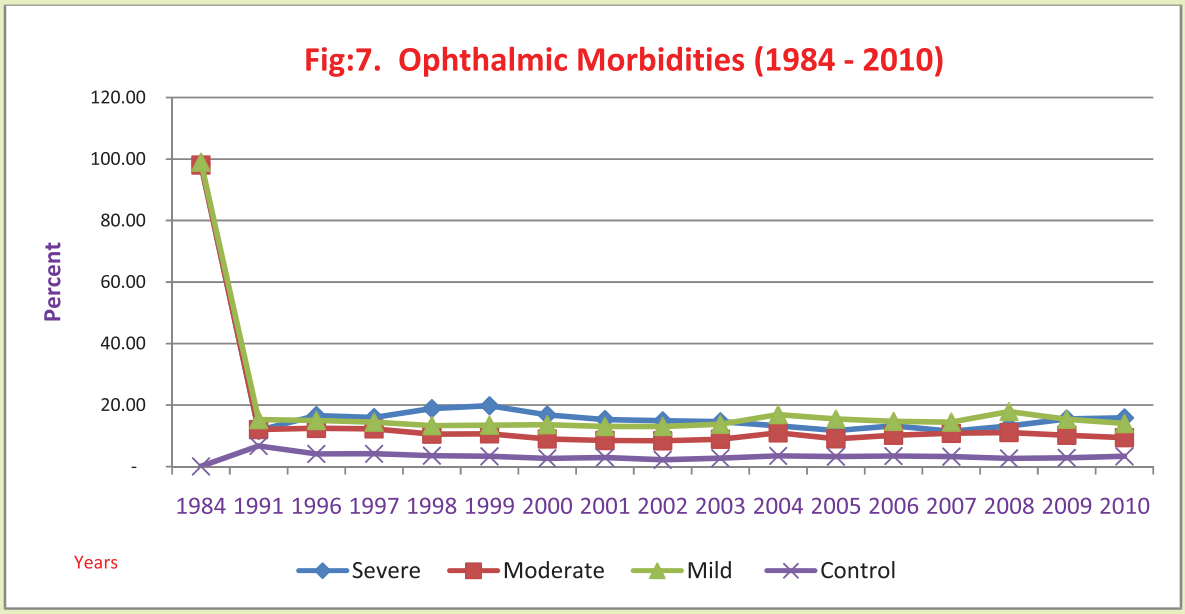
iv. Ophthalmic Morbidities

During acute phase in 1984 affected area experienced 98.50%, 98.08% and 99.00% ophthalmic morbidities in severely, moderately and mildly affected area respectively in comparison to 0.07% experience by control area population. By 1996, ophthalmic morbidity rate came down to 16.60%, 12.41% and 14.98% in the same areas in comparison to 4.31% observed in control area during the same period. These rates declined further and have been seen fluctuating between 11.46%-15.85% in severely affected area, between 9.00%-11.07% in moderately affected area and 13.99%-17.89% in mildly affected area in comparison to 2.84%-3.43% in control area during 2005-2010.

Table 9
Ophthalmic Morbidities (1984-2010)

AREA	SEVERE			MODERATE			MILD			CONTROL		
YEARS	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%
1984	24994	24621	98.50	33442	32802	98.08	18208	18027	99.00	15616	11	0.07
1991	8070	950	11.77	13150	1583	12.03	6952	1062	15.27	7911	533	6.74
1996	10816	1795	16.60	14137	1754	12.41	9527	1428	14.98	7990	330	4.13
2001	6895	1055	15.29	9792	831	8.48	6176	804	13.02	5133	153	2.98
2006	4961	656	13.22	5834	595	10.20	4814	708	14.71	5338	183	3.43
2010	5658	897	15.85	6533	614	9.39	4669	653	13.99	5741	193	3.36

For details see Table no. 33 in annexure



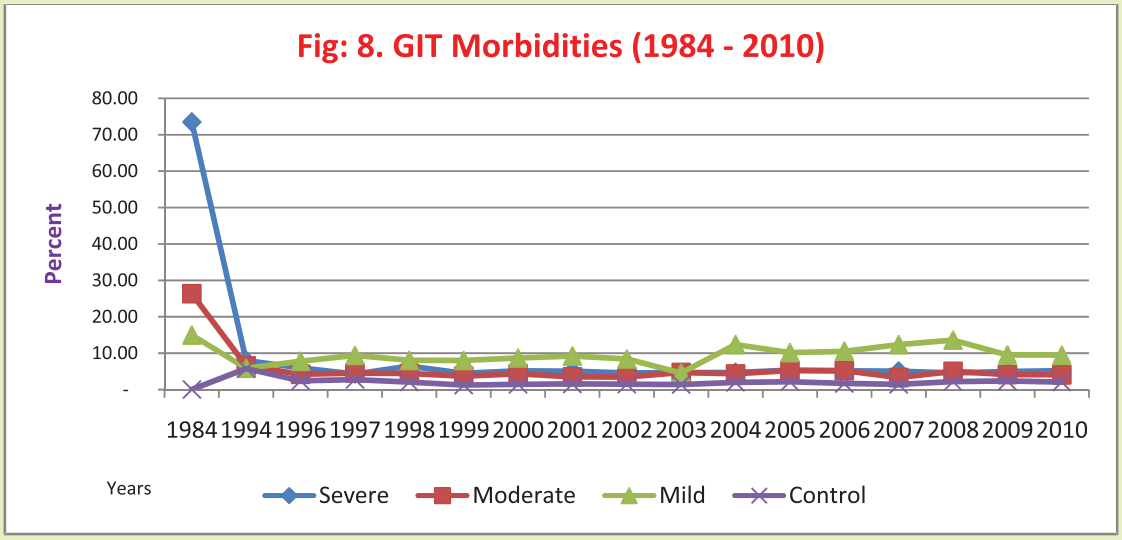
v. Gastrointestinal morbidities

During acute phase in 1984, 73.53%, 26.36% and 15% suffered with gastrointestinal morbidities in severely moderately and mildly affected areas in comparison to 0.01% in control area. However, within five years by 1991, these morbidity rates fell down to 7.99%, 6.52% and 5.88% in the same areas in comparison to increased Gastrointestinal Morbidity rate of 5.80% in control area. Later since 1996 to till date, Gastrointestinal morbidity rates have been seen fluctuating 6.48%-4.49%, 5.21%-3.29% and 4.56%-13.61% in severely, moderately and mildly affected area in comparison to 1.24%-2.77% in control area. The peaks of rise in morbidity rates in mild area were further analyzed and it was found that these peaks noticed in mild area were due to excessive reporting of symptom like abdominal pain (Symptom no 17) and gastritis (Symptom no 31).(Table no. 35-38 in annexure)

Table 10
GASTROINTESTINAL TRACT (GIT) MORBIDITIES (1984 – 2010)

AREA	SEVERE			MODERATE			MILD			CONTROL		
YEARS	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
	Cont.	Morbid		Cont.	Morbid		Cont.	Morbid		Cont.	Morbid	
1984	24994	18379	73.53	33442	8817	26.36	18208	2733	15.00	15616	3	0.01
1991	8070	645	7.99	13150	857	6.52	6952	409	5.88	7911	459	5.80
1996	10816	649	6.00	14137	596	4.21	9527	743	7.80	7990	193	2.42
2001	6895	351	5.09	9792	345	3.52	6176	569	9.21	5133	81	1.58
2006	4961	256	5.16	5834	303	5.19	4814	508	10.55	5338	90	1.69
2010	5658	295	5.21	6533	265	4.06	4669	442	9.47	5741	119	2.07

For details see Table no. 34 in annexure



vi. Skin morbidities

Skin morbidities were observed in less than 1.82% in all area during acute phase observed in 1984, during acute phase no morbidity was reported in control area. Morbidity rates were marginally higher in all areas including control in 1996 which later except one peak in 1998 (2.24%) in severe area remained at the level or less than 1.63% in severe area and less than 1% in all areas including control. Since 2007 to till date even in severely affected area skin morbidity rate remained under 1%.

Table 11
SKIN MORBIDITIES (1984 – 2010)

AREA	SEVERE			MODERATE			MILD			CONTROL		
YEARS	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
	Cont.	Morbid		Cont.	Morbid		Cont.	Morbid		Cont.	Morbid	
1984	24994	321	1.28	33442	610	1.82	18208	163	0.89	15616	0	-
1991	8070	189	2.34	13150	260	1.97	6952	60	0.86	7911	109	1.37
1996	10816	146	1.35	14137	101	0.71	9527	49	0.51	7990	29	0.36
2001	6895	73	1.06	9792	42	0.43	6176	8	0.13	5133	16	0.31
2006	4961	58	1.17	5834	34	0.58	4814	4	0.08	5338	14	0.26
2010	5658	50	0.89	6533	26	0.39	4669	26	0.56	5741	17	0.29

For details see Table no. 39 in annexure

vii. Age specific Morbidities

In all affected areas morbidities increased with increase in age. As age is a confounding factor for increase in morbidities. And the same has been observed in control area as well (Table no.40-43. in annexure)

V. DISCUSSION

a. The Backdrop

The Bhopal Gas Disaster (BGD) which occurred on the 2nd/3rd December, 1984 as a result of escape of 40 tons of a highly toxic liquid in a gaseous form along with other reaction products led to unprecedented damage to environment, and loss to lives both of animals (1000) and human beings (2000) within first 72 hours.

Besides, the immediate loss to human lives as stated above it was believed that the toxicants released during the accident may have long-term effect on human health and its different physiological subsystems like respiratory, ophthalmic gastrointestinal, skin, mental health, growth and development including dentition. It was also feared that the toxicants may have effect on fertility pattern, pregnancy and pregnancy outcome and even on the progeny of the gas victims in form of congenital malformation. Besides this toxicants may lead to damage at microcellular, cellular level thus leading to emergence of cancers among the affected population.

Looking at above, Indian Council of Medical Research in association with Institutes of national prominence and research scientists of international and national reputes developed about 20 studies, whose reports have been published from time to time elsewhere.

One of the above mentioned studies was titled as “long term epidemiological studies on the health effects of toxic gas exposure through community health clinics” this study was conceived immediately after the toxic gas leak in 1985 January and was aimed to investigate the epidemiological fallouts of the disaster. This epidemiological study no doubt is one of the rarest and longest running study in India, as it has completed its 25 years of operation in December 2012. The study continued for more than 25 years with same methodology, the way it was planned while it was under Bhopal Gas Disaster Research Center,

The findings of the part one have already been published by Bhopal Gas Disaster Research Center, Gandhi Medical College, Bhopal, M.P. India/ Indian Council of Medical Research, Ansari Nagar, New Delhi-110029. Under “Health effect of the toxic gas leak from the Union Carbide Methyl Isocyanate plant in Bhopal: Technical Report on population based long term epidemiological studies (1985-1994)”

It is pertinent to recall salient features and conclusions drawn in above mentioned report as below:

a) Soon after the gas disaster, 36 wards having population of 521,262 (62.6%) were found to be exposed and affected, while 20 wards with a population of 311,642 (37.4%) were found to be unaffected by the gas. On the basis of average death rates in the exposed/affected areas, the latter were categorized into: severely exposed/affected area (death rate of 22/1000), moderately exposed/affected area (death rate of 1.33/1000) and mildly exposed/affected area (death rate of 0.20/1000.) The unexposed/unaffected area was categorized as the control area.

b) This study covered affected as well as control area with a cohort base of 80,021 (26,382, 34,964 and 18,675 in severely, moderately and mildly exposed) in affected area and

15,931 in control area. The study was conducted in 16 localities through 6 community clinics. A concurrent family based population survey initially carried out fortnightly and later six monthly was conducted to find out the patterns of socio-economic, pregnanacy outcome, mortality, and morbidity parameters in toxic gas affected population.

c) Age and sex distribution of the population of "affected" as well as "control" areas were almost similar comparable to national population pyramid.

d) "Death rates" were higher in the "exposed areas", than in the "control areas" throughout the ten years period of observations. The severely affected area showed higher mortality in the initial years, which gradually declined and nearly touched "local" or "national levels". Deaths in the exposed area were mainly due to respiratory disorders throughout the period of observations. Death rates were higher in the age group of 45 years and above.

e) Another notable feature was the "pregnancy rate", which is generally associated with disasters in general. The rate was high till 1986-1987 and gradually declined over a period of time. Likewise, by 1989 the "abortion rate" in the affected areas, which was initially 12%, declined to about 7.5%, as against 1.4% in the control area. Such phenomenon has been observed in man-made and even natural disasters.

f) General morbidity as well as that traceable to respiratory or ophthalmic morbidity, based on the symptomatology reported by the patients or the responsible family members, was observed to be consistently higher in affected areas as compared with the control areas.

With above finding in background the present report or covers the period 1996-2010 and for technical content continuity, present report has drawn heavily from the first report mentioned above.

b. Cohort

One of the most challenging tasks in operating a cohort study is to hold the cohort. This study in 1985 started with a cohort of 80,021 in affected (26,382, 34,964 and 18,675 respectively in severely, moderately and mildly affected localities) along with a control population of 15,931. However, of the original above mentioned cohort only 5,658, 6,533 and 4,669 from severely, moderately and mildly affected area respectively (total-16,860) and 5,741 from control area was actually available for study in 2010. In nut shell, study over a period of 25 years suffered a cohort loss of 79% in affected area and 64% in control area. The reasons behind losses are presumably shifting of the population to different places, marriage migration, shifting of young age cohort to older age one and subsequent death of elderly cohort. Now the original cohort in affected area is in the age group exceeding 25 years of their age.

c. Socio economic profile

Study noticed improvement in housing, per capita income and educational status of the population in affected as well in control population.

d. Mortality and related issues

The mortally rates were very high during the acute phase. The mortality rate calculated

for the period of 3rd to 6th December 1984 were 21.98 in severe, 1.33 in moderate and 0.29/1000 in mildly affected area. For period 4th -31st December 1984 these were 12.57/1000 for males and 11.6/1000 for females in severely affected area. Mortality rates showed a decreasing trend with passage of time throughout the study. In present study (1996-2010) mortality rates (2002-2009) are less than the national crude death rate. Death rates observed between 2002-2009 bring out the fact that mortality in all age groups has remained under national urban death rate for respective age groups in respective year, except occasional and slight increase as mentioned in table no.27 and graph no. 3. The study reveals main cause of mortality among gas affected as well control area as respiratory illness.

e. Morbidities

General Morbidities: During acute stage in all the three exposed areas, 98% of persons had both lung and eye symptoms. The gastrointestinal symptoms were observed in 74% in severely exposed area whereas in moderate and mild areas it was 48% and 14% respectively. The morbidity related to skin was about 1-2% in the exposed areas. The morbidity rates in all the areas indicated three distinct trends indicating a low rate up to the survey during May 1988 to November 1988, later an increasing trend up to the survey in November 1990 to May 1991; and afterwards a decrease. The severe area as expected had higher morbidity at all the periods. The morbidity rates in the moderate area were higher than mild area up to May 91. General morbidities showed a decreasing trend, however, always above the control area and since 1999 have been stable under 23%, 20%, 17% and 8% in severely, moderately and mildly affected area and control with occasional peaks in mild and control area till 2010.

Respiratory morbidities: Respiratory morbidities too have followed the similar pattern as seen in case of general morbidities. During acute stage in affected areas 96%-98% people suffered with respiratory morbidities however by end of 7th year post exposure these morbidities came down to 20%, 15% and 16% in severely moderately and mildly affected area and since 1998 have remained below 20 % till 2010.

Ophthalmic morbidities: were seen in 98-99% of the affected population during acute stage. This proportion came down to less than 16% in affected area in 1996 and since 1999 have remained under 20% till 2010.

Gastrointestinal tract morbidities: which started with 74, 26 and 15% during acute stage came down to less than 8% in affected area by 1991 and since then have remained under same level till 2010 with occasional slightly higher peaks in all area. The mild area did show noticeable increase in morbidities ie up to 13% during 2004-2008. The cause of this rise was investigated and it was found that people started complaining excessively about gastritis abdominal pain. This could be possibly due to excessive self medication for pain.

Skin morbidities showed consistent pattern of less than 2% in all areas in all times.

Limitation of the Study: The initial cohort registered population was planned on emergency basis immediately after the disaster in 1984. The study was started with time constrains. The limitations also included study design there were no house numbering or any identification for preparing sampling. In spite of this the areas were demarcated as exposed and unexposed.

There were some effort in shifting of entire population from one area to another which created depletion in the cohort. However, during later period the depletion was not significant as reported in the first technical report of ICMR.

The study was planned as a household study viz. by including only persons living in the households. It should be understood that the deaths of persons without holding the households have not been taken into account. The cohort study was planned to collect information on a longitudinal basis.

Initially, in the acute face, it was planned to collect data every fortnight from all the households and later modifications were made as per the interim recommendations. It may be noted during the period 1993 – 1995 there was no follow-up from any agency, and CRS started follow-up cohort only during 1996.

VI. SUMMARY AND CONCLUSIONS

Multinational Union Carbide factory producing SEVIN, a carbamet pesticide got involved in a disaster due to various operational and safety system failures on the night of 2nd/ 3rd December 1984. It started with ingress of about 500 liters of water in to tank no. E 610 containing 42 tones of Methyl Isocyanate along with some metallic impurities. Ingress of water led to exothermic reaction and thus release of 27-30 tones of Methyl Isocyanate gas along with other products of reaction through 33 meter high vent gas scrubber in to atmosphere at 12^{0}C of temperature and 10-12Km./hrs wind speed in south west direction. Mixture of hot gases got condensed in outside cold air and due to atmospheric inversion phenomenon settled down slowly on the ground. This settled mist or cloud of toxic gas(es) evaporated and spread with low wind velocity,[19] over the densely populated old city situated on comparatively planes surrounded by the high hillocks namely Idgah hills, Shyamla hills and Birla hills on three sides.

The disaster led to death of about 1000 people within 72 hours. Thousands of people symptomatically suffered with irritation of eyes, rapidly developing into intense swelling and burning sensation and inability to keep them open. Simultaneously, people were violently coughing and felt choked, unable to breathe. Many of the exposed persons experienced the smell and sensation like that of burning chilies in eyes. Within twenty-four hours of the single inhalation of the MIC related toxic gas(es), it became clear that this one time exposure is likely to result in multisystem morbidities among the survivors.

Indian Council of Medical Research through its own and along with major research institutions spread all over the country and the academic intellectuals and research scientists of national and international repute planned about twenty two studies to answer this question.

Of the twenty two research projects “The population based long term epidemiological study on health effect of toxic gas exposure through community health clinic was initiated on 1st January 1985 following disaster due to toxic gas leak. The documentation of the part I of the study (1985-1994) is already available in form of a technical report published by Bhopal Gas Disaster Research Center, Gandhi Medical College, Bhopal M.P. India and Indian Council of Medical Research, Ansari Nagar, New Delhi- 110029. The study concluded:

"The mortality and morbidity caused by the toxic gas(es) inhalation was a "one time acute injury" to the respiratory tract and the ophthalmic system and which often healed with resolution or necrosis and fibrosis, but did not lead to progressive ophthalmic disease resulting in blindness. The scars produced after the acute lung injury and their sequel may however, continue to produce recurrent/episodic respiratory illness and possibly disability because of secondary respiratory infection and airway hyper reactivity or fibrosis, emphysema, bronchiectasis etc. for a long time or even the whole life. People with pre-existing lung disease (presumed at least 5% in any population), or smokers, after the gas exposure would have suffered more than those who were healthy before the exposure."

Present report or part II covers the period of 1996-2010. It concludes:

1. Cohort

Over the period of 25 years (14 years under the present period of reporting) study has suffered a cohort loss of 79% in affected area and 64% in control area.

2. Socio-economic profile

In general the profile has improved on all evaluated parameters.

3. Mortality profile

The mortally rates were very high during the acute phase. The mortality rate calculated for the period of 3rd to 6th December 1984 were 21.98 in severe, 1.33 in moderate and 0.29/1000 in mildly affected area. For period 4th - 31st December 1984 these were 12.57/1000 for males and 11.6/1000 for females in severely affected area. Mortality rates showed a decreasing trend with passage of time throughout the study. In present study (1996-2010) Mortality rates most of the times (2002-2009) are less than the national crude death rate. Age specific mortality rates too are observed to be within national averages, in all areas including control. The study reveals main cause of mortality among gas affected as well control area is respiratory.

4. Morbidity profile

General morbidities since 1999 have been fluctuating under 23%, 20%, 17% and 8% in severely moderately and mildly affected and control area till 2010. Respiratory morbidities since 1998 and ophthalmic morbidities since 1999 have remained under 20%. GIT morbidities came down to 8% affected area by 1991 and since then have remained under same level till 2010. In nut shell it can be said that all the morbidity levels have been fluctuating under 20% since 1999. However, all the morbidities in affected area are found to be higher than the morbidities seen in control area.

Hence, it is recommended that the difference in morbidities in affected area in reference to control area needs to be examined with the help of instituting clinical /clinico-epidemiological studies among those who are either chronically ill or chronically and severely ill, with more clinical orientation using newer clinical diagnostic tools to diagnose the clinical entities among the symptomatic cases identified so far.

VII. RECOMMENDATIONS

The Bhopal MIC toxic gas leak disaster on the night of 2nd/3rd December 1984 led to 1000 death within the following 72 hours. A study titled "The Population Based Long term Epidemiological study on health effect of toxic gas exposure through community health clinics" was initiated on 1st January 1985. This study completed its part I (1985-1994) and through part II study period of 1996-2010 is being reported.

Annual mortality rate came down to level lower than national crude death rate as early as 1985. And since then have remained under national crude death rate till 2010. During acute stage 97% to 99% affected people suffered with respiratory and opthalmic morbidities, with high abortion rate of 523/1000 and general morbidities (98.99%), respiratory morbidities (98.2%) and gastrointestinal morbidities (74%) in 1984. Since 1999 general morbidities are fluctuating below 23%, respiratory below 20% since 1998, ophthalmic below 20% since 1999 and GIT morbidities under 8% since 1991, however, these symptomatic morbidities are higher than those seen in control area.

Since this studys is the only cohort study which has been carried out on gas affected people in last two decades and there is no other health monitoring system with inbuilt research component in practice as on date. Hence it is recommended that newer studies on remaining population of original total gas exposed population of 5,74,000 may be undertaken and extensive follow-up with major focus on clinical disease identification and treatment. The studies should be planned in such a manner so that they can impart guidelines for health service sector to implement treatment measures.

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IX. Annexure

Annexure I

Symptoms

SN	Symptom	Code no	SN	Symptom	Code no
1.	Dyspnoea	01	21.	Fever	21
2.	Cough	02	22.	Diarrhoea	22
3.	Expectoration	03	23.	Skin & Allergy	23
4.	Wheezing	04	24.	Any other (Specify)	24
5.	Chest pain	05	25.	Vomiting	25
6.	Reduced work capacity	06	26.	UTI	26
7.	Fatiguability	07	27.	Ulcer	27
8.	Joint pains	08	28.	Hemoptysis	28
9.	Muscle aches	09	29.	Bleeding	29
10.	Restlessness	10	30.	Irregular MC	30
11.	Black outs	11	31.	Gastritis	31
12.	Dizziness	12	32.	Hearing problem related with ear	32
13.	Lack of concentration	13	33.	Sleep Disturbance	33
14.	Defective memory	14	34.	Leucorrhoea	34
15.	Depression	15	35.	Swelling	35
16.	Lack of appetite	16	36.	Tremers/Numbness	36
17.	Abdominal pain	17	37.	Body ache	37
18.	Constipation	18	38.	Head ache	38
19.	Eye Irritation/Lacrimation/burning/photophobia	19	39.	Heamatomesis	39
20.	Defective/Dim vision or any other	20	40.	Back ache	40

SIX MONTHLY VISIT NO. ☐☐

INTEGRATED MULTISYSTEM STUDIES AND MANAGEMENT

DATE OF INTERVIEW (34–39) ☐☐☐☐☐☐

Name of Head of House Hold ..... Specific Address .....

1. Ward No. (1–2) ☐☐
2. Locality (3–4) ☐☐
3. Sl. No. of Family (5–8, 9, 10) ☐☐☐☐☐☐
4. Availibility in the Locality (11) ☐
5. Religion (12) ☐
6. Total Family members (13–14) ☐☐
7. Type of family (15) ☐
8. Monthly Family income (In Rs.) (16–19) ☐☐☐☐
9. Per Capita Monthly income (In Rs.) (20–23) ☐☐☐☐
10. Type of House (24) ☐
11. Latrine facility (25) ☐
12. Ventilation in living rooms (26) ☐
13. Light in living rooms (27) ☐
14. Kitchen (28) ☐
15. Protection of food from flies (29) ☐
16. Smoke outlet (30) ☐
17. Domestic animals kept in the house (31) ☐
18. Cattleshead (32) ☐
19. Disposal of Urine and dung (33) ☐

Mobile No. ☐☐☐☐☐☐☐☐☐☐

Phone No. ☐☐☐☐☐☐☐

Name of Respondant .....

Signature of Respondant .....

Name/Signature of R.A. .....

20. If the family is migrated/Locked
    (a) Reason of migration/Locked (40–41) ☐☐
    (b) Date of migration (42–47) ☐☐☐☐☐☐ (Migration to be coded as the key)
    (c) Place of migration (Destination) .....
    (d) Address if Available .....
    .....

Name of the scrutiniser .....

SIX MONTHLY VISIT NO. ☐☐

DATE 68 ☐☐☐☐☐☐ 73

21-FAMILY COMPOSITION AND GENERAL PARTICULARS OF INDIVIDUALS IN THE FAMILY

NAME	S.No. in Old Family Index Card	Residential status (relating with H.O.F.)	Sex	AGE in completed years	Marital Status	Literacy Status	Occupation	Monthly Income (in Rs.)	Diet Habit	Addiction (Using)	Disability	Cause
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67
	48 49	50 51 52	53	54 55	56	57	58 59	60 63	64	65	66	67

Interviewer .....

SIX MONTHLY VISIT NO. [ ][ ]

22-SCHEDULE FOR ELIGIBLE FEMALES

DATE [1][ ][ ][ ][ ][6]

LOCALITY [7][8][ ][ ]

Family No. [9][ ][ ][ ][12][13]

Is there any eligible female in the Family [14]

NAME OF WOMAN	S.NO. OF OLD FAMILY INDEX	AGE IN YEARS	AGE AT MARRIAGE	AGE AT R.M.	AGE OF HUSBAND AT MARRIAGE	AGE OF HUSBAND R.M.	MARITAL DURATION	AGE AT FIRST PREGNANCY	AGE AT LAST PREGNANCY	NO. OF ABORTIONS/ MISCARRIAGES
	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34
	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34
	15 16	17 18	19 20	21 22	23 24	25 26	27 28	29 30	31 32	33 34

NO. OF STILL BIRTHS	NO. OF LIVE BIRTHS BUT DEAD	NO. OF LIVE BIRTHS STIL ALIVE	NO. OF TOTAL PREGNANCIES (Parity)	NO. OF TOTAL LIVE BIRTHS	NO. OF CHILDREN LESS THAN 5 YEARS OLD	AGE OF YOUNGEST CHILD	KNOWLEDGE OF F.P. METHODS	PRESENT USES
35 36	37 38	39 40	41 42	43 44	45	46 47	48	49
35 36	37 38	39 40	41 42	43 44	45	46 47	48	49
35 36	37 38	39 40	41 42	43 44	45	46 47	48	49

Interviewer .....

SIX MONTHLY VISIT NO. [ ][ ]

23-OUTCOME OF PREGNANCY RECORD

DATE [1][2][3][4][5][6]

LOCALITY [7][8]

~~G.R.S~~. Family No. [9][10][11][12][13]

Is there any termination of pregnancy in the Family [14]

NAME OF THE WOMAN	S.NO. OF OLD FAMILY INDEX CARD	AGE	PARITY	ANTEANATAL CARE 1ST Time	ANTEANATAL CARE 2ND Time	ANTEANATAL CARE 3RD Time	BY WHOM		
	[15][16]	[17][18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]
	[15][16]	[17][18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]
	[15][16]	[17][18]	[19]	[20]	[21]	[22]	[23]	[24]	[25]

DATE OF TERMINATION DAY	MONTH	YEAR	TYPE OF TERMINATION OF PREGNANCY	PLACE OF TERMINATION	ANY MAL-FORMATION	STATUS OF BABY	STATUS OF MOTHER	ID Number of BABY	Sex
[26][27]	[28][29]	[30][31]	[32]	[33]	[34]	[35]	[36]	[37][38]	[39]
[26][27]	[28][29]	[30][31]	[32]	[33]	[34]	[35]	[36]	[37][38]	[39]
[26][27]	[28][29]	[30][31]	[32]	[33]	[34]	[35]	[36]	[37][38]	[39]

Interviewer .....

SIX MONTHLY VISIT NO. [ ][ ]

24-DEATH RECORD

DATE [1][ ][ ][ ][ ][6]

LOCALITY [7][8][ ][ ]

Family No. [9][ ][ ][ ][12][13]

Is there any death in the Family [14]

NAME OF THE PERSON	S.NO. OF OLD FAMILY INDEX CARD	TYPE OF PERSON	AGE	SEX	DATE OF DEATH			PLACE OF DEATH	AUTOPSY DONE	CERTIFICATE OF DEATH BY	VERIFIED WITH CERTIFICATE	CAUSE OF DEATH	
					Day	Month	Year					PRIMARY (for R.A.)	SECONDARY (for R.A.Q.)
	[15][16]	[17]	[18][19]	[20]	[21][22]	[23][24]	[25][26]	[27][28]	[29]	[30]	[31]	[32][33][34]	[35][36][37]
	[15][16]	[17]	[18][19]	[20]	[21][22]	[23][24]	[25][26]	[27][28]	[29]	[30]	[31]	[32][33][34]	[35][36][37]
	[15][16]	[17]	[18][19]	[20]	[21][22]	[23][24]	[25][26]	[27][28]	[29]	[30]	[31]	[32][33][34]	[35][36][37]

Complaints at the time of death (R.A.) 1. _____

2. _____

3. _____

CAUSE OF DEATH (A.R.O.) .....

INTERVIEWER .....

DIAGNOSIS .....

A.R.O. .....

Base of Diagnosis : 1. Certificate : 2. Interogation. (Put ✔ for correct answer.)

CANCER SURVEY

.NO. . . . . .

1. Is there any death in the family due to cancer? ☐
   (FROM 1985 onwards)
   1. Yes
   2. No

2. Name Age Sex

3. Diagnosis :

4. Supporting documents:

5. Is there any person in the family presently suffering from cancer? ☐
   1. Yes
   2. No

6. If yes
   Name Age Sex I.D. No.

7. Diagnosis :

8. Supporting documents

RESPONDANT'S SIGNATURE

SIGNATURE OF THE R.A.

MORBIDITY PROFORMA

SIX MONTHLY VISIT NO. [ ][ ]

TOTAL FAMILY MEMBERS (1 2) [ ][ ]

Source of Information [ ] F : Field C : Clinic

Area (3 4) [ ][ ]

DATE			~~G.R.S.~~ No.	Occurance of Morbidity on house hold	ID	Symptom	Duration		Whether this has restricted the main activities	Place of treatme	Hospital isation	Clinical diagnosis by A.R.O.	
Day	Months	Year					Month	Day				Disease	Duration Months / Days
5 6	7 8	9 10	11 16	17	19 20	21 22	23 25	26 27	56	57	58	59 63	68
				18								Diag	
						49		55				99	108
5 6	7 8	9 10	11 16	17	19 20	21 22	23 25	26 27	56	57	58	59 63	68
				18								Diag	
						49		55				99	108
5 6	7 8	9 10	11 16	17	19 20	21 22	23 25	26 27	56	57	58	59 63	68
				18								Diag	
						49		55				99	108

Research Assistant . . . . . .

A.R.O. . . . . .

DATE [ ][ ][ ][ ][ ][ ] (109 – 114)

8

MORBIDITY PROFORMA

SIX MONTHLY VISIT NO. ☐☐

TOTAL FAMILY MEMBERS (1 2) ☐☐ Source of Information ☐ F : Field C : Clinic Area (3 4) ☐☐

DATE			~~G.R.S~~. No.	Occurance of Morbidity on house hold	ID	Symptom	Duration		Whether this has restricted the main activities	Place of treatme	Hospital isation	Clinical diagnosis by A.R.O.	
Day	Months	Year					Month	Day				Disease	Duration
5 6	7 8	9 10	11 16	17	19 20	21 22	23 25	26 27	56	57	58	59 63	68
				18 ☐		49		55	Diag			99	108
5 6	7 8	9 10	11 16	17	19 20	21 22	23 25	26 27	56	57	58	59 63	68
				18 ☐		49		55	Diag			99	108
5 6	7 8	9 10	11 16	17	19 20	21 22	23 25	26 27	56	57	58	59 63	68
				18 ☐		49		55	Diag			99	108

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Table 12

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986 -2010) SEVERE AREA

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	1550	8.04	5610	29.12	9707	50.39	2050	10.64	343	1.78	19260
1991	0	-	2208	27.36	4597	56.96	952	11.80	313	3.88	8070
1996			1084	10.02	7404	68.46	1783	16.48	545	5.04	10816
1997			577	6.70	6202	72.06	1391	16.16	438	5.09	8608
1998			161	3.05	3950	74.84	903	17.11	264	5.00	5278
1999			2	0.06	2712	76.42	655	18.45	181	5.10	3550
2000			0	-	4360	73.09	1208	20.25	397	6.66	5965
2001			0	-	5054	73.30	1390	20.16	451	6.54	6895
2002					3951	71.61	1203	21.80	365	6.61	5519
2003					3709	71.73	1156	22.36	306	5.92	5171
2004					3913	70.65	1262	22.78	363	6.55	5538
2005					3201	65.52	1264	25.86	421	8.61	4886
2006					3242	41.17	1296	16.46	423	5.37	4961
2007					3720	64.25	1606	27.74	464	8.01	5790
2008					3656	61.74	1783	30.11	482	8.14	5921
2009					3332	62.14	1607	29.96	425	7.92	5364
2010					3278	57.94	1749	30.91	631	11.15	5658

Table– 12, Gives the details of get distribution at different points of follow-up (1986 – 2010) for Severe area.

The age group 0-4 during 1986 for the area severely affected was 8.04% this age group persisted/represented only during 1986. The age group 5-14 years though it was 29.12% in 1986 it was 0.06% by 1999 and beyond this it was not represented. The group 15-44 years during 1986 was 50.39% subsequently it is representation Increased to 76.42% by 1999. Subsequently there was a gross reduction to the level of 57.94 by 2010. It clearly indicates that in the initial years of the disaster participation of this age group was increasing. After. 1999 there was decline may be due to conditions attributable to population going in search of job, some commitment and also their non availability and action of any major morbid condition compelling them to be present at the time of enquiry.

The age group 45-64 during 1986 was 10.64%. Gradually it increased almost 3 folds reaching 30.91% by 2010 indicating their availability for the cohort investigators may be due to morbid condition with a expectation that they get some relief if they make themselves available for the cohort investigator. The age group 65+ at the time of beginning of the cohort during 1986 was 1.78% which gradually increased 10 folds to 11.15% by 2010. The similar reason stated above in respect of 45-64 years can also be referred here.

Table 13

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986 -2010)

MODERATE AREA

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	1940	6.86	8171	28.91	14372	50.90	3172	11.22	596	2.11	28261
1991			3208	24.39	7711	58.64	1743	13.25	488	3.71	13150
1996			1178	8.35	9799	69.45	2436	17.07	724	5.13	14137
1997			708	5.38	9520	72.30	2263	17.18	678	5.15	13169
1998			234	2.47	7063	74.46	1680	17.71	508	5.36	9485
1999			2	0.03	5717	76.86	1330	17.88	389	5.23	7438
2000					6726	72.49	1839	19.82	714	7.69	9279
2001					7100	72.51	1979	20.21	713	7.28	9792
2002					6488	71.55	1918	21.15	663	7.31	9069
2003					6407	71.63	1888	21.10	651	7.28	8946
2004					5172	70.84	1610	22.05	520	7.12	7302
2005					3742	65.51	1450	25.39	520	9.10	5712
2006					3736	64.06	1567	26.86	531	9.10	5834
2007					2678	63.35	1171	27.70	378	8.94	4227
2008					2641	60.78	1307	30.07	399	9.18	4347
2009					3202	60.96	1594	30.34	458	8.72	5254
2010					3811	58.35	1955	29.92	767	11.73	6533

Table No. 13 Shows the age distribution of population at different points of follow-up during 1986-2010 for the Moderate area. It may be noted that trends remained same from 1985 – 2010.

Table -14

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986 -2010) MILD AREA

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	967	6.37	3873	25.50	8249	54.04	1688	11.11	408	2.70	15185
1991			1561	22.45	4166	59.93	929	13.36	296	4.26	6952
1996			752	7.89	6596	69.26	1652	17.34	527	5.53	9527
1997			437	4.84	6523	72.33	1571	17.42	489	5.42	9020
1998			154	2.21	5236	73.86	1200	17.25	366	5.26	6956
1999			1	0.02	3966	75.69	1008	19.23	266	5.08	5241
2000					4664	71.01	1424	21.68	480	7.31	6568
2001					4383	70.98	1351	21.88	442	7.16	6176
2002					4034	69.21	1378	23.64	418	7.17	5830
2003					3810	68.93	1341	24.26	376	6.80	5527
2004					3664	66.67	1434	26.09	398	7.24	5496
2005					3247	63.15	1401	27.24	495	9.62	5143
2006					2950	61.30	1426	29.62	438	9.10	4814
2007					1109	59.81	593	31.95	154	8.30	1856
2008					1451	56.96	883	34.64	215	8.43	2549
2009					1924	55.99	1207	35.11	307	8.93	3438
2010					2467	52.86	1643	35.19	559	11.97	4669

Table No. 14 Shows the age distribution of population at different points of follow-up during 1986-2010 for the Mild area. It may be noted that trends remained same from 1985 – 2010.

Table -15
AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986 -2010) CONTROL AREA

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	1032	7.63	4032	29.80	7092	52.43	1145	8.47	225	1.66	13526
1991			2128	26.90	4641	58.67	887	11.21	255	3.22	7911
1996			787	9.85	5602	70.11	1285	16.08	316	3.95	7990
1997			442	6.18	5263	73.62	1173	16.41	272	3.80	7150
1998			120	2.61	3509	76.29	815	17.71	157	3.41	4601
1999			1	0.02	3630	79.21	795	17.35	158	3.45	4584
2000					3989	72.28	1263	22.88	267	4.84	5519
2001					3706	72.20	1183	23.05	244	4.75	5133
2002					3146	70.98	1084	24.46	202	4.56	4432
2003					3310	69.85	1213	25.59	217	4.58	4740
2004					3230	69.48	1210	26.02	210	4.52	4650
2005					2583	62.95	1241	30.23	281	6.85	4105
2006					3344	62.66	1639	30.70	355	6.65	5338
2007					3414	61.64	1758	31.73	368	6.64	5540
2008					3182	58.65	1881	34.66	364	6.71	5427
2009					3356	57.84	2065	35.59	381	6.57	5802
2010					3182	55.42	2000	34.84	559	9.74	5741

Table No. 15 Shows the age distribution of population at different points of followup during 1986-2010 for the Control area. It may be noted that trends remained same from 1985 – 2010.

Table 16

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986,1991,1996,2001,2006 & 2010)
MALE (SEVERE AREA)

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	810	8.04	2952	29.31	5049	50.14	1102	10.94	157	1.56	10070
1991	0		1164	28.07	2307	55.63	522	12.59	154	3.71	4147
1996	0		553	9.59	3771	67.84	979	17.61	256	4.60	5559
2001	0		0	-	2565	72.66	744	21.08	221	6.26	3530
2006	0		0	-	1594	64.38	677	27.34	205	8.28	2476
2010	0		0	-	1635	58.04	862	30.60	320	11.36	2817

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986,1991,1996,2001,2006& 2010
FEMALE (SEVERE AREA)

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	740	8.05	2658	28.92	4658	50.69	948	10.32	186	2.02	9190
1991	0	-	1044	26.61	2290	58.37	430	10.96	159	4.05	3923
1996	0	-	531	10.10	3632	69.09	805	15.31	289	5.50	5257
2001	0	-	0	-	2488	73.97	646	19.20	231	6.86	3365
2006	0	-	0	-	1647	16.28	619	24.91	219	8.81	2485
2010	0	-	0	-	1642	57.80	888	31.26	311	10.95	2841

Table -17

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986,1991,1996,2001,2006& 2010)

MALE (MODERATE AREA)

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	1006	6.83	4256	28.91	7464	5.16	1691	11.48	307	2.09	14724
1991	0	-	1656	24.69	3852	57.42	953	14.21	241	3.68	6708
1996	0	-	622	8.57	4959	68.29	1302	17.93	379	5.22	7262
2001	0	-	0	-	3597	71.16	1098	21.72	360	7.12	5055
2006	0	-	0	-	1878	63.27	823	27.73	267	8.96	2968
2010	0	-	0	-	1900	57.98	970	29.60	407	12.42	3277

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986,1991,1996,2001,2006& 2010)

FEMALE (MODERATE AREA)

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	934	6.90	3915	28.92	6908	51.03	1491	11.01	289	2.13	13537
1991	0	-	1552	24.09	3859	59.90	790	12.26	241	3.74	6442
1996	0	-	556	8.09	4840	70.40	1134	16.49	345	5.02	6875
2001	0	-	0	-	3503	73.95	881	18.60	353	7.45	4737
2006	0	-	0	-	1858	64.83	744	25.96	264	9.21	2866
2010	0	-	0	-	1911	58.70	985	30.24	360	11.05	3256

Table -18

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986,1991,1996,2001,2006& 2010)

MALE (MILD AREA)

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	483	6.16	2036	25.96	4207	53.64	892	11.37	225	2.87	7843
1991	0	-	794	22.70	2048	58.55	506	14.47	150	4.29	3498
1996	0	-	375	7.68	3334	68.29	896	18.35	277	5.67	4882
2001	0	-	0	-	2179	69.22	720	22.87	249	7.91	3148
2006	0	-	0	-	1425	60.56	712	30.26	216	9.18	2353
2010	0	-	0	-	1203	52.42	803	34.99	289	12.59	2295

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986,1991,1996,2001,2006& 2010)

FEMALE (MILD AREA)

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	484	6.59	1837	25.02	4042	55.05	796	10.84	183	2.49	7342
1991	0	-	767	31.26	2118	61.32	423	12.25	146	4.23	3454
1996	0	-	377	8.12	3262	70.23	756	16.28	250	5.38	4695
2001	0	-	0	-	2204	72.79	631	20.84	193	6.37	3028
2006	0	-	0	-	1526	62.01	714	29.01	221	8.98	2461
2010	0	-	0	-	1264	53.24	840	35.38	270	7.16	2374

Table -19

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986,1991,1996,2001,2006& 2010)

MALE (CONTROL AREA)

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	544	7.48	2136	29.36	3816	52.46	657	9.03	121	1.66	7274
1991	0	-	1123	26.89	2375	56.86	551	13.19	128	3.06	4177
1996	0	-	413	9.70	2871	67.47	817	19.18	158	3.71	4259
2001	0	-	0	-	1858	69.07	708	26.32	124	4.61	2690
2006	0	-	0	-	1675	60.69	884	32.03	201	7.28	2760
2010	0	-	0	-	1611	54.28	1033	34.80	324	10.92	2968

AGE DISTRIBUTION AT DIFFERENT POINTS OF FOLLOW-UP (Year 1986,1991,1996,2001,2006& 2010)

FEMALE (CONTROL AREA)

Years	0-4	%	05-14.	%	15-44	%	45-64	%	65+	%	Total
1986	488	7.84	1970	31.50	3202	51.45	488	7.84	104	1.67	6252
1991	0	-	1005	26.91	2266	60.69	336	9.00	127	3.40	3734
1996	0	-	374	10.02	2731	73.18	468	12.54	158	4.23	3731
2001	0	-	0	-	1848	75.64	475	19.44	120	4.31	2443
2006	0	-	0	-	1859	64.84	744	25.95	264	9.21	2867
2010	0	-	0	-	1572	56.65	966	34.83	235	8.47	2773

Table No. 16-19 gives the age sex distribution of the cohort population at different points of follow up for the years 1986, 1991, 1996, 2001, 2006 and 2010 for exposed and control areas. It is observed that the age group 0-4 years was available for the cohort in the percentage range of 6.16 to 8.04 only during 1986. The age group 5-14 years represented 26 to 29% during 1986 subsequently by 1996 it was the 7 to 10%. After 1996 onwards this age group was not available for the cohort. It can be observed from the tables that the age group 15-44 represented in the range of 50.14 to 53.64% except in moderate area where during 1986 it was 5.16%. It can be observed that9-11% represented age group 45-64 during 1986,among both male and female irrespective of the area.The respective tables for both male and female cohort population in the above mentioned age groups at different point of time indicate statistically comparable percentage/representation. Recognizable and statically acceptable age and sex groups in the respective years validates the observations. It can also be observed from the tables even after 26 years, the same proportion of population in the age group of 15-44 has been maintained and in respect of 44-55 age group there is a 3 fold rise and in respect of 65+ age group 2-5 fold rise in both age and sex distribution.

Table 20
SOCIO-DEMOGRAPHIC CHARACTERISTICS OF PERSONS FROM THE SEVERE MODERATE AND MILD GAS EXPOSED AND CONTROL AREA OF COHORT -85

Socio demographic characteristics	Classification	Exposed areas			
		Severe	Moderate	Mild	Control
Number		26382	34964	18675	15931
Sex	Male	14006 53.09%	18438 52.75 %	9714 52.025%	8574 3 .83%
	Female	12376 46.91%	16526 47.27%	8961 47.98.%	7357 46.18%
Age (year)	00-14	39.27%	38.42%	35.10%	39.7%
	15-44	48.17%	48.11%	51.30%	50.0%
	45-64	10.74%	11.30%	10.91%	8.80%
	65+	1.86%	2.17%	2.67%	1.70%
Education	Illiterate	60.85%	40.69%	34.84%	54.78%
	Literate	4.75%	7.08%	8.27%	7.17%
	Primary	16.149%	21.05%	20.34%	20.50%
	Middle	9.40%	11.62%	12.06%	9.81%
	Higher Secondary	6.15%	10.99%	13.32%	5.85%
	College	2.36%	8.25%	10.64%	2.69%
Religion	Hindu	73.92%	35.05%	40.08%	91.09%
	Muslim	25.49%	62.59%	58.20%	7.55%
	Christian	0.40%	0.91%	1.28%	0.82%
	Sikh	0.03%	0.76%	0.35%	0.50%
	Other	0.11%	0.69%	0.09%	0.04%
Type of House	Kucha	71.79%	37.69%	33.06%	87.17%
	Semi Pacca	12.13%	19.53%	22.11%	1.47%
	Pacca	16.08%	42.78%	44.83%	11.41%
Income	< 145	86.81%	77.43%	76.69%	77.77%
	145 – 284	11.14%	17.85%	17.57%	19.67%
	285 – 464	1.57%	3.05%	4.19%	2.05%
	465 – 964	0.44%	1.52%	1.13%	0.42%
	965 &>	0.04%	0.15%	0.24%	0.09%

Table 20 a

SOCIO-DEMOGRAPHIC CHARACTERISTICS OF PERSONS FROM THE SEVERE MODERATE AND MILD GASEXPOSED AND CONTROL AREA OF COHORT -2010

Socio demographic characteristics	Classification	Exposed areas			
		Severe	Moderate	Mild	Control
Type of House	Kucha	11.50	3.70	3.35	64.23
	Semi Pacca	26.54	17.38	0.00	0.37
	Pacca	61.95	78.23	96.64	35.19
Income	< 145	38.34	40.22	39.19	29.35
	145 – 284	0.00	00.04	0.00	0.12
	285 – 464	0.34	00.04	0.03	0.00
	465 – 964	1.76	00.14	0.00	01.74
	965 &>	59.54	59.54	60.77	68.77
Education	Illiterate	22.77	19.32	7.42	15.72
	Literate	10.46	6.47	1.76	4.89
	Primary	19.90	17.88	14.04	23.07
	Middle	15.22	20.23	26.56	27.81
	Higher Secondary	22.81	28.45	29.11	16.37
	College	8.82	7.62	21.08	12.11
Religion	Hindu	47.50	46.14	36.57	95.13
	Muslim	52.15	52.85	62.46	04.22
	Christian	0.27	0.16	0.56	0.38
	Sikh	0.00	0.42	0.21	0.25
	Other	0.06	0.40	0.17	0.00

The comparison of socio economic profile of the population participated the cohort for the years 1985 and 2010 have been represented in Table no 20 and 20a.

Participation of Religion – Hindus	73.92% in 1985,	47.50% in 2010 in	Severely affected area
	35.05%	44.14%	Moderately
	40.85%	36.57%	Mildly
Muslims	29.49%	52.15%	Severely affected area
	62.05%	52.85%	Moderately
	58.20%	62.46%	Mildly

In General there is a reduction in the participation of other religions namely Christian and Sikh Community. The same observation holds the respect of control area also.

Table 21
Smoking habit (1985,1987, 2006 & 2010)

Area	Period	Smoking (%)	Non-smoking(%)
Severely Affected	1985	14.29	85.71
	1987	14.30	85.64
	2006	12.82	87.18
	2010	16.34	83.66
Moderately Affected	1985	9.30	90.70
	1987	8.18	91.59
	2006	14.97	85.03
	2010	9.95	19.05
Mildly Affected	1985	0.20	93.76
	1987	0.30	93.63
	2006	11.92	88.08
	2010	1.86	98.14
Total	1985	9.90	90.10
	1987	9.64	90.24
	2006	13.01	86.99
	2010	10.11	89.89
Control	1985	10.88	89.12
	1987	12.23	87.77
	2006	13.98	86.02
	2010	6.62	93.38

Table - 22

Annual Death Rate 1996-2010

Years	1996			1997			1998			1999			2000		
	POPULATION	DEATH	DR	POPULATION	DEATH	DR	POPULATION	DEATH	DR	POPULATION	DEATH	DR	POPULATION	DEATH	DR
SEVERE	10816	55	5.08	8608	42	4.88	5278	27	5.11	3550	13	3.66	5965	55	9.22
MOERATE	14137	66	4.67	13169	59	4.48	9485	39	4.11	7438	31	4.17	9279	42	4.53
MILD	9527	45	4.72	9020	41	4.55	6956	28	4.63	5241	22	4.2	6568	46	7
TOTAL	34780	166	4.77	30797	142	4.61	21719	94	4.33	16229	66	4.07	21812	143	6.56
CONTROL	7990	24	3.0	7150	29	4.06	4601	11	2.39	4584	25	5.45	5519	27	4.84

DR - Death Rate

Cont...Table -22

YEAR	2001			2002(National Urban=6.1)			2003(National Urban=6.0)			2004(National Urban=5.8)			2005(National Urban=5.8)		
	POPULATION	DEATH	DR	POPULATION	DEATH	DR	POPULATION	DEATH	DR	POPULATION	DEATH	DR	POPULATION	DEATH	DR
SEVERE	6895	39	5.66	5519	25	4.53	5171	26	5.03	5538	34	6.14	4886	34	6.96
MODERATE	9792	46	4.7	9069	61	6.23	8946	51	5.7	7302	51	6.98	5712	28	4.9
MILD	6176	21	3.4	5830	34	5.83	5527	35	6.33	5496	27	4.91	5143	28	5.45
TOTAL	22863	106	4.64	20418	120	5.88	19644	112	5.70	18345	112	6.11	15741	90	5.72
CONTROL	5133	34	6.62	4432	21	4.74	4740	26	5.49	4650	21	4.52	4105	25	6.09
YEAR	2006(National Urban=6.0)			2007(National Urban=7.0)			2008(National Urban=6.0)			2009(National Urban=5.9)			2010(National Urban=5.4)		
	POPULATION	DEATH	1000	POPULATION	DEATH	1000	POPULATION	DEATH	1000	POPULATION	DEATH	1000	POPULATION	DEATH	1000
SEVERE	4961	23	4.64	5790	45	7.77	5921	40	6.76	5364	38	7.09	5658	31	5.48
MODERATE	5834	34	5.83	4227	24	5.68	4347	36	8.28	5254	45	8.56	6533	53	8.11
MILD	4814	34	7.06	1856	8	4.31	2549	13	5.1	3438	34	9.89	4669	39	8.25
TOTAL	15609	91	5.83	11873	77	6.49	12817	89	6.94	14056	117	8.32	16860	123	7.30
CONTROL	5338	35	6.56	5540	27	4.87	5427	35	6.45	5802	42	7.24	5741	35	6.1

Death indicates – Death rate

Table-23

Primary Cause of Death During 1986 - 1993, Affected Area

Cause	Number	%
Accident & Injuries	77	4.72
Child birth & Pregnancy	13	0.80
Fever	51	3.13
Digestive disorders	157	9.63
Respiratory disorders	649	39.79
C.N.S. disorders	67	4.11
C.V.S. disorders	45	2.76
Other system disorders	23	1.41
Cause peculiar to infancy	37	2.27
Senility	55	3.37
Cause unknown	457	28.02
Total	**1631**	

Table-24

Primary Cause of Death During 1986 - 1993 Control Area

Cause	Number	%
Accident & Injuries	22	9.32
Child birth & Pregnancy	4	1.69
Fever	33	13.98
Digestive disorders	25	10.59
Respiratory disorders	39	16.53
C.N.S. disorders	4	1.69
C.V.S. disorders	9	3.81
Other systyem disorders	4	1.69
Cause peculiar to infancy	33	13.98
Senility	18	7.63
Cause unknown	45	19.07
Total	**236**	

Table-25
Primary Cause of Death During the Years 1996 -2000, 2001-2005,2006-2010

Affected Area

Cause	1996 – 2000	%	2001 - 2005	%	2006 - 2010	%
Accident & Injuries	24	3.93	31	5.74	14	2.82
Fever	30	4.91	24	4.44	18	3.62
Digestive disorders	59	9.66	51	9.44	53	10.66
Respiratory disorders	349	57.12	301	55.74	272	54.73
C.N.S. disorders	30	4.91	16	2.96	45	9.05
C.V.S. disorders	27	4.42	24	4.44	20	4.02
Other systyem disorders	33	5.40	34	6.30	43	8.65
Cause peculiar to infancy	2	0.33	5	0.93	0	-
Senility	27	4.42	29	5.37	12	2.41
Cause unknown	30	4.91	25	4.63	20	4.02
Total	**611**		**540**		**497**	

Table-26

Primary Cause of Death During the Years 1996 -2000, 2001-2005,2006-2010

Control Area

Cause	1996 - 2000	%	2001 - 2005	%	2006 - 2010	%
Accident & Injuries	17	14.66	16	12.60	23	13.22
Fever	16	13.79	28	22.05	27	15.52
Digestive disorders	16	13.79	13	10.24	21	12.07
Respiratory disorders	39	33.62	33	25.98	48	27.59
C.N.S. disorders	2	1.72	3	2.36	2	1.15
C.V.S. disorders	2	1.72	5	3.94	10	5.75
Other systyem disorders	6	5.17	2	1.57	9	5.17
Cause peculiar to infancy	0	-	0	-	2	1.15
Senility	11	9.48	20	15.75	21	12.07
Cause unknown	7	6.03	7	5.51	11	6.32
Total	**116**		**127**		**174**	

Table-27

AGE SPECIFIC MORTALITY RATE DURING THE YEARS 1996 - 2010

Years	1996		1997		1998		1999		2000		2001		2002		2003	
	Affected	Control	Affected	Control	Affected	Control	Affected	Control	Affected	Control	Affected	Control	Affected	Control	Affected	Control
0-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05-9.	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-14.	0.33	1.27	1.16	2.26	-	-	-	-	-	-	-	-	-	-	-	-
15-19	1.46	1.46	1.26	0.78	1.43	1.20	0.83	2.45	1.47	1.25	-	1.92	0.83	-	3.68	-
20-24	1.09	3.97	1.27	2.90	0.99	1.48	-	3.82	2.75	3.27	0.53	3.22	2.45	-	0.89	3.27
25-29	1.33	-	1.76	-	0.66	4.16	-	-	0.96	-	0.96	3.02	2.46	-	1.05	-
30-34	2.21	2.40	0.73	1.15	1.56	4.33	1.37	4.06	0.40	2.11	1.01	2.07	0.88	-	1.11	2.06
35-39	2.76	3.35	3.32	1.35	2.44	-	1.14	-	1.73	-	1.69	-	3.01	7.16	1.32	4.12
40-44	2.17	-	3.18	8.01	2.35	-	0.72	4.01	3.86	6.69	4.16	5.08	3.85	4.20	2.27	6.76
45-49	3.47	1.79	6.52	3.94	7.67	-	5.02	2.82	2.72	5.98	5.07	6.52	7.66	4.50	3.90	2.05
50-54	9.29	11.14	11.54	17.49	5.85	-	10.23	8.73	9.49	7.87	8.91	13.51	3.48	6.54	6.31	2.62
55-59	10.99	-	10.69	9.95	9.99	-	9.98	15.38	17.12	16.74	10.69	9.13	17.56	9.26	9.61	18.35
60-64	23.78	14.49	17.93	16.39	13.78	-	11.65	37.04	30.83	14.29	15.69	22.39	15.90	33.90	26.56	15.75
65-69	19.86	-	18.48	-	26.53	-	33.58	119.05	22.38	34.09	18.87	36.14	26.64	29.41	26.26	40.54
70-74	49.13	23.26	18.69	16.95	32.79	34.48	34.59	48.39	34.16	22.22	34.27	71.43	48.33	-	29.41	25.64
75-79	50.23	25.64	70.27	31.25	36.50	-	80.00	-	44.33	12.99	34.40	45.45	19.50	17.86	47.20	55.56
80-84	33.65	30.30	56.18	37.04	60.87	50.00	37.04	-	63.64	-	17.86	43.48	31.25	133.33	112.36	-
85+	16.26	-	8.85	-	12.20	133.33	14.49	-	58.14	30.30	21.86	33.33	18.87	-	43.48	31.25

Cont.. Table-27

AGE SPECIFIC MORTALITY RATE DURING THE YEARS 1996 - 2010

Years	2004		2005		2006		2007		2008		2009		2010	
	Affected	Control	Affected	Control	Affected	Control	Affected	Control	Affected	Control	Affected	Control	Affected	Control
0-4	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05-9.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-14.	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-24	0.66	-	1.41	1.72	0.65	-	1.29	-	2.63	-	-	-	-	-
25-29	1.01	2.51	0.82	2.88	0.37	2.99	0.99	1.88	2.10	3.69	2.09	0.91	1.30	-
30-34	0.43	2.04	1.36	-	1.89	1.46	1.03	1.18	0.54	1.22	2.09	0.98	1.11	-
35-39	3.76	-	2.25	2.68	0.51	3.86	0.80	-	1.78	3.45	2.77	1.63	1.59	3.77
40-44	2.98	1.66	3.01	2.28	1.84	1.83	3.98	-	3.43	3.59	1.07	9.65	2.46	9.89
45-49	2.97	2.04	4.99	4.61	5.69	3.29	6.27	3.29	4.77	5.63	5.16	6.75	6.62	3.92
50-54	13.35	2.79	3.52	8.33	7.12	4.32	8.61	7.21	4.69	7.30	9.38	9.22	3.46	4.00
55-59	15.07	12.99	4.42	14.23	10.75	8.43	7.67	11.05	15.6	2.46	10.22	16.63	10.36	3.20
60-64	21.05	7.69	13.45	36.14	7.66	28.30	16.19	29.91	14.9	23.15	28.7	15.87	12.93	2.00
65-69	20.04	41.67	32.68	9.90	20.22	22.73	30.41	14.39	25.3	28.17	38.4	27.03	27.30	10.70
70-74	48.78	52.63	36.11	-	41.18	51.28	43.14	25.32	48.7	24.39	58.6	11.49	31.96	9.30
75-79	40.50	19.23	44.20	103.45	50.56	108.11	36.36	28.57	56.0	57.14	50.7	85.71	55.19	39.37
80-84	37.97	86.96	38.46	20.41	47.43	32.26	29.85	15.63	40.2	35.09	25.1	35.71	40.27	12.66
85+	51.47	120.00	17.05	-	28.41	43.48	37.31	19.61	20.1	41.67	36.6	18.18	30.05	90.91

Table-28

AGE SPECIFIC MORTALITY RATE (PER 1000) DURING THE YEARS 1996 - 2010

Affected Area

YEARS	1996			1997			1998			1999		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	R
00-04												
05-09												
10-14	3014	1	0.33	1722	2	1.16	549	0	-	5	0	-
15-19	5498	8	1.46	4749	6	1.26	3487	5	1.43	2407	2	0.83
20-24	4596	5	1.09	4731	6	1.27	3021	3	0.99	2519	0	-
25-29	4520	6	1.33	3412	6	1.76	3017	2	0.66	2132	0	-
30-34	3627	8	2.21	4124	3	0.73	2569	4	1.56	2190	3	1.37
35-39	3256	9	2.76	2710	9	3.32	2454	6	2.44	1761	2	1.14
40-44	2302	5	2.17	2519	8	3.18	1701	4	2.35	1386	1	0.72
45-49	2015	7	3.47	1688	11	6.52	1304	10	7.67	997	5	5.02
50-54	1615	15	9.29	1560	18	11.54	1025	6	5.85	880	9	10.23
55-59	1274	14	10.99	1029	11	10.69	801	8	9.99	601	6	9.98
60-64	967	23	23.78	948	17	17.93	653	9	13.78	515	6	11.65
65-69	554	11	19.86	487	9	18.48	377	10	26.53	268	9	33.58
70-74	692	34	49.13	642	12	18.69	427	14	32.79	318	11	34.59
75-79	219	11	50.23	185	13	70.27	137	5	36.50	100	8	80.00
80-84	208	7	33.65	178	10	56.18	115	7	60.87	81	3	37.04
85+	123	2	16.26	113	1	8.85	82	1	12.20	69	1	14.49
Total	**34480**	**166**	**4.81**	**30797**	**142**	**4.61**	**21719**	**94**	**4.33**	**16229**	**66**	**4.07**

P= Person, D= No of Death, DR= Death Rate

Cont.. of Table-28

YEARS	2000			2001		
AGE GROUP	P	D	DR	P	D	DR
00-04	-	-	-	-	-	-
05-09	-	-	-	-	-	-
10-14	-	-	-	-	-	-
15-19	2712	4	1.47	2085	0	-
20-24	3275	9	2.75	3803	2	0.53
25-29	3111	3	0.96	3135	3	0.96
30-34	2525	1	0.40	2981	3	1.01
35-39	2313	4	1.73	2369	4	1.69
40-44	1814	7	3.86	2164	9	4.16
45-49	1468	4	2.72	1579	8	5.07
50-54	1264	12	9.49	1347	12	8.91
55-59	993	17	17.12	1029	11	10.69
60-64	746	23	30.83	765	12	15.69
65-69	581	13	22.38	583	11	18.87
70-74	322	11	34.16	321	11	34.27
75-79	406	18	44.33	407	14	34.40
80-84	110	7	63.64	112	2	17.86
85+	172	10	58.14	183	4	21.86
Total	21812	143	6.56	22863	106	4.64

P= Person, D= No of Death, DR= Death Rate

Cont.. of Table-28

AGE SPECIFIC MORTALITY RATE (PER 1000) DURING THE YEARS 2002 - 2010
AFFECTED AREA

YEARS	2002			2003			2004			2005		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	R
00-04	-	-	-	-	-	-	-	-	-	-	-	-
05-09	-	-	-	-	-	-	-	-	-	-	-	-
10-14	-	-	-	-	-	-	-	-	-	-	-	-
15-19	1200	1	0.83	543	2	3.68	4	0	-	0	0	-
20-24	3271	8	2.45	3354	3	0.89	3040	2	0.66	2128	3	1.41
25-29	3246	8	2.46	2847	3	1.05	2963	3	1.01	2427	2	0.82
30-34'	2283	2	0.88	2706	3	1.11	2332	1	0.43	2200	3	1.36
35-39	2657	8	3.01	2277	3	1.32	2395	9	3.76	1774	4	2.25
40-44	1816	7	3.85	2199	5	2.27	2015	6	2.98	1661	5	3.01
45-49	1697	13	7.66	1540	6	3.90	1683	5	2.97	1403	7	4.99
50-54	1148	4	3.48	1268	8	6.31	1124	15	13.35	1137	4	3.52
55-59	1025	18	17.56	937	9	9.61	929	14	15.07	906	4	4.42
60-64	629	10	15.90	640	17	26.56	570	12	21.05	669	9	13.45
65-69	563	15	26.64	495	13	26.26	499	10	20.04	459	15	32.68
70-74	269	13	48.33	272	8	29.41	246	12	48.78	360	13	36.11
75-79	359	7	19.50	339	16	47.20	321	13	40.50	181	8	44.20
80-84	96	3	31.25	89	10	112.36	79	3	37.97	260	10	38.46
85+	159	3	18.87	138	6	43.48	136	7	51.47	176	3	17.05
Total	20418	120	5.88	19644	112	5.70	18336	112	6.11	15741	90	5.72

P= Person, D= No of Death, DR= Death Rate

Cont.. of Table-28

AGE SPECIFIC MORTALITY RATE (PER 1000) DURING THE YEARS 2002 – 2010 AFFECTED AREA															
YEARS	2006			2007'			2008'			2009'			2010		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
00-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05-09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-24	1536	1	0.65	777	1	1.29	380	1	2.63	6	-	-	-	-	-
25-29	2696	1	0.37	2030	2	0.99	2384	5	2.10	2387	5	2.09	2312	3	1.30
30-34	2122	4	1.89	1941	2	1.03	1844	1	0.54	2387	5	2.09	2698	3	1.11
35-39	1944	1	0.51	1253	1	0.80	1682	3	1.78	1802	5	2.77	2513	4	1.59
40-44	1630	3	1.84	1506	6	3.98	1458	5	3.43	1876	2	1.07	2033	5	2.46
45-49	1582	9	5.69	1117	7	6.27	1468	7	4.77	1549	8	5.16	1814	12	6.62
50-54	1124	8	7.12	1045	9	8.61	1066	5	4.69	1280	12	9.38	1447	5	3.46
55-59	930	10	10.75	652	5	7.67	834	13	15.6	881	9	10.22	1158	12	10.36
60-64	653	5	7.66	556	9	16.19	605	9	14.9	698	20	28.7	928	12	12.93
65-69	445	9	20.22	296	9	30.41	356	9	25.3	365	14	38.4	696	19	27.30
70-74	340	14	41.18	255	11	43.14	267	13	48.7	324	19	58.6	438	14	31.96
75-79	178	9	50.56	110	4	36.36	125	7	56.0	138	7	50.7	308	17	55.19
80-84	253	12	47.43	201	6	29.85	199	8	40.2	199	5	25.1	149	6	40.27
85+	176	5	28.41	134	5	37.31	149	3	20.1	164	6	36.6	366	11	30.05
	15609	91	5.8	11873	77	6.5	12817	89	6.9	14056	117	8.3	16860	123	7.30

P= Person, D= No of Death, DR= Death Rate

Table-29

AGE SPECIFIC MORTALITY RATE (PER 1000) DURING THE YEARS 1996 - 2010 CONTROL AREA												
YEARS	1996			1997			1998			1999		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	R
00-04	-	-	-	-	-	-	-	-	-	-	-	-
05-09	-	-	-	-	-	-	-	-	-	-	-	-
10-14	787	1	1.27	442	1	2.26	120	-	-	1	-	-
15-19	1371	2	1.46	1282	1	0.78	832	1	1.20	817	2	2.45
20-24	1008	4	3.97	1035	3	2.90	677	1	1.48	786	3	3.82
25-29	799	0	-	585	0	-	481	2	4.16	464	0	-
30-34'	835	2	2.40	873	1	1.15	462	2	4.33	493	2	4.06
35-39	895	3	3.35	739	1	1.35	575	0	-	571	0	-
40-44	694	0	-	749	6	8.01	482	0	-	499	2	4.01
45-49	558	1	1.79	507	2	3.94	388	0	-	355	1	2.82
50-54	359	4	11.14	343	6	17.49	224	0	-	229	2	8.73
55-59	230	0	-	201	2	9.95	132	0	-	130	2	15.38
60-64	138	2	14.49	122	2	16.39	71	0	-	81	3	37.04
65-69	86	0	-	70	0	-	44	0	-	42	5	119.05
70-74	129	3	23.26	118	2	16.95	58	2	34.48	62	3	48.39
75-79	39	1	25.64	32	1	31.25	20	0	-	22	0	-
80-84	33	1	30.30	27	1	37.04	20	1	50.00	19	0	-
85+	29	0	-	25	0	-	15	2	133.33	13	0	-
	7990	24	3.00	7150	29	4.06	4601	11	2.39	4584	25	5.45

P= Person, D= No of Death, DR= Death Rate

Cont of Table-29

AGE SPECIFIC MORTALITY RATE (PER 1000) DURING THE YEARS 1996 - 2010 CONTROL AREA						
YEARS	2000			2001		
AGE GROUP	P	D	DR	P	D	DR
00-04	-	-	-	-	-	-
05-09	-	-	-	-	-	-
10-14	-	-	-	-	-	-
15-19	797	1	1.25	520	1	1.92
20-24	917	3	3.27	931	3	3.22
25-29	638	0	-	662	2	3.02
30-34	473	1	2.11	483	1	2.07
35-39	567	0	-	519	0	-
40-44	598	4	6.69	591	3	5.08
45-49	502	3	5.98	460	3	6.52
50-54	381	3	7.87	370	5	13.51
55-59	239	4	16.74	219	2	9.13
60-64	140	2	14.29	134	3	22.39
65-69	88	3	34.09	83	3	36.14
70-74	45	1	22.22	42	3	71.43
75-79	77	1	12.99	66	3	45.45
80-84	24	0	-	23	1	43.48
85+	33	1	30.30	30	1	33.33
	5519	27	4.89	5133	34	6.62

Cont of Table-29

AGE SPECIFIC MORTALITY RATE (PER 1000) DURING THE YEARS 2002 – 2010 CONTROL AREA												
YEARS	2002			2003			2004			2005		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	R
00-04	-	-	-	-	-	-	-	-	-	-	-	-
05-09	-	-	-	-	-	-	-	-	-	-	-	-
10-14	-	-	-	-	-	-	-	-	-	-	-	-
15-19	284	0	-	120	0	-	1	0	-	0	0	-
20-24	814	0	-	917	3	3.27	852	0	-	580	1	1.72
25-29	660	0	-	711	0	-	797	2	2.51	694	2	2.88
30-34	353	0	-	485	1	2.06	490	1	2.04	497	0	-
35-39	559	4	7.16	485	2	4.12	489	0	-	373	1	2.68
40-44	476	2	4.20	592	4	6.76	601	1	1.66	439	1	2.28
45-49	444	2	4.50	487	1	2.05	490	1	2.04	434	2	4.61
50-54	306	2	6.54	381	1	2.62	359	1	2.79	360	3	8.33
55-59	216	2	9.26	218	4	18.35	231	3	12.99	281	4	14.23
60-64	118	4	33.90	127	2	15.75	130	1	7.69	166	6	36.14
65-69	68	2	29.41	74	3	40.54	72	3	41.67	101	1	9.90
70-74	36	0	-	39	1	25.64	38	2	52.63	61	0	-
75-79	56	1	17.86	54	3	55.56	52	1	19.23	29	3	103.45
80-84	15	2	133.33	18	0	-	23	2	86.96	49	1	20.41
85+	27	0	-	32	1	31.25	25	3	120.00	41	0	-
	4432	21	4.74	4740	26	5.49	4650	21	4.52	4105	25	6.09

Cont of Table-29
AGE SPECIFIC MORTALITY RATE (PER 1000) DURING THE YEARS 2002 – 2010
CONTROL AREA

YEARS	2006			2007'			2008'			2009'			2010		
AGE GROUP	P	D	DR	P	P	P	P	D	DR	P	D	DR			-
00-04	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
05-09	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
10-14	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
15-19	-	-	-	-	-	-	-	-	-	-	-	-	-	-	-
20-24	589	-	-	376	0	-	142	-	-	2	-	-	-	-	-
25-29	1004	-	2.99	1064	2	1.88	1084	4	3.69	1096	1	0.91	904	-	-
30-34	686	-	1.46	851	1	1.18	820	1	1.22	1023	1	0.98	1060	4	3.77
35-39	518	-	3.86	455	0	-	579	2	3.45	613	1	1.63	708	7	9.89
40-44	547	-	1.83	668	0	-	557	2	3.59	622	6	9.65	510	2	3.92
45-49	608	2	3.29	607	2	3.29	710	4	5.63	741	5	6.75	500	2	4.00
50-54	463	2	4.32	555	4	7.21	548	4	7.30	651	6	9.22	625	2	3.20
55-59	356	3	8.43	362	4	11.05	407	1	2.46	421	7	16.63	501	1	2.00
60-64	212	6	28.30	234	7	29.91	216	5	23.15	252	4	15.87	374	4	10.70
65-69	132	3	22.73	139	2	14.39	142	4	28.17	148	4	27.03	215	2	9.30
70-74	78	4	51.28	79	2	25.32	82	2	24.39	87	1	11.49	127	5	39.37
75-79	37	4	108.11	35	1	28.57	35	2	57.14	35	3	85.71	79	1	12.66
80-84	62	2	32.26	64	1	15.63	57	2	35.09	56	2	35.71	33	3	90.91
85+	46	2	43.48	51	1	19.61	48	2	41.67	55	1	18.18	105	2	19.05
	5338	35	6.56	5540	27	4.87	5427	35	6.45	5802	42	7.24	5741	35	6.10

P= Person, D= No of Death, DR= Death Rate

Table - 30
ABORTION AND STILL BIRTH RATES IN EXPOSED AND CONTROL AREAS DURING THE YEAR 1996 – 2010

AREA	SEVERE			MODERATE			MILD			CONTROL		
	Total Preg	Abortion	Still Birth	Total Preg	Abortion	Still Birth	Total Preg	Abortion	Still Birth	Total Preg	Abortion	Still Birth
1996	426	6 (13.73)	5 (11.45)	452	4 (8.72)	3 (6.54)	142	1 (7.0)	2 (13.98)	212	6 (27.27)	2 (9.09)
1997	245	5 (19.85)	2 (7.94)	271	4 (14.39)	3 (10.8)	108	1 (9.18)	1 (9.17)	150	0	1 (6.62)
1998	234	4 (16.81)	0	284	0	2 (7.0)	113	0	2 (17.69)	157	0	2 (12.57)
1999	153	3 (19.23)	0	258	4 (15.7)	4 (15.27)	84	0	0	188	0	1 (5.29)
2000	194	4 (20.21)	0	200	0	0	87	1 (11.36)	1 (11.36)	107	1 (9.25)	0
2001	174	4 (22.35)	1 (5.59)	221	0	1 (4.51)	82	2 (23.80)	0	110	0	1 (9.0)
2002	191	6 (40.55)	1 (6.76)	216	1 (4.61)	0	79	0	1 (12.69)	154	0	1 (6.45)
2003	161	5 (30.12)	0	211	1 (4.72)	0	75	1 (13.15)	1 (13.15)	122	0	0
2004	149	10 (62.90)	0	156	0	0	82	1 (12.04)	0	183	1 (5.40)	1 (5.0)
2005	197	9 (43.48)	1 (4.83)	191	1 (5.13)	3 (15.39)	77	1 (12.87)	1 (12.82)	160	0	3 (18.40)
2006	177	4 (22.1)	0	205	0	1 (4.86)	81	0	0	177	0	0
2007	211	3 (13.96)	1 (4.66)	181	0	0	75	1 (13.15)	1 (13.15)	198	0	0
2008	233	2 (8.51)	0	201	0	1 (4.95)	79	1 (12.5)	0	183	0	3 (16.12)
2009	214	1 (4.65)	0	259	0	0	68	2 (28.57)	0	191	3 (15.46)	0
2010	174	0 (0)	1 (5.72)	206	1 (4.83)	0	84	4(45.45)	4 (45.45)	167	1 (5.91)	1 (5.91)

Figures in Parentheses represent rate per 1000

Table- 31
GENERAL MORBIDITY RATES DURING THE YEARS 1984 – 2010

AREA	SEVERE			MODERATE			MILD			CONTROL		
YEARS	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
	Cont.	Morbid		Cont.	Morbid		Cont.	Morbid		Cont.	Morbid	
1984	24994	24743	98.99	33442	33127	99.05	18208	18126	99.54	15616	27	0.17
1991	8070	2820	34.94	13150	3404	25.88	6952	1931	27.77	7911	1758	22.22
1996	10816	3050	28.20	14137	3426	24.23	9527	2106	22.11	7990	884	11.06
1997	8608	2193	25.47	13169	2996	22.75	9020	1833	20.32	7150	760	10.63
1998	5278	1452	27.50	9485	2012	21.21	6956	1273	18.29	4601	441	9.58
1999	3550	811	22.85	7438	1485	19.97	5241	878	16.75	4584	402	8.77
2000	5965	1415	23.72	9279	1668	17.98	6568	1064	16.20	5519	383	6.94
2001	6895	1500	21.76	9792	1653	16.88	6176	982	15.90	5133	397	7.74
2002	5519	1202	21.77	9069	1527	16.83	5830	878	15.06	4432	286	6.45
2003	5171	1162	22.47	8946	1504	16.81	5527	859	15.54	4740	310	6.54
2004	5538	1298	23.43	7302	1294	17.71	5496	1068	19.43	4650	449	9.66
2005	4886	1151	23.56	5712	924	16.17	5143	920	17.89	4105	332	8.08
2006	4961	1120	22.58	5834	978	16.76	4814	781	16.22	5338	414	7.76
2007	5790	1242	21.44	4227	641	15.16	1856	305	16.43	5540	382	6.90
2008	5921	1224	20.66	4347	761	17.49	2549	508	19.93	5427	404	7.44
2009	5364	1149	21.41	5254	842	16.02	3438	586	17.05	5802	459	7.91
2010	5658	1229	21.72	6533	1093	16.72	4669	772	16.53	5741	480	8.36

Table 31: Gives the details of general morbidity rates observed during the years 1984 till 2010 in affected 3 areas (severe, moderate and mild) and control area.

The years 1992,93,&94 have not been represented in the Table. The reasons for non consideration have been highlighted in technical report 1985-1994. 3 exposed areas viz. severe, moderate and mild and control areas have been highlighted. It may be noted that the percentage of morbidity during 1984 in the cohort is in the order of 99.05% to 98.99% in exposed areas and it remains only 0.17% in control area.

It may be observed that the morbidity reduced to 34.94 (64.05% reduction) in severe area by 1991 over a span of 5 years. Similarly the morbidity comes down to 28.88% from 99.05% in moderate area (reduction by 73.17% by 1991).

The reduction in morbidity to 27.77% during 1991 from 99.54 of 1984,(77.71%)in mild areas was a notable feature. It may be observed that the reduction in morbidity can be noticed right up to 1998 to the range of 18.292 to 27.50% from mild to severe area demonstrating with the minimum reduction in morbidity was noticed by 1998 i.e. 14 years. The notable observation from Table No7 is the reduction in the morbidity in all the 3 exposed areas is from 98.99% to 16.53% by 2010.
The identified morbidity in 2010 under severely exposed area stands at 21.72% when compare to 16.72 and 16.53 of moderate and mild areas which is significant statistically ($z=7.04, p<0.01$)
In comparison to the morbidity of the control population where the percentage of morbidity recorded is 8.36% there is a significant existing morbidity in all the 3 exposed areas in the range of 16.53 to 21.72%.
The salient points to be understood from table 31 are as follows.

- In the severe area between 1984-97, morbidity declined from 98.99 to 27.50 i.e., by 71.49% which is drastic reduction in the morbidity which is highly significant (statistical validation to be undertaken).

In mild areas the reduction in morbidity rate was 71.77% from 1984-1991 thereby informing in a span of five years, morbidity condition reduced significantly (chi-square(x^2)3.84,$p<0.05$,d.f.=1).

- Recorded morbidity of 22.22% during 1991 from the control area may be a total and co-incidence in attributable to post disaster scenario.
- It may be observed that there is a drastic reduction in the morbidity in all the affected areas from 1984-2010 to 21.72% in severe 16.72% to moderate and 16.53% in mild exposed areas over a period of 26 years. The persistent comparable higher percentage of morbidity observed over 26 years in three affected areas in comparison with the control area needs regular follow-up supported by relevant investigations on the various likely influences which may be existing non symptoms becoming symptomatic over the years or condition of the symptoms under medication being not improved because of certain amount of irreparable damage which might have taken place during the course of time of 26 years. This observation needs an element of doubt to rule out the possibility of concomitant influences/confounding factors which needs to be further investigated scientifically and technically reviewed.

Table – 31a GENERAL MORBIDITY RATES DURING THE YEARS 1996 – 2010

AREA	SEVERE			MODERATE			MILD			CONTROL		
VISITS	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
1996 - 10	Cont.	Morbid		Cont.	Morbid		Cont.	Morbid		Cont.	Morbid	
1	11551	3500	30.30	14021	3379	24.10	9489	2311	24.35	8024	973	12.13
2	10080	2600	25.79	14252	3472	24.36	9564	1901	19.88	7955	794	9.98
3	8507	2216	26.05	12154	2790	22.96	8771	1910	21.78	6744	779	11.55
4	8708	2169	24.91	14184	3202	22.57	9268	1756	18.95	7556	740	9.79
5	6453	1843	28.56	11714	2556	21.82	7303	1415	19.38	4227	397	9.39
6	4102	1060	25.84	7255	1468	20.23	6609	1130	17.10	4975	485	9.75
7	4015	906	22.57	7451	1395	18.72	5816	1039	17.86	4861	406	8.35
8	3085	716	23.21	7424	1575	21.21	4665	716	15.35	4306	398	9.24
9	6959	1682	24.17	9050	1756	19.40	6963	1131	16.24	5553	499	8.99
10	4970	1147	23.08	9508	1580	16.62	6172	997	16.15	5484	267	4.87
11	5543	1325	23.90	9386	1643	17.50	5310	931	17.53	4796	419	8.74
12	8246	1675	20.31	10197	1663	16.31	7041	1032	14.66	5469	375	6.86
13	6111	1346	22.03	9782	1627	16.63	6455	1002	15.52	4483	266	5.93
14	4927	1057	21.45	8356	1426	17.07	5205	754	14.49	4381	305	6.96
15	4900	1131	23.08	9373	1562	16.66	6088	977	16.05	5397	264	4.89
16	5441	1193	21.93	8519	1445	16.96	4966	741	14.92	4082	356	8.72
17	6119	1321	21.59	7689	1278	16.62	6596	1111	16.84	4522	371	8.20
18	4957	1274	25.70	6915	1309	18.93	4395	1025	23.32	4778	526	11.01
19	4099	932	22.74	4818	663	13.76	4482	736	16.42	4171	344	8.25
20	5673	1370	24.15	6606	1184	17.92	5804	1103	19.00	4039	319	7.90
21	4824	1071	22.20	6221	1058	17.01	5605	938	16.74	5226	420	8.04
22	5097	1169	22.94	5447	898	16.49	4023	624	15.51	5449	407	7.47
23	6306	1353	21.46	3667	492	13.42	1994	350	17.55	5710	410	7.18
24	5273	1130	21.43	4787	790	16.50	1718	260	15.13	5369	354	6.59
25	6212	1235	19.88	4565	733	16.06	1665	324	19.46	5087	340	6.68
26	5630	1212	21.53	4129	788	19.08	3433	692	20.16	5767	467	8.10
27	5586	1286	23.02	5348	896	16.75	3723	708	19.02	5821	478	8.21
28	5141	1011	19.67	5160	787	15.25	3152	463	14.69	5782	439	7.59
29	5771	1220	21.14	5922	896	15.13	4202	599	14.26	5721	445	7.78
30	5544	1277	23.03	7144	1289	18.04	5136	944	18.38	5761	514	8.92
Cont. - Contacted												

1 - Jan. 96 July 96, 2 - July 96 -Jan 97, 3 - Feb 97 - July 97, 4 - Aug 97 - Dec 97,

5 - Jan 98 - July 98, 6 - July 98 - Dec. 98, 7 - Jan 99 - June 99, 8- July 99 - Dec.99, 9 - Jan 2000 - July 00,

10 - July 00 - Dec.00, 11 - Jan 01 - July 01, 12- July 01- Dec.01, 13 - Jan 02 - June 02, 14 - July 02 - Dec02,

15- Jan 03 - June 03, ±6 July 03- Dec.03, 17 - Jan 04 - June 04, 18 - July 04 - Dec04. 19 - Jan 05 - June 05, 20 July 05 - Dec 05.

21 Jan 06 - June 06. 22 July 06 - Dec 06. 23 Jan 07 - June 07.24 July 07 - Dec 07. 25 Jan 08 - June 08. 26 July 08 - Dec 08.

27 Jan 09 - Junr 09. 28 July 09 - Dec 09. 29 Jan 10 - Jun 10. 30 July 10 - July 11.

Note– 31a Gives the details of general morbidity observed during 30 No. Sixth monthly follow up survey of cohort population, for the period 1996 to 2010, for the purpose of consolidation and expressing the data on yearly basis the specific year two six monthly data have been combined and average has been considered for analysis purpose.

Table- 32

RESPIRATORY MORBIDITY RATES DURING THE YEARS 1984 – 2010

AREA	SEVERE			MODERATE			MILD			CONTROL		
VISITS	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
1986-10	Cont.	Morbid		Cont.	Morbid		Cont.	Morbid		Cont.	Morbid	
1984	24994	24213	96.87	33442	32802	97.45	18208	17958	98.62	15616	10	0.06
1991	8070	1632	20.23	13150	2012	15.30	6952	1147	16.49	7911	288	3.64
1996	10816	2207	20.41	14137	2402	16.99	9527	1568	16.46	7990	349	4.37
1997	8608	1596	18.54	13169	2032	15.43	9020	1426	15.80	7150	264	3.69
1998	5278	1072	20.31	9485	1425	15.02	6956	1004	14.43	4601	153	3.33
1999	3550	628	17.69	7438	1017	13.67	5241	718	13.69	4584	127	2.77
2000	5965	1117	18.73	9279	1193	12.86	6568	910	13.86	5519	119	2.16
2001	6895	1202	17.43	9792	1133	11.57	6176	856	13.86	5133	136	2.65
2002	5519	977	17.70	9069	1070	11.80	5830	778	13.34	4432	83	1.87
2003	5171	897	17.35	8946	1027	11.48	5527	740	13.39	4740	109	2.30
2004	5538	941	16.99	7311	825	11.29	5496	902	16.41	4650	129	2.77
2005	4886	822	16.81	5712	601	10.52	5143	764	14.85	4105	98	2.38
2006	4961	835	16.83	5834	630	10.80	4814	675	14.02	5338	160	3.00
2007	5790	903	15.60	4227	409	9.68	1856	251	13.52	5540	143	2.58
2008	5921	913	15.42	4347	487	11.20	2549	407	15.97	5427	142	2.62
2009	5364	903	16.83	5254	506	9.63	3438	449	13.06	5802	153	2.64
2010	5658	978	17.29	6533	641	9.81	4669	608	13.02	5741	147	2.56

It may be observed that the morbidity which was 96.87% during 1984 drastically dropped to 20.31% by 1998 which is highly significant.

Table – 32 gives the distribution of pulmonary/lung morbidity rates observed during the years 1984-2010. It may be noted in each category for each year the details of number of persons conducted and number of persons with morbidity has been reported.

The recorded morbidity for the year 1984 in the severe area is 96.87%, moderate area 97.40% mild area 98.62% compare to 0.06% for the control area. From the year 1991 onwards there is a gross reduction. Pulmonary morbidity uniformly observed in all exposed area. There by informing that the pulmonary morbidity was only due to a single time exposure area happening. In view of this whoever was exposed at with particular point of time demonstrated morbidity condition thereby resulting in sizable number of subjects coming out with the symptom of pulmonary morbidity.

By 1991 the same pulmonary morbidity started showing decline in terms of 76.642- 82.15% among the exposed area.

However, the percentage of morbidity remained at the higher level among the severely affected population when compare to moderate and mild. However over the years by 2010 the pulmonary morbidity insisted in the range of 9.81 to 17.29% in the affected areas. The reasons for percentage variation of pulmonary morbidity in 3 areas over the years are mainly because of large number of parameters influencing the movement of MIC gas cloud and how it traversed. These factors might be amount of release, it is concentration density, environmental condition in terms of temperature, humidity wind movement and velocity, wind direction, persistence of wind, availability of the concentration during the time of release how long the cloud transverse, how it affected population in different areas, ground level concentration the level at which the concentration were beyond the toxic limits the period of exposure, health condition of the individual at that time of time exposure and large number of relevant observations which can be accounted while assessing the individual exposure. It is extremely difficult to bring all these in to consideration for accounting individual morbidity. However it should be understood from the table that the pulmonary morbidity is a notable morbid condition still existing in the exposed areas which needs be looked into for initiating appropriate monitoring and intervention strategies.

Table -33

OPHTHALMIC MORBIDITY RATES DURING THE YEARS 1984 - 2010

AREA	SEVERE			MODERATE			MILD			CONTROL		
YEARS	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%
1984	24994	24621	98.50	33442	32802	98.08	18208	18027	99.00	15616	11	0.07
1991	8070	950	11.77	13150	1583	12.03	6952	1062	15.27	7911	533	6.74
1996	10816	1795	16.60	14137	1754	12.41	9527	1428	14.98	7990	330	4.13
1997	8608	1374	15.96	13169	1608	12.21	9020	1301	14.42	7150	298	4.17
1998	5278	995	18.85	9485	397	10.51	6956	926	13.31	4601	163	3.54
1999	3550	702	19.77	7438	789	10.61	5241	706	13.47	4584	154	3.36
2000	5965	1001	16.77	9279	831	8.96	6568	895	13.63	5519	148	2.68
2001	6895	1055	15.29	9792	831	8.48	6176	804	13.02	5133	153	2.98
2002	5519	822	14.89	9069	759	8.36	5830	759	13.02	4432	98	2.21
2003	5171	755	14.60	8946	792	8.85	5527	760	13.75	4740	130	2.74
2004	5538	733	13.24	7302	800	10.95	5496	927	16.87	4650	162	3.48
2005	4886	572	11.71	5712	514	9.00	5143	796	15.48	4105	133	3.24
2006	4961	656	13.22	5834	595	10.20	4814	708	14.71	5338	183	3.43
2007	5790	664	11.46	4227	457	10.80	1856	268	14.44	5540	181	3.27
2008	5921	781	13.19	4347	481	11.07	2549	456	17.89	5427	145	2.67
2009	5364	830	15.47	5254	535	10.17	3438	528	15.36	5802	165	2.84
2010	5658	897	15.85	6533	614	9.39	4669	653	13.99	5741	193	3.36

Table-33 presents the details of eye morbidity rates observed during the years 1984-2010. The rate of morbidity was in the range of 98.08 to 99% during the year 1984 in all the 3 exposed areas.By 1991 in a span of 6 years it reduces to a range of 11.772 to 15.27. Subsequently by 2010 it was observed to be in the range of 9.39 to 15.85.This clearly indicates that the eye morbidity was also only at the time of the disaster which took place in 1984 it was only at the time of exposure to the toxic fumes which resulted in eye morbidity condition. There was no other influencing factor in extenuating eye problems over a period of time hence morbidity also showing the declining trend. Thereby it has stabilized the 9.392 to 15.8% in the exposed population .Even this eye morbidity conditions is 3-5% more among the exposed population when compare to the control which is significantly being demonstrated in the table.

Table -34
GASTRO INTESTINAL TRACT (GIT) MORBIDITY RATES DURING THE YEARS 1984 – 2010

AREA	SEVERE			MODERATE			MILD			CONTROL		
YEARS	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%	No. Cont.	No. Morbid	%
1984	24994	18379	73.53	33442	8817	26.36	18208	2733	15.00	15616	3	0.01
1991	8070	645	7.99	13150	857	6.52	6952	409	5.88	7911	459	5.80
1996	10816	649	6.00	14137	596	4.21	9527	743	7.80	7990	193	2.42
1997	8608	369	4.28	13169	596	4.53	9020	848	9.40	7150	198	2.77
1998	5278	342	6.48	9485	419	4.41	6956	559	8.04	4601	95	2.06
1999	3550	160	4.49	7438	274	3.68	5241	420	8.01	4584	57	1.24
2000	5965	309	5.17	9279	402	4.33	6568	571	8.69	5519	80	1.45
2001	6895	351	5.09	9792	345	3.52	6176	569	9.21	5133	81	1.58
2002	5519	252	4.56	9069	312	3.44	5830	491	8.42	4432	66	1.49
2003	5171	244	4.72	8946	418	4.67	5527	504	4.56	4740	66	1.39
2004	5538	262	4.73	7302	316	4.33	5496	680	12.37	4650	93	2.00
2005	4886	262	5.35	5712	298	5.21	5143	523	10.17	4105	89	2.17
2006	4961	256	5.16	5834	303	5.19	4814	508	10.55	5338	90	1.69
2007	5790	293	5.06	4227	139	3.29	1856	229	12.34	5540	80	1.44
2008	5921	270	4.56	4347	219	5.03	2549	347	13.61	5427	120	2.21
2009	5364	267	4.98	5254	217	4.13	3438	328	9.54	5802	138	2.38
2010	5658	295	5.21	6533	265	4.06	4669	442	9.47	5741	119	2.07

Table-34 presents gastro intestinal tract morbidity rates observed during the year 1984 and 2010. It may be seen from the tables during 1984 the study morbidity was in the range of 15% to 73.5% among the exposed population. By 1991 it reduced to 5.88 to 7.99.By the year 2010 it is between 4.06 to 9.47%. Thereby indicating it may be a influence of one time exposure persisting for a long time over the years. When are to the prevalence of the similar morbidity it is 2 to 5% more in the exposed population. Persistent GIT morbidity might have been contributed by the drugs which have been advised for number of other ailments thereby it might have become persistent over the years in the exposed population.

Table – 35
GIT SYMPTOM-WISE ANALYSIS IN SEVRE AREA DURING THE YEAR 1986-2010

Year	1986		1991		1996		2001		2006		2010	
GIT SYMPTOMS	Morbid	%	Morbid	%	Morbid	%	Morbid	%	Morbid	%	Morbid	%
Lack of appetite	89	11.82	101	15.66	216	31.39	20	5.7	7	3	7	2.37
Abdominal pain	463	61.5	453	70.23	373	54.21	161	45.84	160	62.5	182	61.69
Diarrhoea	94	12.48	47	7.29	25	3.63	6	1.7	4	1.56	4	1.35
Vomiting	141	18.73	30	4.65	14	2.03	2	0.56	2.5	9.76	2.5	8.47
Gastritis	89	11.8	152	23.57	94	13.66	80	22.79	145	56.64	183	62.03
Haematomesis	0	0	0	0	1	0.14	0	0	0	0	0	0
Total GIT	**753**		**645**		**688**		**351**		**256**		**295**	

Table –36
GIT SYMPTOM- WISE ANALYSIS IN MODERATE AREA DURING THE YEAR 1986-2010

Year	1986		1991		1996		2001		2006		2010	
GIT SYMPTOMS	Morbid	%	Morbid	%	Morbid	%	Morbid	%	Morbid	%	Morbid	%
Lack of appetite	77	16.39	136	15.87	38	6.38	12	3.48	3	0.99	6	2.08
Abdominal pain	326	69.36	555	64.76	435	72.99	174	50.43	294	97.03	165	62.26
Constipation	11	2.34	13	1.52	3	0.50	52	15.07	5	1.49	10	3.77
Diarrhoea	42	8.94	68	7.94	25	4.11	3	0.72	6	1.82	6	2.08
Vomiting	36	7.66	58	6.77	23	3.78	1	0.29	1	0.17	11	3.96
Gastritis	88	18.73	227	26.49	255	42.70	126	36.52	177	58.25	148	55.85
Haematomesis	0	0.00	1	0.12	1	0.08	0	0.00	0	0	0	0.00
Total GIT	**470**		**857**		**596**		**345**		**303**		**265**	

Table –37
GIT SYMPTOM- WISE ANALYSIS IN MILD AREA DURING THE YEAR 1986-2010

Year	1986		1991		1996		2001		2006		2010	
GIT SYMPTOMS	Morbid	%	Morbid	%	Morbid	%	Morbid	%	Morbid	%	Morbid	%
Lack of appetite	49	23.77	47	11.50	49	6.59	20	3.51	3	0.59	21	4.64
Abdominal pain	126	61.17	205	50.12	315	42.40	84	14.76	210	41.34	192	43.44
Constipation	12	5.83	18	4.40	28	3.77	21	3.69	2	0.39	11	2.38
Diarrhoea	44	21.36	37	9.10	13	1.75	3	0.53	1	0.10	4	0.79
Vomiting	5	2.43	27	6.60	9	1.21	0	0.00	2	0.30	1	0.23
Gastritis	5	2.43	234	57.22	570	76.72	298	52.37	502	98.82	404	91.40
Haematomesis	0	0.00	1	0.24	20	2.62	0	0.00	0	0.00	0	0.00
Total GIT	206		409		743		569		508		442	

Table – 38
GIT SYMPTOM- WISE ANALYSIS IN CONTROL AREA DURING THE YEAR 1986-2010

Year >	1986		1991		1996		2001		2006		2010	
GIT SYMPTOMS	Morbid	%	Morbid	%	Morbid	%	Morbid	%	Morbid	%	Morbid	%
Lack of appetite	9	10.12	173	37.69	16	8.29	6	7.41	9	9.44	8	6.30
Abdominal pain	31	34.84	254	55.34	180	93.26	50	61.73	76	84.44	98	82.35
Constipation	0	0.00	17	3.70	4	1.81	2	1.85	1	0.56	0	0.00
Diarrhoea	48	53.93	44	9.59	9	4.40	1	1.23	3	3.33	10	8.40
Vomiting	12	13.49	25	5.45	8	4.15	0	0.00	7	7.78	4	2.94
Gastritis	11	12.36	145	31.59	57	29.27	23	28.40	23	25.56	15	12.18
Haematomesis	0	0.00	4	0.87	0	0.00	1	0.62	0	0.00	2	1.26
Total GIT	89		459		193		81		90		119	

Table 35-38 present the details of gastrointestinal symptoms in 4 areas for the period 1986-2010. It can be noticed the GIT symptoms include lack of appetite/loss of appetite, abdominal pain, constipation/passing of hard stools/diarrhoea , vomiting, epigastric burning and hematamosis/vomiting of blood. The tables also gives the details of persons who had more than one type of GIT symptoms in the form of total GIT symptoms recorded. Uniformly it can be observed that the morbidity in respect of abdominal pain and epigastric burning are very prominently seen in all the areas for the period 1986-2010. This particular symptom may be due to the influence of dietary habit, number of drugs being taken for different ailments and the influence of large number stressors. However, this needs to be assessed and closely monitored through clinical investigation to exactly pinpoint the risks and also to resort to suitable intervention measures to contain this symptom, which is persistently observed over a sizeable population. The comparison between 3 exposed areas and control further reveals the prevalence of abdominal pain is equally identified in control area almost with similar number of individuals complaining of the specific morbidity. However, the epigastric burning is significant.

Table -39
SKIN MORBIDITY RATES DURING THE YEARS 1984– 2010

AREA	SEVERE			MODERATE			MILD			CONTROL		
YEARS	No.	No.	%	No.	No.	%	No.	No.	%	No.	No.	%
	Cont.	Morbid		Cont.	Morbid		Cont.	Morbid		Cont.	Morbid	
1984	24994	321	1.28	33442	610	1.82	18208	163	0.89	15616	0	-
1991	8070	189	2.34	13150	260	1.97	6952	60	0.86	7911	109	1.37
1996	10816	146	1.35	14137	101	0.71	9527	49	0.51	7990	29	0.36
1997	8608	99	1.15	13169	99	0.75	9020	45	0.50	7150	22	0.31
1998	5278	118	2.24	9485	70	0.74	6956	22	0.32	4601	22	0.48
1999	3550	52	1.46	7438	30	0.40	5241	15	0.29	4584	18	0.39
2000	5965	84	1.41	9279	38	0.41	6568	13	0.20	5519	12	0.22
2001	6895	73	1.06	9792	42	0.43	6176	8	0.13	5133	16	0.31
2002	5519	63	1.14	9069	52	0.57	5830	12	0.21	4432	13	0.29
2003	5171	68	1.32	8946	29	0.32	5527	11	0.20	4740	7	0.15
2004	5538	90	1.63	7302	51	0.70	5496	17	0.31	4650	11	0.24
2005	4886	66	1.35	5712	19	0.33	5143	14	0.27	4105	11	0.27
2006	4961	58	1.17	5834	34	0.58	4814	4	0.08	5338	14	0.26
2007	5790	53	0.92	4227	18	0.43	1856	2	0.11	5540	10	0.18
2008	5921	54	0.91	4347	28	0.64	2549	11	0.43	5427	15	0.28
2009	5364	47	0.88	5254	21	0.40	3438	3	0.09	5802	21	0.36
2010	5658	50	0.89	6533	26	0.39	4669	26	0.56	5741	17	0.29

Table – 39 gives the prevalence of skin morbidity rates observed during the year 1984-2010 the initial morbidity which was identified during 1984 subsequent to the disaster was in the range of 0.89 to 1.82%. Even during 2010 it is prevailing at 0.39 to 0.89% it is statistically insignificant($z=1.27, p>0.05$) When compare to the similar morbidity from the control it is not significant. Hence the skin morbidity cannot be considered as a contributed morbid condition due to 1984 disaster.

Table 40

AGE SPECIFIC (Present Age) MORBIDITY RATE DURING THE YEAR 1986-2010 SEVERE AREA

Yrs./Age	0-4 C	M	%	05-14.C	M	%	15-44 C	M	%	45-64 C	M	%	65+ C	M	%	Total
1984	3313	3222	97.25	6604	6549	99.16	11985	11900	99.29	2636	2621	99.43	456	452	99.12	24994
1991	0	0		2208	462	20.92	4597	1574	34.24	952	604	63.44	313	180	57.50	8070
1996	0	0		1084	132	12.18	7404	1509	20.38	1783	1141	63.99	545	268	49.17	10816
2001	0	0		0	0		5054	478	9.46	1390	814	58.56	451	208	46.17	6895
2006	0	0		0	0		3242	227	7.00	1296	691	53.31	423	202	47.75	4961
2010	0	0		0	0		3278	110	3.36	1749	789	45.01	631	330	52.29	5658

C= Contacted, M = No. of Morbid

Table – 41

AGE SPECIFIC (Present Age) MORBIDITY RATE DURING THE YEAR 1986-2010 MODERATE AREA

Yrs./Age	0-4 C	M	%	05-14.C	M	%	15-44 C	M	%	45-64 C	M	%	65+ C	M	%	Total
1984	3874	3798	98.03	9110	9021	99.02	15997	15863	99.16	3745	3732	99.65	716	713	99.58	33442
1991	0	0		3208	626	19.51	7711	2063	26.75	1743	917	52.61	488	248	50.82	13150
1996	0	0		1178	86	7.30	9799	1558	15.89	2436	1393	57.18	724	389	53.72	14137
2001	0	0		0	0		7100	597	8.40	1979	791	40.00	713	265	37.17	9792
2006	0	0		0	0		3736	233	6.24	1567	571	36.41	531	174	32.76	5834
2010	0	0		0	0		3811	153	4.00	1955	644	32.94	767	296	38.55	6533

C - No. of Contacted, M- Number of morbid

Table – 42

AGE SPECIFIC (Present Age)MORBIDITY RATE DURING THE YEAR 1986-2010 MILD AREA

Yrs./Age	0-4 C	M	%	05-14.C	M	%	15-44 C	M	%	45-64 C	M	%	65+ C	M	%	Total
1984	1895	1875	98.94	4527	4514	99.73	9300	9265	99.62	1999	1991	99.59	487	481	98.76	18208
1991	0	0		1561	153	9.80	4166	991	19.18	929	591	64.16	296	196	66.21	6952
1996	0	0		752	42	5.58	6596	788	11.94	1652	978	59.19	527	298	56.60	9527
2001	0	0		0	0		4383	185	4.22	1351	567	41.98	442	230	51.98	6176
2006	0	0		0	0		2950	64	2.17	1426	502	35.20	438	215	49.03	4814
2010	0	0		0	0		2467	37	1.49	1643	456	27.73	559	279	49.87	4669

C - No. of Contacted, M- Number of morbid

Table – 43

AGE SPECIFIC (Present Age) MORBIDITY RATE DURING THE YEAR 1986-2010 CONTROL AREA

Yrs./Age	0-4 C	M	%	05-14.C	M	%	15-44 C	M	%	45-64 C	M	%	65+ C	M	%	Total
1984	2004	4	0.20	4238	3	0.07	7836	12	0.15	1320	8	0.61	268	0	-	15666
1991	0	0		2128	294	13.81	4641	1030	22.19	887	338	38.10	255	96	37.64	7911
1996	0	0		787	35	4.45	5602	463	8.26	1285	287	22.30	316	99	31.17	7990
2001	0	0		0	0		3706	162	4.37	1183	187	15.77	244	48	19.71	5133
2006	0	0		0	0		3344	90	2.69	1639	238	14.53	355	86	24.12	5338
2010	0	0		0	0		3082	28	0.91	2100	287	13.65	559	165	29.52	5741

C= Contacted, M = No. of Morbid.

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