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 (1985 - 1994)

Bhopal Gas Disaster Research Centre
Gandhi Medical College
Bhopal (M.P.), India

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TECHNICAL REPORT
POPULATION BASED LONG TERM EPIDEMIOLOGICAL STUDIES ON HEALTH EFFECTS OF BHOPAL TOXIC GAS EXPOSURE
ICMR PROJECT 02

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PREFACE

On the night of 2nd/3rd December 1984, world's worst industrial accident took place at the pesticide plant in Bhopal in the state of Madhya Pradesh of India, owned by an American Multinational, the Union Carbide Corporation. Approximately, 40 tons of highly toxic liquid Methyl Isocyanate (MIC) stored in tank 610 suddenly escaped in a gaseous form into the atmosphere, apparently precipitated by entry of water into the tank. This occurred around midnight when the ambient temperature was below 10º Celsius. Most people were at home when the tank burst out emitting a thick cloud of deadly fumes into the night. The Gases came into their houses without warning. They woke up choked and coughing, unable to breathe; rubbing their eyes unable to see because of acute swelling and burning. In a state of utter confusion and panic they tumbled out of their houses, sometimes only to be engulfed by more gas waiting there. Approximately, 5 lac individuals out of a total population of over 8 lac were reported/estimated to have been affected. A large number of deaths occurred in the exposed population – a conservative estimate of about 2500 deaths was derived.

Ironically, despite the existence of the Union Carbide MIC manufacturing plant since 1980, at the time of the disaster no information whatsoever on the toxicity of MIC was or could be provided by the Union Carbide management, let alone there being any contingency plans for disaster management. Immediate observations on the dead (post mortem) and the pattern of morbidity amongst the survivors left no doubt that although lung and eyes seemed the main target organs, multiorgan involvement in the survivors was only to be expected! Certain pertinent questions were raised in this regard : How long will the effects last? What permanent disabilities can be expected? What is the outlook for these victims? What of their offsprings?

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 and 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 who contributed in this endeavour. Twenty main research projects on various aspects of the gas injury ranging form epidemiology to molecular biology were initiated. The ICMR established the Bhopal Gas Disaster Research Centre (BGDRC) at the Gandhi Medical College to coordinate research activities.

A matter of pride! In addition to several ICMR institutes many prominent medical research institutions all 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 who were residing in notified 36 municipal wards of Bhopal affected by the 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.

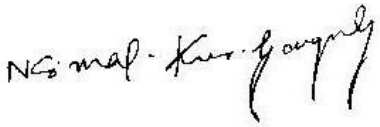
It is indeed sad to report the demise of two of the key scientists of the ICMR who were actually associated with the writing of the Epidemiological Report : Dr.C.R.Ramachandran – Senior Deputy Director General (Non-communicable Diseases) in 2000 and Dr.M.P.Dwivedi – Director, BGDRC in 2001.

The outcome of painstaking efforts in the implementation of these projects have been compiled in this report. Special thanks are offered to Prof. S.K. Jain, formerly of the V.P. Chest Institute, University of Delhi and currently Sr. Consultants, Pulmonary, MCKR Hospital, New Delhi, who at the invitation of ICMR, provided insightful and constructive suggestaion which have helped in the completion of the Report.

My special thanks are offered to Dr. S. Sriramachari, Ex. Addl D.G. & INSA Hon. Scientist, who as Editor has contributed his time and expertise, and diligently steered the ICMR team in preparation of this Report. Without his guidance, this Report could not have been finalized. I am also grateful to Dr. A.K. Prabhakar , Ex. DDG, ICMR in facilitating the preparation of this report. I thank Dr. Bela Shah, Sr. DDG (NCD) and Dr. D.K. Shukla, DDG(SG) for bringing out this report.

The details of methodology, results and conclusions of the project on "Population Based Long Term Epidemiological Studies on the Health Effects of Bhopal Toxic Gas Exposure (1985 – 1994)" are presented here in the form of a TECHNICAL REPORT.

The results show that the Toxic Gas exposees for long after the exposure, continued to suffer from multisystem involvement but predominantly from respiratory, eye and gastro-intestinal disorders. Several other Technical Reports on “Other Aspects of Health Effects” will follow.



(N.K.Ganguly)
Director General

ACKNOWLEDGEMENTS

This project has been conducted for almost a decade and a large number of scientists from different parts of the country have contributed in these studies. Hence, our utmost thanks are due to all these scientists.

Thanks are due to Late Dr.V.Ramalingaswami, Dr.A.S.Paintal, Dr.S.P. Tripathi and Dr.G.V.Sathyavati, Ex-Director Generals, Dr.S.Sriramachari, Dr. Usha K.Luthra, Ex-Additional Director Generals, Dr.Padam Singh, Addl. Director General, Late Dr.C.R.Ramachandran, Ex-Sr.Deputy Director General, Dr.A.K.Prabhakar, Deputy Director General, Dr.Rashmi Parhee, Sr.Research Officer, officers of NCD Division and other members of the Indian Council of Medical Research for technical guidance. Ministry of Health & Family Welfare and Director General, ICMR for the prompt financial support.

The Council wishes to place on record its sincere thanks to Shri Tanwant Singh Keer, Minister, Bhopal Gas Relief and Rehabilitation Department, Govt. of Madhya Pradesh, Shri Ishwar Das, Shri S.Satyam and Shri C.S.Chadha, the then Principal Secretaries, Govt. of M.P., Department of Bhopal Gas Relief for enabling such a major activity to be successfully carried out. Dr.P.K.Bhat, Director, Centre for Rehabilitation Studies provided valuable support and cooperation for preparation of this report.

It is our pleasure to place on record our sincere thanks to the members of Review Committee, Scientific Advisory Committee and Project Advisory Committee who have greatly contributed with their valuable guidance for this study. I am also grateful to the Deans and members of Gandhi Medical College, Bhopal for their cooperation in various fields of activities.

Thanks are also due to the secretarial staff of BGDRC and Division of Noncommunicable Diseases, ICMR for typing the manuscript of this report. I wish to place on record my sincere thanks to all the team members for their willing cooperation and for very hard work. 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.

(Bela Shah)
Sr.DDG (NCD)

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Chapter-I

Toxic Gas Leak And Health Effects : Overview

1.1 Geophysical Characteristics of Bhopal

Bhopal, the capital of the state of Madhya Pradesh is situated in the centre of India, at an altitude of 505 M above seal level (Fig.1.1a). The city is located at longitude 77°12' - 77°40' eastern and latitude 23°07' - 23°94' 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 6.72 lac in 1981. For administrative purposes the city is divided into 56 wards (Fig.1.1b and Table 1.1). The density of population is 2355.2/sq km.

Table 1.1 Fifty six municipal wards of Bhopal as in Fig.1.1b

Ward No.	Ward Name	Ward No.	Ward Name	Ward No.	Ward Name
1.	Gandhi Nagar	20.	Bus Stand	39.	A.N.Nagar
2.	C.T.O.	21.	M.Azad Library	40.	Ash Bag
3.	Nehru Nagar	22.	Islampupra	41.	Jinci
4.	One Tree Hill	23.	Bhoipura	42.	Jahangirabad
5.	Gufa Mandir	24.	Moti Masjid	43.	Mandilaxmiganj
6.	Noor Mahal	25.	Kamla Park	44.	Berkheri
7.	Mali Pura	26.	R.Tegore Bhawan	45.	Chandbad
8.	Bagmunshihusain	27.	Rang Mahal	46.	Kapra Mill
9.	Sharma Colony S.C.	28.	Vidhan Sabha	47.	Narela Shankri
10.	P.G.B.T.College	29.	Malviya Nagar	48.	Sona Giri
11.	Jamal Pura	30.	Prakash Pushpkar	49.	Berkhera Pathani
12.	Shajahanabad	31.	T.T.Nagar	50.	Berkhera L.Colony
13.	Vergikrut Bazar	32.	Shastri Nagar	51.	Piplani
14.	Ibrahimganj	33.	Kotra Sultanabad	52.	Piplani L.Colony
15.	Jawahar Chowk	34.	Punchsheel Nagar	53.	Govindpura
16.	Jain Mandir	35.	Shahpura	54.	Anna Nagar
17.	Lakherapura	36.	Arera Colony	55.	Shaktinagar
18.	Marwari Road	37.	Char Imli	56.	Kaliyasote
19.	Mangalwara	38.	Meda Mill		

In this city of lakes and hills, climate is moderate in all seasons. The coldest month is January with mean daily maximum temperature at about 25.7°C, and the mean daily minimum at 10.4°C. After February, the ambient temperature increases steadily till May which is usually the hottest month with mean daily maximum temperature at 40.7°C, and mean daily minimum temperature at 26.4°C. 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.

1.2.1 The Union Carbide Factory

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 seventy acre plot on Berasia Road at the North-West end of Bhopal city. This was meant to mix and package pesticides imported from the USA. From late 1977, the Union Carbide India Limited (UCIL) started manufacturing Sevin at the Bhopal plant by using imported primary raw materials viz., alphanaphthol and methyl-isocyanate (MIC) manufactured at the Union Carbide Plant in the USA and shipped in stainless steel containers to the Bhopal Factory. From early 1980, however, the MIC was being manufactured in the 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.

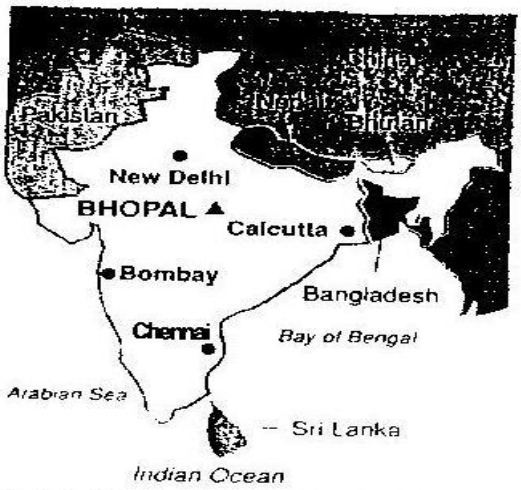


Fig.1.1a Map of India showing location of Bhopal

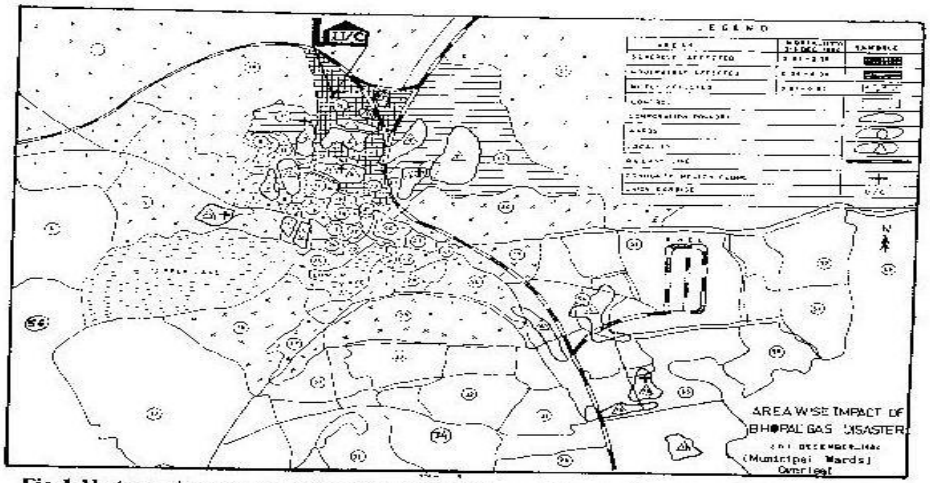


Fig.1.1b Areawise map showing 56 wards of Bhopal City and location of Union Carbide Factory and impact of the Gas Disaster – 2/3 December, 1984

1.2.2 Storage of Methyl Isocyanate (MIC)

MIC storage system consisted of three horizontally mounted tanks designated as 610, 611 and 612. The storage tanks (dia. 8 ft and length 40 ft) were made of stainless steel. These could withstand full vacuum to 2.72 kg/cm^{2}g (40 Psig) at 121°C. MIC was to be stored under pressure in atmosphere of high purity (HP) nitrogen. The contents of the tanks were circulated through heat exchangers cooled by a refrigeration system to maintain temperature at 0°C. Each of these tanks was fitted with various monitoring and safety devices. The Vent Gas Scrubber (VGS) was meant to neutralize the toxic exhausts from the MIC plant and storage system (Fig.1.2.2).

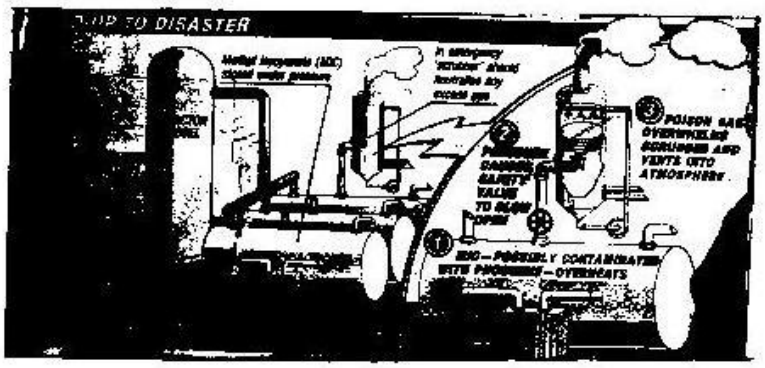


Fig.1.2.2: Diagramatic sketch showing the MIC storage tank and build-up to Disaster (Gas Escape)

1.2.3 Toxic Gas Leak/Escape

At around 00.15 hours on 2nd/3rd December, 1984 when MIC leakage was first reported, the control room operator observed that the tank pressure indicator in the control room showed the pressure shooting up and it was in the range of 25-30 psig. Between 00.15 and 00.30 hours the local temperature and pressure transmitter on the tank were indicating beyond their ranges (i.e. +25°C and 55 psig). It was also observed that there was no circulation of caustic soda solution through the VGS. In the mean time, a gaseous cloud was seen coming out from the stack by the field operator. Reportedly, the siren was sounded around 00.30 hours and the plant personnel were alerted about the MIC leakage. From around 01.00 hours, water was sprayed on the MIC structure but reportedly it did not reach the top of the stack from where the Gases were coming out. Around 03.00 hours the Gas stopped coming out of the stack. It is said that this runaway chemical reaction was triggered off by entry of water into tank 610, however, failure of all control and safety systems played a major role in causing the disaster. MIC possibly contaminated with phosgene could also overheat the Tank contents.

The MIC has a S.G. of 0.96 and boiling point (760) of 39°C[1]. The toxic gas that had escaped into the atmosphere condensed on contact with cold air and due to atmospheric inversion phenomenon settled down slowly on the ground. It then evaporated and spread in the atmosphere gradually to low wind velocity to affect the human and animal life on the ground. It is noteworthy that the entire contents of 610 (approx. 40 tons) escaped into the atmosphere in a couple of hours. Thus, the initial speed of escape must have been very high because of the high temperature and pressure built up inside the tank. The Union Carbide Factory, the MIC storage and its final escape into the atmosphere are described in greater

detail in the Technical Report on the Clinical Studies Due to Toxic Gas Inhalation (under preparation).

1.3.1 Acute Toxic Gas Inhalation Injury

Most people were at home when the tank 610 burst out of the earth emitting a huge cloud of deadly fumes into the night, spreading in different directions according to the prevailing winds and the low ambient temperature. It is estimated that what actually escaped from Tank 610 was a mixture of MIC and other toxic reaction products, together called the Toxic Gas(es). The first effects were 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 of burning chillies. Nobody knew what had happened! Suddenly, cries of "Gas, Gas" and "Run, Run" were heard. A vast majority of people came out of their houses for safety, into the dark and often poorly lit streets, moving in different directions. Many a time, instead of running towards safe gas free zones, they would have inadvertently walked into more concentrated gas pockets, into death traps as it were! Cows and cattle ran with the owners or were left behind to perish in large numbers.

The Factory is located in a densely population, highly congested part of Bhopal in the old city. The gas fumes spread rapidly into J.P.Nagar, Kazi Camp, Chola Road, Chandbad, New Kabbad Khana, Sindhi Colony and Railway Colony (see Fig.1.3.1a).

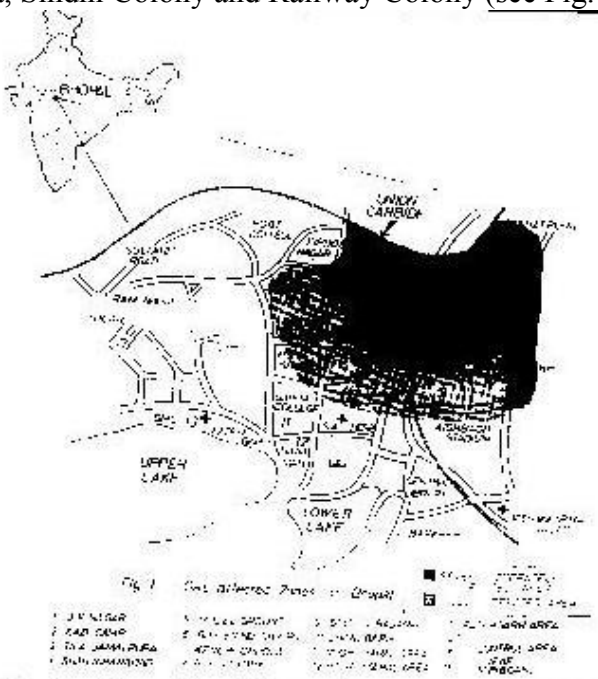


Fig.1.3.1a Map showing the residential areas in close vicinity of the Union Carbide Factory

Rough estimates placed the number of persons living in these areas as varying between 100,000 to 200,000. A large number of deaths occurred instantly at home, in streets and hospitals (Figs. 1.3.1b and 1c) and over the next 72 hours. Estimates placed the number of dead persons around 2,000 and dead cattle around 1,000.

It is noteworthy that a large number of people stayed back in their own homes if gas fumes did not enter their premises. Also, those who shut all doors and windows or covered their faces with wet cloth suffered much less severe symptoms.

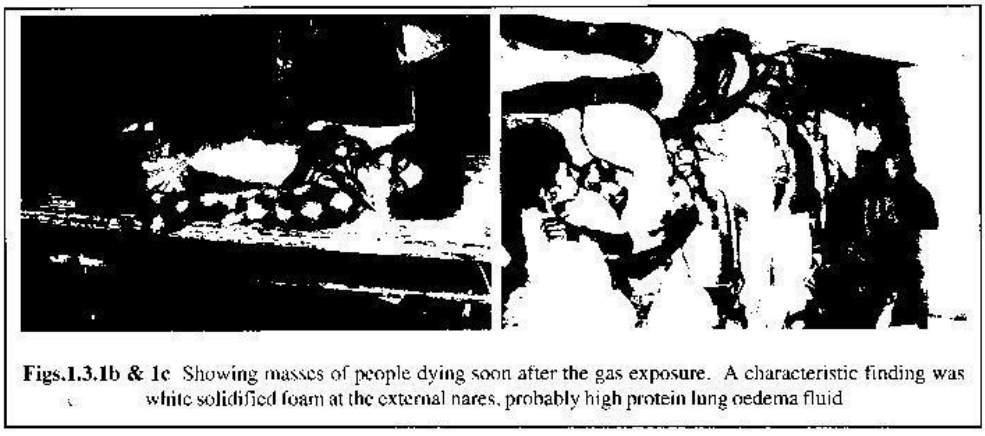
1.3.2 Autopsy Findings

Within twenty-four hours of the single inhalation of the MIC related Toxic Gas(es), it became abundantly clear that this was not only a potentially lethal gas but also produced multisystem morbidities among the survivors. Autopsy was the only effective way to determine the cause of death and understand the nature of morbidities to follow among the survivors.

Autopsy studies were carried out by the Medico-Legal Institute under Prof.Heeresh Chandra and his colleagues and the Department of Pathology led by Prof.D.S.Darbari from the third day onwards i.e. about 72 hours. The ICMR Team consisting of Dr.S.Sriramachari and Dr.H.M.K.Saxena 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 hemorrhages, generalized visceral congestion, cerebral edema, ring hemorrhages 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)[2].



Figs.1.3.1b & 1c Showing masses of people dying soon after the gas exposure. A characteristic finding was white solidified foam at the external nares, probably high protein lung oedema fluid

Experimental studies on rats exposed to a single sub-lethal dose of MIC, undertaken by the ICMR Toxicology Project scientists in collaboration with DRDE, Gwalior revealed a similar spectrum of pathological changes over a period of 24 hours to 10 weeks. It was found that aqueous and or thermal derivatives of MIC also showed similar though milder changes[3,4].

1.4 Clinical Features

Many clinico-epidemiological studies were initiated soon after the Gas Disaster. Some of the important, relevant findings are quoted from published studies[5-11] as well as unpublished work to be reported separately.

Clinical features in the exposed/affected population compared with the relatively unexposed/unaffected (control) population are briefly reviewed below, mainly for the purpose of interpretation of the findings of the epidemiological studies.

1.4.1 Acute Phase

Acute phase arbitrarily relates to the first month post-exposure. Men and women of all age groups flooded the hospitals in Bhopal within a few hours of the occurrence of the Disaster. Over 2,000 hospital beds belonging to the Government and public sector were commissioned, but these were far too insufficient to deal with the patient load. Therefore, a large number of improvised „Camp Hospitals' were set up for treating the never ending stream of casualties.

Most exposees complained of sensing a strong smell and irritation of burning chillies. The main symptoms with which almost every patient to the hospitals were related to the effects of the Gas on the eyes and on the respiratory tract. At the time of Gas leak, common eye complaints were foreign body sensation, burning, excessive lacrimation, photophobia and blurring of vision. On detailed examination, 60-70% of the patients had both conjunctival and circumcorneal congestion with relatively little oedema[5]. A fair number of cases had superficial corneal ulcers, mostly involving the central zone and interpalpebral fissure. A mild flare with constructed pupils sluggishly reacting to light could be seen in few cases. Fundus was essentially normal except in a few cases who showed oedema and superficial hemorrhages in retina, probably due to hypoxia. With the prompt and appropriate treatment the patients responded well and became asymptomatic within a few days.

Symptoms related to the respiratory tract consisted of choking, sudden onset of difficulty in breathing, pain in chest, severe cough – dry or with expectoration. Moist sounds with or without rhonchi were present on auscultation bilaterally. Chest radiographs showed diffuse bilateral pulmonary infiltrates consistent with pulmonary oedema with focal atelectasis. The rapid deaths which followed exposure to the Gas were related to acute inflammation of the lung i.e. acute alveolar injury and respiratory failure. A rather unusual symptom observed in some of the Toxic Gas exposees was the feeling of intense heat in the body so much so that there was a strong urge to take off clothes even as it was winter of December.

Misra et al[6] carefully documented and analysed 544 patients admitted into the Hamidia Hospital soon after the Gas leak. The prevalence rates of some of the important findings recorded were : breathlessness – 99%; cough – 95%; irritation upper respiratory tract (choking) – 46%; pain chest – 25%; expectoration – 16%; extreme muscle weakness – 25%; apathy (listlessness) – 21%; hypersomnolescence – 16%; coma – 7%; loss of appetite – 92%;

nausea vomiting – 52%; eye irritation and lacrimation – 86%; rhonchi/crepts in chest – 82%; tachypnoea – 80%; tachycardia – 54%; fever – 2%.

Kamat et al[7] studied 78 patients in acute phase. 79% had respiratory symptoms and 74% had eye symptoms. 78% showed restrictive pulmonary impairment with reversible airflow obstruction in 24%, reduced oxygen uptake in exercise in 55%, and raised levels of carboxyhaemoglobin and met haemoglobin in blood. Eighty-nine percent of these patients were residing within 2 km of the Union Carbide Factory.

Five hundred chest radiographs of patients with severe respiratory symptoms, taken within 72 hours of the Gas inhalation were evaluated. Ninety-eight percent of these chest skiagrams showed abnormalities of interstitial and alveolar lesions, destructive lesions or evidence of pre-existing lung disease[8] (unpublished data).

In a preliminary study (unpublished data) of 300 families, 968 males and 863 females were surveyed. Forty-seven deaths in males and 35 deaths in females were recorded. The maximum mortality was seen in the 0-5 years and above 60 years of age. The main symptoms observed in the survivors were cough (74%), breathlessness (34%), pain in the chest (6%) and burning eyes (36%).

In a small study, haematological profile of 237 cases were investigated during the first two weeks post-exposure. Polymorphonuclear cells were increased in 35% of cases. Another 52% had raised lymphocyte count. About 19% of cases had eosinophilia in excess of 20%. Haemoglobin levels about 14 g% were found in 15% of the patients (unpublished data).

1.4.2 Sub-acute Phase

The sub-acute phase was characterized by persistent morbidities caused by toxic gas inhalation amongst survivors of the acute phase. This period arbitrarily relates to 1-3 month post-exposure. These patients were now presenting themselves to the hospitals and community clinics for relief of their persistent symptoms suggestive of multiorgan involvement. A number of hospital and community based studies were initiated to identify the delayed and long term effects of the exposure, to institute a rational treatment. The preliminary data gathered indicated that even 2 months after exposure to the Gas, nearly 40% of persons attending the hospitals presented with respiratory symptoms such as breathlessness, chest pain, cough, and fever in some cases. Persistent tachypnoea was a characteristic feature in these patients. In a significant number of patients the symptoms were out of proportion to the physical and radiological signs. Pulmonary function testing in 224 patients with severe persistent symptoms, between January to March 1985 showed normal function in 126 patients, restrictive cum obstructive pattern in 36, obstructive pattern in 24 and restrictive pattern in 38 patients. Only a few patients showed hypoxaemia but none had hypercapnia. The most important finding was that there was no correlation between the severity of breathlessness and impairment of lung function[9].

A significant proportion of the exposed/affected patients presented with gastrointestinal symptoms including loss of appetite, nausea, vomiting and burning sensation in the epigastrium. Endoscopic examination revealed evidence of superficial gastritis and oesophagitis in some cases. A small proportion of cases had hepatomegaly.

A follow-up of patients who had predominantly eye symptoms during the acute phase, indicated that the primary pathology was in the anterior chamber of the eye. In most cases, the lesions had healed with no progressive deterioration of vision. Detailed investigations also did not suggest the involvement of the posterior chamber. A proportion of cases might end up with superficial corneal opacities requiring lamellar keratoplasty, it was opined.

The social, demographic and psychological consequences of mental trauma following such a disaster are well documented. According to the local physicians (personal communication), approximately 10-12% of the Gas affected persons visiting the medical clinics at Bhopal presented with psychiatric manifestations. Symptoms of anxiety and depression were the foremost. Disturbed sleep, „Gas phobia', feeling of hopelessness were some of the other common complaints. Families of the affected population were unable to cope with this extremely stressful situation. Delayed psychological problems especially amongst the bereaved, widowed and orphaned children were only to be expected !

1.4.3 Chronic Phase

In a 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, severe loss of work capacity persisted even 3 to 4 months after the Disaster. Kamat et al[10] followed up 113 severely affected subjects at 3 and 6 months respectively. Several subjects showed improvement clinically. However, cough, chest pain, dyspnoea and weakness persisted. Some of the subjects developed for the first time respiratory symptoms of wheezing during the course of these months. Lung function tests showed abnormalities in a significant number of patients. It is noteworthy that clinically, the severity of respiratory symptoms did not always correlate with chest radiographs, pulmonary function test results and even physical examination.

Standard P.A. chest radiograph constitutes an important method of detecting lung disease. In a systematic long term investigation, 9569 patients (5247 from OPD, indoor and 4322 from the ICMR field survey) were analysed. Nearly 15% had evidence of pre-existing lung disease, 22% showed interstitial/alveolar lesions, while more than 50% cases were found to be within the normal limits. However, when 672 skiagrams were analysed according to ILO classification, 511 were found to be normal[11]. In a series subjected to randomized assessment of outpaitnets at 10 Government clinics during the period from March to May 1985, 22.6% of the screened population was found to be suffering from mental disorders. Of the 193 patients detected, 37.3% of suffered from neurotic depression, 24.9% from anxiety state, and 35.2% from adjustment reaction[12].

The study carried out on a sample of the main cohort to list the major ocular morbidities revealed chronic conjunctivitis, trachoma, corneal opacity and cataract[5]. The cross-sectional survey carried out to estimate the prevalence of cataract in the exposed and control areas showed that the prevalence of cataract was nearly four times higher in exposed area compared to the control area. The follow-up study carried out on different ocular morbidities showed persistence of changes in lens and cornea with further progression of

lenticular changes in persons living in the Gas affected areas. Persistence of chronic conjunctivitis was also observed in the affected area.

It is noteworthy that even four years after the Gas Disaster, thousands of the affected population were daily seeking medical treatment, e.g. see Table 1.4.3 which represents only some of the clinics/hospitals in Bhopal.

Table 1.4.3 Institution-wise information regarding daily average outpatient attendance & indoor admissions of Gas affected patients in some of the institutions in Bhopal
(January 1989 to October 1989)

Name of Institutions	Total Outdoor Patients	Daily Average
Outpatient Jawahar Lal Nehru Hospital	235374	774
Shakir Ali Khan Hospital	214356	705
Master Lal Singh Hospital (No indoor beds)	63611	209
Rukmani Bai Hospital (No indoor beds)	87466	288
C.D. Keinchichhola	46429	153
C.D. Chandbad	85187	280
C.D. Kazicamp	57988	191
C.D. Putlighar	42360	140
C.D. Jehangirabad	117193	385
C.D. Chhola (Old)	35572	117
Polyclinic Ibrahimganj	83238	274
C.D. Baag Umrao Dulha	61703	203
Total	**1130476**	**3719**
Indoor Admissions J.N.Hospital (100 beds)	6883	23
S.A.K.Hospital (30 beds)	1746	3
Total	**8629**	**26**

1.4.4 Pregnancy Outcome

During 1985, a detailed study on the genetic risk evaluation of outcome in pregnant women exposed to the Toxic Gas was initiated to monitor its teratogenic potential, development of the new born delivered by exposed mothers as well as to collect data on neonatal, infant mortality and feeding pattern of these children. The information obtained on 2566 women who were pregnant at the time of exposure and who were followed up, revealed that there were 373 abortions and 82 stillbirths. While the abortion rate was higher than that reported from other parts of the country, perinatal mortality rate seemed to be within the limits, reported from other parts of the country.

A special study was made on the infants born to mothers who were in the first trimester of pregnancy at the time of Gas Disaster to find out the pattern of congenital

malformations. Thirty infants were born with congenital malformations. This study does not reveal any increase in the incidence of congenital malformations.

1.5 Management of Patients

A Disaster of such magnitude and suddenness caused by the abrupt release of a massive quantity of highly toxic chemical Methyl Isocyanate and related compounds into a densely populated habitat is unparalleled in human history. The doctors, medical students, civil servants, governmental institutions, public sector and voluntary bodies, and the people themselves rose to the occasion in a human gesture equally unparalleled. The situation was handled in the most effective manner possible under the circumstances and the relief measures provided promptly. Afflicted persons were transported to hospitals and the doctors and the supporting staff worked round-the-clock to save lives and to provide relief. In the midst of a great human tragedy, the organization of relief measures shines as a fine example of collective human effort in which medical care played a very important role.

It is most ironical, however, that although MIC was being manufactured at the Union Carbide Factory since 1980, no information whatsoever was ever provided before or after the Disaster by the Management regarding its toxicity, antidote, nor how to protect workers from being exposed to these Toxic Gases. If only the people at risk had covered their face with wet cloth and stayed indoors, severe morbidities could have been avoided or at least mitigated.

The number of people suffering from respiratory, ophthalmic, gastro-intestinal and musculo-skeletal ailments were just too many to be handled by the available medical and paramedical staff. To make things worse, no guidelines were available for the management of these patients. Thus, groups of medical and paramedical personnel were trained in the management of these patients. It is noteworthy that two manuals for clinical management[13,14] and one for managing psychiatric problems[15] were prepared by experts for the benefit of practioners of medicine. Moreover, newer methods of treatment e.g. with sodium thiosulphate, corticosteroids, bronchodilators were also evaluated scientifically.

The management of cases in the hospitals at Bhopal during the acute phase was mainly directed towards the relief of eye and respiratory tract symptoms. The treatment provided for the ocular manifestations mainly consisted of washing the eyes, application of antibiotic ointment, dilatation of pupils, wherever indicated, with atropine. This regimen produced remarkably beneficial results. Patients with pulmonary symptoms were provided with supportive therapy in the form of oxygen, diuretics, bronchodilators and antibiotics. Some cases also received large doses of corticosteroid drugs. Gastro-intestinal symptoms were ameliorated in most instances by symptomatic treatment including antacids.

Apart from continuing the earlier lines of treatment, clinical and toxicological studies were initiated soon after the Disaster at Bhopal. These were aimed at identifying the presence of any circulating toxic substances and finding means of detoxification. The efficacy of antidotes was also investigated to deal with immediate morbidity. Preliminary studies in exposed persons having respiratory symptoms indicated increased levels of thiocyanate in urine. A double-blind placebo controlled study using sodium thiosulphate revealed that administration of sodium thiosulphate resulted in symptomatic improvement

and increased excretion of thiocyanate in urine. This suggested clearance of cyanide pool from the bodies of persons exposed to the Gas. On the basis of these results the State Government was advised to administer sodium thiosulphate to the exposed population suffering from symptoms, and the guidelines provided for the treatment regimen under medical supervision. Clinical and toxicological studies are described in greater detail in the Technical Reports on Clinical and Toxicological aspects.

The prevalence rates of multisystem morbidities remained high. Advanced facilities for investigations and treatment were created in the old as well as several newly established clinics and hospitals.

Chapter II

Planning Research Studies

2.1 The Need

The sudden leak/escape on 2nd/3rd December 1984, of highly Toxic Gases from Tank 610 containing 40 tons of MIC was the worst industrial accident and environmental disaster. The manner in which thousands of people as well as animals died, and plant life was seriously damaged, leaves no doubt whatsoever that these were potentially lethal Gases. Besides the dead, lacs of people who were exposed to the deadly fumes, depending upon their concentration, were left suffereing from multisystem morbidities – the worst affected being the respiratory, gastrointestinal, ophthalmic systems; musculo-skeletal weakness and psychiatric disturbances.

The gravity of health effects was compounded by the fact that nobody had a clue about the nature of the toxic effects of MIC. Furthermore, even though the Tank 610 contained MIC, what escaped into the atmosphere was not MIC alone, but may contain many more deadly chemical compounds due to chemical reactions going on inside the Tank. It was mandatory to understand and determine the exact nature of the Toxic Gases and their biological effects.

As stated in Chapter I, hundreds of thousands of the residents presented with multisystem involvement. A most careful clinical surveillance was needed to understand the nature of morbidities in order to provide rational treatment. Serious, never the less vital, questions were raised regarding the health problems of the Toxic-Gas-exposed population. What would be the course of their disease and disabilities? How long will these last? Will they suffer from progressive systemic disorders? Will they suffer from brain damage or severe mental disorders? Will they develop more cancers? Will it lead to genetic defects? Will the pregnant women at the time of Gas exposure have abnormal babies?

In view of the above, there was an urgent need to generate precise information on the nature of the Toxic Gases inhaled by the exposed population and generate reliable data on the long term clinical course of the systemic disorders caused, through biochemical and morphological studies on the exposed population. The results of these studies were expected to be useful for improved patient management and for better clinical outcome.

It was of paramount importance to study the health effects on a long term basis, including damage to respiratory system, growing foetus, teratogenecity, gene mutations and carcinogenicity, neurological and mental health effects. Affected persons were to be followed up over a period of decades perhaps, together with appropriate control subjects not affected by the Gas.

2.2 Strategy

The Indian Council of Medical Research (ICMR) established a Research Unit at the Gandhi Medical College, Bhopal. A Research Coordination Committee was formed with the

Dean of the College as the Chairman and Heads of Departments involved in research studies as Members. The Committee were assisted in preparing study design, execution of studies and analysis of data by the ICMR and groups of biomedical scientists invited from different parts of the country who had the requisite experience in the respective areas. The studies were carried out at Bhopal. The required technologies wherever necessary were transferred to the College to strengthen its research capabilities. Equipment and other supplies, technical procedures, training and expert consultation were made available to the scientists at Bhopal. Communication channels were established between the Research Coordination Committee and the Coordinating Cell at the ICMR Headquarters to facilitate execution of research programmes.

2.3 Monitoring and Evaluation

The progress including mid-course corrections of each Project was closely monitored by a Project Advisory Committee (PAC) consisting of members who were experts in their respective fields of specialization. The principal investigator/project coordinator was a member of this team.

The PAC of each Project were responsible to review the progress, evaluate the results, and suggest future strategies for research at meetings held periodically for the purpose.

2.4 Research Projects (List)

The main Research Projects which were carried out during 1985–1994 are listed below.

1. Long term epidemiological studies on the health effects of the Toxic Gas exposure through Community Health Clinics.

2. Pattern of lung disease caused by inhalation of Toxic Gas in Bhopal Gas victims, including follow-up studies.

3. Clinical studies including pulmonary function tests among Toxic Gas affected people (adults).

4. Study of pulmonary function tests including blood gas analysis.

5. Lung imaging studies of the Toxic Gas affected population.

6. Sequential respiratory, psychological, and immunological studies in Toxic Gas exposed subjects at Bhopal.

7. Follow-up studies of ocular changes in Toxic Gas affected population.

8. Mental health studies in Toxic Gas affected population (adults).

9. Neurological manifestations of exposure to Toxic Gas.

10. Study of immunological parameters in Toxic Gas exposed victims of Bhopal.

11. Genetic risk evaluation of pregnancy outcome in women exposed to Toxic Gas at Bhopal.

12. Study of pulmonary effects in children (6-15 years) exposed to Toxic Gas.

13. Follow-up studies in children (0-5 years) exposed to Toxic Gas.

14. A pilot psychiatric study of children affected by Toxic Gas at Bhopal.

15. Study of mucosal, gingival, orodental anomalies in children whose mothers were exposed to Toxic Gas in the first trimester of pregnancy.

16. Thyroid status in Toxic Gas affected and control areas of Bhopal – a long term assessment.

17. Histo-pathological, clinical and forensic toxicological studies in Toxic Gas affected population.

18. Establishment of population based cancer registry at Bhopal.

19. Experimental toxicological studies of the Toxic Gases.

20. ICMR establishment of data base information system for Toxic Gas follow-up studies at Bhopal.

The results of all the ongoing projects have been reported from time to time at least on yearly basis in the form of Annual Reports by the ICMR.

The Indian Journal of Medical Research had also brought out a special supplement to Vol.86 (1987), on Scientific Studies on Bhopal Gas Victims Part-A.

The results of these research projects would be reported in the form of three Technical Reports . These are (i) Epidemiological which will include the data on morbidity and mortality during the period 1984-93, (ii) Clinical – which will include the results of clinical studies and (iii) Toxicological- which will provide results on the autopsy and other related toxicological studies.

This TECHNICAL REPORT presents -

"Health Effects of the Toxic Gas Leak from the Union Carbide Methyl Isocyanate Plant in Bhopal : Population Based Long Term Epidemiological Studies (1985 – 1994)".

Chapter -III

Population Based Long Term Epidemiological Studies (1985 - 1994)

3.1 Aims And Objectives

The Population Based Long Term Epidemiological Studies on the Health Effects of the Toxic Gas were actually started 45 days after the disaster, i.e. from January 15, 1985 and were completed by May, 1994. As the size of the exposed/affected population was very large, the statistical design of the studies required to register a sufficiently large number of persons from the exposed areas to document the immediate and the long term effects of the Toxic Gas inhalation. It was also necessary to register a matching cohort from the unexposed/unaffected areas, for comparison. Detailed information on demographic, socio-economic status and the base line data on the effects of Gas exposure were recorded initially for preparing a comprehensive register of persons for undertaking detailed clinical and other studies. Keeping these in view, the objectives of the long term epidemiological studies were:

(i) To register Sample Cohorts in the Affected and Unaffected (control) areas of Bhopal.
(ii) To collect base line data on socio-economic and demographic profiles and to study changes over a period of time in the context of exposure to the Toxic Gas.
(iii) To observe mortality and morbidity in the Registered Cohorts of population and to establish relationship with the grades of exposure of the affected population.
(iv) To identify subcohorts for in-depth clinico-epidemiological 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 questionnaire (see Annexure II) were administered to 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.

The objectives of the study were modified in 1987, these were:

(i) To study the changes in socio-economic and demographic patterns of study area through annual surveys.
(ii) To study mortality and socio-economic and demographic events occurring in the sample.
(iii) To study point prevalence morbidity in the sample cohort along with the six monthly morbidity data.
(iv) To establish linkages with the clinical studies initiated by the ICMR.

The following were the changes made in the periodicity of data collection. In the beginning, it was planned to collect data on morbidity and mortality every fortnight. In 1986, the fortnightly surveys were changed to six monthly morbidity and mortality surveys.

3.2 Material And Methods

3.2.1 The Gas Exposed Population (Tables 3.2.1a and b)

The sudden escape of approximately 40 tons of methyl isocyanate (MIC) and its reaction products in a gaseous state from the Union Carbide plant into the environment would imply – at least theoretically – that the entire population of Bhopal would be exposed to their effects. According to current international concept, the permissible concentration of MIC is 0.02 ppm in 8-hour workshift. There is only one human study on toxicology of MIC, on 4 volunteers[16]. Experimental exposure for a period of 1 to 5 minutes produced the following effects. Concentration of 0.4 ppm = No effect; 2.0 ppm = lacrimation/irritation; 4 ppm = marked effects; 21 ppm = unbearable effects. On the basis of the presence or absence of such symptoms the population of Bhopal residing in 56 wards were divided into "exposed and affected" or "exposed but unaffected" (Tables 3.2.1a and b). However, throughout the document, the terms.affected is used interchangeably with exposed; similarly unaffected is used interchangeably with unexposed or control in relation to both areas as well as population.

From the 1971-81 base, the population of Bhopal was estimated after allowing an annual growth rate of 7.4%, which comes to 832904 in 1984 and 894538 in 1985.

The Municipal Corporation of Bhopal initially prepared a map on the basis of information available, indicating 31 wards as "exposed and affected" and 25 wards as unaffected. This was modified later, indicating 36 wards as affected (population 521262, 62.58%) and 20 wards as unaffected (population 311642, 37.42%).

3.2.2 Immediate Mortality

As the Gas exposure occurred at midnight and, as the majority of deaths occurred during the night, mapping of the area for grading the severity of exposure was a difficult task. It was argued that the nearby area of UCIL might have had higher exposure but an important consideration was that the air movement on the night of December 3, 1984, might have influenced the spread of the Gas. The only available information was that of mortality which occurred immediately after the exposure. This information was obtained from the records of municipalities and the burial grounds.

As per the available mortality data during December 3 to 6, the affected areas were subcategorized as : **Severe** with average death rate of 22.0 per 1000 (range 20.2 to 23.8), as **Moderate** with average death rate of 1.33 per 1000 (range 0.5 to 3); and **Mild** with average death rate of 0.2 per 1000 (range 0.1 to 0.4). It can be seen from Tale 3.2.1a that **severely affected area** had a population of 32476 (3.9% of total), **moderately affected area** had a population of 71,917 (8.6% of total), while **mildly affected area** had population of 416,869 (50.1% of total). The population residing in **unaffected/control area** was estimated to be 311,642 (37.4% of total).

Table 3.2.1a

Distribution of the Population of Bhopal : (1) Estimated for December 2/3 1984 in the Exposed and Affected (Subcategorized as Severe, Moderate and Mild) Areas, compared with Exposed but Unaffected (Control)Area. (2) According to Death Rates during December 3 to 6, Wards, Localities; and (3) Estimated Population for 1985 to provide Registered Cohorts for the Population Based Long Term Epidemiological Studies

Areas Affected/ Exposed	Municipal Wards	No. of Municipal Wards	**Estimated population 1984	No. of Deaths (December 3-6, 1984)	Death Rate/1000 Range (Mean)	**Estimated Population for 1985	Cohort Population (Loc. No.)	Percent of Population Covered
Severely	13,20	2	32476	714	20.2-23.8 (22.0)	34879	26382 (01+02+07+08)	75.64
Moderately	8,11,14,45,46	5	71917	96	(0.5-3.0) (1.33)	77239	34964 (03+04+05+06+09+10)	45.27
Mildly	$7,9,12,14	4	64293	19	0.1-0.4 (0.2)	447717	18675 (11+12+13)	4.17
		11	168686	829				
	*1, 5, 6, 10, 15-19, 21-29, 38-44	25	352576					
Total		36	521262 (62.58%)	829	0.1-23.8 (5.0)	559835	80021 (01-13)	14.29
Unaffected/ Control	2,3,4,30,31,32, 33,34,35,36,37, 48,49,50,51,52, 53,54,55,56	20	311642 (37.42%)	2		334703	15931 (14+15+16)	4.76
Grand Total		56	832904			894538	95952	10.73

$ Sample for study was drawn from 11 Wards with population 168686 having gas related mortalities

* Wards not included in the sample

** 7.4% annual population growth rate (base 1971-81)

Table 3.2.1b
Distribution of Families and their Population (1985) According to Area and Locality

Areas	Locality Number	Name of the Locality	Families Covered Aug-Oct'85	Population Covered Aug-Oct'85	Average Family Size
Severely Affected	01	J.P.Nagar	1724	8060	4.67
	02	Kazi Camp	1647	7829	4.75
	07	Kanchi Chhola	1147	4623	4.03
	08	Railway Colony	1106	5870	5.30
Total	04		5620	26382	4.69
Moderately Affected	03	Teela Jamalpura	990	5575	5.63
	04	Shahajahanabad	1185	6243	5.26
	05	Straw Product	1096	5292	4.82
	06	Ibrahimganj	1096	5486	5.00
	09	Station Bajaria	1420	7057	4.96
	10	Chandbad	1174	5311	4.52
Total	06		6961	34964	5.02
Mildly Affected	11	Noor Mahal	1467	7876	5.36
	12	Hawa Mahal	1119	5841	5.21
	13	Fatehgarh	951	4958	5.21
Total	03		3537	18675	5.27
Grand Total	13		16122	80021	4.96
Control	14	Anna Nagar	1428	6091	4.26
	15	Vishwakarmanagar	1109	5026	4.53
	16	Habibganj	1112	4814	4.32
Total	03		3649	15931	4.36

3.2.3 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 3.2.3 was the number of persons enumerated in the 1985 survey. It can be seen that in the severe and moderate areas it is higher and in the mild and control areas it is less than 20,000. It can be due to population moving out of the area.

The distribution of population in the three types of exposed and the control areas is given in Tables 3.2.1a and b. 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. The details of localities are indicated in the Map (Fig.1.1b).

A major part of the exposed area, which was near the UCIL, had slum localities 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 to ensure better linkage of data collected on a long-term basis through various projects. Each of the selected exposed and control areas was covered in this operation, which was completed by March 1985. All the persons listed in the base line 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 also in the control area. The details of the number of persons enumerated in the study in the exposed and unexposed areas are given in Table 3.2.1a.

During the survey period (August to October 1985), the collection of fortnightly morbidity and mortality data was discontinued. 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 register to exclude the persons 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 repeat surveys instead of fortnightly surveys, from May 1987. These surveys were planned on a subsample from the main sample. The localities included in the severely affected areas were 1 and 3; in moderate 3, 5 and 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. upto 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 was continued up to December, 1994.

3.2.4. Validation of data

The validation of data was carried out at two stages. Initially, the data scrutinized by the statistical unit of the ICMR were entered through offline devices i.e. floppy and later on transferred on to computer tapes. The consistency checks were carried out to check any inconsistency in the data entered on the floppy. The internal consistency checks included some data checks collected in each round of surveys and also checks were made for linking the data of different rounds. The necessary corrections were carried out either by verifying the data from field, if found necessary or by linking the data with previous rounds.

The second type of validation exercise was carried out by analyzing the data by a different procedure. A data file was prepared to include persons available at all follow-up points. The morbidity rates were estimated for this group and compared with the results derived by the cross-sectional approach.

3.2.5 Presentation of data

As per the objectives laid down, the base line data were utilized to prepare a list of affected and unaffected persons in the cohort. A comprehensive register was prepared for each area providing the identification number of household, the names of all the individuals residing in the household with their identification number within the family along with their age and sex.

The information presented in the Report refers only to the cohort registered in the study. The results of six monthly surveys, have been presented only for three rounds of fortnightly data, viz., 15th visit - (January16-31, 1986), 25th visit - (June 16-30, 1986) and 32nd visit (26th Oct.-25th November, 1986) to enable presentation of data at six monthly interval from the epidemiological survey which was completed in October 1985. The data on six monthly surveys have been presented for the following periods: May 1987- November 87, November 1987 – May 88, May 1988- November 88, November 1988-May 89, May 1989- November 1989, November 1989- May 90, May 1990- November 90, November 1990- May 91, May 1991- November 91, November 1991-May 92, May 1992- November 92, November 1992- May 1993, May 1993- November 93, November 1993-May 94.

Mortality: The mortality rates have been derived for those persons who were included in the base line cohort. The mortality rates are given for calendar year. Initially, each individual survival and residential status was checked from base line to the last follow-up period. If the person's survival status at the last follow-up point was known and if he/she was surviving, then he/she was included in the denominator of all the calendar years for estimating death rate. If a person was dead during any follow-up point, his/her data were utilized up to that calendar year. Thirdly, if a person’s living status was

known up to a certain follow-up point and later his/her residential status was not known, he/she was considered up to that point where the survival status was known and for other point it was considered as non-respondent or lost to follow-up. The mortality rates considering the above two points were derived. The mortality rates for December 1984 and for each calendar year from 1985 to 1994 are presented by age and sex.

Morbidity: As mentioned earlier, only the persons registered in the base line 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.

Pregnancy: The pregnancies and their outcome for the year 1984 and for calendar year up to 1988-89 are also presented for women registered under baseline cohort up to 1988-89.

3.2.6 Operational Plan

The study was broadly carried out in four phases (i) Listing of households and preparation of family folders in the selected exposed and control areas, (ii) Fortnightly morbidity and mortality survey, (iii) Six monthly morbidity survey on sub sample, and (iv) Six monthly survey on total cohort.

The study team included both the medical and non-medical personnel. The non-medical personnel (Research Assistants - RA) were involved in the survey work for visiting each household for collection of information on morbidity and mortality and the medical personnel (Assistant Research Officers - ARO) for quality control purposes as well as for recording the cause of death. Initially the Research Assistants completed the house listing of all the selected areas within a period of three months during January to March 1985.

The fortnightly morbidity survey was planned from April 1985. To carry out this operation the total area was divided into areas each covering approximately a sample of 5,000 persons. One RA was allotted to cover one area. It was planned that each RA would visit his/her area and enumerate all the information regarding morbidity, mortality and on pregnancy within the registered cohort. 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 any other information regarding hospitalization *etc.* were recorded. The morbidity data were collected on the basis of symptoms. A list of 30 items 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. All these families, were followed by the ARO to confirm the cause of death. A built-in mechanism was followed for checking the information generated by the RA.

The ARO checked on 10% basis the work carried out by RA's in their respective areas. The families with morbidity were visited by ARO to verify the recording of the RA on 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 Death was followed for coding the cause of death.

Six community health clinics were set up in the study area, which were managed by the ARO. 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 specialised 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.

A Statistical Unit was started during January 1985 to scrutinise the data received from the RAs.

A detailed proforma (see Annexure II) for recording the information on the immediate morbidity and mortality in the exposed and unexposed areas was developed and pretested in the field before starting the epidemiological study in August 1985. A comprehensive "Instruction Manual" was prepared providing details for collecting each item of the information. For the purpose of collection of information, a training programme was organised for all RAs. The reliability exercises were also carried out.

During the data collection period, the RAs visited each household and recorded the information on a standard proforma. The 10% check on the completed proformas was conducted by the ARO and any booster training needed was continued during survey period whenever required.

During the epidemiological study, the RA submitted, on weekly basis, the completed proformas to the statistical unit for scrutiny. The data received at the statistical unit were scrutinised within a week. All the discrepancies observed were listed and the proformas needing any correction were kept separately. A weekly meeting was arranged with the Principal Investigator along with RAs, AROs 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.

During the six monthly surveys, the procedures followed in the base line epidemiological survey were continued. A detailed proforma was drawn for recording both point and period prevalence morbidity. An instruction manual was prepared both in Hindi and English for collection of information by the RAs. A training programme was arranged before initiation of the field operation. The list of symptoms regarding morbidity was updated to 40 items.

In addition to the "Statistical Unit", a separate Unit for Data Processing was started which was called "Data Base Information System". Initially a "HCL work Horse II" computer system was utilized and a programmer was appointed. Later, keeping in view the large data generated in the study, the computer system was upgraded and also additional programmers were appointed.

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.

Chapter – IV

Observations

It may be noted that in the entire text of this document, the areas which were severely, moderately or mildly exposed to the Toxic Gas are often referred to simply as **severe, moderate** or **mild** areas and the unexposed areas as the control area. Also, the data Tables referred to in the text are listed at Annexure III & presented 1-42 in Annexure IV.

4.1 Characteristic Profile of Persons in the Long Term Follow-up Study:

Basic information on socio-economic and demographic status of all persons was collected at the time of registration of families during February-March, 1985. The survey carried out during August-October 1985 updated the information and the same has been incorporated in the Present Report. Data were collected based on retrospective information on the various aspects of Toxic Gas exposure and on socio-economic and demographic variables such as household structure, family composition, marital status, etc. (see Annexure II).

4.2 Age, Sex Distribution:

Analysis of core demographic data collected in the original cohort in 1985, revealed that age and sex distribution of the affected and control population cohorts were similar (Table 1a**).**

4.3 Socio-economic Status:

Relevant information on education status and religion are presented in Table 1a. In severely affected area 60.85% were illiterate as against 54.78% in control area. However, illiteracy in moderately and mildly affected area was 41% and 35% respectively. In control area persons belonging to Hindu religion were more, being 91.1% as compared to 74% in severely, 35% in moderately and 40% in mildly affected areas.

The distribution of the cohort population according to economic class is given in Table 1b. It can be seen that 68 to 86% of population belong to very depressed socio-economic class, in the affected population as well as the control population. Furthermore, more than 70% population, both in the severely affected area as well as the control area, live in poor quality „kacha' houses, while the quality of housing was slightly better in both the moderately and mildly affected areas (Table 1c).

At the time of Gas leak, nearly 98% of the population was sleeping indoors (Table 1d). On experiencing the first symptoms of burning, chillies sensation, respiratory or eye symptoms or hearing the cries of Gas – Gas, 60-82% (more in the severely affected area) ran away from their houses, more than 7% on foot (Table 1e). Most of the people included in the Study Cohorts had no fixed occupation, thus no fixed source of income (Table 1f). Prevalence rates of tobacco smoking were found to range from 0.2 to 14.3% (Table 1g).

4.4 Mortality:

4.4.1 Mortality Rates During 1984-93 (See Annexure IV, Tables 2 and 3)

It may be noted that the year 1984 is represented by December 4 to 31, post-exposure. It can be seen that the mortality figures per thousand for 1984 were 12.6 (males) and 11.6 (females) in the severe area – in sharp contrast with 0.35 (males) and 0.41 (females) in the control area. The corresponding figures for the moderate and mild areas were 0.79 and 0.1 respectively for males, and 0.56 and 0.22 respectively for females. Both these areas are comparable with the control area.

During the follow-up years 1985-93, the yearly mortality figures in the severe area ranged between 7.4 and 3.4 for males, and 7.8 to 1.6 for females; in the moderate area between 6.5 and 3.2 in males and 5.4 and 2.6 in females; in the mild area 6.1 to 2.5 in males (except an out of the range figure of 9.8 in 1993) and 4.6 to 2.4 in females (except an out of the range figure of 6.4 in 1993); in the control area – 3.9 and 1.9 in males and 4.2 to 1.9 in females. For the high figures in 1993, although no obvious explanation can be offered, it may be due to very high death rates among elderly in the age groups 60-64, 65-69, and 70+ years. It may be concluded that there has been a decreasing trend in the death rate in all the areas with time. However, the death rates in exposed areas were noted to be generally higher than the control area.

4.4.2 Age specific Mortality Rates for the Period 1984-1993 (Annexure IV, Tables 4-11)

The age specific mortality rates (per 1000 persons) for the three exposed areas and the control area for the years 1984 to 1993 are presented in Tables 4-11. In the text, charts (1-4) have been included for comparison between the areas for the years 1984 and 1992 and within each area the information for alternative years starting from 1984.

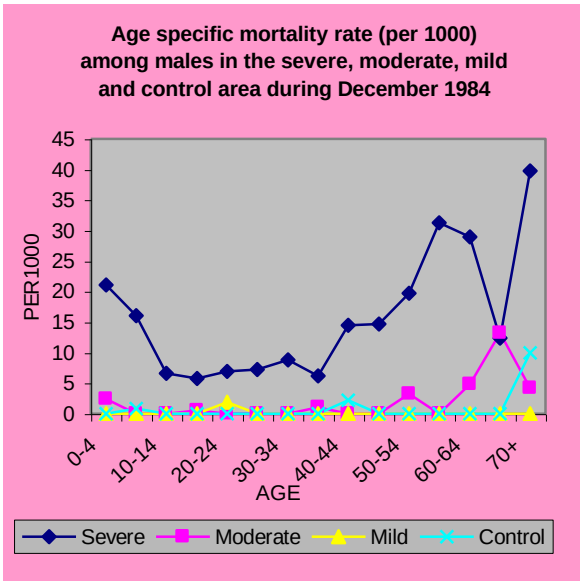


Chart-1

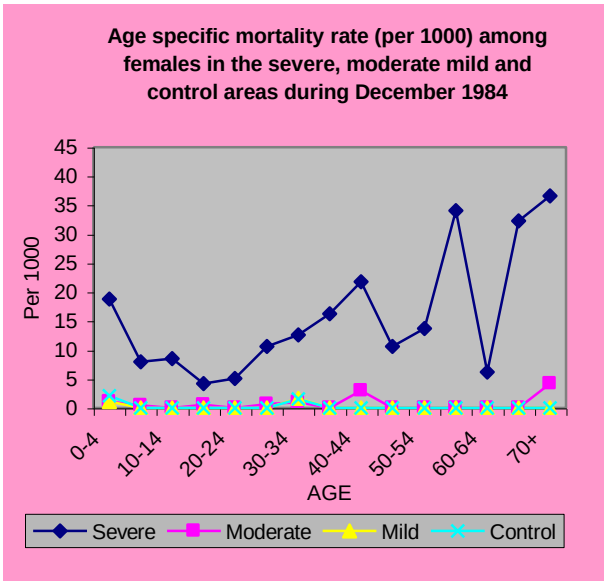


Chart-2

4.4.2.1 Between Areas:

During December 1984, the mortality rate in "severely affected area" was highest for all ages compared to other areas. Among males, the rates were higher in the younger age groups (0-4 and 5-9) and there was lower but almost uniform trend for age groups 10-14 years to 35-39 years and later an increasing trend was observed with highest mortality in the age group 70 years and above. In "the moderately affected area" there was an increasing trend from the age group 40-44 years compared to "mild" and "control" areas. The mortality rates in the "mildly affected area" were almost similar to the "control area" for all the age groups. In females also, "the severe area" had highest rates of mortality for all the age groups compared to the other three areas. The age groups (0-4), (65-69) and 70 years and above had higher death rates compared to other age groups. An increasing trend was observed from the age group 15-19 years. The remaining three areas did not indicate any differences in the age specific mortality rates.

In 1992, the mortality rates for most of the ages among both males and females were lower in the severe area compared to moderate and mild areas. Among males the moderate and mild areas had higher rate for older ages (65-69 and 70 years and above). The control area had lower rates for most of the ages compared to the exposed areas in both the years 1984 and 1992.

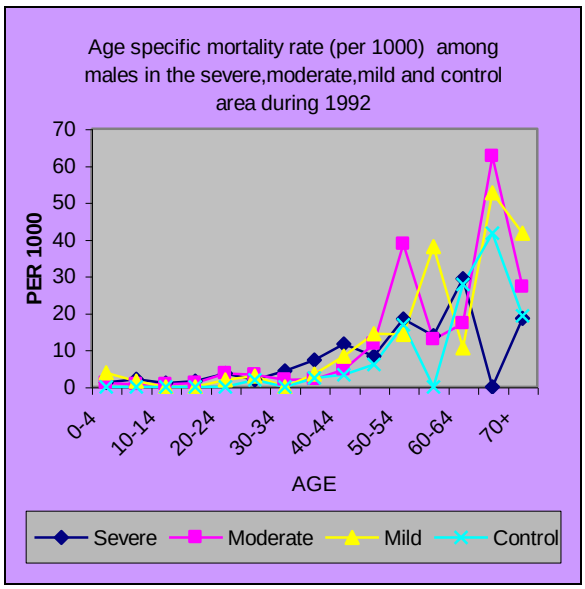


Chart -3

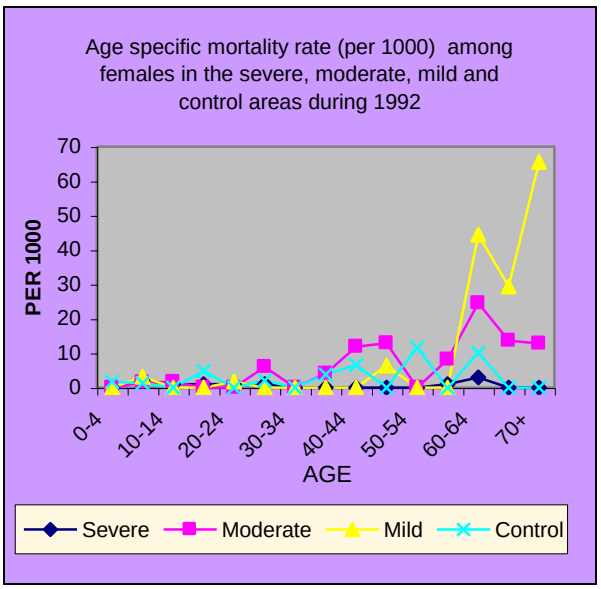


Chart -4

4.4.2.2 Within Areas :

During December 1984, among males, the severe area indicated higher mortality rates for the younger age groups and for the adults up to the age group 40-44 years compared to other periods. The younger age groups (0-4 and 5-9 years) had higher rates in 1985 compared to the periods 1986 and onwards. The mortality rates in the older age groups (50-69 and 70 years and above) were the highest in 1984. There was a gradual increase in the rates from the age group 35-39 years to 70 years and above in 1990. Among females, during 1984, the age specific mortality rates showed consistently higher rates for all the age groups upto 55-59 years compared to other periods and also it was high in the age groups 65-69 years and for 70 years and above. The elderly age groups had high rates for all the periods (Chart 5-6, Tables 4-5) (Annexure IV).

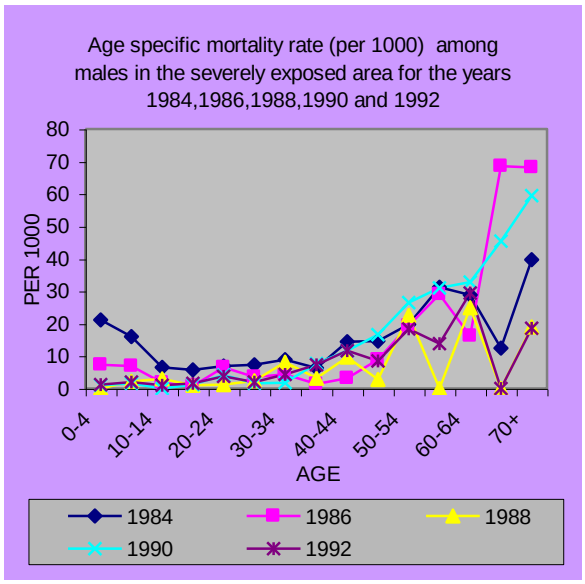


Chart-5

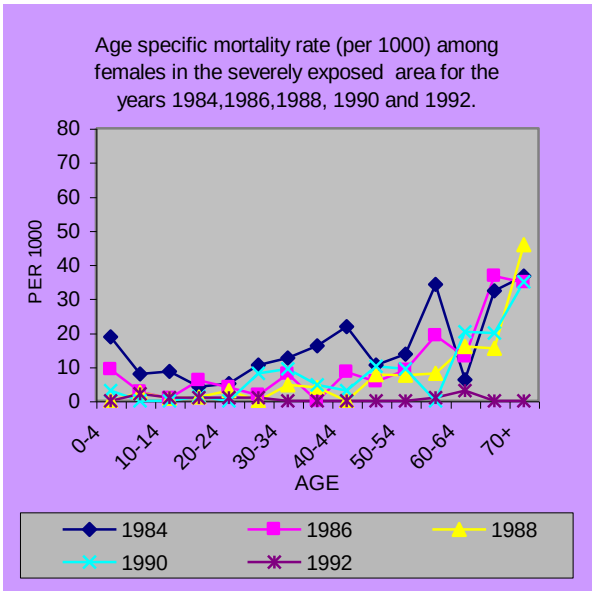


Chart-6

Among males, in moderate area, almost similar trends as observed in the severe area in the age specific mortality rates were observed for the age groups from 0-4 years 40-44 years in all the periods. The mortality rates for the ages 45-49 years and 65-69 years were the highest in 1985 compared to other periods. Among females, the mortality rates were almost similar in the age groups 0-4 to 20- 24 years in all the periods. In 1985, higher rates were observed for all ages from 20-24 years compared to other periods (Chart 7-8, Table 6-7).

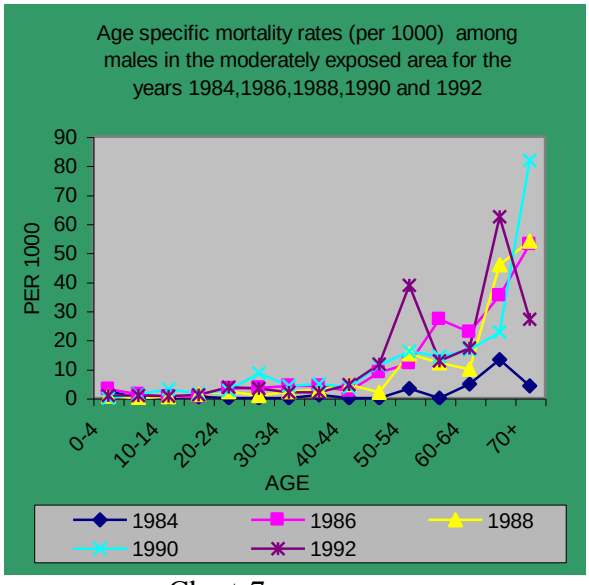


Chart-7

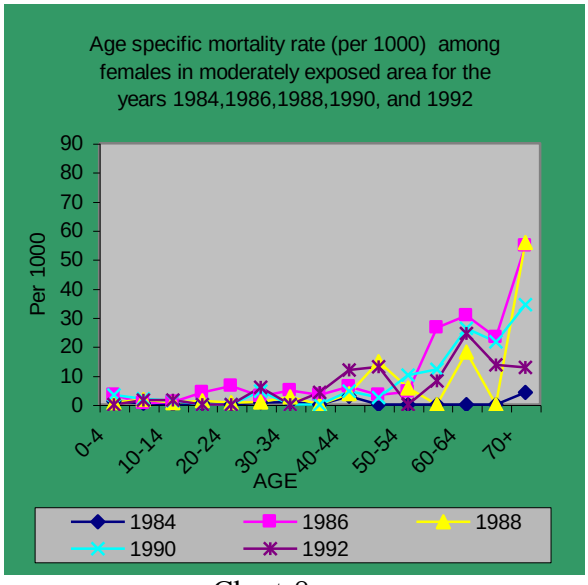


Chart-8

In “the mild area”, among both males and females the mortality rates were similar for all periods for ages 0-4 to 30-34 years. The mortality rates for the periods 1990 and 1992 indicated an increasing trend from the age group 30-34 years in males and among females the increase was observed for the period 1992 (Chart 9-10, Table 8-9).

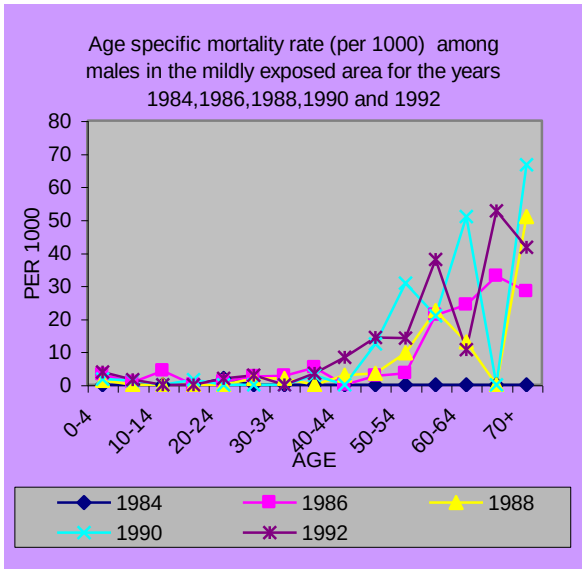


Chart-9

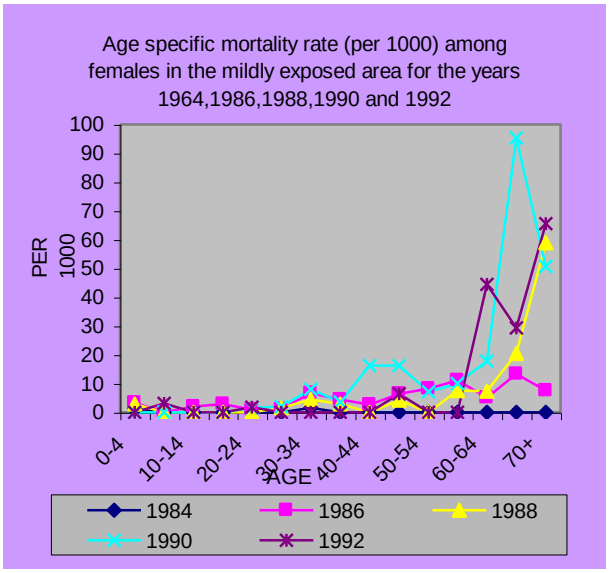


Chart-10

In "the control area" excepting a few peaks for some age groups the age specific mortality were similar in all periods (Chart 11- 12, Table 10-11).

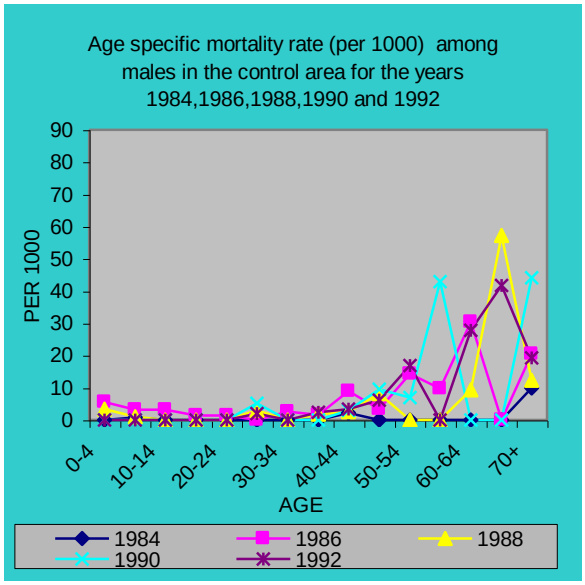


Chart-11

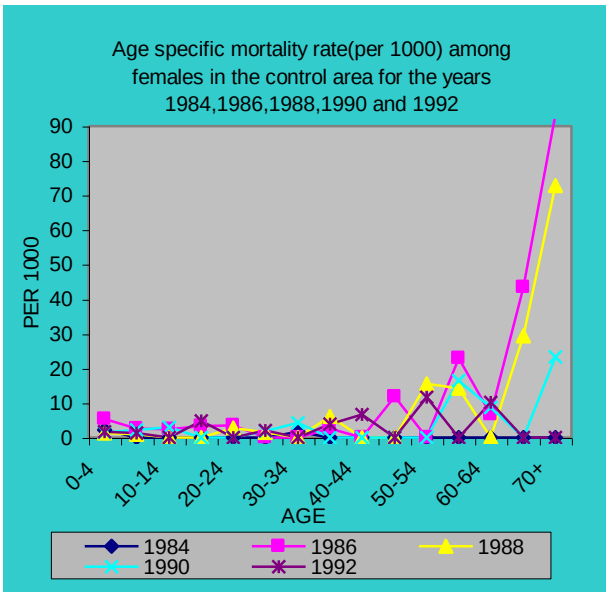


Chart-12

4.5. Cause of Death (Table 12-19, Annexure IV)

The information on causes of death was included from 1986. The coverage is almost 100 percent in the three exposed and in "the control areas". The details of causes of death is presented in Tables 12-19 (Annexure IV). In the text, for discussion only, the data on alternative years, 1986, 1988, 1990, 1992 are presented in charts for comparison within the areas and for between areas only the data for the years 1986 and 1992 are utilised.

4.5.1 Between Areas:

During 1986, it was observed that among males the maximum percentage of death was due to unknown causes in all the four areas. The deaths due to respiratory diseases contributed only about 10-12 percent in the exposed areas. In mild area an equal percentage of deaths was observed due to digestive disorders. The control area had comparatively less number of deaths due to respiratory diseases. Among females also the number of deaths were maximum in the category „unknown'. Excepting in mild area which had a higher mortality due to respiratory diseases, other areas did not indicate any differences compared to control area. In 1992, among males, the deaths due to unknown causes were lower compared to 1986 and in the mild and control areas it was nil. The deaths due to respiratory causes were highest in the mild area and the severe area had the lowest compared to the three exposed areas. In mild area the deaths due to circulatory or neurological causes was also high in comparison to other areas. Among females, almost a similar observation was seen indicating that the deaths due respiratory causes were high in all the three exposed areas (Charts 13-16, Table 12-19).

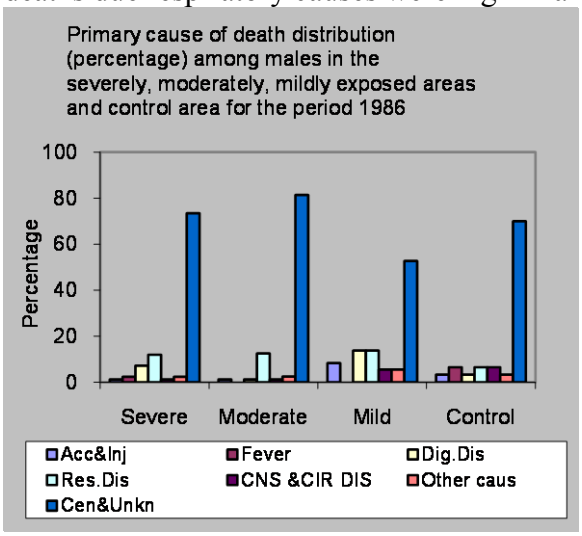


Chart-13

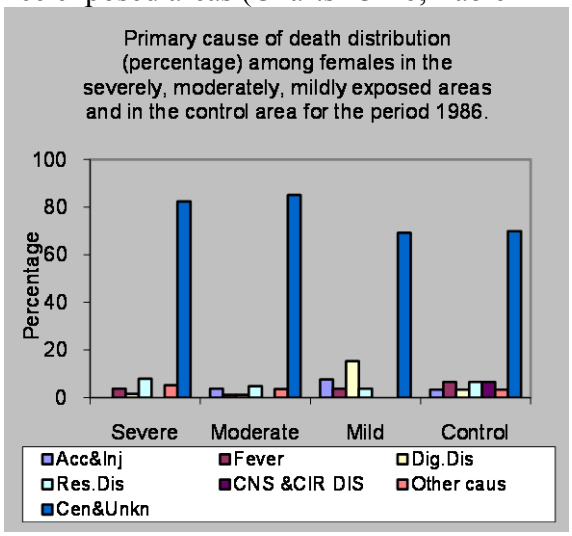


Chart-14

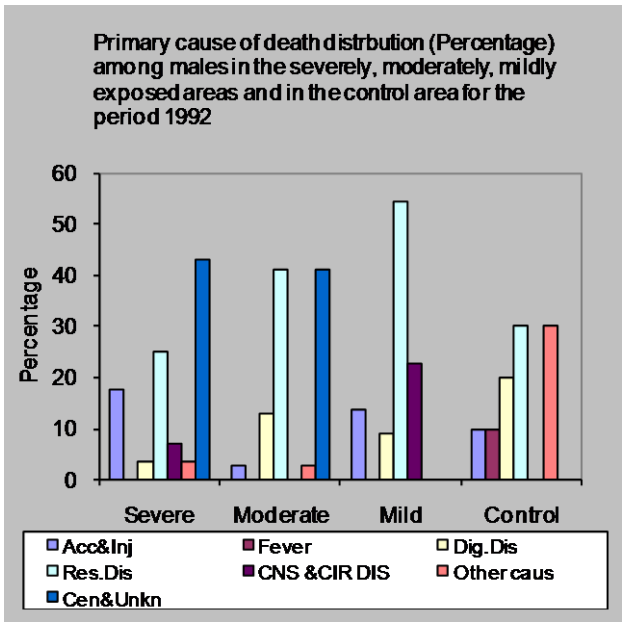


Chart-15

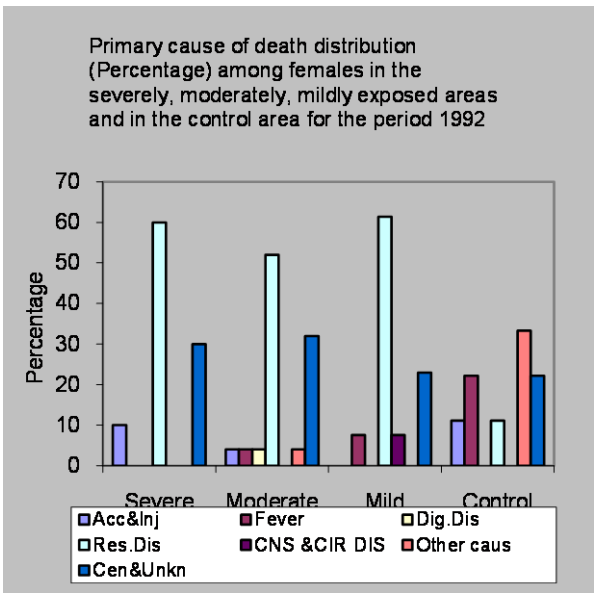


Chart-16

4.5.2 Within Areas:

In “the severe area”, in 1986 the deaths due to “unknown causes” were highest compared to other periods. The deaths due to respiratory causes were observed to be high in all periods, but there was a clear decrease in the percentages from 1988 to 1992.The other major causes were neurological or circulatory disorders. Among females, in 1990 the deaths due digestive diseases and accidents and injuries were observed to be higher than in other periods (Charts 17-18, Table 12-13).

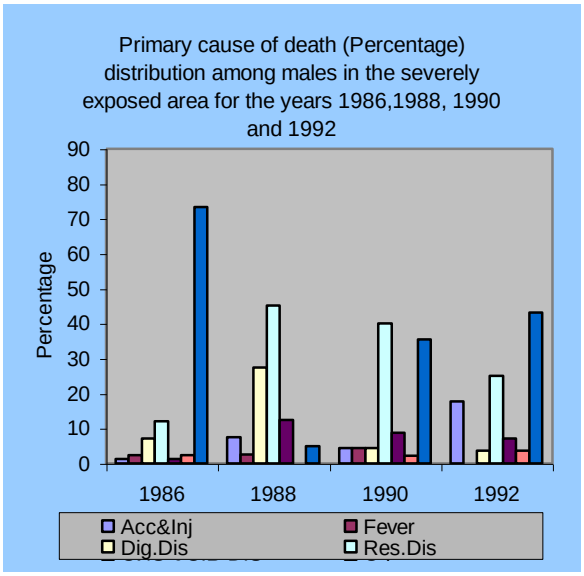


Chart-17

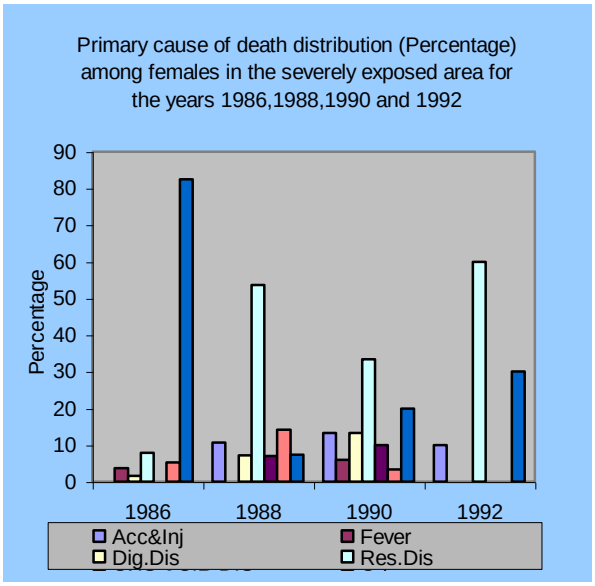


Chart-18

In “the moderate area”, among males findings were similar as observed in severe area, indicating a decreasing trend in the deaths due to respiratory disease with time. The death rates due to digestive disorders among males were high for the periods 1988 and 1992 and among females these were high in 1988 and 1990 (Charts 19-20, Tables 14-15).

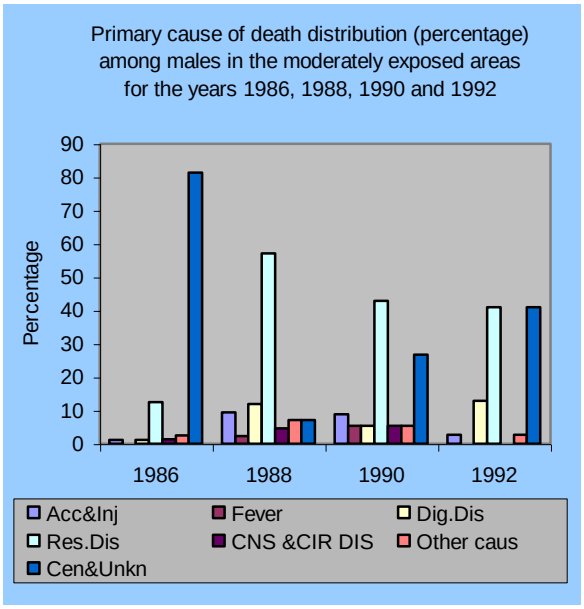


Chart-19

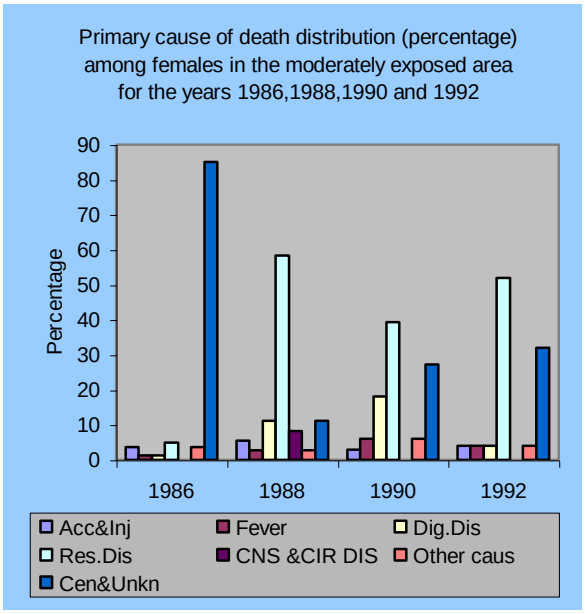


Chart-20

In “the mild area”, among males, almost similar percentage of deaths was observed due to respiratory causes for the periods 1988,1990 and 1992. The other major cause was CNS or circulatory diseases. Among females, no specific disease was prominent. In 1988, the deaths due to digestive

In “the mild area”, among males, almost similar percentage of deaths was observed due to respiratory causes for the periods 1988,1990 and 1992. The other major cause was CNS or circulatory diseases. Among females, no specific disease was prominent. In 1988, the deaths due to digestive diseases and causes unknown were high, and in 1990 and 1992 deaths due respiratory causes were high (Charts 21-22, Tables 16-17).

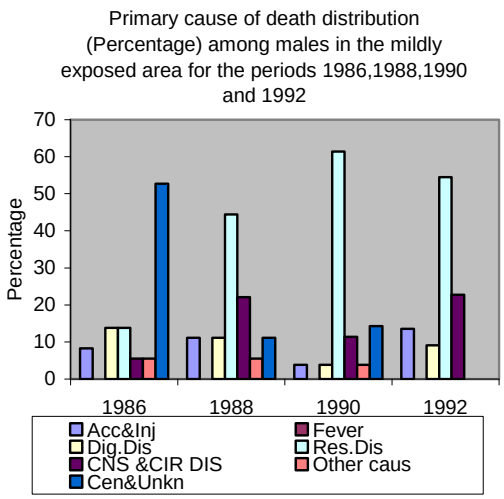


Chart-21

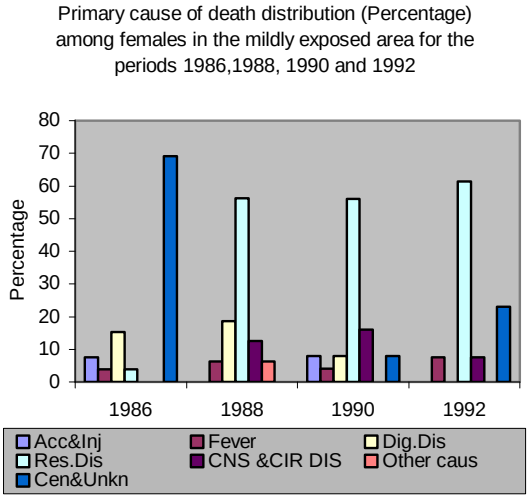


Chart-22

In “control area”, the causes of death are uniformly distributed and there were not much differences between periods (Charts 23-24, Table 18-19).

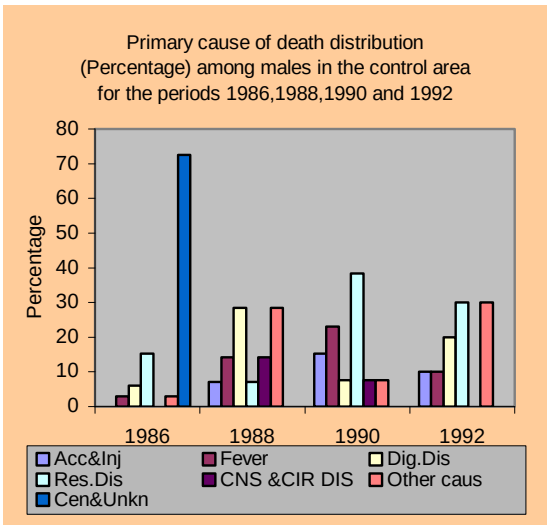


Chart-23

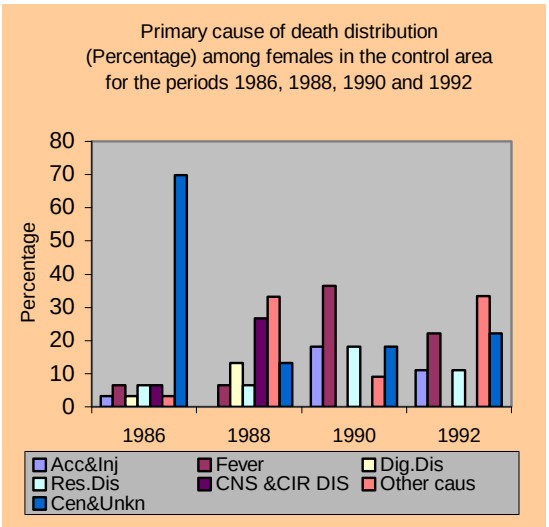


Chart-24

4.6 Morbidity (Table 20-37, Annexure IV)

The information on specific morbidity as related to lung, eye and gastro intestinal tract and skin which occurred immediately after the gas episode amongst age groups 0-4, 5-14, 15-44, 45-59 and 60

22-37. In the text, the charts have been included to provide information on the crude morbidity rates for all morbidities, lung and eye during the follow up periods and also the age specific morbidity rates for five follow up points, viz, for 16th Jan.1986 to 31stJan 1986, Nov, 1987 to May 88, May 90 to Nov. 90, Nov.92 to May 93 and Nov. 93 to May 94.

4.6.1 Between Areas:

In all the three exposed areas 98 percent 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 control area had very low morbidity during the same period. The age specific morbidity also indicated similar picture as was observed in all ages.

The morbidity rates in all the areas indicated three distinct trends indicating a low rate up to the survey during May 88 to November 88, later an increasing trend up to the survey in November 90 to May 91; 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 to November 91. The mild area showed a higher rate compared to the moderate area from May 91 to November 91 and during the last two follow up periods the rates were similar to the one observed in the severe area. The control area had lowest rates for all the periods compared to the three exposed areas.

Lungs: 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 areas. There was no clear pattern of increase or decrease in the rates in the severe area up to the period May 88 to November 88 and later an increase reaching the peak in period November 1990 to May 1991 and a fall afterwards. In the moderate and mild areas the increase was observed from age 0-4 years; the moderate area reaching the peak in May 1990 to November 1990 and mild area in November 89 to May 1990. The control area had also shown a similar pattern as observed in the moderate and mild area but having lower rates for all the periods. In females also, more or less similar trend was observed in all the areas excepting that from period November 1991 to May 1992, the rates in the mild area were higher compared to the severe and moderate areas.

Eyes: During the follow-up (1986-94) phase, the ophthalmic morbidity among males was about 2 per cent. In the three exposed areas, the rates were almost same up to the period November 87- to May 88 and later an increasing trend was observed. The increase in mild area was highest after the period May 90 to November 90. Again a fall in the rate was seen from May 92 to November 92. Among females, the morbidity rates were higher in moderate and mild areas compared to severe area in most of the periods. The mild area had higher rate compared to moderate area from the period May 91 to November 91. A decreasing trend was observed in all the three-exposed areas from the period May 92 to November 92 and again an increase in the rates was observed from November 92 to May 93.

In the acute phase the age specific morbidity rates among males at all the four areas indicated a distinct trend, which showed that at all the ages the highest was “in severe area” and the lowest in “control area” and the other two areas lying in between. In “the severe area” the age group 5-14 years had lowest rate compared to other age groups and there was a sharp increase from age 5-14 years onwards. In “the moderate area”, the morbidity rate was almost constant up to 15-44 years and later there was an increase. The “mild area and control area” did not indicate any specific trend in the age specific morbidity rates. Among females a similar picture observed among males was seen excepting that in all the three exposed areas the increase in the morbidity rate was observed from age 5-14 years and onwards. Also a fall in the rate was observed in all the three exposed areas in persons aged 60 years and above (Charts 25-26, Tables 22-29).

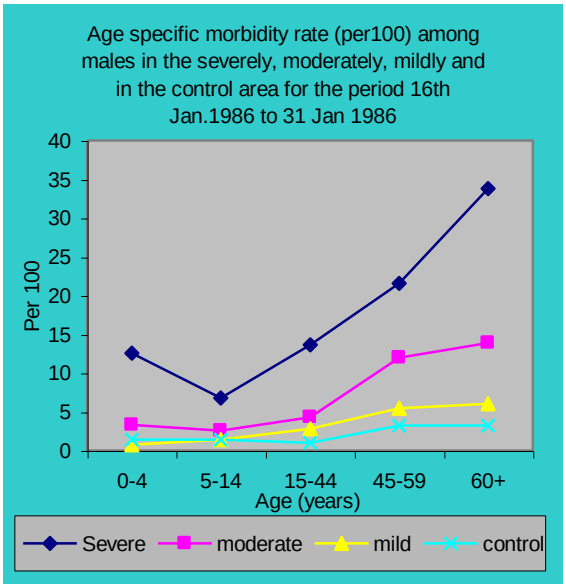


Chart-25

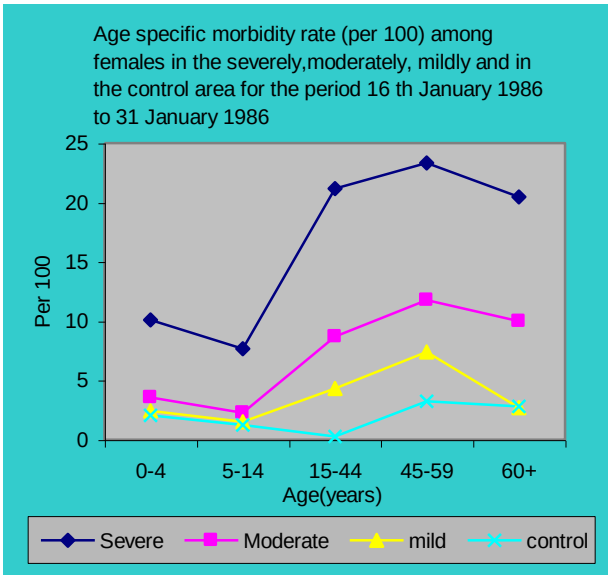


Chart-26

The age specific morbidity rates during period November 1993 to May 1994 among both males and females showed almost a similar pattern for the three exposed areas. A constant rate of around 5% to 7 % for ages 0-4 and 5-14 years was seen and afterwards an increase up to 45-59 years was observed. In the mild area the increase was higher from the age group 15-44 years. The control area had lowest rates for all the age groups compared to the three exposed areas (Charts 27-28, Tables 22-29).

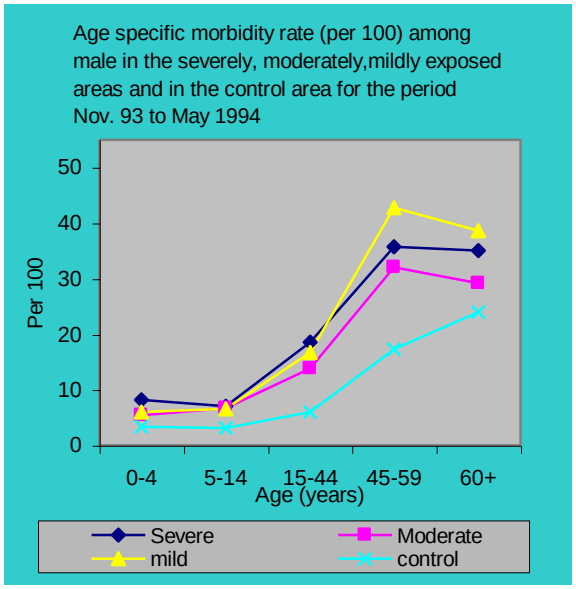


Chart-27

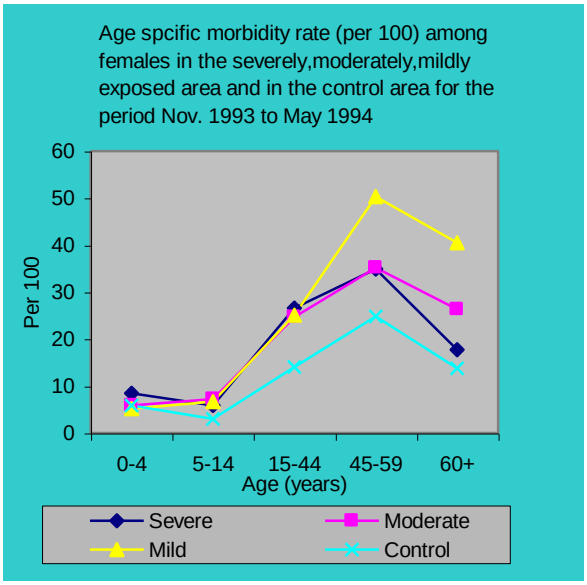


Chart-28

4.6.2 **Within Areas:**

In “the severe area” among both males and females higher morbidity rates were observed in all the age groups during the period May 90 to November 90. The other distinct observation in both males and females was that in the period November 87 to May 88 the morbidity in children aged 0-4 years was highest compared to other periods. In all the periods the peak was in the age group 45-49 years (Charts 29-30, Tables 22-23).

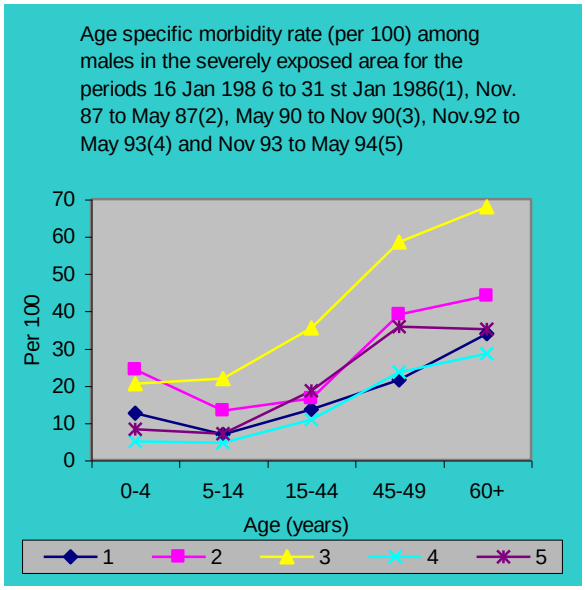


Chart-29

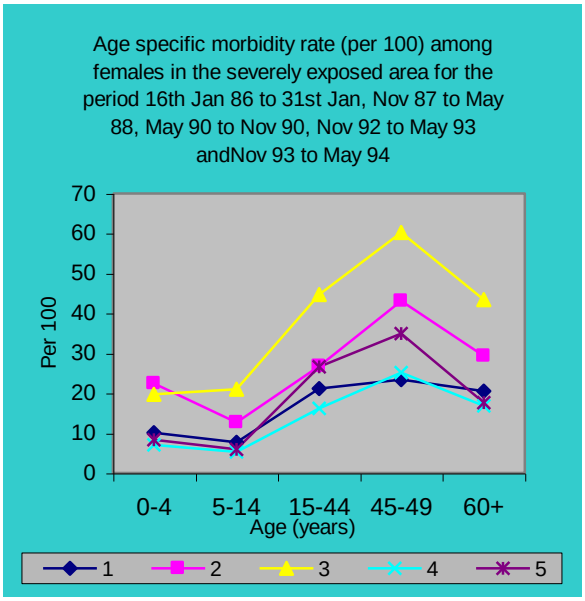


Chart-30

The age specific morbidity rates between the periods indicated a similar pattern in "the moderate area" as observed in "the severe area". All the periods excepting May 90 to November 90 had almost same rates in the age groups 0-4, 5-14 and 15-44 years and in the age groups 45- 59 and 60 years had marginal variations (Charts 31-32, Tables 24-25).

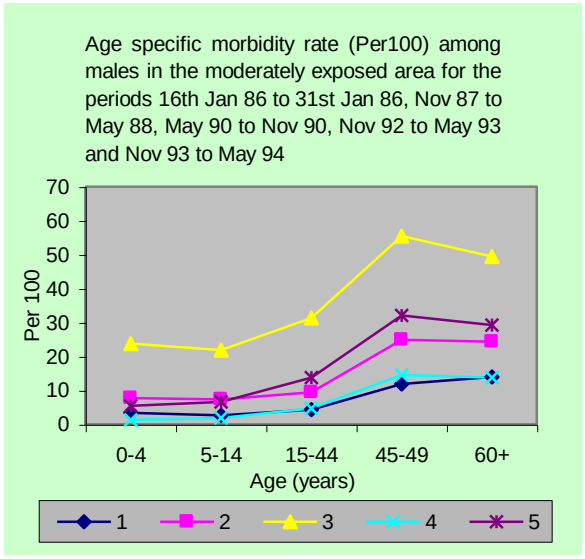


Chart-31

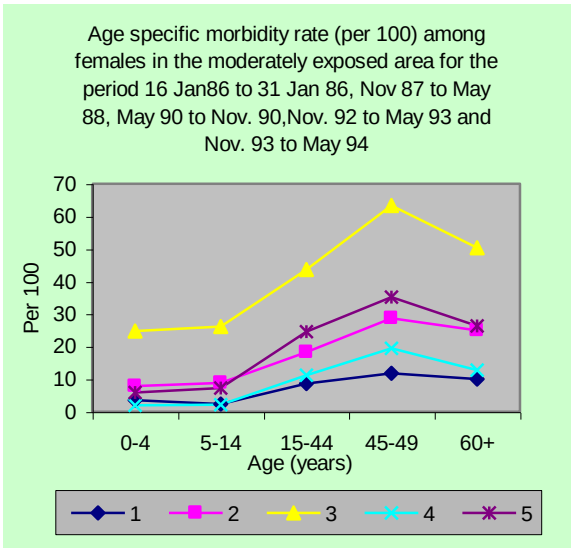


Chart-32

In "the mild area" the morbidity rates in all the age groups were the highest for the period May 90 to November 90 in both males and females. Also a high rate was observed for age groups 45- 49 and 60 years and above for the periods November 92 to May 93 and November 93 to May 94 (Charts 33-34, Tables 26-27).

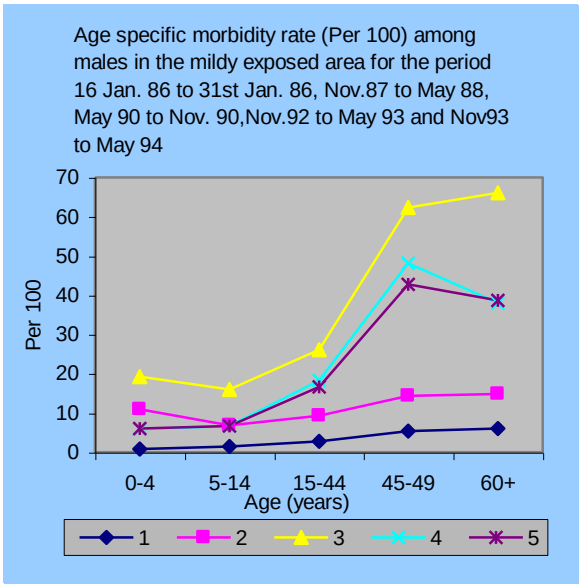


Chart-33

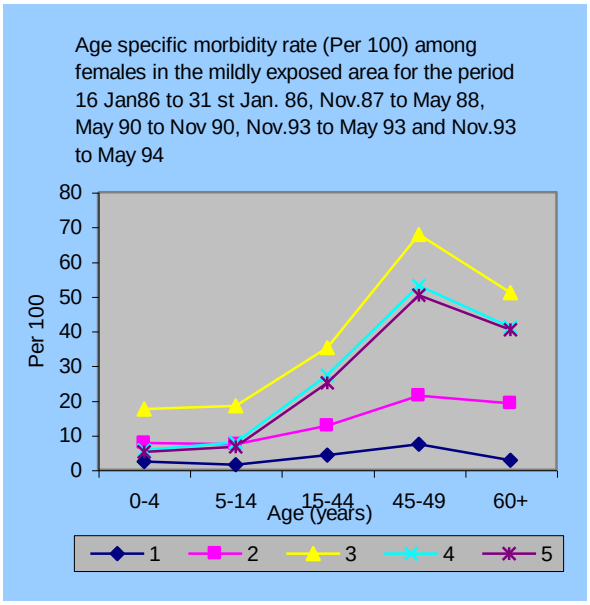


Chart-34

The "control area" also had the highest rates in all the age groups for the period May 90 to November 90 compared to other periods in both males and females. Among males the peak was observed at the age above 60 years compared to females, where the peak was at 45-59 years (Charts 35-36, Tables 28-29).

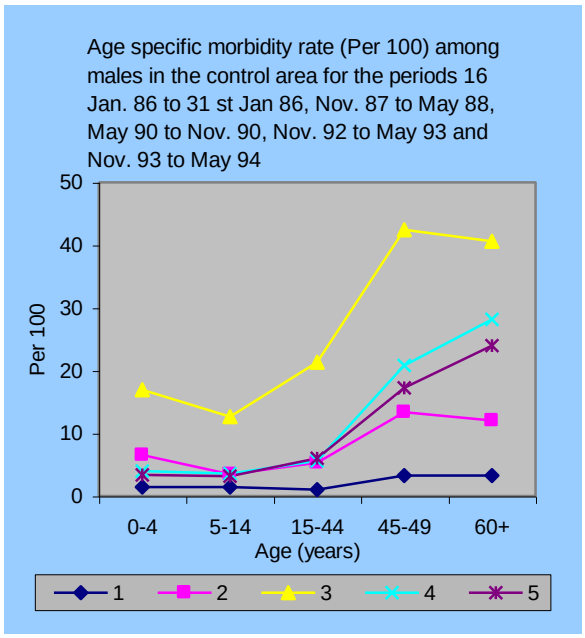


Chart-35

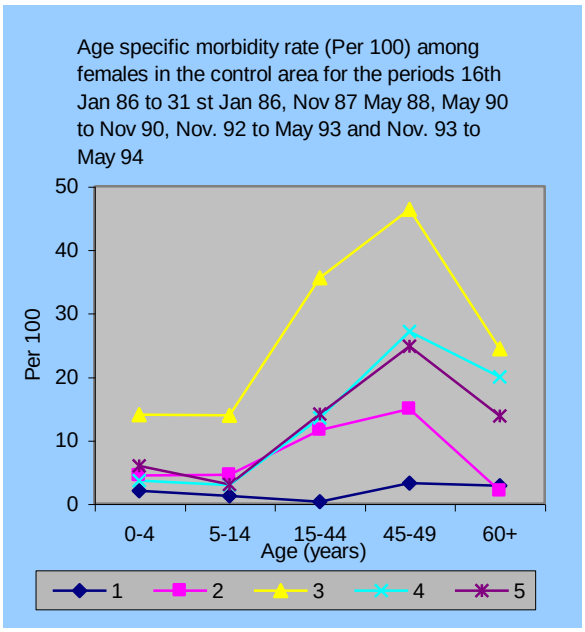


Chart-36

4.6.3 Validation of Morbidity Data

The analysis of morbidity has been carried out only for persons included in the baseline data. The presentation of information has been carried out as "**cross-sectiona**l" data, as this will have larger

number of person available at each follow-up points compared to the cohort, that is to include persons followed at all point of time. The **"cohort approach",** i.e. to include only those persons initially exposed and available at all points of follow up may be a better approach but, due to small number of persons present at all points of time, this may not provide adequate number for presentation of results by age and sex and other variables.

It was observed in **"the cross-sectional approach",** that nearly 57-64 percent males and 57-62 percent females were available at the last follow-up i.e. during 1994, whereas only 3-6 percent were observed through cohort approach for the same period.

To validate cross-sectional approach, a comparison of morbidity rates related to lung observed in both cross-sectional and cohort was carried out.

It was observed that the morbidity rates among the cohort approach in the severely exposed area indicated higher morbidity rates compared to the morbidity rates of cross-sectional approach. In the initial follow-up points the difference was observed to be higher i.e. (follow-up points 1, 2 and 3) compared to later follow-up points) The maximum difference (8 per cent in males and 9 per cent in females) was observed in the first follow-up and later the difference was around 3 to 4 percent among both male and female (Charts 37-40, Tables 30-31).

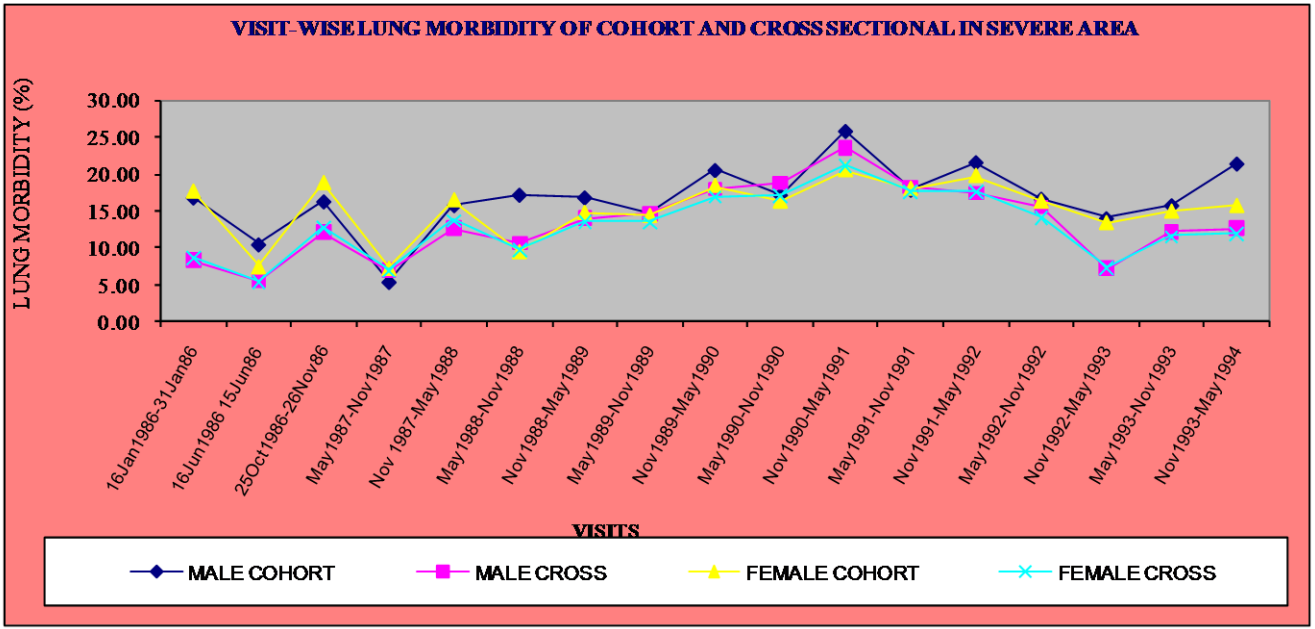

VISIT-WISE LUNG MORBIDITY OF COHORT AND CROSS SECTIONAL IN SEVERE AREA
LUNG MORBIDITY (%)
30.00
25.00
20.00
15.00
10.00
5.00
0.00
16Jan1986-31Jan86
16Jun1986 15Jun86
25Oct1986-26Nov86
May1987-Nov1987
Nov 1987-May1988
May1988-Nov1988
Nov1988-May1989
May1989-Nov1989
Nov1989-May1990
May1990-Nov1990
Nov1990-May1991
May1991-Nov1991
Nov1991-May1992
May1992-Nov1992
Nov1992-May1993
May1993-Nov1993
Nov1993-May1994
VISITS
MALE COHORT
MALE CROSS
FEMALE COHORT
FEMALE CROSS

Chart-37

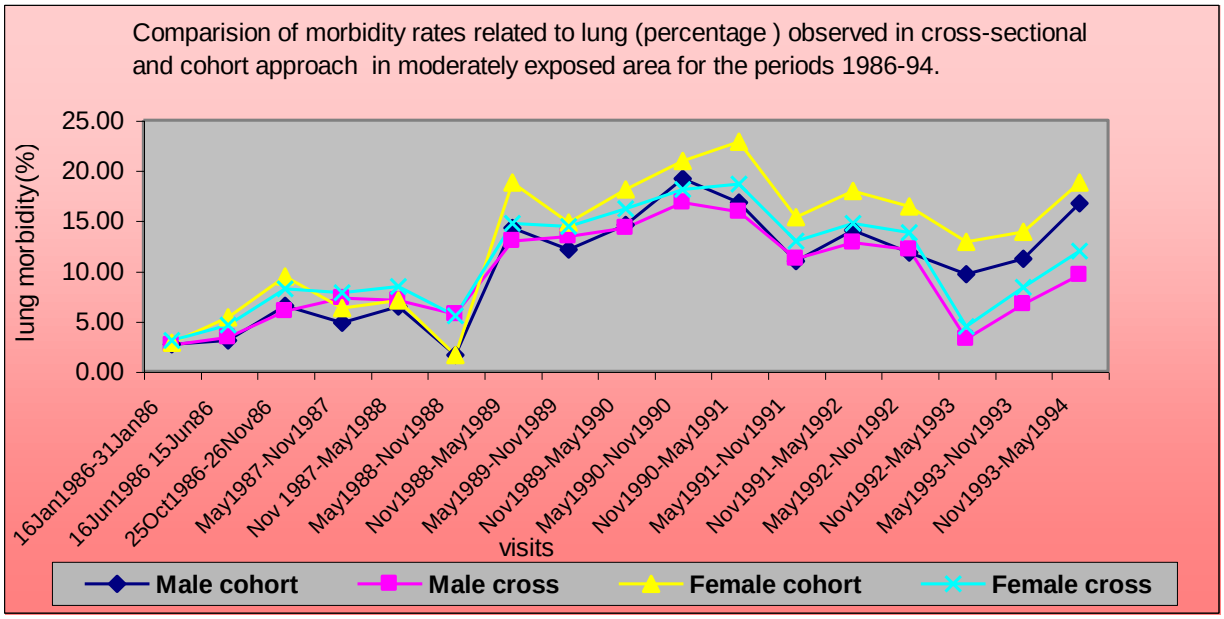


Chart 38

In moderately exposed area, it was seen that both among males and females there was a very good concordance in the morbidity rates by both **cohort and cross-sectional approach.** A similar result was observed in mildly exposed area also.

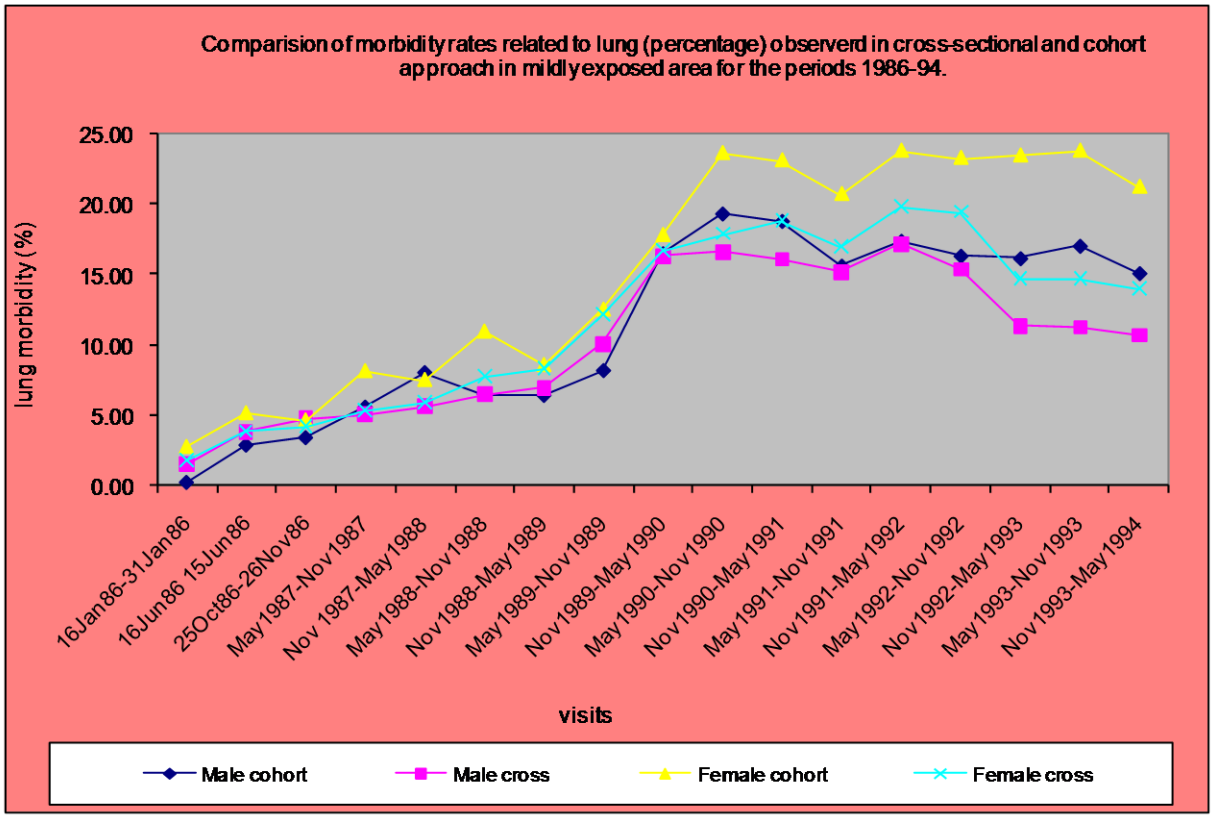


Chart-39

The comparison of morbidity rates between cohort and cross-sectional data indicated a good agreement in the control area at all follow-up points.

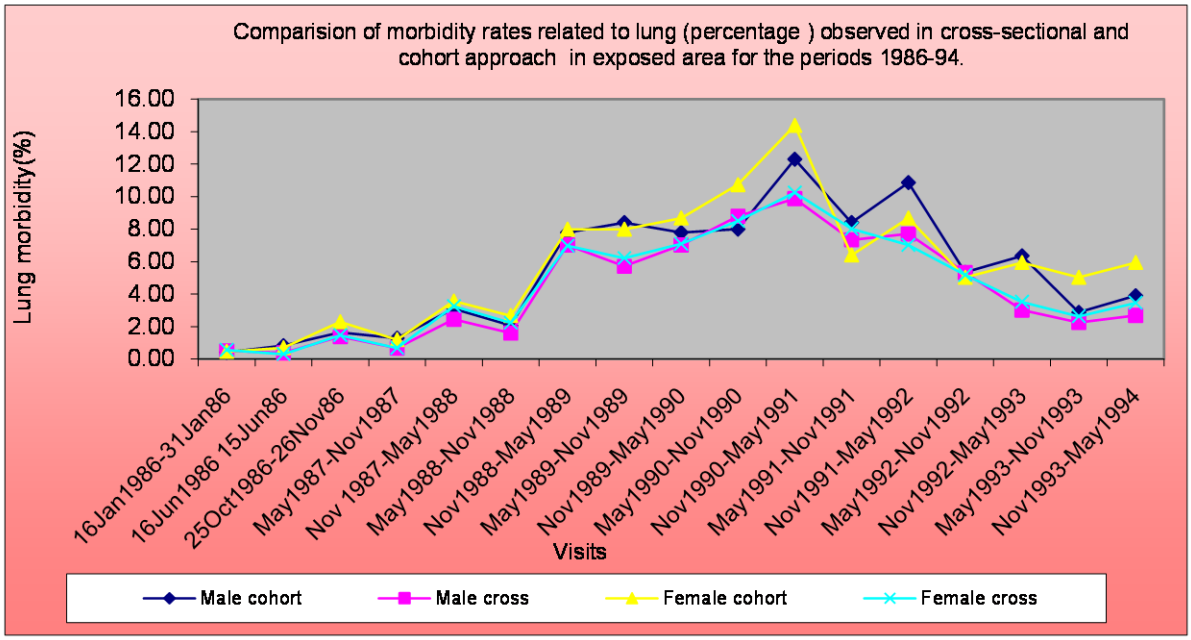


Chart-40

The results of ophthalmic, gastro-intestinal and skin morbidities are presented in Tables 32 to 37. Comparison between cohort and cross sectional pulmonary morbidities are presented in Tables 38 to 41. Table 42 presents the abortion and still birth rates in the exposed and control areas.

4.7 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 the survey in Aug-Oct. 1985. During Jan-Dec., 1986 a different format was introduced to collect the detailed information on pregnancies through fortnightly visits of the families. From the year 1987 onward, these data were collected through yearly follow up of the families. The data for December 1984 and for the years 1985-89 are presented in this report.

Results on pregnancy outcome have been presented in Table 42 for the year 1984-1989. It can be seen that immediately after the disaster, in the severely affected area the abortion rate was 523 per 1000. The abortion rate showed a decreasing trend from "severely" to "mildly" affected area. In the subsequent years there was a declining trends in the abortion rate in all the exposed area. In the control area abortion rate for Dec1984 was 83 per 1000. No clear pattern was observed in the exposed area with regard to still birth rates (Table 42).

Chapter - V

Discussion

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 was undoubtedly, the world's worst industrial accident. On the occasion of the Indo-Pacific Confernence on Legal Medicine held at Madras (Chennai) in December 1989, Ivor Doney, Editor of Legal Medicine referred to Bhopal Gas Tragedy, thus "A silent stunned audience listened with awe the terrible story of 1984, when on one tragic day poisonous fumes killed hundreds of people and maimed thousands of them. He likened the tragedy to Pompei which suddenly engulfed Vesuvious or Hiroshima when the atom bomb was dropped. He concludes : "The story should be told again and again and again". On an in-depth analysis of events leading to the Disaster, one is inevitably driven to the conclusion that this was largely man-made and was perhaps preventable. It is now learnt that there had been at least three previous accidents of Gas leakage from this Plant of the Union Carbide in October and December 1982 and in February 1983 respectively. Indeed, the final Report of UCC itself was very critical of safety standards and stated that the Plant represented rather high potential for more serious accident to occur. However, no preventive measures seem to have been instituted.

In the accompanying documents prepared by the Indian Council of Medical Research the grim story of the tragic human effects of exposure to the Toxic Gas(es) in Bhopal as it unfolded itself (based on autopsy, toxicological studies) the long term epidemiological studies on mortality and morbidity – has been presented.

The expert opinion is categorical that MIC must never be kept stored for a long time as happened in the Bhopal Gas Disaster, but should be consumed immediately. Referring to the Final Report of the ICMR Project 08 under Prof.Heeresh Chandra; "Everyone in the world believed that the Union Carbide Killer tank 610 contained nothing but MIC that was supposed to be stored by UCIL for more than 6 weeks (Vardarajan et al[17]) at ambient temperature against all norms so prescribed by the manufacturer themselves". The same document points out that it was not known for how long the adverse reaction inside the tank had been going on; why the refrigerator unit had been removed 6 months prior to the Accident; why the hydrants did not function effectively and why the scrubber had been out of order. The monitoring devices and safety measures like valves, flare tower, scrubbers and water sprayers did not function, leading to an enormous build-up of pressure and temperature inside the tank, resulting in escape of Gas(es) into the atmosphere. From recounting of the events leading to the loss and suffering of human life, it is obvious that if the MIC manufacture and storage had been 3-4 km away from the periphery of any residential area, deaths would have been prevented and inhalation injury would have been minimal. Furthermore, although it may sound ridiculously simple, if only the exposees had covered their faces with a wet cloth perhaps the impact of inhalational injury would have been considerably reduced. It is regrettable that the residents of Bhopal were never made aware of the possibility of a Gas Leak and the preventive measures to be adopted in the event of a mishap.

As stated earlier, the permissible concentration of MIC is 0.02 ppm in air averaged over an 8-hour work shift. In four human volunteers, experimental exposure for a period of 1-5 minutes, 0.4 ppm of MIC produced no symptoms; 2-4 ppm produced symptoms of increased irritation of eyes with lacrimationm, blepharospasm; and of respiratory passage with cough, chest pain and dyspnoea. When the concentration was increased to 21 ppm the effects were unbearable[16].

Varadarajan et al[17] conducted a number of scientific studies to understand the chemical behavior and reactivity of Methyl Isocyanate. The prevailing conditions of its manufacture, storage, utilization and disposal along with full examination of the buried tank and its contents and other constituents were studied to understand the circumstances which led to the violent chemical reaction and rapid leakage of the Toxic Gases. They collected samples of residue removed from different sections of the tank and reported presence of over 12 different chemical entities, which are given below.

The following are some of the Methyl Isocyanate (MIC) related compounds: -

1. Methylisocyanate Trimer (MICT);
2. Dimethyl Urea (DMU);
3. Dimethyl Isocyanate (DMI);
4. Trimethyl Urea (TMU);
5. Dione;
6. Trimethyl Biuret (TMB);
7. Tetramethyl Biuret (TRMB);
8. Mono Methyl Amine (MMA);
9. Dimethyl Amine (DMA);
10. Trimethyl Amine (TMA);
11. Chloride and
12. Metallic ions (Fe, Cr, Ni, Mo, Na, Ca, & Mg)

Prof.Heeresh Chandra and his colleagues of the ICMR Task Force on Toxicological Study demonstrated, 11 more new hitherto unidentified components in the Tank Residue with the help of Finnegan Mat G.C.M.S, coupled with ion-trap detector (itd) with specific mass fragmentation pattern[18]. However, the exact identification of the MIC-based agent responsible/contributing to the mortality and morbidities in Bhopal are far from understood.

They also demonstrated the presence of high cyanide levels in blood and preserved post-mortem tissues from persons who died between 3-6 December, 1984. This provided convincing evidence that hydrogen cyanide (HCN) was also one of the constituents of the Gases generated as a result of pyrolation effects of MIC[19,20]. Thus, the „cherry red' discoloration of the lungs and viscera could be readily explained.

This Group also postulated and confirmed that on entering the blood stream MIC causes irreversible N-Carbamoylation of end-terminal valine residues of haemoglobin. Depending on the number of Hb chains affected, transport of CO_2 is impaired, with consequent higher affinity for oxygen. This partly accounts for the reddish discoloration of blood. More importantly, the resultant diminished unloading of oxygen in tissues could be responsible for anoxic tissue damage of all organs but most seriously of the brain, manifesting as cerebral oedema and perivascular hemorrhages. Instantaneous interaction of inhaled MIC seem to have resulted in destruction of alveolar membrane proteins; this seems to have caused massive exudation of fluid into the alveoli and compensatory emphysema. Passage of MIC down the respiratory tract seems to have caused destruction of the highly specialized alveolar membrane leading to wide spread systemic effects as in the case of inhalational injury due to phosgene (cited by Cohen and Oppenheimer[21]). The massive exudation of fluid into the alveoli and compensatory emphysema without obvious inflammatory changes seen in the initial autopsies could either be due to direct effect or mediated through nerve endings, and reactive inflammatory changes were observed only later on.

The Gas(es) entered residential places without warning on a wintry night leaving residents stunned with unbearable respiratory symptoms like cough, expectoration, inability to breathe and chest pain, severe irritation of eyes with lacrimation, photophobia and blepharospasm. They rushed out in large numbers, out of their houses in panic to take shelter in places of relatively greater safety. But sometimes they walked inadvertently into pockets of lethal concentrations of the Gas. One of the several examples of catastrophic effect of exposure to the Toxic Gases in close-by areas is vividly described by Kamat et al[7] at the Bhopal Railway Station – merely 1 km away from the Factory. " Within an hour, 21 persons died, 200 were found unconscious and the whole station complex was littered around with 600 suffering subjects lying among their own excreta. Some Railway Passengers died in sleep within a few minutes. Six hour after the Gas leak, 73 residents of the Railway Colony were found dead".

Methyl isocyanate is a highly reactive chemical which was subjected to very high temperature and pressure inside the Tank 610. Thus, it is possible that thermal degradation products of MIC, i.e. hydrocyanic acid, carbon-monoxide and oxides of nitrogen were released with the MIC cloud. This is corroborated by the early post mortem findings of the dead. This is perhaps an over simplification of actually a much more complicated nature of MIC and its reaction products. Following the Bhopal Gas Tragedy, intensive research work has been done on MIC toxicity by the Toxicology Group under late Prof.Heeresh Chandra and Dr.S.Sriramachari. It has provided valuable insights on the biological effects of these Toxic Gases, as discussed in the accompanying Report on the Toxicological aspects of Bhopal Disaster.

The toxic vapour cloud from Tank 610 quickly spread into the adjacent densely populated region of Bhopal. It is possible that the emitted vapour condensed in the cool air and formed an aerosol which was inhaled, settled in the respiratory passage from where it evaporated (boiling point of MIC is 39.1°C) and spread deeper into the respiratory bronchioles and alveoli, causing extensive tissue damage. During bouts of coughing and hyperventilation some of the vapour could have been swallowed into the gastro-intestinal tract and depending on its concentration caused structural and/or functional damage. Of course, the extent of damage caused would be proportional to the concentration of MIC inhaled.

The Scope for Long-term Epidemiological Studies:

There was no way of identifying the Toxic Gases or measuring their concentration in the areas of spread, to correlate the morbidities and the deaths. It is noteworthy that reportedly 75% of the MIC deaths occurred in the first 48-72 hours. The death rate then rapidly declined. The long term epidemiological studies were of paramount importance to know how the damage caused by the potentially killer Toxic Gas(es), among the survivors, evolved over months and years following the exposure. The epidemiological data would also help in clinical management and determining prognosis of the disorders caused. It was absolutely necessary to grade the exposed population in terms of the intensity of exposure.

As stated above, the Toxic Gases caused morbidity and mortality through inhalational route. It is also known that the eye and upper as well as lower respiratory passages are extremely sensitive to even as low as 2-4 ppm of MIC[16]. This symptomatology could therefore be used as a dividing line between the exposed/affected and the unexposed/unaffected population, strictly for the purpose of epidemiological studies. It is also a safe assumption that higher the concentration of the Toxic Gases inhaled, the more severe would be the mortality and greater the morbidity. For example, the largest number of deaths occurred in the close vicinity of the Union Carbide Factory. Undoubtedly, there would be several other factors which would determine the distribution of the toxic cloud and thus the concentration of toxic gases. But, these factors remained largely unexplored.

On the basis of clinical symptomatology after Toxic Gas inhalation, the entire population of Bhopal – 832904 in 56 Municipal Wards was divided into the Exposed and Affected population – 521262 in 36 Municipal Wards; and Exposed at least theoretically but unaffected population – 311642 in 20 Municipal Wards. The exposed and affected population was further categorized on the basis of death rates during 3rd December to 6th December, 1984, into severely exposed/affected area – average death rate 21.98/1000 (population 32476); moderately affected/exposed area – average death rate 1.33/1000 (population 71917); and mildly affected/exposed area – average death rate 0.2/1000 (population 416869).

The entire area with exposed but unaffected population of 311642, for the sake of epidemiological studies, was treated as "Control Area", to draw comparisons with the affected areas.

Expressed as percent of the total population of Bhopal, 3.9% was severely affected, 8.6% was moderately affected, 50.1% was mildly affected, while 37.4% was unaffected.

From the affected/exposed areas the "Registered Cohort" consisted of 80021 persons from severe = 26382; moderate = 34964; and mild = 18675, for long term epidemiological studies and another Cohort of 15931 persons was registered from the "Control Area" for comparison. A questionnaire from a prestructured proforma (Annexure II) was administered to the population of the Registered Cohort and the data analysed.

A number of medical and bio-scientists at national level were actively involved in the planning and execution of epidemiological studies following the Disaster.

Limitations of Study Results

Any study which was planned on emergency basis such as Bhopal Gas Disaster having time constraints for working out details regarding the population to be covered, information to be generated and mechanism of data collection, will have some limitations in the results generated, as indicated below which should be kept in mind while interpreting the results.

1. Study design: (a) The study as mentioned under Material and Methods, was planned as a "Cohort study". For this purpose, a large sample was selected from the affected and control population. The areas affected by Gas mainly catered to low socio-economic population. There were no house numbering or any identification for preparing a sampling frame and thus specific areas were demarcated for the study and all persons living there were included in the cohort. Initially there were some shifting of entire population from one area to another and that created depletion in the cohort. However, the loss during later period was not that significant.

(b) The study was planned as an "Household study" viz., by including only persons living in households. This might have under enumerated the immediate deaths since the deaths of persons without having household have not been taken into account.

(c) The study was planned to collect information on a longitudinal basis. Initially, in the acute phase it was planned to collect data every fortnight from all the households and later modifications were made as per the interim recommendations. This has led to certain changes in the data structure and methodology of data collection.

2. Information generation: (a) To record the immediate morbidity and mortality occurring in the cohort an initial survey was conducted during August – October, 1985. It was planned to complete the study in a short period and thus a number of social workers were utilized. Although intensive training was given and quality control aspects were in-built still some bias might have crept in the data collection which may be beyond control in such a large survey.

(b) During the "acute phase", each of the social worker was expected to visit an area covering a sample of 5,000 persons and enumerate the morbidity and mortality observed in the family. It was a stupendous task and it is a fact that the social worker did it with all sincerity. Some minor variation was observed between the workers which was minimized with proper quality control checks.

(c) The "fortnightly surveys" carried out in the acute phase followed the method of enquiring from the elderly member regarding the morbidity and mortality status of each member and if any member had any morbidity it was recorded in the Proforma. As the total sample of 5,000 persons had to be covered in six months, it was difficult to elicit information at individual level. Thus, some information might have been lost.

(d) The "six monthly surveys" included a detailed proforma for collecting morbidity data and also separate cards were utilised for recording the deaths. It is a known fact when issue of compensation was being discussed there might be some persons intentionally providing some false information regarding the health status. A proper check on sample bias was in-built to be carried out by Research Officer (Medical) to minimize such false information, however, it was difficult to completely remove this from the survey.

e) The high overall death rates among males in 1993 in the mild area was due to very high death rates among elderly in the age groups 60-64, 65-69 and 70 years and above. The major cause of death in all the three exposed areas was due to respiratory diseases.

f) Immediately after gas exposure it was observed that nearly 95 % of the persons living in the gas exposed area experienced some problems related to lung and eye. The gastrointestinal symptoms were also observed in 74 percent of persons in the severe area.

The collection and interpretation of long term mortality and morbidity data relating to the hitherto unknown, but potentially fatal disease(s) caused by the inhalation of Toxic Gas(es), is the only means of characterizing its natural history and finding rational methods of treatment. Interpreted in the light of early and post mortem findings it would be possible to determine whether the disease(s) would follow a relentless progressive course or would be self limiting. Also whether the Toxic Gas(es) would have long term genetic or carcinogenic effects was considered worth investigation.

For probing in depth, a large number of clinico-epidemiological studies were initiated. These studies were based on the original registered cohort. All the individuals in the various study groups were identifiable by a common code. As a consequence data of all such studies could be linked with the help of computer for rational analysis and scientific interpretation.

The present Report discusses the results of short and long-term mortality and morbidity observed in the Gas-affected areas and also in a control area, which was included for comparison.

The comparison of socio-demographic characteristics of persons showed that the gas exposed Cohort and Control Cohort were almost similar with respect to age and educational and socio-economic status.

Furthermore, the distribution of the cohort population according to economic class showed that 68 to 86 percent of population belongs to very depressed socio-economic class, in the affected population as well as the control population. Furthermore, more than 70% population, both in the severely affected area as well as the control area, lived in poor quality „kacha' houses, while the quality of housing was slightly better in both the moderately and mildly affected areas.

At the time of Gas leak, nearly 98% of the population was sleeping indoors. On experiencing the first symptoms of "burning chillies sensation", respiratory or eye symptoms or hearing the cries of "Gas – Gas", 60-82% (more in the severely affected area) ran away from their houses, more than 75% on foot. Most of the people included in the Study Cohorts had no fixed occupation; nor fixed source of income. Prevalence rates of tobacco smoking were found to range from 0.2 to 14.3%. These are important factors in analyzing any mortality and morbidity data, most important the respiratory illnesses. Apart from the mortality, continuing respiratory morbidity is the most important finding of the epidemiological studies. It will be difficult to analyse how much it was due to the Toxic Gas(es) per se and how much the outcome of the exposure influenced by other factors stated above.

One of the outstanding findings was that 75% of deaths occurred in the first 4 days post-exposure after which the death rate rapidly dropped and no secondary humps were seen. Also, the post-exposure chest radiograph findings showed resolution of the lung lesions with clearance or fibrosis, following the acute lung injury. This is suggestive of a self limiting disease process, but does not rule out persistent symptoms as a result of the residual scar lesions or their sequelae of recurrent infections, development of emphysema and airway hyper-reactivity.

Regarding the exact number of deaths there is an understable confusion - being stated as 2000-2500 for the entire population. In the catastrophic, disastrous and chaotic situation following the Gas leak, thousands of the people must have left their own residential areas and died elsewhere in or outside the city. Necessarily, the floating population of city like visitors, daily wage labour and passengers at the Railway Station who might have died but did not have a residential address, thus precluding them from inclusion in the subsequently registered cohorts. Similarly, many families are known to have perished leaving nobody alive, or only one orphan. It was also rumoured that many dead bodies were disposed off without being registered. Thus, there were practical difficulties in finding the exact number of dead. The commonly accepted figures are 2000 to 2500 for the acute episode. With 2500 deaths, the mortality rate for the reportedly exposed/affected population of 521262 would be 4.8/1000.

It was a safe presumption that mortality as well as morbidity would be directly related to the concentration of the inhaled Toxic Gas, thus making the distribution of deaths in the exposed area assume a heterogenous character. It was therefore a good idea to categorise the entire exposed/affected area into : severely exposed i.e. with average mortality of 22/1000; moderate area with average mortality of 1.33/1000 and mildly exposed area with an average mortality of 0.2/1000.

In the "Registered Cohort", however, the mortality rates are completely different for the month of December 1984. For example, in the severely affected area the mortality rates were found to be 12.6 and 11.59 for males and females respectively.

The average **mortality rate**, which was 22/1000 in males during December 1984, came down to an annual mortality of 7.5 per 1,000 in 1985 in the "Severe area", which was almost similar to "Moderate area". After 1985, the death rates were almost similar in the entire exposed area, which was only marginally higher than the "Control area". A similar feature was observed also among females. Age specific mortality in the severe area showed that the children were most affected during the immediate phase (December 1984), while in later periods, no differences were observed. The mortality

amongst the elderly was very high in 1985 and 1990. The moderate and mild exposure did not indicate any significant trends in the age specific mortality rates during the subsequent periods. The "Control area" had almost uniformly similar rates for all the ages in all periods. Initially, it was difficult to assign the actual cause of death. Thus, the percentage of "causes unknown" was very high in all the areas. In 1986, the deaths due to respiratory causes were high in both "Severe and Moderate areas" whereas in the Mild area the deaths due to digestive and respiratory causes were high. During 1992, in the three exposed areas, deaths due to respiratory causes was the highest. In the mild area, in nearly 20% the cause of death was neurological or circulatory disorders.

The **morbidity**, which was observed in more than 95% in all the population of the exposed areas, came down to 12% and 17% amongst males and in females respectively in the Severe area after one year of Gas exposure and in the Moderate and Mild area it came down almost similar to "Control area". The "Severe area" had consistently higher rates for all periods. The morbidity rate in "Mild area" was observed to be almost similar to "Severe area" from 1992 and onwards. The age-specific morbidity rate during the acute phase indicates that it was highest in all the age groups compared to other areas. The "Moderate area" had a higher rate in the age groups 45-64 and above 65 years, compared to mild and control area. During the last follow-up (Nov.93 to May 94), in both males and females, the morbidity in the ages 45-54 and above 60 years was highest compared to other areas. The age-specific morbidity in all the areas inclusive of Control area was observed to be highest. To confirm the findings, an exercise was carried out to study the reliability of information collected through social workers. The exercise was carried out by selecting at random a few proformae completed by social workers which were cross checked by medical officers. An agreement of 70% was observed with the information related to morbidity. No specific reasons could be assigned to the higher rate.

Immediately after the Gas exposure in 1984 the **abortion rate** expressed as a percentage, was highest amounting to nearly 50% in the Severe area and nearly one third and one fifth in Moderate and Mild areas respectively. The rates came down during successive years in all the exposed/affected areas. This is known to happen in the wake of any disaster involving human beings, like earthquakes, floods or wars.

Under epidemiological studies, the natural history of Bhopal Toxic Gas Disease with reference to important findings on "**Agent, Host and Environmental Factors**" were required to be discussed. But in the present study, the main focus has been on the long-term health effects on the host, which were based on observations over a 10 year period. However, information on the possible Agent Factor/s is often quoted from other studies[22-24]. The main difficulty in making comparisons has been that all the experimental studies were based on exposure of animals essentially to MIC, whereas in Bhopal Gas Tragedy the people were exposed not only to MIC but to a number of other gases, which were produced as a result of pyrolation of cold liquid MIC from Tank No. 610[3,4,18].

To initiate the study on the **Host Factor** i.e. the population which was exposed to the Toxic Gas, as stated earlier, a total of 36 Municipal wards were considered as gas affected (Table 3.2.1a). Based on the mortality figures of first 4 days i.e. during 3rd-6th December, 1984, the 36 wards were subdivided into severely, moderately and mildly affected areas. A total population of about 80,021 was registered from out of affected areas.

The results are based on analysis of data of periodical morbidity surveys which were initially carried out on fortnightly basis from April, 1985 to December, 1986 and subsequently at six monthly intervals from May, 1987 May, 1994. The data included in this Report are mainly on outcomes, mortality, morbidity, and pregnancy and some socio-demographic profiles of the exposed population. In order to make comparison, a sample of 15,931 was registered as a cohort from unaffected population.

It was ensured that this sample was almost similar in age-sex and socio-economic structure as that of the exposed population except that there was no effect of the Toxic Gas. The only difference was the sample included under exposed area had higher number of Muslims as compared to the sample of persons included in the control area. It was perhaps governed by unintended aggregation of population groups in the vicinity of the UC Factory.

Information collected on **mortality** and other vital indices indicate that there was a persistent higher rate of mortality in the affected area as compared to control area during 1984-93. The major cause of death was respiratory disorders.

Morbidity studies showed that there has been multisystem involvement due to exposure to the Toxic Gas[5-8]. The information collected based on 40 symptoms covering different systems showed that there was persistently high overall morbidity along with high respiratory, ophthalmic and GIT morbidity in the affected areas with highest morbidity in severely affected area. Attempt was made to group the symptoms according to the main systems involved. The main cause of higher morbidity as well as mortality was due to respiratory disorders.

Ophthalmic morbidity was next to the lung morbidity. These two systems were reported by others[5, 6.]

It may not be out of place to mention that in order to carry out in-depth study on different systems i.e. Lung, Eye, Cyto-genetic, Immunology, Toxicology Mental health etc. sub cohorts based on sound criteria were derived from the Main Cohort. These studies were carried out in detail as specific projects and will be discussed in separate Technical Reports. General and respiratory morbidity indicated increasing trend in the mildly affected area during later phase of observation (1992-94).

Neuropsychiatric Symptoms developed in a very large number of the exposed persons. The intensity of symptoms decreased with the passage of years. Mental health studies in the exposed population have been extensively carried out; this did not constitute a part of the Epidemiological studies, but will be reported separately.

The morbidity rates in all the years under observation were high in the affected area as compared to control area. The factors for high morbidity may have to be looked into very carefully. The different pattern of mortality as well as morbidity in different areas cannot be explained only on the basis of intensity of exposure, or near- ness to the factory or health of the population, before exposure but may also be due to the type of Gases the person was exposed to in the course of 4-5 hours of leakage of the Toxic Gases. Ten years follow up observation showed that mortality and morbidity rates have not declined close to the level of the control area even at the end of ten years.

Chapter – VI

Summary, Recommendations And Conclusions

1. The Bhopal Gas Disaster – the worst industrial accident of the world – occurred on the night of $2^{nd}/3^{rd}$ December, 1984, in Bhopal – the capital city of the state of Madhya Pradesh in Central India, at the Pesticide Plant owned by an American Multinational, the Union Carbide Corporation. Approximately, 40 tons of highly toxic liquid Methyl Isocyanate (MIC – boiling point 39.1°C) was stored in Tank 610. The toxic material, under conditions of extremely high temperature and pressure generated inside the tank suddenly escaped in a gaseous form over a period of 2 to 3 hours into the atmosphere, while all monitoring devices and safety mechanisms had failed. It was estimated that what actually escaped into the atmosphere was a mixture of MIC and other products of chemical reaction triggered off inside the Tank 610.

2. It was estimated that of the total population of over 8 lac, about 5 lac were exposed to the Toxic Gas(es), inhaling it either inside their houses or outside in the streets as they panicked out of their houses for safety. The Gases condensed on contact with cold air, and due to phenomenon of atmospheric inversion settled down on the ground. It then evaporated and gradually spread in the atmosphere to low wind velocity and affected the human, animal and plant life. The MIC Plant was located in a densely populated, highly congested part of Bhopal. Out of the total population, nearly 1.6 lac people present within a radius of 3 km from the Factory were exposed presumably to a higher concentration of gas and also perhaps for a longer period of time. The maximum number of deaths occurred in them and 85% of these in the first three days. The estimates placed the number of dead persons at 2000 and dead cattle around one thousand.

3. Early autopsy studies unequivocally established asphyxia as the immediate cause of death, resulting from acute lung injury, chemical pneumonia and acute respiratory distress syndrome (ARDS) and other toxic effects like anoxic brain damage. During subsequent autopsies, extensive pulmonary oedema and exudative lesions were noted. Still later, i.e. from 4 months to one year and beyond, diffuse interstitial pulmonary fibrosis could be detected.

Further, the toxicological studies in the survivors clearly established the presence of elevated levels of "cyanide" in many of the victims, alongside evidence of Carbamoylation or binding of MIC to the end terminal valine residue of circulating haemoglobin and possibly myoglobin. Both factors could account for the cherry red discoloration of the lungs and viscera, as also the blood gas disturbances. The demonstration of the toxic chemicals viz., MIC or its related compounds in the blood of victims in Bhopal is from all accounts a unique and unprecedented event in the annals of **Chemical Disasters**. Similarly, there was every likelihood that N-Carbamoylation of end-terminal residue of myoglobin could have occurred, although it is not easy to explain the muscle weakness which was dramatically reversed by administration of sodium thiosulphate. The possibility of S-Carbamoylation of SH groups of muscle enzymes like cholinesterase and aldolase remain unanswered.

4. The survivor population in large numbers suffered from multisystem morbidities, particularly the respiratory, ophthalmic and gastro-intestinal systems. (a) In the **"Acute Phase"** i.e. immediately following the Toxic Gas inhalation, the prevalence rates for the different clinical findings were : breathlessness – 99%; cough – 90%, pain chest – 40%, irritation of upper respiratory tract (choking) – 46%, extreme muscle weakness – 25%, apathy (listlessness) – 21%, hypersomnolesence – 16%, coma – 7%, loss of appetite – 92%, nausea and vomiting – 52%, eye irritation, lacrimation, swelling, blepharospasm – 86%, taclycardia – 54%, fever – 2%, Chest radiographs also showed extensive abnormalities.

(b) In the **"Subacute Phase"** i.e. 1 to 3 months post-exposure, majority of the already affected population continued to suffer from respiratory symptoms of breathlessness, cough, chest pain etc., which did not correlate well with the chest radiograph or lung function studies. The latter showed in a proportion of the symptomatics, evidence of obstructive, restrictive or combined impairment. A significant proportion of them also continued to suffer from gastrointestinal psychiatric symptoms and muscle weakness. In most patients who had eye symptoms in the acute phase, the lesions had healed with no evidence of progressive loss of vision.

(c) In the **"Chronic Phase"** i.e. after three months of the exposure, a very large number of people continued to suffer from respiratory, gastrointestinal, ophthalmic, psychiatric symptoms and muscle weakness. With passage of time, the prevalence rates and intensity of clinical signs and symptoms gradually decreased. However, even five years after the Toxic Gas exposure, several thousand exposees daily attended the hospital and clinics seeking medical relief.

(d) Of the 2566 pregnancies at the time of the gas exposure, 373 ended in abortions, 82 still births, both incidences being higher than in other parts of the country. This is known to happen following any major life threatening disasters.

5. Management of patients suffering from multisystem morbidities largely comprised symptomatic relief in the face of lack of any specific antidotes. Three working manuals were prepared by the experts, including one for mental health, providing treatment guidelines for the benefit of medical practitioners treating these patients.

There was definitely no known specific antidote to MIC as such nor was this the lone incriminated compound. On the other hand, symptomatic treatment with bronchodilators and corticosteroids was perfectly in order. The experience in Bhopal also emphasized the need for treatment with repeated doses of intravenous sodium thiosulphate which was quite effective in combating apparently protracted "cyanide toxicity" as judged by both subjective relief as well as the objective parameters like increased excretion of urinary thiocyanate. However, the reasons for protracted cyanide toxicity remain enigmatic in the absence of evidence in favour of S-carbamoylation.

6. **Long Term Epidemiological Studies:** At the time of the Toxic Gas Disaster nothing was known regarding the exact nature of the Gases inhaled and the morbidities caused and least their clinical management. From the magnitude of the deaths and morbidities caused several pertinent questions were raised about (i) the exact nature of the Toxic Gases, their biological effects including the long term genetic and teratogenic effects, the clinical course of the morbidities suffered and the residual permanent disabilities if any, outlook for the victim's offsprings, increased incidence of cancers etc. In order to answer these queries, at least twenty research projects were designed and initiated by the ICMR. Bhopal Gas Disaster Research Centre (BGDRC) was established at the Gandhi Medical College along with a Research Coordinating Committee to work with the Coordinating Cell at the ICMR Headquarters to facilitate the execution of the Research Programmes.

Planned Population Based Long Term Epidemiological studies were conducted from January 1985 through May 1994. The findings are presented in this Technical Report.

(a) Soon after the Gas Disaster, 36 wards having population of 521262 (62.6%) were found to be exposed and affected, while 20 wards with a population of 311642 (37.4%) were found to be unaffected by the Gas.

(b) On the basis of average death rates in the exposed/affected areas, the latter was categorized into : severely exposed/affected – death rate of 22/1000, moderately exposed/affected area – death rate of 1.33/1000, and mildly exposed/affected with 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 areas.

(c) The objective of the epidemiological study was to find out both the short term and long term health effects of the Gas in the exposed population. For this purpose cluster sampling technique was used to register a cohort of 26382, 34964, 18675 and 15931 persons from the severe, moderate, mild and control areas respectively during August – October 1985. This registered cohort also served as database for cutting subset samples for other clinico-epidemiological studies.

(d) A door-to-door survey was carried out in the selected localities, 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 and also in the Control area. A questionnaire from a prestructured proforma was administered to the persons in the cohort.

(e) The normal "epidemiological triad" of information comprised the Agent, Host and Environment. Particularly, very little information was available about the Agent and Environment, the two factors beyond the purview of this study. Hence, efforts were concentrated on "Host Factor" based on the extensive mortality and morbidity to which excessible population of Bhopal was exposed. The results of the analysis of data are based only on population cohorts in the unaffected control areas, in comparison with comparable population based cohorts from mildly, moderately and severely effected areas.

(f) Initially, for the first six weeks, schedules of "fortnightly home visits" were undertaken by a system of rotation. Later, due to practical difficulties that had arisen, it was decided to change over to a "half yearly monitoring and survey" by a similar rotation system. Thus, each cohort was covered once in six months. However, no significant loss of information was observed by the change over. Thus, each cohort was covered once in six months. However, no significant loss of information was observed by the changeover.

(g) While the "**cohort based approach"**, in terms of numbers was adequate for the analysis of mortality studies, the numbers were rather small in assessment of morbidity data. As soon as the difficulty was recognized, it was decided to adopt additionally a cross-sectional approach. However, as shown graphically, results demonstrated substantial comparability between the two epidemiological approaches. Thus, the choice of the alternative approach was validated.

The following are some of the noteworthy features that have emerged from this epidemiological study.

1) At the outset, it may be pointed out that age and sex distribution of the population of "affected" as well as "control" areas were almost similar comparable to national population pyramid.

2) 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.

3) The "Gas exposure" particularly in the severely effected 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.

4) 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. Such phenomena has been observed in man-made and even natural disasters.

5) 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. But there was no rapid drop within a short term of 2-3 months. However, the eye condition worsened once again later on. Interestingly enough, in the last phase beyond 1992, ocular morbidity was higher in the mildly affected areas.

Thus, from the analysis of the data on the effect of Toxic Gas exposure on health and review of the meagre literature, especially the nature of the Bhopal Gas Exposure, it is obvious that apart from the immediate raised mortality, there was persistence of morbidity in the affected areas existing over 10 years of study.

6. Based on the Epidemiological Study the following recommendations have emerged:

i) In any widespread Chemical Disaster, relief measures should be taken for the victims without delay. Simultaneously, steps should be taken from the earliest to launch well-planned epidemiological studies to monitor mortality rates and morbidity status of affected population.

ii) Detailed steps should be taken to ensure that the natural history and the evolution of disease entities is finally characterized.

iii) The consequence of extensive chronic pulmonary disease in the wake of chemical accidents should be investigated for functional rehabilitation and restoration of physiological function and effected systems. Wherever necessary, norms for the clinical management and relief of airway obstruction with the state of the art instrumentation and physiotherapy should be accepted simultaneously.

iv) In the unfortunate event of lack of information on the exact nature of the chemicals or their toxic metabolites, and the specific antidotes, symptomatic relief drugs only remain the mainstay of clinical management.

v) It would be desirable to extend the long-term study of the same cohort in Bhopal to study in the potential hazards of cancer and long-term involvement of other organs.

Conclusions

1. The Bhopal Gas Disaster was entirely man made because : (a) If the Union Carbide Pesticide Factory did not have any habitation within 4 km radius, nobody would have been hurt; (b) If Methyl Isocyanate had not been stored for such a long time (rather unusual) the accident could have been averted; (c) If the monitoring and safety devices had been maintained, the accident would have been averted.

2. The Toxic Gas to which the Bhopal population was exposed consisted of MIC and a vast amount of its reaction products inside Tank 610.

3. 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 pulmonary or ophthalmic disease resulting in blindness. The scars produced after the acute lung injury and their sequelae 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 (at least 5% in any population), or smokers, after the Gas exposure would have suffered more than those who were healthy before the exposure.

Chapter – VII

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Annexure I

Supervisory And Working Staff

Research Officer

1.	Dr. N. Banerjee (R.O.)	02.05.85 to 31.12.94

Assistant Research Officers (Medical)

1.	Dr. O.P. Yadav	07.09.85 to 30.11.90
2.	Dr. Ajit Saluija	02.07.87 to 31.12.94
3.	Dr. B.S. Panwar	06.11.87 to 31.12.94
4.	Dr. G.S. Saxena	29.12.87 to 31.12.94
5.	Dr. P.U.M. Rao	06.02.89 to 31.12.94
6.	Dr. K.K. Soni	01.01.90 to 31.12.94
7.	Dr. Ruma Takle	08. 11.90 to 31.12.94

Computer & Statistical Officers

1.	Mr. Sushil Singh, R.O.	28.08.85 to 31.12.94
2.	Mr. K.K. Dubey, A.R.O.	14.07.86 to 31.12.94
3.	Dr. O.P. Tiwari, A.R.O.	15.12.89 to 31.12.94
4.	Mrs. Moina Sharma, A.R.O.	05.07.85 to 31.12.94

Research Assistants

1.	Mrs. Shashi Sharma	01.11.85 to 31.12.94
2.	Mr. Mohd. Shoieb Khan	07.11.85 to 31.12.94
3.	Shri Vivek Mishra	23.11.85 to 31.12.94
4.	Mrs. Renuka Sen	01.10.85 to 31.12.94

5.	Mrs. Rekha Yadav	24.06.85 to 31.12.94
6.	Mr.V.S. Rathore	25.07.85 to 31.12.94
7.	Mrs. Anita Shukla	04.02.87 to 31.12.94
8.	Mr. D.S. Shukla	06.04.87 to 31.12.94
9.	Mrs. Swapna Azahar	27.04.87 to 31.12.94
10.	Mr. U.S. Chouhan	02.05.87 to 31.12.94
11.	Mrs. Gouri Shrivastava	02.05.87 to 31.12.94
12.	Mr. Ajay Vijayvargya	01.04.86 to 02.03.87
13.	Miss Neera Garg	19.08.85 to 30.9.85
14.	Miss Minu Mishra	15.07.85 to 31.01.87
15.	Mr. Sudhir Shrivastava	24.02.85 to 21.05.87
16.	Mr. K.N. Raghu Nair	01.04.86 to 02.06.89
17.	Mrs. Vasanti Karnik	07.02.85 to 14.05.90
18.	Mr. Yuvraj Padole	01.08.85 to 30.09.86
19.	Miss Kavita Tripathi	08.02.85 to 31.08. 87
20.	Mr. Aslam Khan	05.02.85 to 30.09.89
21.	Mr. U.C. Dalal	01.05.85 to 30.09.86
22.	Dr. Vibhash Majumdar	01.02.85 to 15.07.85
23.	Dr. A.K. Sharma	01.02.85 to 30.09.85

Computer & Statistical Staff

1	Mr. M. M. Sarmandal	01.02.85 to 30.04.86

2.	Mr. S.K. Khare	14.09.87 to 31.12.94
3.	Mr. C.S. Pillai	14.05.85 to 31.12.94
4.	Mr. Sunil Sharma	27.07.87 to 31.12.94
5.	Mr. Anand Kori	06.12.89 to 31.12.94
6.	Mr. R.K. Pandey	07.07.89 to 31.12.94
7.	Mr. Manoj Dixit	04.03.88 to 31.12.94

Field Attendants

1.	Miss Aisha Khan	12.02.85 to 31.12.94
2.	Mr. R.K. Shrivastava	23.04.85 to 31.12.94
3.	Mrs. Rukmani Lalwani	07.08.85 to 31.12.94
4.	Mr. Mehfooz Ahmad	08.08.86 to 31.12.94
5.	Mr. K.D. Sharma	07.01.87 to 31.12.94
6.	Mrs. Pratima Parihar	17.01.89 to 11.12.89

Drivers

1.	Mr. P.K. Sharma	01.02.85 to 31.12.92
2.	Mr. Mehmood Khan	01.01.93 to 31.12.94

ANNEXURE II

I.C.M.R - G.M.C., STUDY ON LONG TERM EFFECT OF MIC GAS,
DEPARTMENT OF PREVENTIVE & SOCIAL MEDICINE,
GANDHI MEDICAL COLLEGE, BHOPAL

NAME OF HEAD OF HOUSE HOLD :

(IN CAPITALS)

NAME OF INDIVIDUAL :

(IN CAPIPTALS)

ADDRESS :

1. JOB NO 1–5 [B 0 2 1 1]

2. TYPE OF HOUSE HOLD 6
(Key-House hold old, interviewed 1.
House hold old, not interviewed 2.
New house hold, interviewed 3.
New house hold, not interviewed 4.

3. LOCALITY 7–8

4. SL. NO. OF FAMILY 9–12 13

5. SL. NO. OF MEMBER 14–15 16

6. TYPE OF HOUSE

Key-KUPACHA		PICCA	
Canvas	0	Canvas	5.
Thatched	1	Thatched	6.
Tiles	2	Tiles	7.
Tin	3	Tin	8.
Concrete	4	Concrete	9.

7. TOTAL NO OF FAMILY MEMBERS (AS ON 3-12-84) 17–18

8. NO. OF GUESTS (IF ANY. ON (3-12-84) 19–20

9. PER CAPITA MONTHLY INCOME (IN RUPIELS) 21–24

10. RELIGION 25
Key-Hindu 1
Muslim 2
Christian 3
Sikhs 4
Others 5

11. AGE ON COMPLETED YEARS (AS ON 3-12-1984) 26–27

12. SEX 28
(Key-Male 1.
(Female 2.

13. EDUCATION 29
(Key-illiterate 1
Literate 2
Primary 3
Middle 4
Secondary 5
College 6
Technical 7

14. OCCUPATION (Key in instruction manual) 30–31

15. PRESENTA/ABSENT IN THE HOUSE ON THE NIGHT ON GAS-LEAKAGE 32
Key-Present 1)
Absent 2)

16. IF ABSENT FROM HOUSE WHERE WERE YOU- 33
(Key-Not in Bhopal 1)
in Bhopal 2)

17. IF IN BHOPAL WHICH AREA (MENTION THE AREA BY NAME) NOT TO BE CODED

18. LIVING STATUS ON THE DAY OF INTERVIEW 34 ☐
(Key-Alive 1
Dead 2
Absent 3
Missing 4)

19. DATE OF DEATH 35 ☐☐☐☐ 40
NAME OF INFORMANT

20. TYPE OF EXPOSURE ☐ 41
(Key-Sleeping) 1
Outside
Sleeping - 2
inside

21. IF SLEEPING INSIDE WHERE WINDOWS OPEN OR CLOSED ☐ 42
(Key-Open) 1
Closed 2

22. WHAT DID YOU DO WHEN THE GAS LEAK OCCURED ☐ 49
(Key-Ran away) 1
Went outside 2
Protected face by wet/cloth 3
Stayed indoor 4
Covered with sheet/ 5
(Please specify)

23. IF YOU RAN AWAY, WHAT MODE DID YOU TAKE ☐ 44
(Key-By-Feat) 1
By vehicle 2
Both 3

24. NATURE OF WORK DONE BY YOU BEFORE THE EPISODE (SPECIFY) ☐ 45

25. ARE YOU ABLE TO DO THE SAME WORK NOW ☐ 46
(Key-Yes 1
No 2)

26. IF NOT WHAT ARE YOUR PROBLEMS ☐ 47
Key-Breathlessness 1
Chest Pain 2
Fatigue 3
Blackout 4
(1 + 2) 5
(1 + 3) 6
(1 + 4) 7
Any other combination 8
(Specify Combination)

27. HABITS ☐ 48
SMOKING-EVER
(Key-Yes 1
No 2

28. SMOKING CURRENT ☐ 49
(Key-Yes 1
No 2

29. ALCOHOL EVER ☐ 50
(Key-Yes 1
No 2

30. ALCOHOL-CURRENT ☐ 51
(Key-Yes 1
No 2

31. DID YOU CONSUME ALCOHOL ON THE NIGHT OF EPISODE ☐ 52
(Key-Yes 1
No 2

32. CHEW TOBACO-EVER ☐ 53
(Key-Yes 1
No 2

33. CHEW TOBACO-EVER ☐ 54
(Key-Yes 1
No 2

34. IMMEDIATE EFFECTS ☐ 55
DID THE GAS, EXPOSURE HAVE ANY EFFECT IMMEDIATELY ON 9.12.84
(Key-Yes 1
No 2
IF YES, CONTINUE IF NO, PROCEED TO QUESTION 41.

TYPES

Condition	Effect Key-Yes 1 No	Were you hospital- Key-Yes 1 No 2	Duration of hospitalisation 2	Duration of Illness in day	Dates of hospi-talisation (Not to be closed)	Name of hos-pital (Not to be coded)
	1	2	3	4	5	6 7
35. Lung	☐ 56	☐ 57	58 ☐☐ 59	60 ☐☐ 61		
36. Eye.	☐ 62	☐ 63	64 ☐☐ 65	66 ☐☐ 67		
37 GPP	☐ 68	☐ 69	70 ☐☐ 71	72 ☐☐ 73		
38 Skin	☐ 74	☐ 75	76 ☐☐ 77	78 ☐☐ 79		
39 Hearing	☐ 80	☐ 81	82 ☐☐ 83	84 ☐☐ 85		
40. Mental	☐ 86	☐ 87	88 ☐☐ 89	90 ☐☐ 91		

LATER EFFECTS (ON Set on 1.12.1984 or later)

41 DID YOU DEVELOP ANY COMPLICATIONS ☐ 02
ON 4.12.1984 OR LATER
(Key-Yes 1)
No 2)

IF YES, CONTINUE IF NO, CLOSE INTERVIEW. PROCEED TO ITEM 49 ONLY FOR MARRIED WOMEN BETWEEN 15-49 YEARS.

Condition	Effect Key-Yes 1 No 2	After how-many weeks Key*	Were you hospita-lised Key-Yes No 2	Duration of hospitali-sation 1	Duration of illness in weeks Key	Dates of hospita-lisation (Not to be coded)	Name of hosp -ital
	1	2	3	4	5	6 7	8
42. LUNG	☐ 93	☐ 94	☐ 95	☐ 96	☐ 97		
43. EYE	☐ 98	☐ 99	☐ 100	☐ 101	☐ 102		
44 GIT	☐ 103	☐ 104	☐ 105	☐ 106	☐ 107		
45. SKIN	☐ 108	☐ 109	☐ 110	☐ 111	☐ 112		
46 Hearing	☐ 16	☐ 17	☐ 18	☐ 19	☐ 20		
47 Mental	☐ 21	☐ 22	☐ 23	☐ 24	☐ 25		

Within 1 week	-	1
1-2 week	-	2
2-3 week	-	3
3-4 week	-	4
4-8 week	-	5
8-12 week	-	6
More than 12 week	-	7
Still Containing		8
Repeated illness	-	9

48. DID YOU DEVELOP ANY OTHER COMPLAINTS AFTER 4.12.84

a) Tiredness ☐ 26
Key-Yes 1
No 2

b) Fatigue ☐ 27
No 2

c) Giddiness (Chakkar) ☐ 28
Key-Yes 1
No 2

d) Anxiety (Ghabharat) ☐ 29
Key-Yes 1
No 2

e) Headache ☐ 30
Key-Yes 1
No 2

f) Bodyache ☐ 31
Key-Yes 1
No 2

g) Pain in the limbs ☐ 32
Key-Yes s 1
No 2

PREGENANCY STATUS ONLY MARRIED WOMEN IN 15-49 YEARS AGE GROUP)

49. PRESENT PREGNANCY STATUS ☐ 33
Key-Yes 1
No 2

50. PERIOD OF GESTATION IN WEEKS 34 35 ☐☐

51. PREGNANCY STATUS ON 3.12.1984 36
Key Yes 1
No 2

52. OUTCOME OF PREGNANCY ☐ 37
Key-Live Birth 1
Still Birth 2
Abortion 3
MTP 4
Continuing 5

53. DURATION OF GESTATION AT THE TIME OF OUT COME OF PREGNANCY (IN WEEKS) 38 39 ☐☐

DATE OF OUTCOME 40 ☐☐☐☐☐☐ 15

NAME OF INTERVIEWER

SIGNATURE OF INTERVIEWER

DATE

NAME OF A.R.O.

NAME OF STATISTICIAN

DATE OF SCRUINING

Key for occupation (No 14)

01.	No occupation	02.	Professional technical and related worker.
03	Sales worker	04.	Farmers, fisherman, hunters, Lumperman, related worker.
05.	Worker in mines quarry	06	Worker in transport occupation. 0% Craftsman labour not elsewhere clarified
08	Services workers.	09.	Occupation unreported
10.	Members of armed forces.	11.	Housewife.

28-Family Composition and General Particulars of Individuals in the Family.

Name	S.No. old family Index card (36–37)	Residential Status (38)	Sex (39–40)	Age in completed years (41–42)	Marital status (43)	Literacy status (44–45)	Occupation (46–49)	Monthly Income (In Rs.) (50)	Diet Habit (51)	Addiction (Using) (52)	Disability cause (53)

Interviewer _____

Scrutinizer _____

ICMR-STUDY ON LONG TERM EFFECT OF MIC GAS
BHOPAL GAS DISASTER RESEARCH CENTRE, BHOPAL 1987

Name of Head hold

Specific Address

1 5 — M 8 7 0 1

1. Job No.

2. Locality — 6 7

3. Sl. No. of Family — 8 11 12

4. Availability in the Locality — 13

5. Religion — 14

6. Total Family members — 15 16

7. Type of Family — 17

8. Monthly Family Income (In Rs.) — 18 21

9. Per Capita Monthly Income (In Rs.) — 22 25

10 Type of House — 26

11. Letrine Facility — 27

12. Ventilation in living rooms — 28

13. Light in living rooms — 29

14. Kitchen — 30

15. Protection of food from flies — 31

16. Smoke outlet — 32

17. Domestic animals kept in the house — 33

18. Cattleshed — 34

19. Disposal of Urine and dung — 35

21 SCHEDULE FOR ELIGIBLE FEMALES

Name of Head of the Household _____ Specific Address _____

Job No. M 8 7 0 3 (1–5) | Locality (6–7) | ICMR Family No. (8–11) | Is there any eligible female in Family (12) | (13)

Name of Woman	S.No. in old Family Index Card	Age in years	Age at marriage	Age of Husband at Marriage	Age of Husband at R.M.	Marital Duration	Age at Care Firsts Pregnancy	Age at Care Last Pregnancy	No. of Abortions/ Miscarriages
	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31 32 33
	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31 32 33
	14 15	16 17	18 19	20 21	22 23	24 25	26 27	28 29	30 31 32 33

No. of still Births	No. of Live Birth but dead	No. of Live Birth still 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 Present uses f.p. methods	
34 35	36 37	38 39	40 41	42 43	44	45 46	47	48
34 35	36 37	38 39	40 41	42 43	44	45 46	47	48
34 35	36 37	38 39	40 41	42 43	44	45 46	47	48

Interviewer _____

Scrutiniser _____

22 TERMINATION OF PREGNANCY RECORD

1 5 | M | 8 | 7 | 0 | 3 | 6 7 | | | ICMR Family No. 8 11 12 | | | | | | 13 |

Job No. | Locality | ICMR Family No. | Is there any termination of Pregnancy in Family

Name of Woman	S.No. in old Family Index Card	Age	Parity	Antenatal Care 1st trime	2nd trime	3rd trime	By whom
	14 15	16 17	18	19	20	21	22 23 24
	14 15	16 17	18	19	20	21	22 23 24
	14 15	16 17	18	19	20	21	22 23 24

	Date of Termination Day	Month	Year	Type of Termination	Place of Termination	Any mal-formation baby	Status of baby	Status of mother	ID number of baby	sex
	25 26	27 28	29 30	31	32	33	34	35	36 37	38
	25 26	27 28	29 30	31	32	33	34	35	36 37	38
	25 26	27 28	29 30	31	32	33	34	35	36 37	38

Interviewer _____

Scrutinser _____

HISTORY OF LACTAION

Age of youngest child on the day of Gas Exposure	Parity	Were you lactating child on 2nd December, 1984	Nature of location	Was location suppressed after gas exposure on 3rd Dec. 1984	Type of suppression	Lactation restoration	Duration of restoration	Present status of lactation	Nature of lactation	Is it as before gas exposure	Nature of suppression	Current Pgeganacy	
												Present Status	Duration (weeks)
49 50	51 52	53	54	55	56	57	58 59	60	61	62	63	64	65 66
49 50	51 52	53	54	55	56	57	58 59	60	61	62	63	64	65 66
49 50	51 52	53	54	55	56	57	58 59	60	61	62	63	64	65 66

23 DEATH RECORD

Job No. 1 M 8 7 81 4 5 Locality 6 7 ICMR Family No. 8 11 12 Is there any death in Family 13

Name of the Person	S.No of old Family Index Card	Type of person	Age	Sex	Date of Death: Day	Month	Year	Place of death	Autopsy done	Certificate of death by	Verified with Certificate	Cause of Death: Primary	Secondary
	14 15	16	17 18	19	20 21	22 23	24 25	26 27	28	29	30	31 33	34
	14 15	16	17 18	19	20 21	22 23	24 25	26 27	28	29	30	31 33	34
	14 15	16	17 18	19	20 21	22 23	24 25	26 27	28	29	30	31 33	34

Annexure-III

List of Tables

ANNEXURE IV (TABLES 1 TO 42)

Table 1a. Socio-demographic characteristics of Persons from the Severe, Moderate and Mild Gas Exposed Areas and Control Area

Socio-Demographic Characteristic	Classification	Exposed Areas			Control Area
		Severe	Moderate	Mild	
Number		26382	34964	18675	15931
Sex	Male	14006(53.09%)	18438(52.73%)	9714(52.02%)	8574(53.82%)
	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	16.14%	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	73.97%	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%
	Others	0.11%	0.69%	0.09%	0.04%

Literate : Can just write his/her name

Table 1b
Percentage of population distribution by economic class

Area	Period	Monthly per capita income in rupees				
		Below 145	145-284	285-464	465-964	965 & above
	Socio class	V	IV	III	II	I
Severely	1985	86.81	11.14	1.57	0.44	0.04
Affected	1987	77.68	19.06	2.69	0.54	0.03
Moderately	1985	77.43	17.85	3.05	1.52	0.15
Affected	1987	68.60	23.83	5.47	1.62	0.48
Mildly	1985	76.69	17.57	4.19	1.31	0.24
Affected	1987	72.23	22.70	3.50	1.33	0.24
Total	1985	80.29	15.54	2.94	1.09	0.14
	1987	72.92	21.80	3.88	1.15	0.25
Control	1985	77.77	19.67	2.05	0.42	0.09
	1987	68.82	27.84	2.86	0.48	0.00

Table 1c
Distribution of population by type of house (1985 & 1987)

Area	Period	Kucha House	%	Semi Pucca House	%	Pucca House	%
Severely Affected	1985	8901	71.79	1504	12.13	1993	16.08
	1987	8836	73.92	1215	10.16	1903	15.92
Moderately Affected	1985	4716	37.69	2444	19.53	5353	42.78
	1987	3651	31.09	2358	20.08	5336	48.83
Mildly Affected	1985	4204	33.06	2811	22.11	5700	44.83
	1987	3551	30.82	2740	23.78	5231	45.40
Total	1985	17821	47.36	6759	17.96	13046	34.68
	1987	16038	15.54	6313	17.92	12870	36.54
Control	1985	9332	87.12	158	1.47	1222	11.41
	1987	9103	86.54	329	3.13	1087	10.33

Table 1d
Population sleeping inside or outside of their houses at the Gas Leakage

Exposed areas	Population Sleeping					
	Cohort 1985	Covered	Inside House		Outside House	
			No.	%	No.	%
Severely affected	26382	25018	24754	98.95	264	1.05
Moderately affected	34964	33500	32804	97.92	496	2.08
Mildly affected	18675	18162	17873	98.47	279	1.53
Total	80021	76670	75431	98.38	1239	1.62

Note: Population of 140+80+43 = 263 (0.3%) could not be elicited (Reference table 3)

Table 1e
Mode of running away from house

Area	Population Inside House	Population Who Ran Away	On Foot	In Vehicle	Both
Severely affected	24754	20473 (82.7%)	83.10	11.50	5.40
Moderately affected	32804	23873 (72.77%)	84.34	8.53	7.13
Mildly affected	17873	10792 (60.38%)	75.51	17.33	7.16
Total	75431	55138 (73.09%)	82.15	11.36	6.49

Table 1f
Occupation-wise percentage population distribution (1985 & 1987)

Area	Period	Service	Business	Agriculture	Labourers		No Occupation
					Skilled	Unskilled	
Severely Affected	1985	11.87	3.29	0.95	9.83	1.89	72.17
	1987	8.71	4.01	0.37	7.51	5.92	73.48
Moderately Affected	1985	11.76	4.25	1.39	6.72	2.24	73.00
	1987	11.69	5.10	0.10	4.63	4.31	74.00
Mildly Affected	1985	13.41	4.25	1.03	4.26	2.01	75.00
	1987	11.82	5.57	0.74	5.49	2.75	73.00
Total	1985	12.39	3.92	1.12	6.89	2.04	73.00
	1987	10.72	4.88	0.40	5.88	4.35	73.00
Control	1985	9.34	2.54	0.44	20.47	0.81	66.00
	1987	8.00	3.17	0.21	15.17	3.97	69.00

* “No Occupation” includes all children up to 4 years, students, housewives and not working
** Please refer table 1d for population

Table 1g. Percentage of population distribution by smoking habit (1985 and 1987)

Area	Period	Smoking	Non-smoking
Severely	1985	14.29	85.71
Affected	1987	14.30	85.64
Moderately	1985	9.30	90.70
Affected	1987	8.18	91.59
Mildly	1985	0.20	93.76
Affected	1987	0.30	93.63
Total	1985	9.90	90.10
	1987	9.64	90.24
Control	1985	10.88	89.12
	1987	12.23	87.77

Note: For population please refer table 1d

Table 2. Annual Mortality Rate {per 1000} among Males during the years 1984-1993 in the Severe, Moderate, Mild Gas Exposed Areas and Control Area

Type of Area	Years																			
	Dec.1984		1985		1986		1987		1988		1989		1990		1991		1992		1993	
	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D
Severe	13449	169 (12.57)	13294	99 (7.4)	12554	83 (6.6)	10185	37 (3.6)	9953	40 (4.0)	9315	37 (3.9)	8157	45 (6.5)	6976	28 (4.0)	6421	28 (4.3)	5607	19 (3.4)
Moderate	17612	14 (.79)	17598	115 (6.5)	17155	80 (4.7)	13533	47 (3.5)	13239	42 (3.2)	12365	55 (4.4)	11139	56 (5.0)	9726	38 (3.9)	8611	39 (4.5)	6988	35 (5.0)
Mild	9472	1 (.10)	9471	35 (3.7)	9292	36 (3.9)	7253	25 (3.4)	6982	18 (2.5)	5170	32 (6.1)	5623	26 (4.6)	5247	21 (4.0)	4785	22 (4.6)	3993	39 (9.8)
Control	8462	3 (.35)	8459	19 (2.2)	8330	33 (3.9)	7008	22 (3.1)	6946	14 (2.0)	6660	13 (1.9)	6074	13 (2.1)	5572	13 (2.3)	5098	10 (1.9)	3228	7 (2.2)

P - Persons, D – Number of deaths, Figures in parenthesis represent death rates

Table 3. Annual Mortality Rate {per 1000} among Females during the years 1984-1993 in the Severe, Moderate, Mild Gas Exposed Areas and Control Area

Type of Area	Years																	
	1984		1985		1986		1987		1988		1989		1990		1991		1992		1993	
	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D	P	D
Severe	12008	139 (11.6)	11869	92 (7.8)	11299	59 (4.8)	9288	26 (2.8)	9108	28 (3.0)	8581	21 (2.4)	7577	30 (3.9)	6578	28 (4.2)	6050	10 (1.6)	5335	19 (3.6)
Moderate	16019	9 (.56)	16010	86 (5.4)	15656	81 (5.2)	12514	33 (2.6)	12274	36 (2.9)	11553	34 (2.9)	10511	33 (3.1)	9296	37 (3.9)	8241	25 (3.0)	6718	32 (4.7)
Mild	8800	2 (.22)	8798	35 (3.9)	8631	26 (3.0)	6886	26 (3.8)	6644	16 (2.4)	5951	21 (3.5)	5442	25 (4.6)	5113	17 (3.3)	4674	13 (2.8)	3928	25 (6.4)
Control	7254	3 (.41)	7251	25 (3.4)	7140	30 (4.2)	6110	16 (2.6)	6066	15 (2.5)	5808	11 (1.9)	5379	11 (2.0)	4963	10 (2.0)	4580	9 (1.9)	2953	8 (2.7)

P - Persons, D – Number of deaths, Figures in parenthesis represents death rates

Table 4. Age-specific Death Rate (per 1000) among Males in Severely Affected Area during the years 1984-93

	1984			85			86			87			88			89		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	1774	39	21.98	1735	28	16.14	1631	12	7.36	1332	6	4.50	1300	0	.00	1225	3	2.45
5-9	1871	30	16.03	1841	10	5.43	1755	12	6.84	1471	3	2.04	1445	3	2.08	1363	2	1.47
10-14	1675	11	6.57	1664	5	3.00	1610	3	1.86	1342	0	.00	1319	4	3.03	1259	1	.79
15-19	1376	8	5.81	1368	6	4.39	1298	1	.77	1051	1	.95	1029	1	.97	981	1	1.02
20-24	1308	9	6.88	1299	3	2.31	1215	8	6.58	942	2	2.12	915	1	1.09	840	2	2.38
25-29	1234	9	7.29	1225	3	2.45	1140	4	3.51	890	2	2.25	862	2	2.32	785	3	3.82
30-34	1017	9	8.85	1008	5	4.96	937	4	4.27	755	0	.00	740	6	8.11	683	0	.00
35-39	801	5	6.24	796	5	6.28	760	1	1.32	639	3	4.69	629	2	3.18	584	2	3.42
40-44	689	10	14.51	679	4	5.89	640	2	3.13	532	2	3.76	520	5	9.62	487	5	10.27
45-49	477	7	14.68	470	1	2.13	453	4	8.83	369	6	16.26	356	1	2.81	346	3	8.67
50-54	457	9	19.69	448	4	8.93	415	8	19.28	313	1	3.19	309	7	22.65	279	8	28.67
55-59	192	6	31.25	186	1	5.38	172	5	29.07	119	1	8.40	117	0	.00	108	1	9.26
60-64	346	10	28.90	336	10	29.76	309	5	16.18	251	5	19.92	241	6	24.90	220	5	22.73
65-69	81	1	12.35	80	5	62.50	73	5	68.49	56	3	53.57	52	0	.00	49	1	20.41
70-	151	6	39.74	145	9	62.07	132	9	68.18	109	2	18.35	105	2	19.05	93	0	.00
TOTAL	13449	169	12.57	13280	99	7.45	12540	83	6.62	10171	37	3.64	9939	40	4.02	9302	37	3.98

	90			91			92			93		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	1083	1	.92	938	0	.00	881	1	1.14	780	0	.00
5-9	1229	2	1.63	1070	0	.00	989	2	2.02	872	1	1.15
10-14	1131	0	.00	991	2	2.02	934	1	1.07	822	1	1.22
15-19	855	1	1.17	708	0	.00	644	1	1.55	565	0	.00
20-24	719	3	4.17	597	0	.00	547	2	3.66	478	0	.00
25-29	657	1	1.52	559	0	.00	508	1	1.97	439	2	4.56
30-34	587	1	1.70	510	3	5.88	452	2	4.42	385	3	7.79
35-39	522	4	7.66	453	3	6.62	416	3	7.21	360	0	.00
40-44	429	5	11.66	366	3	8.20	345	4	11.59	298	2	6.71
45-49	300	5	16.67	256	3	11.72	238	2	8.40	203	1	4.93
50-54	226	6	26.55	182	3	16.48	163	3	18.40	141	4	28.37
55-59	97	3	30.93	81	3	37.04	72	1	13.89	67	0	.00
60-64	183	6	32.79	153	5	32.68	136	4	29.41	117	2	17.09
65-69	44	2	45.45	35	1	28.57	32	0	.00	29	1	34.48
70-	84	5	59.52	66	2	30.30	54	1	18.52	44	2	45.45
TOTAL	8146	45	5.52	6965	28	4.02	6411	28	4.37	5600	19	3.39

P – Number of persons, D – Number of deaths, DR - Death rate

Table 5. Age-specific Death Rate (per 1000) among Females in Severely Affected Area during the years 1984-93

	1984			85			86			87			88			89		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	1648	31	18.81	1617	31	19.17	1522	14	9.20	1235	3	2.43	1205	0	.00	1125	2	1.78
5-9	1632	13	7.97	1619	9	5.56	1538	4	2.60	1281	2	1.56	1260	3	2.38	1199	0	.00
10-14	1520	13	8.55	1507	6	3.98	1460	1	.68	1230	0	.00	1218	1	.82	1166	1	.86
15-19	1201	5	4.16	1196	2	1.67	1147	7	6.10	939	1	1.06	923	1	1.08	884	2	2.26
20-24	1365	7	5.13	1358	5	3.68	1287	5	3.89	1030	2	1.94	1002	3	2.99	934	1	1.07
25-29	1228	13	10.59	1215	6	4.94	1142	2	1.75	930	2	2.15	912	0	.00	850	0	.00
30-34	795	10	12.58	785	2	2.55	758	6	7.92	640	1	1.56	628	3	4.78	585	1	1.71
35-39	617	10	16.21	607	1	1.65	588	0	.00	507	0	.00	501	2	3.99	475	2	4.21
40-44	504	11	21.83	493	3	6.09	478	4	8.37	393	0	.00	385	0	.00	372	2	5.38
45-49	377	4	10.61	373	3	8.04	353	2	5.67	264	1	3.79	261	2	7.66	239	1	4.18
50-54	365	5	13.70	360	5	13.89	336	3	8.93	274	5	18.25	264	2	7.58	247	1	4.05
55-59	176	6	34.09	170	6	35.29	157	3	19.11	127	0	.00	125	1	8.00	119	0	.00
60-64	323	2	6.19	321	1	3.12	307	4	13.03	257	4	15.56	250	4	16.00	230	5	21.74
65-69	93	3	32.26	90	3	33.33	82	3	36.59	67	2	29.85	65	1	15.38	57	0	.00
70-	164	6	36.59	158	9	56.96	144	5	34.72	114	3	26.32	109	5	45.87	99	3	30.30
TOTAL	12008	139	11.58	11869	92	7.75	11299	59	5.22	9288	26	2.80	9108	28	3.07	8581	21	2.45

	90			91			92			93		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	1003	3	2.99	874	0	.00	803	0	.00	703	0	.00
5-9	1066	0	.00	939	0	.00	864	2	2.00	779	1	1.28
10-14	1049	0	.00	922	2	2.17	852	1	1.00	756	1	1.32
15-19	776	1	1.29	681	2	2.94	634	1	1.00	549	2	3.64
20-24	799	0	.00	695	0	.00	627	1	1.00	548	1	1.82
25-29	751	6	7.99	644	3	4.66	588	1	1.00	526	1	1.90
30-34	531	5	9.42	456	1	2.19	424	0	.00	364	1	2.75
35-39	421	2	4.75	361	1	2.77	340	0	.00	298	1	3.36
40-44	332	1	3.01	299	2	6.69	273	0	.00	239	1	4.18
45-49	197	2	10.15	158	1	6.33	151	0	.00	134	0	.00
50-54	215	2	9.30	178	1	5.62	163	0	.00	142	2	14.08
55-59	104	0	.00	82	1	12.20	77	1	1.00	72	2	27.78
60-64	197	4	20.30	164	6	36.59	150	3	3.00	137	1	7.30
65-69	50	1	20.00	46	0	.00	41	0	.00	33	1	30.30
70-	86	3	34.88	79	8	101.27	63	0	.00	55	4	72.73
TOTAL	7577	30	3.96	6578	28	4.26	6050	10	10.00	5335	19	3.56

P - Number of persons, D - Number of deaths, DR - Death rate

Table 6. Age-specific Death Rate (per 1000) among Males in Moderately Affected Area during the years 1984-93

	1984			85			86			87			88			89		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	2038	5	2.45	2033	22	10.82	1978	6	3.03	1570	5	3.18	1543	1	.65	1446	0	.00
5-9	2437	0	.00	2437	13	5.33	2378	3	1.26	1906	0	.00	1880	0	.00	1791	2	1.12
10-14	2315	0	.00	2315	1	.43	2284	1	.44	1905	1	.52	1877	1	.53	1771	2	1.13
15-19	1948	1	.51	1947	3	1.54	1909	1	.52	1543	2	1.30	1508	2	1.33	1419	2	1.41
20-24	1915	0	.00	1915	6	3.13	1871	6	3.21	1412	3	2.12	1370	3	2.19	1255	4	3.19
25-29	1451	0	.00	1451	2	1.38	1417	5	3.53	1037	2	1.93	1013	1	.99	934	0	.00
30-34	1205	0	.00	1205	3	2.49	1175	5	4.26	894	2	2.24	874	2	2.29	808	4	4.95
35-39	986	1	1.01	985	3	3.05	959	4	4.17	735	3	4.08	719	2	2.78	677	1	1.48
40-44	840	0	.00	840	5	5.95	821	2	2.44	667	3	4.50	655	3	4.58	604	3	4.97
45-49	707	0	.00	707	4	5.66	685	6	8.76	537	3	5.59	523	1	1.91	493	9	18.26
50-54	609	2	3.28	607	14	23.06	583	7	12.01	472	2	4.24	460	7	15.22	414	5	12.08
55-59	344	0	.00	344	6	17.44	333	9	27.03	253	3	11.86	247	3	12.15	235	5	21.28
60-64	412	2	4.85	410	8	19.51	395	9	22.78	314	4	12.74	301	3	9.97	278	8	28.78
65-69	151	2	13.25	149	2	13.42	142	5	35.21	115	5	43.48	109	5	45.87	97	4	41.24
70-	236	1	4.24	235	23	97.87	208	11	52.88	161	9	55.90	148	8	54.05	131	6	45.80
TOTAL	17594	14	.80	17580	115	6.54	17138	80	4.67	13521	47	3.48	13227	42	3.18	12353	55	4.45

	90			91			92			93		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	1310	0	.00	1154	2	1.73	1028	1	.97	806	1	1.24
5-9	1623	2	1.23	1430	0	.00	1287	1	.78	1060	1	.94
10-14	1634	5	3.06	1466	0	.00	1335	1	.75	1119	1	.89
15-19	1291	2	1.55	1131	1	.88	1003	1	1.00	846	5	5.91
20-24	1108	3	2.71	945	3	3.17	817	3	3.67	654	1	1.53
25-29	817	7	8.57	694	1	1.44	601	2	3.33	464	0	.00
30-34	712	3	4.21	609	3	4.93	524	1	1.91	402	2	4.98
35-39	615	3	4.88	547	2	3.66	478	1	2.09	382	0	.00
40-44	549	2	3.64	477	4	8.39	434	2	4.61	351	3	8.55
45-49	447	5	11.19	389	3	7.71	344	4	11.63	283	3	10.60
50-54	372	6	16.13	322	1	3.11	284	11	38.73	231	5	21.65
55-59	210	3	14.29	184	7	38.04	155	2	12.90	127	1	7.87
60-64	241	4	16.60	201	5	24.88	175	3	17.14	148	7	47.30
65-69	88	2	22.73	78	2	25.64	64	4	62.50	50	2	40.00
70-	110	9	81.82	89	4	44.94	74	2	27.03	59	3	50.85
TOTAL	11127	56	5.03	9716	38	3.91	8603	39	4.53	6982	35	5.01

P - Number of persons, D - Number of deaths, DR - Death rate

Table 7. Age-specific Death Rate (per 1000) among Females in Moderately Affected Area during the years 1984-93

	1984			85			86			87			88			89		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	1861	2	1.07	1859	16	8.61	1813	6	3.31	1428	4	2.80	1398	1	.72	1318	0	.00
5-9	2225	1	.45	2224	5	2.25	2188	1	.46	1782	4	2.24	1753	3	1.71	1653	1	.60
10-14	2155	0	.00	2155	1	.46	2117	2	.94	1749	2	1.14	1724	1	.58	1636	0	.00
15-19	1902	1	.53	1901	4	2.10	1869	8	4.28	1523	3	1.97	1492	2	1.34	1406	2	1.42
20-24	1768	0	.00	1768	7	3.96	1726	11	6.37	1337	3	2.24	1305	1	.77	1221	1	.82
25-29	1415	1	.71	1414	4	2.83	1380	4	2.90	1053	3	2.85	1034	1	.97	973	1	1.03
30-34	1037	1	.96	1036	6	5.79	1012	5	4.94	790	0	.00	783	2	2.55	734	2	2.72
35-39	900	0	.00	900	5	5.56	879	3	3.41	715	0	.00	698	0	.00	659	5	7.59
40-44	673	2	2.97	671	6	8.94	653	4	6.13	536	2	3.73	526	2	3.80	490	1	2.04
45-49	615	0	.00	615	2	3.25	603	2	3.32	486	1	2.06	476	7	14.71	437	1	2.29
50-54	455	0	.00	455	4	8.79	444	2	4.50	353	2	5.67	345	2	5.80	335	2	5.97
55-59	270	0	.00	270	3	11.11	264	7	26.52	209	2	9.57	201	0	.00	188	1	5.32
60-64	372	0	.00	372	9	24.19	360	11	30.56	286	3	10.49	276	5	18.12	257	6	23.35
65-69	135	0	.00	135	1	7.41	129	3	23.26	103	1	9.71	102	0	.00	101	2	19.80
70-	236	1	4.24	235	13	55.32	219	12	54.79	164	3	18.29	161	9	55.90	145	9	62.07
TOTAL	16019	9	.56	16010	86	5.37	15656	81	5.17	12514	33	2.64	12274	34	2.93	11553	34	2.94

	90			91			92			93		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	1181	4	3.39	1064	1	.94	932	0	.00	745	0	.00
5-9	1526	3	1.97	1378	2	1.45	1240	2	1.61	1025	1	.98
10-14	1514	2	1.32	1371	1	.73	1229	2	1.63	1015	2	1.97
15-19	1299	0	.00	1139	1	.88	1022	0	.00	845	5	5.92
20-24	1089	0	.00	950	1	1.05	840	0	.00	670	3	4.48
25-29	881	4	4.54	770	2	2.60	664	4	6.02	514	2	3.89
30-34	665	0	.00	588	1	1.70	525	0	.00	434	0	.00
35-39	612	0	.00	539	0	.00	488	2	4.10	399	5	12.53
40-44	440	2	4.55	376	2	5.32	335	4	11.94	282	1	3.55
45-49	405	1	2.47	362	2	5.52	309	4	12.94	256	3	11.72
50-54	296	3	10.14	254	9	35.43	221	0	.00	180	2	11.11
55-59	166	2	12.05	139	1	7.19	122	1	8.20	102	1	9.80
60-64	228	6	26.32	195	7	35.90	163	4	24.54	129	2	15.50
65-69	93	2	21.51	78	1	12.82	73	1	13.70	55	3	54.55
70-	116	4	34.48	93	6	64.52	78	1	12.82	67	2	29.85
TOTAL	10511	33	3.14	9296	37	3.98	8241	25	3.03	6718	32	4.76

P – Number of persons, D – Number of deaths, DR - Death rate

Table 8. Age-specific Death Rate (per 1000) among Males in Mildly Affected Area during the years 1984-93

	1984			85			86			87			88			89		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	970	0	.00	970	3	3.09	952	3	3.15	754	1	1.33	729	1	1.37	651	1	.54
5-9	1199	0	.00	1199	5	4.17	1176	1	.85	942	3	3.18	906	0	.00	818	1	1.22
10-14	1193	0	.00	1193	4	3.35	1172	5	4.27	989	0	.00	962	0	.00	873	2	
15-19	1064	0	.00	1064	1	.94	1051	0	.00	852	0	.00	830	0	.00	735	1	1.36
20-24	1110	1	.90	1109	0	.00	1088	1	.92	815	1	1.23	786	0	.00	675	2	2.96
25-29	817	0	.00	817	1	1.22	803	2	2.49	565	0	.00	541	1	1.85	456	0	.00
30-34	733	0	.00	733	0	.00	717	2	2.79	529	0	.00	506	1	1.98	438	0	.00
35-39	594	0	.00	594	2	3.37	580	3	5.17	449	1	2.23	426	0	.00	375	3	8.00
40-44	441	0	.00	441	0	.00	436	0	.00	346	2	5.78	333	1	3.00	301	1	3.32
45-49	370	0	.00	370	0	.00	367	1	2.72	293	2	6.83	284	1	3.52	255	1	3.92
50-54	285	0	.00	285	2	7.02	280	1	3.57	222	5	22.52	208	2	9.62	184	2	10.87
55-59	196	0	.00	196	2	10.20	190	4	21.05	139	3	21.58	133	3	22.56	112	1	8.93
60-64	215	0	.00	215	4	18.60	207	5	24.15	160	1	6.25	153	2	13.07	135	7	51.85
65-69	93	0	.00	93	2	21.51	91	3	32.97	69	3	43.48	64	0	.00	57	3	52.63
70-	187	0	.00	187	9	48.13	177	5	28.25	126	3	23.81	118	6	50.85	102	7	68.63
TOTAL	9467	1	.11	9466	35	3.70	9287	36	3.88	7250	25	3.45	6979	18	2.58	6167	32	5.19

	90			91			92			93		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	602	1	1.66	557	1	1.80	521	2	3.84	418	0	.00
5-9	753	1	1.33	714	0	.00	650	1	1.54	559	0	.00
10-14	793	0	.00	753	1	1.33	674	0	.00	580	1	1.72
15-19	682	1	1.47	635	0	.00	579	0	.00	479	1	2.09
20-24	612	0	.00	572	2	3.50	514	1	1.95	427	0	.00
25-29	409	0	.00	376	1	2.66	345	1	2.90	279	2	7.17
30-34	397	0	.00	361	0	.00	337	0	.00	270	1	3.70
35-39	335	1	2.99	317	1	3.15	292	1	3.42	243	2	8.23
40-44	278	0	.00	265	2	7.55	239	2	8.37	197	4	20.30
45-49	243	3	12.35	224	0	.00	209	3	14.35	183	4	21.86
50-54	162	5	30.86	151	1	6.62	141	2	14.18	118	3	25.42
55-59	96	2	20.83	89	2	22.47	79	3	37.97	66	6	90.91
60-64	118	6	50.85	106	3	28.30	94	1	10.64	83	7	84.34
65-69	50	0	.00	47	4	85.11	38	2	52.63	27	4	148.15
70-	90	6	66.67	78	3	38.46	72	3	41.67	63	4	63.49
TOTAL	5620	26	4.63	5245	21	4.00	4784	22	4.60	3992	39	9.77

P – Number of persons, D – Number of deaths, DR - Death rate

Table 9. Age-specific Death Rate (per 1000) among Females in Mildly Affected Area during the years 1984-93

	1984			85			86			87			88			89		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	930	1	1.08	929	5	5.38	911	3	3.29	724	2	2.76	694	2	2.88	615	1	1.63
5-9	1102	0	.00	1102	5	4.54	1080	0	.00	880	0	.00	851	0	.00	787	0	.00
10-14	1043	0	.00	1043	0	.00	1026	2	1.95	849	2	2.36	827	0	.00	773	0	.00
15-19	1081	0	.00	1081	4	3.70	1069	3	2.81	872	1	1.15	845	0	.00	747	3	4.02
20-24	1165	0	.00	1165	2	1.72	1142	1	.88	878	2	2.28	859	0	.00	752	2	2.66
25-29	878	0	.00	878	1	1.14	862	1	1.16	676	3	4.44	647	1	1.55	557	2	3.59
30-34	617	1	1.62	616	1	1.62	605	4	6.61	478	0	.00	451	2	4.43	407	0	.00
35-39	447	0	.00	447	2	4.47	442	2	4.52	354	3	8.47	343	1	2.92	313	3	9.58
40-44	365	0	.00	365	0	.00	361	1	2.77	300	0	.00	294	0	.00	270	2	7.41
45-49	313	0	.00	313	0	.00	310	2	6.45	252	3	11.90	242	1	4.13	212	1	4.72
50-54	253	0	.00	253	4	15.81	243	2	8.23	175	0	.00	171	0	.00	155	1	6.45
55-59	183	0	.00	183	1	5.46	179	2	11.17	142	2	14.08	133	1	7.52	114	1	8.77
60-64	202	0	.00	202	3	14.85	193	1	5.18	143	1	6.99	136	1	7.35	120	1	8.33
65-69	78	0	.00	78	0	.00	75	1	13.33	54	4	74.07	49	1	20.41	44	1	22.73
70-	143	0	.00	143	7	48.95	133	1	7.52	109	3	27.52	102	6	58.82	85	3	35.29
TOTAL	8800	2	.23	8798	35	3.98	8631	26	3.01	6886	26	3.78	6644	16	2.41	5951	21	3.53

	90			91			92			93		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	559	0	.00	539	0	.00	492	0	.00	388	0	.00
5-9	728	0	.00	691	0	.00	639	2	3.13	532	1	1.88
10-14	714	0	.00	670	1	1.49	604	0	.00	514	0	.00
15-19	676	0	.00	638	0	.00	588	0	.00	506	0	.00
20-24	683	1	1.46	637	1	1.57	577	1	1.73	468	2	4.27
25-29	512	1	1.95	476	1	2.10	447	0	.00	367	0	.00
30-34	374	3	8.02	350	0	.00	320	0	.00	274	0	.00
35-39	287	1	3.48	274	1	3.65	253	0	.00	212	0	.00
40-44	247	4	16.19	227	1	4.41	210	0	.00	188	7	37.23
45-49	186	3	16.13	174	0	.00	155	1	6.45	138	1	7.25
50-54	142	1	7.04	132	4	30.30	117	0	.00	108	0	.00
55-59	101	1	9.90	95	1	10.53	87	0	.00	74	0	.00
60-64	112	2	17.86	103	3	29.13	90	4	44.44	78	5	64.10
65-69	42	4	95.24	37	0	.00	34	1	29.41	29	2	68.97
70-	79	4	50.63	70	4	57.14	61	4	65.57	52	7	134.62
TOTAL	5442	25	4.59	5113	17	3.32	4674	13	2.78	3928	25	6.36

P – Number of persons, D – Number of deaths, DR - Death rate

Table 10. Age-specific Death Rate (per 1000) in Males in Control Area during the years 1984-93

	1984			85			86			87			88			89		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	1077	0	.00	1077	4	3.71	1062	6	5.65	913	1	1.10	907	3	3.31	868	1	1.15
5-9	1245	1	.80	1244	3	2.41	1227	4	3.26	1043	1	.96	1036	1	.97	1000	0	.00
10-14	961	0	.00	961	1	1.04	947	3	3.17	810	3	3.70	804	0	.00	770	0	.00
15-19	763	0	.00	763	1	1.31	759	1	1.32	650	1	1.54	643	0	.00	613	0	.00
20-24	777	0	.00	777	0	.00	759	1	1.32	613	1	1.63	607	0	.00	584	2	3.42
25-29	839	0	.00	839	3	3.58	819	0	.00	684	2	2.92	679	2	2.95	655	1	1.53
30-34	764	0	.00	764	1	1.31	753	2	2.66	611	2	3.27	604	0	.00	581	0	.00
35-39	671	0	.00	671	1	1.49	659	1	1.52	559	1	1.79	557	1	1.80	540	1	1.85
40-44	454	1	2.20	453	1	2.21	448	4	8.93	385	0	.00	384	1	2.60	368	0	.00
45-49	303	0	.00	303	0	.00	300	1	3.33	250	1	4.00	248	2	8.06	230	0	.00
50-54	212	0	.00	212	1	4.72	209	3	14.35	172	3	17.44	166	0	.00	158	0	.00
55-59	106	0	.00	106	1	9.43	103	1	9.71	82	0	.00	82	0	.00	80	3	37.50
60-64	135	0	.00	135	1	7.41	132	4	30.30	111	4	36.04	107	1	9.35	100	1	10.00
65-69	46	0	.00	46	0	.00	46	0	.00	35	0	.00	35	2	57.14	31	2	64.52
70-	100	1	10.0	99	1	10.10	98	2	20.41	84	2	23.81	81	1	12.35	76	2	26.32
TOTAL	8453	3	.35	8450	19	2.25	8321	33	3.97	7002	22	3.14	6940	14	2.02	6654	13	1.95

	90			91			92			93		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	801	0	.00	731	0	.00	692	0	.00	450	0	.00
5-9	921	0	.00	863	0	.00	797	0	.00	496	0	.00
10-14	710	0	.00	658	2	3.04	610	0	.00	401	0	.00
15-19	560	0	.00	505	1	1.98	455	0	.00	304	0	.00
20-24	517	0	.00	464	0	.00	418	0	.00	251	0	.00
25-29	592	3	5.07	551	0	.00	503	1	1.99	301	1	3.32
30-34	527	0	.00	475	0	.00	433	0	.00	260	3	11.54
35-39	487	0	.00	445	4	8.99	406	1	2.46	247	0	.00
40-44	348	1	2.87	328	2	6.10	297	1	3.37	180	1	5.56
45-49	211	2	9.48	187	0	.00	165	1	6.06	113	0	.00
50-54	142	1	7.04	132	2	15.15	119	2	16.81	80	0	.00
55-59	70	3	42.86	59	0	.00	52	0	.00	40	1	25.00
60-64	89	0	.00	83	2	24.10	72	2	27.78	49	0	.00
65-69	26	0	.00	26	0	.00	24	1	41.67	21	0	.00
70-	68	3	44.12	61	1	16.39	52	1	19.23	35	1	28.57
TOTAL	6069	13	2.14	5568	13	2.33	5095	10	1.96	3228	7	2.17

P – Number of persons, D – Number of deaths, DR - Death rate

Table 11. Age-specific Death Rate (per 1000) among Females in Control Area during the years 1984-93

	1984			85			86			87			88			89		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	938	2	2.13	936	4	4.27	923	5	5.42	792	4	5.05	783	1	1.28	739	0	.00
5-9	1184	0	.00	1184	4	3.38	1167	3	2.57	1005	0	.00	1001	1	1.00	950	1	1.05
10-14	851	0	.00	851	1	1.18	842	2	2.38	734	0	.00	730	0	.00	712	1	1.40
15-19	615	0	.00	615	1	1.63	605	2	3.31	528	0	.00	527	0	.00	506	2	3.95
20-24	885	0	.00	885	1	1.13	871	3	3.44	748	2	2.67	744	2	2.69	722	0	.00
25-29	803	0	.00	803	2	2.49	790	0	.00	655	1	1.53	650	1	1.54	625	0	.00
30-34	625	1	1.60	624	3	4.81	612	0	.00	533	3	5.63	528	0	.00	505	1	1.98
35-39	393	0	.00	393	3	7.63	386	1	2.59	326	0	.00	325	2	6.15	313	1	3.19
40-44	267	0	.00	267	1	3.75	263	0	.00	225	2	8.89	220	0	.00	209	0	.00
45-49	172	0	.00	172	0	.00	170	2	11.76	144	0	.00	143	0	.00	138	2	14.49
50-54	154	0	.00	154	0	.00	152	0	.00	130	0	.00	129	2	15.50	119	0	.00
55-59	89	0	.00	89	2	22.47	87	2	22.99	70	0	.00	70	1	14.29	65	0	.00
60-64	152	0	.00	152	0	.00	151	1	6.62	127	0	.00	127	0	.00	126	1	7.94
65-69	48	0	.00	48	1	20.83	46	2	43.48	36	2	55.56	34	1	29.41	32	0	.00
70-	78	0	.00	78	2	25.64	75	7	93.33	57	2	35.09	55	4	72.73	47	2	42.55
TOTAL	7254	3	.41	7251	25	3.45	7140	30	4.20	6110	16	2.62	6066	15	2.47	5808	11	1.89

	90			91			92			93		
AGE GROUP	P	D	DR	P	D	DR	P	D	DR	P	D	DR
0-4	685	1	1.46	642	0	.00	600	1	1.67	388	1	2.58
5-9	881	2	2.27	809	1	1.24	750	1	1.33	475	0	.00
10-14	666	2	3.00	618	0	.00	567	0	.00	387	0	.00
15-19	477	0	.00	444	0	.00	410	2	4.88	254	0	.00
20-24	664	0	.00	606	0	.00	558	0	.00	339	1	2.95
25-29	568	1	1.76	516	1	1.94	482	1	2.07	306	1	3.27
30-34	463	2	4.32	427	0	.00	391	0	.00	244	1	4.10
35-39	297	0	.00	283	0	.00	263	1	3.80	163	0	.00
40-44	196	0	.00	169	1	5.92	152	1	6.58	104	0	.00
45-49	126	0	.00	118	0	.00	111	0	.00	82	0	.00
50-54	107	0	.00	101	0	.00	86	1	11.63	64	2	31.25
55-59	61	1	16.39	57	2	35.09	53	0	.00	31	0	.00
60-64	116	1	8.62	107	4	37.38	99	1	10.10	76	2	26.32
65-69	29	0	.00	27	1	37.04	24	0	.00	16	0	.00
70-	43	1	23.26	39	0	.00	34	0	.00	24	0	.00
TOTAL	5379	11	2.04	4963	10	2.01	4580	9	1.97	2953	8	2.71

P – Number of persons, D – Number of deaths, DR - Death rate

Table 12. Primary Cause of Death Distribution (in percentage) among Males in Severely Affected Area for The years 1986-93

Primary Causes	Years 1986		1987		1988		1989		1990		1991		1992		1993	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Accident & injuries	1	1.22	1	2.70	3	7.5	2	5.40	2	4.44	1	3.84	5	17.85	5	26.31
Child birth & Pregnancy	0	.0	0	.0	1	2.5	1	2.70	0	.0	0	.00	0	.00	0	.0
Fever	2	2.40	1	2.70	0	.0	2	5.40	2	4.44	0	.00	0	.00	0	.0
Digestive disorders	6	7.22	6	16.2	11	27.5	6	16.2	2	4.44	0	.00	1	3.57	1	5.26
Respiratory disorders	10	12.0	15	40.54	18	45.2	22	59.47	18	40.1	20	76.92	7	25.00	9	47.36
C.N.S. disorders	0	.0	1	2.7	1	2.5	0	.00	1	2.22	1	3.84	0	.00	0	.0
C.V.S. disorders	1	1.2	2	5.4	4	10.0	2	5.40	3	6.66	2	7.69	2	7.14	0	.0
Other system disorders	2	2.4	1	2.7	0	.0	1	2.70	0	.0	0	.00	1	3.57	1	5.26
Causes peculiar to infancy	0	.0	2	5.4	0	.0	1	2.7	1	2.22	0	.00	0	.00	0	.0
Senility	1	1.2	3	8.1	2	5.0	0	.0	3	6.66	1	3.84	3	10.71	1	5.26
Cause unknown	60	72.2	5	13.51	0	.0	0	.00	13	28.88	3	11.53	9	32.52	0	.0
Total	83		37		40		37		45		26		28		19	

Table 13. Primary Cause of Death Distribution (in percentage) among Females in Severely Affected Area for the years 1986-93

Primary Causes	Years 1986		87		88		89		90		91		92		93	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Accident & injuries	0	.0	0	.0	2	7.14	0	.0	2	6.66	1	3.57	0	.0	1	5.2
Child birth & pregnancy	0	.0	0	.0	1	3.57	0	.0	2	6.66	1	3.57	1	10.0	0	.0
Fever	2	3.7	1	3.8	0	.0	3	14.2	2	6.66	2	7.14	0	.0	0	.0
Digestive disorders	1	1.58	5	19.2	2	7.14	1	4.7	4	13.3	6	21.42	0	.0	0	.0
Respiratory disorders	5	7.92	12	46.1	15	53.57	14	66.0	10	33.3	9	32.1	6	60.0	10	52.6
C.N.S. disorders	0	.0	0	.0	1	3.57	0	.0	0	.0	2	7.14	0	.0	1	5.2
C.V.S. disorders	0	.0	0	.0	1	3.57	0	.0	3	10.0	1	3.57	0	.0	0	.0
Other system disorders	2	3.7	1	3.8	1	3.57	1	4.7	0	.0	0	.0	0	.0	0	.0
Causes peculiar to infancy	1	1.58	1	3.8	3	10.7	1	4.7	1	3.3	1	3.57	0	.0	0	.0
Senility	0	.0	2	7.6	2	7.4	0	.0	0	.0	1	3.57	1	10.0	0	.0
Causes unknown	52	82.5	4	15.38	0	.0	1	4.7	6	20.0	4	14.2	2	20.0	7	36.8
Total	63		26		28		21		30		28		10		19	

Table 14. Primary Cause of Death Distribution (in percentage) among Males in Moderately Affected Area for the years 1986-93

Primary Causes	Years 1986		87		88		89		90		91		92		93	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Accident & injuries	1	1.25	3	6.38	4	9.52	4	7.27	5	8.92	0	.0	1	2.56	0	.0
Child birth & Pregnancy	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
Fever	0	.0	2	4.25	1	2.38	2	3.67	3	5.35	2	5.26	0	.0	3	8.57
Digestive disorders	1	1.25	9	19.14	5	11.9	8	14.58	3	5.35	3	7.89	5	12.82	2	5.71
Respiratory disorders	10	12.5	11	23.4	24	57.06	34	61.85	24	42.85	17	44.73	16	41.02	12	34.28
C.N.S. disorders	1	1.25	6	12.76	2	4.76	1	1.81	2	3.57	1	2.63	0	.0	1	2.85
C.V.S. disorders	0	.0	3	6.38	0	.0	1	1.81	1	1.78	0	.0	0	.0	1	2.85
Other system disorders	0	.0	0	.0	0	.0	1	1.81	1	1.78	0	.0	1	2.56	0	.0
Causes peculiar to infancy	2	2.5	0	.0	3	7.14	4	7.27	2	3.57	0	.0	0	.0	0	.0
Senility	3	3.75	4	8.5	2	4.76	0	.0	0	.0	2	5.26	2	5.12	0	.0
Cause unknown	62	77.5	9	19.14	1	4.76	0	.0	15	26.78	13	34.2	14	35.89	16	45.71
	80		47		42		55		56		38		39		35	

Table 15. Primary Cause of Death Distribution (in percentage) among Females in Moderately Affected Area for the years 1986-93

Primary Causes	Years 1986		87		88		89		90		91		92		93	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Accident & injuries	3	3.70	0	.0	2	5.55	0	.0	1	3.03	0	.0	1	4.0	1	3.12
Child birth & Pregnancy	0	.0	1	3.03	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
Fever	1	1.2	1	3.03	1	2.77	1	2.9	2	6.06	1	2.7	1	4.0	1	3.12
Digestive disorders	1	1.2	9	27.2	4	11.11	7	20.7	6	18.1	3	8.1	1	4.0	5	15.6
Respiratory disorders	4	4.9	12	36.3	21	58.32	20	58.8	13	39.33	12	32.43	13	52.0	8	25.0
C.N.S. disorders	0	.0	2	6.06	2	5.55	1	2.9	0	.0	3	8.1	0	.0	3	9.37
C.V.S. disorders	0	.0	1	3.03	1	2.77	0	.0	0	.0	0	.0	0	.0	1	3.12
Other system disorders	1	1.2	0	.0	1	2.77	0	.0	1	3.03	0	.0	1	4.0	0	.0
Causes peculiar to infancy	2	2.4	1	3.03	0	.0	4	11.76	1	3.03	1	2.7	0	.0	0	.0
Senility	2	2.4	1	3.03	4	11.11	1	2.9	0	.0	2	5.4	1	4.0	2	6.24
Cause unknown	67	82.71	5	15.15	0	.0	0	.0	9	27.3	15	40.5	7	28.0	11	34.37
Total	81		32		34		36		33		37		25		32	

Table 16. Primary Cause of Death Distribution (in percentage) among Males in Mildly Affected Area for the years 1986-93

Primary Causes	Years 1986		87		88		89		90		91		92		93	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Accident & injuries	3	8.3	0	.0	2	11.1	0	.0	1	3.8	0	.0	3	13.6	1	2.56
Child birth & Pregnancy	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
Fever	0	.0	1	4.0	0	.0	3	9.3	0	.0	0	.0	0	.0	2	5.2
Digestive disorders	5	13.8	2	8.0	2	11.1	4	12.5	1	3.8	0	.0	2	9.09	1	2.56
Respiratory disorders	5	13.8	16	64.0	8	44.4	20	62.5	16	61.4	10	47.6	12	54.54	27	69.16
C.N.S. disorders	2	5.55	2	8.0	3	16.6	3	9.3	1	3.8	5	23.8	3	13.6	4	10.4
C.V.S. disorders	0	.0	0	.0	1	5.5	1	3.1	2	7.6	0	.0	2	9.09	0	.0
Other system disorders	2	5.55	1	4.0	0	5.5	0	.0	0	.0	0	.0	0	.0	0	.0
Causes peculiar to infancy	0	.0	1	4.0	0	.0	0	.0	1	3.8	0	.0	0	.0	1	2.56
Senility	0	.0	2	8.0	0	.0	1	3.1	1	3.8	3	14.2	0	.0	1	2.56
Cause unknown	19	52.7	0	.0	2	11.1	0	.0	3	11.5	3	14.2	0	.0	2	2.56
Total	36		25		18		32		26		21		22		39	

Table 17. Primary Cause of Death Distribution(in percentage) among Females in Mildly Affected Area for the years 1986-93

Primary Causes	Years 1986		87		88		89		90		91		92		93	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Accident & injuries	1	3.8	0	.0	0	.0	0	.0	2	8.0	1	5.8	0	.0	2	8.0
Child birth & pregnancy	1	3.8	2	7.6	0	.0	0	.0	0	.0	2	11.76	0	.0	0	.0
Fever	1	3.8	0	.0	1	6.25	1	.7	1	4.0	0	.0	1	7.6	1	4.0
Digestive disorders	4	15.3	1	3.8	3	18.75	4	19.0	2	8.0	1	5.8	0	.0	1	4.0
Respiratory disorders	1	3.8	19	72.9	9	56.25	11	52.3	14	56.0	9	52.8	8	61.4	13	52.0
C.N.S. disorders	0	.0	2	7.6	0	.0	1	4.7	2	8.0	1	5.8	1	7.6	4	16.0
C.V.S. disorders	0	.0	1	3.8	2	12.5	2	9.4	2	8.0	0	.0	0	.0	2	8.0
Other system disorders	0	.0	1	3.8	1	6.25	0	.0	0	.0	0	.0	0	.0	0	.0
Causes peculiar to infancy	0	.0	0	.0	0	.0	1	4.7	0	.0	1	5.8	0	.0	0	.0
Senility	0	.0	0	.0	0	.0	1	4.7	0	.0	0	.0	0	.0	0	.0
Cause unknown	18	69.2	0	.0	0	.0	0	.0	2	8.0	2	11.6	3	23.0	2	8.0
Total	26		26		16		21		25		17		13		25	

Table 18. Primary Cause of Death Distribution (in percentage) among Males in Control Area for the years 1986-93

Primary Causes	Years 1986		87		88		89		90		91		92		93	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Accident & injuries	0	.0	6	27.27	1	7.1	1	7.6	2	15.2	2	14.2	1	10.0	0	.0
Child birth & Pregnancy	0	.0	1	4.5	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
Fever	1	3.0	5	22.7	2	14.2	3	23.0	3	23.0	3	21.4	1	10.0	0	.0
Digestive disorders	2	6.1	1	4.5	4	28.4	0	.0	1	7.6	3	21.4	2	20.0	1	14.2
Respiratory disorders	5	15.2	0	.0	1	7.1	4	30.7	5	38.3	4	28.4	3	30.0	6	85.7
C.N.S. disorders	0	.0	0	.0	1	7.1	0	.0	1	7.6	0	.0	0	.0	0	.0
C.V.S. disorders	0	.0	2	9.0	1	7.1	1	7.6	0	.0	0	.0	0	.0	0	.0
Other system disorders	0	.0	1	4.5	1	7.1	0	.0	0	.0	0	.0	0	.0	0	.0
Causes peculiar to infancy	1	3.0	2	9.0	3	21.4	2	15.2	1	7.6	1	7.1	3	30.0	0	.0
Senility	1	3.0	2	9.0	0	.0	2	15.2	0	.0	1	7.1	0	.0	0	.0
Cause unknown	23	69.6	2	9.0	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
Total	33		22		13		13		13		14		10		7	

Table 19. Primary Cause of Death Distribution (in percentage) among Females in Control Area for the years 1986-93

Primary Causes	Years 1986		87		88		89		90		91		92		93	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
Accident & injuries	1	3.3	3	18.75	0	.0	1	9.09	2	18.1	1	10.0	1	11.1	0	.0
Child birth & Pregnancy	0	.0	3	18.75	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
Fever	2	6.6	3	18.75	1	6.6	1	9.09	4	36.4	1	10.0	2	22.2	0	.0
Digestive disorders	1	3.3	0	.0	2	13.3	2	18.18	0	.0	0	.0	0	.0	1	12.5
Respiratory disorders	2	6.6	2	12.4	1	6.6	5	45.45	2	18.18	3	30.0	1	11.1	1	12.5
C.N.S. disorders	1	3.8	0	.0	1	6.6	0	.0	0	.0	0	.0	0	.0	0	.0
C.V.S. disorders	1	3.3	1	6.2	3	20.0	0	.0	0	.0	0	.0	0	.0	0	.0
Other system disorders	0	.0	0	.0	1	6.6	0	.0	0	.0	0	.0	1	11.1	0	.0
Causes peculiar to infancy	1	3.3	4	25.0	4	26.6	1	.0	1	9.09	3	30.0	2	22.2	4	50.0
Senility	1	3.3	0	.0	2	13.3	1	.0	2	18.18	2	20.0	2	22.2	2	25.0
Cause unknown	20	66.6	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0	0	.0
Total	30		16		15		11		11		10		9		8	

Table 20. Immediate Morbidity after Gas Exposure among Males on 3rd December,1984 according to Major Systems and Age

Area and No. Of persons	Age	No.of persons surveyed	Systems involved			
			Lung	Eye	GIT	Skin
Severe (14006)	0-4	1719	1607 (93.48)	1654 (96.2)	1233 (71.72)	31 (1.80)
	5-14	3491	3358 (96.19)	3440 (98.5)	2534 (72.58)	37 (1.05)
	15-44	6352	6216 (97.85)	6276 (98.8)	4696 (73.92)	71 (1.11)
	45-64	1424	1405 (98.66)	1407 (98.8)	1039 (72.96)	15 (1.05)
	65+	212	209 (98.58)	210 (99.05)	155 (73.11)	5 (2.35)
	Total	13198	12792 (96.94)	12984 (98.40)	9654 (73.16)	159 (1.20)
Moderate (18438)	0-4	2027	1922 (94.8)	1924 (94.91)	1083 (52.90)	71 (3.50)
	5-14	4740	4601 (97.06)	4653 (98.16)	2382 (50.25)	70 (1.47)
	15-44	8332	8170 (98.05)	8216 (98.30)	3886 (46.63)	113 (1.35)
	45-64	2047	2022 (98.77)	2029 (99.12)	991 (48.41)	39 (1.90)
	65+	0000	0000	0000	0000	000
	Total	17146	16715 (97.4)	16822 (98.11)	8342 (48.65)	293 (1.70)
Mild (9714)	0-4	970	953 (98.20)	956 (98.5)	148 (15.2)	13 (1.34)
	5-14	2385	2365 (99.16)	2374 (99.53)	363 (15.2)	25 (1.04)
	15-44	4756	4704 (98.9)	4727 (99.39)	656 (13.79)	38 (.79)
	45-64	1057	1047 (99.05)	1048 (99.14)	177 (16.74)	8 (.75)
	65+	271	210 (77.49)	211 (77.85)	23 (8.48)	1 (.36)
	Total	9439	9279 (98.30)	9316 (98.69)	1367 (14.48)	85 (.90)
Control (8574)	0-4	1073	0000	0000	000	00
	5-14	2206	1 (.04)	1 (.04)	000	00
	15-44	4263	3 (.07)	4 (.09)	2 (.04)	00
	45-64	755	0000	0000	000	00
	65+	144	0000	0000	000	00
Total		8391	4 (.04)	5 (.05)	2 (.02)	00

Figures in parenthesis represent percentages
GIT – Gastro Intestinal Tract

Table 21. Immediate Morbidity after Gas Exposure among Females on 3rd December,1984 according to Major Systems and Age

Area and No. Of persons	Age	No.of persons surveyed	Systems involved			
			Lung	Eye	GIT	Skin
Severe (12376)	0-4	1594	1483 (93.03)	1529 (95.92)	1180 (74.02)	26 (1.67)
	5-14	3113	3009 (96.65)	3083 (99.03)	2309 (74.17)	49 (1.57)
	15-44	5633	5508 (97.78)	5583 (99.11)	4166 (73.95	66 (1.17)
	45-64	1212	1182 (97.52)	1200 (99.0)	887 (73.18)	19 (.81)
	65+	244	239 (96.82)	242 (98.65)	183 (73.96)	2 (1.37)
	Total	11796	11421 (96.82)	11637 (98.65)	8725 (73.96)	162 (1.37)
Moderate (16526)	0-4	1847	1755 (95.0)	1754 (94.96)	1019 (55.17)	60 (3.28)
	5-14	4370	4248 (97.2)	4283 (98.0)	2194 (50.20)	69 (1.57)
	15-44	7665	7488 (97.69)	7555 (98.56)	3738 (48.76)	124 (1.61)
	45-64	1698	1676 (98.70)	1682 (99.05)	835 (49.17)	41 (2.41)
	65+	359	355 (98.88)	354 (98.60)	177 (49.30)	12 (3.34)
	Total	15939	15522 (97.38)	15628 (98.04)	8023 (50.33)	306 (1.91)
Mild (8961)	0-4	925	912 (98.59)	909 (98.27)	133 (14.37)	13 (1.40)
	5-14	2142	2122 (99.06)	2130 (99.43)	334 (15.59)	14 (.65)
	15-44	4544	4499 (99.00)	4522 (99.51)	727 (15.99)	37 (.81)
	45-64	942	936 (99.36)	939 (99.68)	149 (15.81)	13 (1.38)
	65+	216	210 (97.22)	211 (97.68)	23 (10.64)	1 (.46)
	Total	8769	8679 (98.97)	8711 (99.33)	1366 (15.57)	78 (.88)
Control (7357)	0-4	931	1 (.10)	1 (.10)	00	00
	5-14	2032	1 (.04)	1 (.04)	00	00
	15-44	3573	2 (.05)	2 (.05)	1 (.02)	00
	45-64	565	2 (.35)	2 (.35)	00	00
	65+	124	00	00	00	00
	Total	7225	6 (.08)	6 (.08)	1 (.01)	00

Figures in parenthesis represent percentages
GIT – Gastro Intestinal Tract

Table 22. Age-specific Morbidity Rates among Males in Severely Affected Area during the years 1986-94

	Age Groups											
	0-4		5-14		15-44		45-64		65+		Total	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	1250	157 (12.57)	2597	177 (6.81)	4514	614 (13.60)	1048	226 (21.56)	142	48 (33.80)	9549	1222 (12.79)
2	1303	100 (7.67)	2658	197 (7.41)	4802	503 (10.47)	1076	244 (22.67)	164	50 (30.48)	10003	1094 (10.93)
3	1376	237 (17.22)	2883	379 (13.11)	5048	877 (17.37)	1117	406 (36.34)	164	65 (39.63)	10588	1964 (18.54)
4	690	77 (11.15)	1293	99 (7.65)	2419	288 (11.90)	490	135 (27.55)	82	32 (39.02)	4974	631 (12.68)
5	583	141 (24.18)	1135	151 (13.30)	2019	335 (16.590	405	158 (39.0)	68	30 (44.11)	4210	815 (19.35)
6	605	99 (16.36)	1154	126 (10.91)	2087	383 (18.35)	433	169 (39.03)	63	29 (46.03)	4342	806 (18.56)
7	997	180 (18.05)	2168	303 (13.97)	3529	787 (22.30)	784	369 (47.06)	103	55 (53.39)	7581	1694 (22.34)
8	943	185 (19.61)	2097	383 (18.26)	3395	919 (27.06)	752	362 (48.13)	109	63 (57.79)	7296	1912 (26.20)
9	890	218 (24.49)	1954	419 (21.44)	3016	1013 (33.58)	637	366 (57.45)	95	59 (62.10)	6592	2075 (31.47)
10	839	175 (20.55)	1872	409 (21.84)	2919	1032 (35.35)	634	371 (58.51)	81	55 (67.90)	6345	2042 (32.18)
11	588	131 (22.27)	1313	332 (25.28)	1955	781 (39.94)	403	266 (66.00)	60	45 (75.00)	4319	1555 (36.00)
12	542	105 (19.37)	1215	235 (19.34)	1764	562 (31.85)	401	240 (59.85)	52	31 (59.6)	3974	1173 (29.51)
13	676	99 (14.64)	1512	239 (15.80)	2187	666 (30.45)	439	261 (59.45)	62	46 (74.19)	4885	1311 (26.83)
14	728	90 (12.36)	1609	182 (11.31)	2336	652 (27.91)	488	287 (58.81)	72	43 (59.72)	5233	1254 (23.96)
15	1127	56 (4.96)	2394	110 (4.59)	4149	449 (10.82)	939	222 (23.64)	119	34 (28.57)	8728	871 (9.97)
16	979	101 (10.31)	2085	214 (10.26)	3406	683 (20.05)	715	279 (39.02)	97	30 (30.97)	7282	1307 (17.94)
17	1143	94 (8.22)	2393	168 (7.02)	3979	739 (18.57)	818	292 (35.69)	112	40 (35.07)	8445	1333 (15.72)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 23. Age-specific Morbidity Rates among Females in Severely Affected Area during the years 1986-94

	Age Groups											
	0-4		5-14		15-44		45-64		65+		Total	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	1175	127 (10.08)	2326	178 (7.65)	4121	872 (21.15)	892	208 (23.31)	181	37 (20.44)	8695	1422 (16.35)
2	1203	99 (8.22)	2445	145 (5.93)	4340	861 (19.83)	954	242 (25.36)	185	32 (17.29)	9127	1379 (15.10)
3	1283	189 (14.73)	2628	384 (14.61)	4604	1203 (26.12)	987	361 (36.37)	185	62 (33.51)	9687	2199 (17.13)
4	656	73 (11.12)	1171	90 (7.68)	2164	450 (20.74)	459	145 (31.59)	74	77 (22.97)	4524	775 (17.13)
5	535	120 (22.42)	1011	128 (12.66)	1840	492 (26.73)	401	173 (43.14)	58	17 (29.31)	3845	930 (24.18)
6	571	63 (11.03)	1055	96 (9.09)	1901	539 (28.35)	401	157 (39.15)	59	19 (32.20)	3987	883 (22.14)
7	913	130 (14.23)	1960	308 (15.71)	3347	1098 (32.80)	683	330 (48.31)	122	35 (28.68)	7025	1901 (27.06)
8	884	163 (18.43)	1898	316 (16.64)	3282	1203 (36.65)	666	333 (50.00)	119	36 (30.25)	6849	2051 (29.94)
9	810	179 (22.09)	1749	362 (20.69)	2970	1326 (44.64)	583	369 (63.29)	110	43 (39.09)	6222	2279 (36.62)
10	778	153 (19.66)	1689	355 (21.01)	2812	1256 (44.66)	556	335 (60.25)	92	40 (43.47)	5927	2139 (36.08)
11	569	132 (23.19)	1173	253 (21.56)	1952	986 (50.51)	353	226 (54.02)	72	36 (50.00)	4119	1633 (39.64)
12	508	85 (16.73)	1056	193 (18.27)	1774	772 (43.51)	329	205 (62.31)	61	24 (39.34)	3718	1279 (34.40)
13	603	95 (15.75)	1358	233 (17.15)	2190	931 (42.51)	387	260 (67.18)	80	35 (43.75)	4618	1554 (33.65)
14	674	82 (12.16)	1415	142 (10.03)	2353	916 (38.92)	438	260 (59.36)	81	30 (37.03)	4961	1430 (28.82)
15	1032	73 (7.07)	2182	114 (5.22)	3883	629 (16.19)	833	210 (25.21)	154	26 (16.88)	8084	1052 (13.01)
16	894	88 (9.84)	1876	162 (8.64)	3207	945 (29.46)	668	232 (34.73)	111	22 (19.81)	6756	1449 (21.44)
17	1000	84 (8.4)	2156	127 (5.89)	3646	971 (26.63)	744	260 (34.94)	147	26 (17.68)	7693	1468 (19.08)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 24. Age-specific Morbidity Rates among Males in Moderately Affected Area during the years 1986-94

	Age Groups											
	0-4		5-14		15-44		45-64		65+		Total	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	1721	57 (3.31)	4048	104 (2.56)	7050	299 (4.26)	1728	207 (11.97)	295	41 (13.89)	14842	708 (4.77)
2	1615	73 (4.52)	3897	147 (3.77)	6573	443 (6.73)	1644	270 (16.42)	285	59 (20.70)	14014	992 (7.09)
3	1691	97 (5.73)	4074	200 (4.90)	6859	623 (9.08)	1704	385 (22.59)	296	86 (29.09)	14624	1391 (9.51)
4	545	62 (11.37)	1363	92 (6.74)	2287	297 (12.98)	553	174 (31.46)	86	33 (38.37)	4834	658 (13.61)
5	485	38 (7.83)	1206	89 (7.37)	2034	192 (9.43)	479	119 (24.84)	74	18 (24.32)	4278	456 (10.65)
6	442	39 (8.82)	1105	65 (5.88)	1788	178 (9.84)	427	112 (26.22)	63	16 (25.39)	3825	410 (10.71)
7	1054	160 (15.18)	2634	355 (13.47)	4122	989 (23.99)	1038	475 (45.76)	160	64 (40.00)	9008	2043 (22.67)
8	1072	168 (15.67)	2663	404 (15.17)	4245	1065 (25.08)	1063	507 (47.69)	173	80 (46.24)	9216	2224 (24.13)
9	1008	142 (14.08)	2591	392 (15.12)	3907	1006 (25.74)	956	474 (49.58)	160	76 (47.5)	8622	2090 (24.24)
10	1022	243 (23.77)	2620	576 (21.98)	3963	1241 (31.31)	983	545 (55.44)	168	83 (49.40)	8756	2688 (30.49)
11	997	216 (21.66)	2537	511 (20.14)	3747	986 (26.31)	922	483 (52.38)	147	74 (53.34)	8350	2270 (27.18)
12	596	101 (16.94)	1529	240 (15.69)	2277	447 (19.63)	573	246 (42.93)	90	41 (45.55)	5065	1075 (21.22)
13	855	117 (13.68)	2183	321 (14.70)	3163	726 (22.95)	777	383 (49.29)	116	55 (47.41)	7094	1602 (22.58)
14	587	67 (11.41)	1511	192 (12.70)	2142	450 (21.00)	512	250 (48.82)	77	30 (38.96)	4829	989 (20.48)
15	1509	19 (1.25)	3677	69 (1.87)	6177	292 (4.72)	1463	213 (14.55)	197	27 (13.70)	13023	620 (4.76)
16	1274	62 (4.86)	3195	180 (5.63)	5386	565 (10.49)	1263	301 (23.83)	181	43 (23.75)	11299	1151 (10.18)
17	1201	65 (5.41)	2972	199 (6.69)	4900	677 (13.81)	1164	373 (32.04)	161	47 (29.19)	10398	1361 (13.08)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 25. Age-specific Morbidity Rates among Females in Moderately Affected Area during the years 1986-94

	Age Groups											
	0-4		5-14		15-44		45-64		65+		Total	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	1572	56 (3.56)	3760	86 (2.28)	6517	568 (8.71)	1427	168 (11.77)	290	29 (10.00)	13566	907 (6.68)
2	1498	75 (5.00)	3532	149 (4.21)	6152	989 (16.07)	1362	302 (22.17)	272	49 (18.01)	12816	1564 (12.20)
3	1567	97 (6.19)	3752	211 (5.62)	6439	1115 (17.31)	1425	384 (26.94)	286	65 (22.72)	13469	1872 (13.89)
4	526	57 (10.83)	1247	123 (9.86)	2132	514 (24.10)	479	205 (42.79)	91	30 (32.96)	4475	929 (20.75)
5	476	37 (7.77)	1107	99 (8.94)	1893	347 (18.33)	421	121 (28.74)	76	19 (25.00)	3973	623 (15.68)
6	419	26 (6.20)	1002	66 (6.58)	1686	281 (16.66)	377	102 (27.05)	71	10 (14.08)	3555	485 (13.64)
7	990	152 (15.35)	2496	364 (14.58)	4059	1427 (35.15)	923	507 (54.92)	180	72 (40.00)	8648	2522 (29.16)
8	998	160 (16.03)	2480	418 16.85)	4112	1480 (35.99)	924	537 (58.11)	173	78 (45.08)	8687	2673 (30.77)
9	942	150 (15.92)	2396	450 (18.18)	3919	1555 (39.67)	855	505 (59.06)	162	77 (47.53)	8274	2737 (33.07)
10	927	229 (24.70)	2448	639 (26.10)	3965	1731 (43.65)	840	532 (63.33)	161	81 (50.31)	8341	3212 (38.50)
11	920	194 (21.08)	2413	525 (21.75)	3791	1589 (41.91)	801	523 (65.29)	146	69 (47.26)	8071	2900 (35.93)
12	544	78 (14.33)	1412	252 (17.84)	2283	837 (36.66)	499	269 (63.90)	76	26 (34.21)	4814	1462 (30.36)
13	785	125 (15.92)	2079	356 (17.12)	3209	1269 (39.54)	665	399 (60.00)	124	54 (43.54)	6862	2203 (32.10)
14	532	83 (15.60)	1459	213 (14.59)	2211	792 (35.82)	427	237 (55.50)	82	35 (42.68)	4711	1360 (28.86)
15	1371	27 (1.96)	3425	77 (2.24)	5802	649 (11.18)	1232	240 (19.48)	219	28 (12.78)	12049	1021 (8.47)
16	1180	53 (4.49)	2951	202 (6.84)	5054	968 (19.15)	1089	307 (28.19)	187	35 (18.71)	10461	1565 (14.96)
17	1099	65 (5.91)	2765	200 (7.23)	4682	1155 (24.66)	1020	365 (35.18)	171	45 (26.31)	9737	1830 (18.79)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 26. Age-specific Morbidity Rates among Males in Mildly Affected Area during the years 1986-94

	Age Groups											
	0-4		5-14		15-44		45-64		65+		Total	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	808	6 (0.74)	2040	29 (1.42)	4127	117 (2.83)	916	50 (5.45)	233	14 (6.00)	8124	216 (2.65)
2	801	24 (2.99)	1967	66 (3.35)	3928	293 (7.45)	864	111 (12.84)	224	30 (13.39)	7784	524 (6.73)
3	779	17 (2.18)	1896	57 (3.00)	3839	392 (10.21)	841	133 (15.81)	206	29 (14.070	7561	628 (8.30)
4	536	29 (5.41)	1290	86 (6.66)	2488	215 (8.64)	551	115 (20.87)	117	32 (27.35)	4982	477 (9.57)
5	483	53 (10.97)	1170	80 (6.83)	2239	207 (9.24)	501	72 (14.37)	101	15 (14.85)	4494	427 (9.50)
6	473	35 (7.39)	1119	77 (6.88)	2051	215 (10.48)	467	133 (28.47)	91	34 (37.36)	4201	494 (11.75)
7	584	46 (7.87)	1461	87 (5.95)	2570	286 (11.12)	607	178 (29.32)	132	47 (35.60)	5354	644 (12.02)
8	548	60 (10.94)	1409	158 (11.21)	2445	362 (14.80)	572	239 (41.78)	117	65 (55.55)	5091	884 (17.36)
9	487	69 (14.17)	1285	208 (16.18)	2203	589 (26.73)	523	314 (60.03)	112	68 (60.71)	4610	1248 (27.07)
10	526	101 (19.20)	1353	217 (16.03)	2422	632 (26.09)	558	348 (62.36)	115	76 (66.08)	4974	1374 (27.62)
11	398	38 (9.54)	1047	125 (11.93)	1744	440 (25.22)	420	277 (65.95)	83	56 (67.46)	3674	936 (25.47)
12	354	21 (5.93)	925	99 (11.70)	1582	363 (22.94)	381	243 (63.77)	77	49 (63.63)	3319	775 (23.35)
13	383	30 (7.83)	979	108 (11.03)	1649	428 (25.95)	376	283 (75.26)	79	55 (69.62)	3466	904 (26.08)
14	430	31 (7.20)	1112	88 (7.91)	1879	475 (25.27)	437	296 (67.73)	82	50 (60.97)	3940	940 (23.85)
15	572	34 (5.94)	1499	100 (6.67)	2770	506 (18.26)	617	297 (48.13)	126	48 (38.09)	5584	985 (17.63)
16	551	44 (7.78)	1455	112 (7.69)	2731	492 (18.01)	594	279 (46.94)	119	43 (36.13)	5450	970 (17.79)
17	565	34 (6.01)	1434	95 (6.62)	2692	449 (16.67)	585	250 (42.73)	119	46 (38.65)	5395	874 (16.20)

Figures in parenthesis represent percentage morbidity, Cont.- contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 27. Age-specific Morbidity Rates among Females in Mildly Affected Area during the years 1986-94

	Age Groups											
	0-4		5-14		15-44		45-64		65+		Total	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	784	19 (2.42)	1845	28 (1.51)	3926	169 (4.30)	812	60 (7.38)	185	15 (2.70)	7551	291 (3.85)
2	760	26 {3.42)	1772	68 (3.83)	3786	421 (11.11)	788	116 (14.72)	158	16 (10.12)	7264	647 (8.90)
3	747	30 (4.01)	1667	65 (3.89)	3687	418 (11.33)	758	107 (14.11)	174	22 (12.64)	7133	642 (9.00)
4	509	30 (5.89)	1200	73 (6.08)	2419	348 (14.38)	479	130 (27.13)	96	24 (25.00)	4703	605 (12.86)
5	461	36 (7.80)	1076	79 (7.34)	2216	281 (12.68)	429	92 (21.44)	89	17 (19.10)	4271	505 (11.82)
6	415	41 (9.87)	1034	71 (6.86)	2052	361 (17.59)	402	144 (35.82)	78	24 (30.76)	3981	641 (16.10)
7	523	35 (6.69)	1333	89 (6.67)	2666	512 (19.20)	517	205 (39.65)	113	39 (34.51)	5152	880 (17.08)
8	497	65 (13.07)	1283	143 (1.14)	2519	614 (24.37)	485	256 (52.72)	105	48 (45.71)	4889	1126 (23.03)
9	437	68 (15.56)	1179	188 (15.94)	2284	860 (37.65)	444	315 (70.94)	99	53 (53.53)	4443	1484 (33.40)
10	496	87 (17.54)	1236	229 (18.52)	2462	885 (35.13)	484	328 (67.76)	98	50 (51.02)	4776	1579 (33.06)
11	362	37 (10.22)	979	138 (14.09)	1817	688 (37.86)	350	250 (71.42)	70	40 (57.14)	3578	1153 (32.22)
12	353	29 (8.21)	891	114 (12.79)	1680	564 (33.57)	333	243 (72.97)	75	47 (62.66)	3332	997 (29.92)
13	351	23 (6.55)	903	123 (13.62)	1757	676 (38.47)	315	258 (81.90)	65	42 (64.61)	3391	1122 (33.08)
14	390	23 (5.89)	1044	117 (11.20)	1989	750 (37.70)	376	285 (75.79)	77	48 (62.33)	3876	1223 (31.55)
15	523	30 (5.73)	1322	104 (7.86)	2776	757 (27.26)	536	285 (53.17)	102	42 (41.17)	5259	1218 (23.16)
16	507	45 (8.87)	1273	106 (8.32)	2732	711 (26.02)	540	278 (51.48)	94	41 (43.61)	5146	1181 (22.94)
17	507	26 (5.12)	1267	85 (6.70)	2707	680 (25.12)	529	266 (50.28)	89	36 (40.44)	5099	1093 (21.43)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 28. Age-specific Morbidity Rates among Males in Control Area during the years 1986-94

	Age Groups											
	0-4		5-14		15-44		45-64		65+		Total	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	909	13 (1.43)	1867	27 (1.44)	3604	35 (0.97)	641	24 (3.25)	123	4 (3.25)	7144	99 (1.38)
2	839	7 (0.83)	1721	15 (0.87)	3362	36 (1.07)	587	16 (2.72)	113	6 (5.30)	6622	80 (1.20)
3	944	34 (3.60)	1971	94 (4.76)	3721	103 (2.76)	649	17 (2.61)	116	2 (1.72)	7401	250 (3.37)
4	589	18 (3.05)	1131	18 (1.51)	1992	54 (2.71)	372	20 (5.36)	66	3 (4.54)	4150	113 (2.72)
5	517	34 (6.57)	1010	35 (3.46)	1748	92 (5.26)	330	44 (13.33)	58	7 (12.06)	3663	212 (5.78)
6	415	30 (7.22)	834	23 (2.75)	1419	58 (4.08)	273	27 (9.89)	46	1 (2.71)	2987	122 (4.08)
7	609	72 (11.82)	1241	103 (8.29)	2212	368 (16.63)	409	114 (27.87)	70	19 (27.14)	4541	676 (14.88)
8	637	69 (10.83)	1260	103 (8.17)	2386	367 (15.38)	403	127 (31.51)	74	21 (28.37)	4760	687 (14.43)
9	609	68 (11.16)	1247	129 (10.34)	2207	403 (18.26)	377	127 (33.68)	74	26 (35.13)	4514	753 (16.68)
10	607	103 (16.96)	1212	153 (12.62)	2166	462 (21.32)	372	158 (42.47)	64	26 (40.62)	4421	902 (20.40)
11	653	109 (16.69)	1362	172 (12.62)	2394	556 (23.22)	406	156 (38.42)	80	32 (40.00)	4895	1025 (20.93)
12	464	56 (12.06)	960	107 (11.14)	1682	267 (15.87)	294	101 (34.35)	56	20 (35.71)	3456	551 (15.94)
13	575	55 (9.56)	1175	108 (9.19)	2012	365 (18.14)	340	123 (36.17)	65	26 (40.00)	4167	677 (16.24)
14	610	35 (5.73)	1257	94 (7.47)	2187	301 (13.76)	352	110 (31.25)	65	21 (32.30)	4471	561 (12.54)
15	772	31 (4.01)	1564	56 (3.58)	2930	164 (5.59)	495	103 (20.80)	78	22 (28.20)	5839	376 (6.43)
16	743	34 (4.57)	1471	44 (2.99)	2839	103 (3.62)	447	63 (14.09)	71	14 (19.71)	5571	258 (4.63)
17	661	22 (3.32)	1308	41 (3.13)	2488	150 (6.02)	423	73 (17.25)	71	17 (23.94)	4951	303 (6.11)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 29. Age-specific Morbidity Rates among Females in Control Area during the years 1986-94

	Age Groups											
	0-4		5-14		15-44		45-64		65+		Total	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	788	16 (2.03)	1733	22 (1.26)	3031	9 (0.29)	492	16 (3.25)	106	3 (2.83)	6150	116 (1.88)
2	736	8 (1.08)	1594	16 (1.02)	2797	74 (2.64)	416	14 (3.36)	88	0 (0.00)	5631	112 (1.98)
3	823	29 (3.52)	1803	93 (5.15)	3156	142 (4.49)	476	28 (5.88)	99	3 (3.03)	6357	295 (4.64)
4	523	14 (2.67)	1055	29 (2.74)	1840	101 (5.48)	311	25 (8.03)	51	2 (3.92)	3780	171 (4.52)
5	463	23 (4.46)	953	43 (4.51)	1612	187 (11.60)	268	40 (14.92)	50	1 (2.00)	3346	294 (8.78)
6	372	46 (12.36)	795	27 (3.39)	1337	117 (8.75)	235	35 (14.89)	38	2 (5.26)	2777	197 (7.09)
7	505	48 (9.50)	1191	105 (8.81)	1976	567 (28.69)	327	125 (38.22)	58	20 (34.48)	4057	855 (21.07)
8	534	49 (9.17)	1215	119 (9.79)	2097	622 (29.66)	329	120 (36.47)	59	20 (33.89)	4234	930 (21.96)
9	497	57 (11.46)	1167	126 (1.02)	2052	656 (31.96)	323	126 (39.00)	48	15 (31.25)	4047	980 (24.21)
10	515	72 (13.98)	1113	155 (13.92)	1935	688 (35.55)	317	147 (46.37)	45	11 (24.44)	3925	1073 (27.33)
11	568	101 (17.78)	1280	181 (14.14)	2180	782 (35.87)	338	146 (43.14)	52	16 (30.76)	4418	1226 (27.75)
12	395	44 (11.13)	882	81 (9.18)	1506	477 (31.67)	238	101 (42.43)	32	11 (34.37)	3053	714 (23.38)
13	500	57 (11.4)	1135	99 (8.72)	1873	566 (30.21)	301	129 (42.85)	47	15 (31.91)	3856	866 (22.45)
14	534	39 (7.30)	1189	94 (7.90)	1988	471 (23.69)	307	121 (39.41)	52	16 (30.76)	4070	741 (18.20)
15	640	23 (3.59)	1452	43 (2.96)	2559	345 (13.48)	395	107 (27.08)	65	13 (20.00)	5111	531 (10.38)
16	601	38 (6.32)	1414	39 (2.75)	2400	264 (11.00)	351	66 (18.80)	62	9 (14.51)	4828	416 (8.61)
17	540	32 (5.92)	1264	38 (3.00)	2173	306 (14.08)	339	84 (24.77)	58	8 (13.79)	4374	468 (10.69)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 30. Lung Morbidity Rates among Males during the years 1986-94

	Area							
	Severe		Moderate		Mild		Control	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	9549	788 (8.26)	14842	386 (2.60)	8124	120 (1.47)	7144	36 (0.50)
2	10003	556 (5.55)	14014	473 (3.37)	7784	297 (3.81)	6622	25 (0.37)
3	10588	1278 (12.07)	14624	878 (6.00)	7561	361 (4.77)	7401	102 (1.37)
4	4974	346 (6.95)	4834	352 (7.28)	4982	253 (5.07)	4150	28 (0.67)
5	4210	533 (12.66)	4278	302 (7.05)	4494	252 (5.60)	3663	90 (2.45)
6	4342	460 (10.59)	3825	216 (5.64)	4201	271 (6.45)	2987	48 (1.60)
7	7581	1056 (13.92)	9008	1168 (12.96)	5354	371 (6.92)	4541	319 (7.02)
8	7296	1062 (14.55)	9216	1240 (13.45)	5091	511 (10.03)	4760	272 (5.71)
9	6592	1185 (17.97)	8622	1231 (14.27)	4610	750 (16.26)	4514	317 (7.02)
10	6345	1190 (18.75)	8756	1474 (16.83)	4974	824 (16.56)	4421	389 (8.79)
11	4319	1017 (23.54)	8350	1327 (15.89)	3674	591 (16.08)	4895	484 (9.88)
12	3974	723 (18.19)	5065	568 (11.21)	3319	503 (15.15)	3456	254 (7.34)
13	4885	851 (17.42	7094	908 (12.79)	3466	595 (17.16)	4167	321 (7.70)
14	5233	812 (15.51)	4829	587 (12.15)	3940	606 (15.38)	4471	238 (5.32)
15	8728	625 (7.16)	13023	420 (3.22)	5584	632 (11.31)	5839	176 (3.01)
16	7282	887 (12.18)	11299	752 (6.65)	5450	612 (11.22)	5571	125 (2.24)
17	8445	1069 (12.65)	10398	994 (9.55)	5395	576 (10.67)	4951	133 (2.68)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 31. Lung Morbidity Rates among Females during the years 1986-94

	Area							
	Severe		Moderate		Mild		Control	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	8695	750 (8.62)	13566	420 (3.09)	7551	134 (1.77)	6150	35 (0.56)
2	9127	490 (5.36)	12816	590 (4.60)	7264	281 (3.86)	5631	17 (0.30)
3	9687	1226 (12.66)	13469	1104 (8.19)	7133	297 (4.16)	6357	94 (1.47)
4	4524	311 (6.87)	4475	350 (7.82)	4703	250 (5.31)	3780	26 (0.68)
5	3845	526 (13.68)	3973	336 (8.45)	4271	254 (5.94)	3346	109 (3.25)
6	3987	385 (9.65)	3555	196 (5.51)	3981	308 (7.73)	2777	62 (2.23)
7	7025	951 (13.53)	8648	1275 (14.74)	5152	428 (8.30)	4057	283 (6.97)
8	6849	920 (13.43)	8687	1252 (14.41)	4889	593 (12.12)	4234	263 (6.21)
9	6222	1053 (16.92)	8274	1342 (16.21)	4443	785 (16.66)	4047	287 (7.09)
10	5927	1010 (17.04)	8341	1508 (18.07)	4776	855 (17.90)	3925	334 (8.50)
11	4119	872 (21.17)	8071	1504 (18.63)	3578	674 (18.83)	4418	453 (10.25)
12	3728	657 (17.62	4814	624 (12.96)	3332	566 (16.98)	3053	245 (8.02)
13	4618	817 (17.69)	6862	1011 (14.73)	3391	673 (19.84)	3856	271 (7.02)
14	4961	701 (14.13)	4711	650 (13.79)	3876	755 (19.47)	4070	211 (5.18)
15	8084	594 (7.34)	12049	537 (4.45)	5259	771 (14.66)	5111	180 (3.52)
16	6756	777 (11.50)	10461	878 (8.39)	5146	758 (14.72)	4828	128 (2.63)
17	7693	921 (11.97)	9737	1166 (11.97)	5099	716 (14.04)	4374	151 (3.46)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 32. Ophthalmic Morbidity Rates among Males during the years 1986-94

	Area							
	Severe		Moderate		Mild		Control	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	9549	200 (2.09)	14842	143 (.96)	8124	48 (.59)	7144	9 (0.12)
2	10003	150 (1.49)	14014	214 (1.52)	7784	99 (1.27)	6622	8 (0.12)
3	10588	375 (3.54)	14624	254 (1.73)	7561	65 (0.85)	7401	10 (0.13)
4	4974	121 (2.43)	4834	149 (3.08)	4982	112 (2.24)	4150	21 (0.51)
5	4210	124 (2.94)	4278	77 (1.79)	4494	89 (1.98)	3663	22 (0.60)
6	4342	138 (3.17)	3825	71 (1.85)	4201	85 (2.02)	2987	25 (0.85)
7	7581	372 (4.90)	9008	527 (5.85)	5354	118 (2.20)	4541	141 (3.10)
8	7296	393 (5.38)	9216	578 (6.27)	5091	174 (3.41)	4760	183 (3.84)
9	6592	559 (8.47)	8622	586 (6.79)	4610	395 (8.56)	4514	210 (4.65)
10	6345	541 (8.52)	8756	775 (8.85)	4974	536 (10.77)	4421	271 (6.12)
11	4319	476 (11.02)	8350	735 (8.80)	3674	489 (13.30)	4895	246 (5.02)
12	3974	360 (9.05)	5065	302 (5.96)	3319	394 (11.87)	3456	142 (4.10)
13	4885	552 (11.29)	7094	606 (8.54)	3466	569 (16.41)	4167	159 (3.81)
14	5233	508 (9.70)	4829	383 (7.93)	3940	600 (15.22)	4471	143 (3.19)
15	8728	384 (4.39)	13023	280 (2.15)	5584	595 (10.66)	5839	111 (1.90)
16	7282	490 (6.72)	11299	444 (3.92)	5450	558 (10.23)	5571	71 (1.27)
17	8445	635 (7.5)	10398	616 (5.92)	5395	576 (10.67)	4951	118 (2.38)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 33. Ophthalmic Morbidity Rates among Females during the years 1986-94

Visits (1986-94)	Area							
	Severe		Moderate		Mild		Control	
	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	8695	250 (2.87)	13566	420 (3.09)	7551	134 (1.77)	6150	35 (5.69)
2	9127	217 (2.37)	12816	590 (4.60)	7264	281 (3.86)	5631	17 (0.30)
3	9687	400 (4.12)	13469	1104 (8.19)	7133	297 (4.16)	6357	94 (1.47)
4	4524	143 (3.16)	4475	350 (7.82)	4703	250 (5.31)	3780	26 (0.68)
5	3845	213 (5.53)	3973	336 (8.45)	4271	254 (5.94)	3346	109 (3.25)
6	3987	174 (4.36)	3555	196 (5.51)	3981	308 (7.73)	2777	62 (2.23)
7	7025	465 (6.61)	8648	1275 (14.74)	5152	428 (8.30)	4057	283 (4.97)
8	6849	482 (7.03)	8687	1252 (14.41)	4889	593 (12.12)	4234	263 (6.21)
9	6222	669 (10.75)	8274	1342 (16.21)	4443	785 (17.66)	4047	287 (7.09)
10	5927	642 (10.83)	8341	1508 (18.07)	4776	855 (17.90)	3925	334 (8.50)
11	4119	596 (14.46)	8071	1504 (18.63)	3578	674 (18.83)	4418	453 (10.25)
12	3728	468 (12.55)	4814	624 (12.96)	3332	566 (16.78)	3053	245 (8.02)
13	4618	723 (15.65)	6862	1011 (14.73)	3391	673 (19.84)	3856	271 (7.02)
14	4961	594 (11.97)	4711	650 (13.79)	3876	755 (19.47)	4070	211 (5.18)
15	8084	440 (5.44)	12049	537 (4.45)	5259	771 (14.66)	5111	180 (3.52)
16	6756	586 (8.67)	10461	878 (8.39)	5146	758 (14.72)	4828	128 (2.65)
17	7693	756 (9.82)	9737	1166 (11.97)	5099	716 (14.04)	4374	151 (3.45)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 34. Gastro Intestinal Tract Morbidity Rates among Males during the years 1986-94

Visits (1986-94)	Area							
	Severe		Moderate		Mild		Control	
	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	9549	227 (2.37)	14842	149 (1.00)	8124	47 (0.57)	7144	25 (0.34)
2	10003	211 (2.10)	14014	188 (1.34)	7784	161 (2.06)	6622	19 (0.28)
3	10588	394 (3.72)	14624	242 (1.65)	7561	157 (2.07)	7401	59 (0.79)
4	4974	156 (3.13)	4834	148 (3.06)	4982	104 (2.08)	4150	20 (0.48)
5	4210	164 (3.89)	4278	96 (2.24)	4494	102 (2.26)	3663	39 (1.06)
6	4342	196 (4.51)	3825	63 (1.640	4201	110 (2.61)	2987	28 (0.93)
7	7581	363 (4.78)	9008	444 (4.92)	5354	122 (2.27)	4541	152 (3.34)
8	7296	419 (5.74)	9216	502 (5.44)	5091	173 (3.39)	4760	162 (3.40)
9	6592	392 (5.94)	8622	445 (5.16)	4610	273 (5.92)	4514	199 (4.40)
10	6345	417 (6.57)	8756	630 (7.19)	4974	302 (6.07)	4421	258 (5.83)
11	4319	256 (5.92)	8350	455 (5.44)	3674	206 (5.00)	4895	282 (5.76)
12	3974	274 (6.89)	5065	229 (4.52)	3319	172 (5.18)	3456	148 (4.28)
13	4885	249 (5.09)	7094	328 (4.62)	3466	221 (6.37)	4167	147 (3.52)
14	5233	275 5.25)	4829	218 (4.51)	3940	241 (6.11)	4471	130 (2.90)
15	8728	184 (2.10)	13023	85 (0.65)	5584	271 (4.85)	5839	58 (0.99)
16	7282	348 (4.77)	11299	200 (1.77)	5450	268 (4.91)	5571	57 (1.02)
17	8445	363 (4.29)	10398	271 (2.60)	5395	248 (4.59)	4951	56 (1.13)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 35. Gastro Intestinal Tract Morbidity Rates among Females during the years 1986-94

	Area							
	Severe		Moderate		Mild		Control	
Visits (1986-94)	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	8695	333 (3.82)	13566	197 (1.45)	7551	73 (0.96)	6150	23 (0.37)
2	9127	306 (3.35)	12816	295 (2.30)	7264	211 (2.90)	5631	28 (0.49)
3	9687	552 (5.69)	13469	352 (2.61)	7133	134 (1.87)	6357	70 (1.10)
4	4524	215 (4.75)	4475	252 (5.763)	4703	147 (3.12)	3780	33 (0.87)
5	3845	226 (0.57)	3973	159 (4.00)	4271	117 (2.73)	3346	48 (1.43)
6	3987	251 (6.29)	3555	82 (2.30)	3981	166 (4.16)	2777	51 (1.83)
7	7025	426 (6.06)	8648	534 (6.17)	5152	174 (3.37)	4057	197 (4.85)
8	6849	527 (7.69)	8687	663 (7.63)	4889	223 (4.56)	4234	201 (4.74)
9	6222	506 (8.13)	8274	680 (8.21)	4443	289 (6.50)	4047	258 (6.37)
10	5927	499 (8.41)	8341	800 (9.59)	4776	316 (6.61)	3925	388 (9.88)
11	4119	351 (8.52)	8071	678 (8.40)	3578	231 (6.45)	4418	313 (7.08)
12	3728	309 (8.28)	4814	352 (7.31)	3332	208 (6.24)	3053	174 (5.69)
13	4618	300 (6.49)	6862	493 (7.18)	3391	258 (7.60)	3856	196 (5.08)
14	4961	339 (6.83)	4711	296 (6.28)	3876	305 (7.86)	4070	159 (3.90)
15	8084	267 (3.30)	12049	208 (1.72)	5259	322 (6.12)	5111	69 (1.35)
16	6756	390 (5.77)	10461	296 (2.82)	5146	307 (5.96)	4828	109 (2.25)
17	7693	434 (6.64)	9737	401 (4.11)	5099	279 (5.47)	4374	87 (1.98)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 36. Skin Morbidity Rates among Males during the years 1986-94

Visits (1986-94)	Area							
	Severe		Moderate		Mild		Control	
	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid
1	9549	92 (0.96)	14842	94 (0.63)	8124	22 (0.27)	7144	10 (0.13)
2	10003	106 (1.05)	14014	106 (0.75)	7784	60 (0.77)	6622	7 (0.10)
3	10588	236 (2.22)	14624	129 (0.88)	7561	26 (0.34)	7401	35 (0.47)
4	4974	83 (1.66)	4834	50 (1.03)	4982	44 (0.88)	4150	8 (0.19)
5	4210	71 (1.68)	4278	28 (0.65)	4494	36 (0.80)	3663	25 (0.68)
6	4342	86 (1.98)	3825	26 (0.67)	4201	25 (0.59)	2987	10 (0.33)
7	7581	100 (1.31)	9008	91 (1.01)	5354	38 (0.700	4541	45 (0.99)
8	7296	157 (2.15)	9216	157 (1.70)	5091	52 (1.02)	4760	46 (0.96)
9	6592	150 (2.27)	8622	104 (1.20)	4610	53 (1.14)	4514	53 (1.17)
10	6345	159 (2.50)	8756	176 (2.01)	4974	73 (1.46)	4421	77 (1.74)
11	4319	113 (2.61)	8350	166 (1.98)	3674	35 (0.95)	4895	73 (1.49)
12	3974	100 (2.51)	5065	91 (1.79)	3319	24 (0.72)	3456	44 (1.27)
13	4885	85 (1.74)	7094	100 (1.40)	3466	25 (0.72)	4167	55 (1.31)
14	5233	106 (2.02)	4829	50 (1.03)	3940	16 (0.40)	4471	41 (0.91)
15	8728	64 (0.73)	13023	25 (0.19)	5584	24 (0.42)	5839	18 (0.30)
16	7282	113 (1.55)	11299	70 (6.61)	5450	23 (0.42)	5571	17 (0.30)
17	8445	94 (1.110	10398	56 (0.53)	5395	25 (0.46)	4951	7 (0.14)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 37. Skin Morbidity Rates among Females during the years 1986-94

Visits (1986-94)	Area							
	Severe		Moderate		Mild		Control	
	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No. Cont.	No. Morbid	No Cont.	No. Morbid
1	8695	95 (1.09)	13566	85 (0.68)	7551	31 (0.41)	6150	14 (0.22)
2	9127	93 (1.01)	12816	92 (0.71)	7264	92 (1.26)	5631	12 (0.21)
3	9687	205 (2.11)	13469	162 (1.20)	7133	26 (0.36)	6357	37 (0.58)
4	4524	957 (21.15)	4475	53 (1.18)	4703	42 (0.89)	3780	16 (0.42)
5	3845	45 (1.17)	3973	27 (0.67)	4271	34 (0.79)	3346	23 (0.68)
6	3987	60 (1.50)	3555	27 (0.75)	3981	43 (1.08)	2777	15 (0.54)
7	7025	115 (1.63)	8648	105 (1.21)	5152	45 (0.87)	4057	41 (1.01)
8	6849	106 (1.54)	8687	136 (1.56)	4889	51 (1.04)	4234	37 (0.87)
9	6222	136 (2.18)	8274	134 (1.61)	4443	91 (2.04)	4047	53 (1.30)
10	5927	132 (2.22)	8341	179 (2.14)	4776	78 (1.63)	3925	44 (1.12)
11	4119	98 (2.37)	8071	163 (2.01)	3578	37 (1.03)	4418	69 (1.56)
12	3728	67 (1.79)	4814	99 (2.05)	3332	23 (0.69)	3053	31 (1.01)
13	4618	74 (1.60)	6862	113 (1.64)	3391	28 (0.82)	3856	54 (1.40)
14	4961	77 (1.55)	4711	66 (1.40)	3876	15 (0.38)	4070	44 (1.08)
15	8084	60 (0.74)	12049	31 (0.25)	5259	18 (0.34)	5111	27 (0.52)
16	6756	84 (1.24)	10461	62 (0.51)	5146	21 (0.40)	4828	20 (0.41)
17	7693	96 (1.24)	9737	67 (0.68)	5099	20 (0.39)	4374	22 (0.50)

Figures in parenthesis represent percentage morbidity, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88 6=May88-Nov88
7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90 11=Nov90-May91 12=May91-Nov91
13=Nov91-May92 14=May92-Nov92 15=Nov92-May93 16=May93-Nov93 17=Nov93-May94

Table 38. Comparison between Cohort and Cross Sectional Pulmonary Morbidity Rates in Severely Affected Males and Females during the years 1986-94

Visits	Males				Females			
	Cross-sectional		Cohort		Cross-sectional		Cohort	
(1986-94)	No. Cont.	Morbidity	No. Cont.	Morbidity	No. Cont.	Morbidity	No. Cont.	Morbidity
1	9549	788 (8.26)	565	95 (16.81)	8695	750 (8.62)	522	92 (16.62)
2	10003	556 (5.55)	565	59 (10.44)	9127	490 (5.36)	522	39 (7.47)
3	10588	1278 (12.07)	565	92 (16.28)	9687	1226 (12.66)	522	98 (18.77)
4	4974	346 (6.95)	355	19 (5.35)	4524	311 (6.87)	316	23 (7.28)
5	4210	533 (12.66)	355	56 (15.77)	3845	526 (13.68)	316	52 (16.46)
6	4342	460 (10.59)	355	61 (17.17)	3987	385 (9.65)	316	30 (9.49)
7	7581	1056 (13.92)	565	95 (16.81)	7025	951 (13.53)	522	77 (14.75)
8	7296	1062 (14.55)	565	82 (14.51)	6849	920 (13.43)	522	75 (14.37)
9	6592	1185 (17.97)	565	116 (20.53)	6222	1053 (16.92)	522	96 (18.39)
10	6345	1190 (18.75)	565	97 (17.17)	5927	1010 (17.04)	522	85 (16.28)
11	4319	1017 (23.54)	565	146 (25.84)	4119	872 (21.17)	522	107 (20.50)
12	3974	723 (18.19)	565	101 (17.88)	3728	657 (17.62)	522	94 (18.01)
13	4885	851 (17.42)	565	122 (21.59)	4618	817 (17.69)	522	103 (19.73)
14	5233	812 (15.51)	565	94 (16.64)	4961	701 (14.13)	522	85 (16.28)
15	8728	625 (7.16)	565	79 (13.98)	8084	594 (7.34)	522	70 (13.41)
16	7282	887 (12.18)	565	89 (15.75)	6756	777 (11.5)	522	78 (14.94)
17	8445	1069 (12.65)	565	121 (21.42)	7693	921 (11.97)	522	82 (15.71)

Figures in parenthesis represent percentages, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88
6=May88-Nov88 7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90
11=Nov90-May91 12=May91-Nov91 13=Nov91-May92 14=May92-Nov92 15=Nov92-May93
16=May93-Nov93 17=Nov93-May94

Table 39. Comparison between Cohort and Cross Sectional Pulmonary Morbidity Rates in Moderately Affected Males and Females during the years 1986-94

Visits	Males				Females			
	Cross-sectional		Cohort		Cross-sectional		Cohort	
(1986-94)	No. Cont.	Morbidity	No. Cont.	Morbidity	No. Cont.	Morbidity	No. Cont.	Morbidity
1	9549	788 (8.26)	565	95 (16.81)	8695	750 (8.62)	522	92 (16.62)
2	10003	556 (5.55)	565	59 (10.44)	9127	490 (5.36)	522	39 (7.47)
3	10588	1278 (12.07)	565	92 (16.28)	9687	1226 (12.66)	522	98 (18.77)
4	4974	346 (6.95)	355	19 (5.35)	4524	311 (6.87)	316	23 (7.28)
5	4210	533 (12.66)	355	56 (15.77)	3845	526 (13.68)	316	52 (16.46)
6	4342	460 (10.59)	355	61 (17.17)	3987	385 (9.65)	316	30 (9.49)
7	7581	1056 (13.92)	565	95 (16.81)	7025	951 (13.53)	522	77 (14.75)
8	7296	1062 (14.55)	565	82 (14.51)	6849	920 (13.43)	522	75 (14.37)
9	6592	1185 (17.97)	565	116 (20.53)	6222	1053 (16.92)	522	96 (18.39)
10	6345	1190 (18.75)	565	97 (17.17)	5927	1010 (17.04)	522	85 (16.28)
11	4319	1017 (23.54)	565	146 (25.84)	4119	872 (21.17)	522	107 (20.50)
12	3974	723 (18.19)	565	101 (17.88)	3728	657 (17.62)	522	94 (18.01)
13	4885	851 (17.42)	565	122 (21.59)	4618	817 (17.69)	522	103 (19.73)
14	5233	812 (15.51)	565	94 (16.64)	4961	701 (14.13)	522	85 (16.28)
15	8728	625 (7.16)	565	79 (13.98)	8084	594 (7.34)	522	70 (13.41)
16	7282	887 (12.18)	565	89 (15.75)	6756	777 (11.5)	522	78 (14.94)
17	8445	1069 (12.65)	565	121 (21.42)	7693	921 (11.97)	522	82 (15.71)

Figures in parenthesis represent percentages, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88
6=May88-Nov88 7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90
11=Nov90-May91 12=May91-Nov91 13=Nov91-May92 14=May92-Nov92 15=Nov92-May93
16=May93-Nov93 17=Nov93-May94

Table 40. Comparison between Cohort and Cross Sectional Pulmonary Morbidity Rates in Mildly Affected Males and Females during the years 1986-94

Visits (1986-94)	Males				Females			
	Cross-sectional		Cohort		Cross-sectional		Cohort	
	No. Cont.	Morbidity	No. Cont.	Morbidity	No. Cont.	Morbidity	No. Cont.	Morbidity
1	8124	120 (1.47)	563	1 (0.18)	7551	134 (1.77)	584	16 (2.74)
2	7784	297 (3.81)	563	16 (2.84)	7264	281 (3.86)	584	30 (5.14)
3	7561	361 (4.77)	563	19 (3.37)	7133	297 (4.16)	584	27 (4.62)
4	4982	253 (5.07)	324	18 (5.56)	4703	250 (5.31)	320	26 (8.13)
5	4494	252 (5.6)	324	26 (8.02)	4271	254 (5.94)	320	34 (7.50)
6	4201	271 (6.45)	324	21 (6.48)	3981	308 (7.73)	320	35 (10.94)
7	5354	371 (6.92)	563	36 (6.39)	5152	428 (8.3)	584	50 (8.56)
8	5091	511 (10.03)	563	46 (8.17)	4889	593 (12.12)	584	73 (12.50)
9	4610	750 (16.26)	563	93 (16.52)	4443	785 (16.66)	584	104 (17.81)
10	4974	824 (16.56)	563	109 (19.36)	4776	855 (17.9)	584	138 (23.63)
11	3674	591 (16.08)	563	106 (18.83)	3578	674 (18.83)	584	135 (23.12)
12	3319	503 (15.15)	563	88 (15.63)	3332	566 (16.98)	584	121 (20.72)
13	3466	595 (17.16)	563	98 (17.41)	3391	673 (19.84)	584	139 (23.80)
14	3940	606 (15.38)	563	92 (16.34)	3876	755 (19.47)	584	136 (23.29)
15	5584	632 (11.31)	563	91 (16.16)	5259	771 (14.66)	584	137 (23.46)
16	5450	612 (11.22)	563	96 (17.05)	5146	758 (14.72)	584	139 (23.80)
17	5395	576 (10.67)	563	85 (15.10)	5099	716 (14.04)	584	124 (21.23)

Figures in parenthesis represent percentages, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88
6=May88-Nov88 7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90
11=Nov90-May91 12=May91-Nov91 13=Nov91-May92 14=May92-Nov92 15=Nov92-May93
16=May93-Nov93 17=Nov93-May94

Table 41. Comparison between Cohort and Cross Sectional Pulmonary Morbidity Rates in Control Males and Females during the years 1986-94

	Males				Females			
Visits	Cross-sectional		Cohort		Cross-sectional		Cohort	
(1986-94)	No. Cont.	Morbidity	No. Cont.	Morbidity	No. Cont.	Morbidity	No. Cont.	Morbidity
1	7144	36 (0.5)	488	2 (0.41)	6150	35 (0.56)	438	2 (0.46)
2	6622	25 (0.37)	488	4 (0.82)	5631	17 (0.3)	438	3 (0.68)
3	7401	102 (1.37)	488	8 (1.64)	6357	94 (1.47)	438	10 (2.28)
4	4150	28 (0.67)	389	5 (1.29)	3780	26 (0.68)	337	4 (1.19)
5	3663	90 (2.45)	389	12 (3.08)	3346	109 (3.25)	337	12 (3.56)
6	2987	48 (1.6)	389	8 (2.06)	2777	62 (2.23)	337	9 (2.67)
7	4541	319 (7.02)	488	38 (7.79)	4057	283 (6.97)	438	35 (7.99)
8	4760	272 (5.71)	488	41 (8.40)	4234	263 (6.21)	438	35 (7.99)
9	4514	317 (7.02)	488	38 (7.79)	4047	287 (7.09)	438	38 (8.68)
10	4421	389 (8.79)	488	39 (7.99)	3925	334 (8.5)	438	47 (10.73)
11	4895	484 (9.88)	488	60 (12.30)	4418	453 (10.25)	438	63 (14.38)
12	3456	254 (7.34)	488	41 (8.40)	3053	245 (8.02)	438	28 (6.39)
13	4167	321 (7.7)	488	53 (10.86)	3856	271 (7.02)	438	38 (8.68)
14	4471	238 (5.32)	488	26 (5.33)	4070	211 (5.18)	438	22 (5.02)
15	5839	176 (3.01)	488	31 (6.35)	5111	180 (3.52)	438	26 (5.94)
16	5571	125 (2.24)	488	14 (2.87)	4828	128 (2.63)	438	22 (5.02)
17	4951	133 (2.68)	488	19 (3.89)	4374	151 (3.46)	438	26 (5.94)

Figures in parenthesis represent percentages, Cont. - contacted

1=16Jan86-31Jan86 2=16Jun86-30Jun86 3=26Oct86-25Nov86 4=May87-Nov87 5=Nov87-May88
6=May88-Nov88 7=Nov88-May89 8=May89-Nov89 9=Nov89-May90 10=May90-Nov90
11=Nov90-May91 12=May91-Nov91 13=Nov91-May92 14=May92-Nov92 15=Nov92-May93
16=May93-Nov93 17=Nov93-May94

Table 42. Abortion and Still Birth Rates in Exposed and Control Areas during the years 1984-89

Year	Severe			Moderate			Mild			Control		
	Total Preg.	Abortion	Still Birth	Total Preg.	Abortion	Still Birth	Total Preg.	Abortion	Still Birth	Total Preg.	Abortion	Still Birth
1984	195	102	4	160	62	1	30	6	1	36	3	1
	(523.0)		(20.5)		(387.5)	(6.250)		(200)	(33.3)		(83.3)	(27.7)
1985	1261	169	21	1257	158	32	437	65	12	359	8	8
	(134.0)		(16.6)		(125.7)	(25.45)		(148.75)	(27.45)		(22.28)	(22.28)
1986	0949	122	24	478	72	22	319	19	10	329	13	3
	(128.5)		(25.3)		(150.6)	(46.0)		(59.5)	(31.3)		(39.5)	(9.0)
1987	125	18	0	222	30	2	98	8	1	167	8	4
	(14.4)		(0.0)		(135.0)	(9.0)		(81.6)	(10.0)		(47.9)	(23.9)
1988	277	19	2	253	8	3	104	9	3	137	1	2
	(68.6)		(7.2)		(31.6)	(11.8)		(86.5)	(28.8)		(7.3)	(14.0)
1989	451	35	5	325	23	7	138	13	1	205	5	3
	(77.0)		(11.1)		(70.7)	(21.5)		(94.2)	(7.3)		(24.0)	(14.4)

Figures in parenthesis represent rate per 1000

Annexure V

List of Charts