Research Article

INFANT MORTALITY AND THEIR CAUSES AMONG MIC LEAK EXPOSED COHORT IN 1984: 24 YEARS OF EXPERIENCE

Sushil Singh[1] and Nalok Banerjee[2]

ICMR-National Institute for Research in Environmental Health (ICMR), Kamla Nehru Hospital, Bhopal (M.P.), India

ARTICLE INFO	ABSTRACT

Back ground: One of the biggest chemical disasters resulting in tragic loss of human life accounting for more than 2500 deaths and serious damage to thousands of people, animal and plants took place in Bhopal (Madhya Pradesh, India). The disaster followed leakage of large quantity of highly toxic gas on the mid night of 2nd-3rd Decmber,1984 at the union Carbide Factory in Bhopal from stainless steel Tank No.610 Besides death, it led to multisystem/organ involvement, by symptomatic morbidities (lungs/ eyes main target organs) which caused high infant mortality .

Methodology: To study mortalities and morbidities besides other objectives a long term Prospective epidemiological study was planned through six community health clinics to follow the cohort of affected people living in gas affected area an a matched control living in distant are a through six monthly house to house survey. Interview of head of family or an adult respondent was taken on the visit.

Results: Over the 24 years of the data collection exercise reveals that after acute stage was over the mortalities came down to levels or lower than the national averages for matching age groups. However respiratory causes were the main reason for the mortalities, among both affected as well as control cohort. Respiratory, ophthalmic, gastrointestinal and skin morbidities attained a plateau since 1999 where all morbidities are occurring within 20%. We found that control area was very near to national urban infant mortality rate but affected area infant mortality rate were lower than the national figure in the year 2010.The Government has increased access to minimum essential services at door step that would significantly reduce high infant mortality rate.

INTRODUCTION

One of the biggest chemical disasters resulting in tragic loss of human life accounting for more than 2500 deaths and serious damage to thousands of people, animal and plants took place in Bhopal (Madhya Pradesh, India). The disaster followed leakage of large quantity of highly toxic gas on the mid night of 2nd-3rd Decmber, 1984 at the union Carbide Factory from stainless steel Tank No.610[1,2].

Looking in to multi organ damage observed in survivors and the unknown quantum and nature of toxicants as on date, a long term epidemiological study was launched to understand the morbidity status among the exposed population. The objectives of this study were a)To register cohorts in the affected and unaffected (control) areas and collect baseline data on socio-economic and demographic profiles and study the changes over a period of time in context of the exposure to the toxic gas. b) To observe mortality and morbidity in the registered cohorts and comparable control and establish a relationship with the grades of exposure of the affected population [1].

Infant mortality rate is indicators of life and socio-economic conditions of country. This recognition has made the Government to intensify their efforts to reduce infant mortality. As a result, their have been considerable improvements in the infant mortality rate. The National plan of action for children, 2005 commits itself to ensure all rights to all children upto the age of 18 years. To ensure child survival, the goals setup in the National plan below 30, and neonatal mortality below 18 per 1000 lives births by 2010. The pace of reducing child deaths has accelerated sharply since 2000, according to new release in September, 2012 by the world Health Organization, UNICEF, the UN Population Division and the World Bank. The gains in child survival, although significant, are still insufficient to achieve Millennium Development Goal 4 of reducing the global under- five rate by two-thirds between 1990 and 2015.

Corresponding author: **Sushil Singh**

ICMR-National Institute for Research in Environmental Health (ICMR), Kamla Nehru Hospital, Bhopal (M.P.), India

In 2012, the percentage of neonatal deaths to total infant deaths is 68.5 percent at national level and varies from 56.8 percent in urban areas to 70.4 percent in rural areas. Cost effective interventions are required at the community level for accelerating the reduction in under–five mortality by expending preventive and curative interventions that target the most vulnerable children. Infant mortality and Child mortality trends, differentials, and determinations in India have been the subject of various studies. These studies have provided a framework for analyzing factors that contributed to it. These included proximate factors (such as antenatal period, care at birth, and preventive and curative care in the postnatal period);maternal factors(age, parity and birth interval);and household and community level factors (water, sanitation and housing). These studies concluded that a substantial decline in infant mortality rate is possible without significant improvement in economic development with no service gaps. These purpose increased access to minimum package of essential services at door step that would significantly reduce high infant mortality rate; reproductive health services; prenatal care; immunization; improved breastfeeding practice; timely introduction of supplementary foods; home based treatment diarrhoea [6].

The present paper deals only with long term Infant mortalities to analyze the levels and trends in infant mortality and provide a reference tool to appraise the progress in infant and child mortality to develop the implement initiatives with proven success to improve the status of children.

MATERIAL AND METHODS

It was observed that out of 56 ward of Bhopal Municipal Corporation 36 (population- 559835) suffered toxic gas exposure while remaining 20 was declared (population-334703) non-exposed. The affected area was divided in to three areas based on mortality rate experienced during 3-6 December 1984. The epidemiological study drew its sample form those areas and a population of 80021was sampled from those areas (Table-1) A population of 15931 as control population was selected from localities located about 9 kms, away after matching it for their socioeconomic status like age and sex.

The study was designed to be executed through six community health clinics. Each community health clinic was headed by an Assistant Research Officer (Medical) and four Research Assistants (RA); one each for one locality. Research Assistants were to ask and record all the information regarding morbidity, mortality, vital events, pregnancy outcome within the registered cohort since last visit (six months back). The Assistant Research Officer was assigned to maintain quality control, to provide primary health care and referral services, to record morbidity pattern through the clinics and support other research activities.

Six monthly data on mortality, symptomatic morbidity and vital events was being collected through house to house visit through interview of "Head" of the household. The morbidity data was collected on the basis of symptoms. A list of 40 symptoms was provided to the RA for this purpose.

Data validation exercises were in built in the study. These were planned to be conducted at field, pre analysis and analysis level. At Field level, the ARO were supposed to verify all the work done by RAs. All the Families with morbidity and 10 % of the families without morbidity were visited by ARO to verify the accuracy of the collected morbidity data.100 % of the deaths in the cohort were supposed to be verified by ARO in accordance to the International Classification of the diseases. At Pre analysis level data was scrutinized at statistical unit for missing information, discrepancy and inconsistency. The data needed correction, if required was sent to the field. At analysis level during computer analysis the data was to be checked for duplication of information or any other inconsistency.

On completion of every six monthly survey, a report was generated. Present paper is culmination of the reports generated and data analysis during 1996-2010.

Observations

Data of the study has been presented under four headings namely cohort progression, demographic and socio-economic profile, mortality and morbidity profile. The data for crisp presentation has been presented at five year interval in tables.

Table 1 Affected area severity wise and population and sample for studies

Area ward (Population) (Esti-1985)	Affected Zones (Population)(Esti-1985) Death rate/1000$	Wards no[#]	Localites[#]	Population Covered for acute stage study (Aug-Oct 1985)	Population for present study in 1986
Affected Wards-36 (559835)	Severe (34879) 21.98	13,20	1,2,7,8,	26382	19260
	Moderate (77239) 1.33	11,08,14,45,46	3,4,5,6,9,10	34964	28261
	Mild (447717) 0.29	7,9,12,44	11,12,13	18675	15185
Sub total	559835	11	13	80021	62706
Unaffected/ control Wards 20 (334703)	(334703)	54,55,36	14,15,16	15931	13526
Grand Total	894538	14	16	95952	76232
#under study, Esti- estimated) , $ death rate 3-6 December 1984					

1. ***Socioeconomic Profile:*** over the period of 1986- 2010 educational status has improved in all areas and proportional literacy has increase up to secondary level. Per capita income in the affected as well as in control area too has improved 1986- 2010[3].

2. It is well known that Smoking is a strong contributor to the respiratory morbidities and the cancer hence, it was specifically monitored. It was found that over the period of study smoking has increase in affected area and in control area and these findings are in agreement with that of population based Cancer Registry[4].

Mortality

Annual Mortality

Immediate post exposure (4th -31st December 1984) mortality was very high i.e. 12.57/1000 for males and 11.6/1000 for females in severely affected area. Correspondingly in moderate area it was 0.71 and 0.56 and in mild area it was 0.1 and 0.22. It was higher to that observed in control area [1] (0.35 and 0.41 respectively)[1].
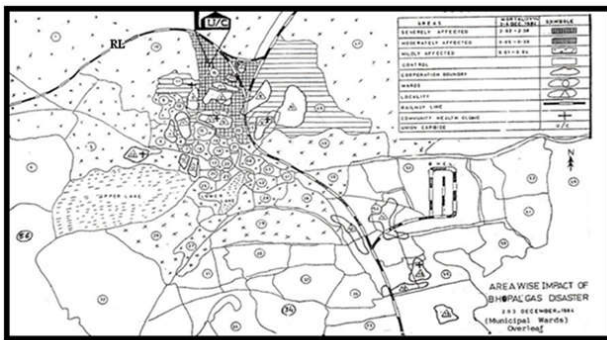

Fig.1 Affected area on the basis of Mortality (ICMR:Epidemiological study)

During 1985 to 1993 the annual mortality figures in severe area ranged between 7.4 -3.4, for males and 7.8-1.6 for females. For moderate area these figures ranged between 6.5-3.2 for males and 5.4-2.6 for females and in mild area 6.1-2.5 and 4.6-2.4 for females. In control area these figures ranged 3.9 and 1.9 in males and 4.2 and 1.9 in females. [1] Generally a decreasing trend in death rates have been observed in all the areas. However, the death rates were observed to be higher in affected area in comparison to control.

Table 2 Infant Mortality Rate (1996-2010)

Year	Affected Area			Control Area		
	Live Birth	Infant death	Infant mortality rate	Live Birth	Infant death	Infant mortality rate
1996-2000	3192	83	26.0	801	33	41.19
2001-2005	2211	50	22.61	722	30	41.55
2006-2010	2420	55	22.72	908	27	29.73

*National Urban Infant Mortality rate(SRS,1991-2013) – 44, 40 and 31 per 1000 live birth for the year 2000, 2005 and 2010 respectively.

Table 3 Neonatal Mortality Rate (1996-2010)

Year	Affected Area			Control Area		
	Live Birth	Neonatal Death	Neonatal mortality rate	Live Birth	Neonatal Death	Neonatal mortality rate
1996-2000	3192	51	15.98	801	23	28.72
2001-2005	2211	30	13.57	722	20	27.7
2006-2010	2420	30	12.40	908	13	14.32

*National Urban Neonatal Mortality rate(SRS,1991-2013) – 44, 37 and 33 per 1000 live birth for the year 2000, 2005 and 2010 respectively.

Table 4 Post Neonatal Mortality Rate (1996-2010)

Year	Affected Area			Control Area		
	Live Birth	Post Neonatal death	Post Neonatal mortality rate	Live Birth	Post Neonatal death	Post Neonatal mortality rate
1996-2000	3192	36	11.28	801	10	12.48
2001-2005	2211	21	9.50	722	10	13.85
2006-2010	2420	22	9.09	908	14	15.42

*National Urban Post Neonatal Mortality rate(SRS,1991-2013) – 24, 21 and 14 per 1000 live birth for the year 2000, 2005 and 2010 respectively.

Table 5 Primary cause of Infant Mortality during the years 1996-2000, 2001-2005, 2006-2010

Affected area

Cause	1996-2000	%	2001-2005	%	2006-2010	%
Accident & Injuries	0	0	0	0	1	1.9
Child Birth & Pregnancy	2	2.5	3	5.8	4	7.7
Fever	12	14.8	4	7.9	3	5.8
Digestive disorders	8	9.9	1	2	6	11.6
Respiratory Disorders	8	9.9	2	3.9	2	3.8
C.N.S. disorders	0	0	0	0	2	3.8
C.V.S. disorders	1	1.2	0	0	0	0
Other system disorders	0	0	1	2	1	1.9
Cause peculiar to infancy	50	61.7	38	74.5	33	63.5
Cause Unknown	0	0	2	3.9	0	0
Total	81		51		52	

Table 6 Primary cause of Infant Mortality during the years 1996-2000,2001-2005,2006-2010

Control area

Cause	1996-2000	%	2001-2005	%	2006-2010	%
Accident & Injuries	0	0	0	0	2	7.4
Child Birth & Pregnancy	0	0	1	3.4	0	0
Fever	10	30.3	4	13.4	7	25.9
Digestive disorders	4	12.2	2	6.6	0	0
Respiratory Disorders	0	0	2	6.6	1	3.7
C.N.S. disorders	1	3.0	0	0	1	3.7
C.V.S. disorders	0	0	0	0	0	0
Other system disorders	0	0	0	0	1	3.7
Cause peculiar to infancy	18	54.5	21	70	15	55.6
Cause Unknown	0	0	0	0	0	0
Total	33		30		27	

In present study (1996-2010) Mortality rates most of the time were less than national crude urban death rate for the respective age group and period. This phenomenon was specially found comparable during 2002-2009.[3] However, death rates observed in 2010 reveal that except in severely affected area (5.48/1000) death rate were higher in mildly (8.25/1000), moderately (8.11/1000) and control area (6.1/1000). This observation may be the out come of excessive higher age group representation in the cohort follow-up.

Estimated results on infant mortality, neonatal and post-neonatal mortality, are presented in tables 2-4 for the interval 1996-2000, 2001-2005 and 2006-2010 respectively. Infant, neonatal as well as post neonatal death rate were also observed to be higher in control areas in comparison to that of the affected areas. Infant mortality rate in affected and control areas for the year 2006-2010 were 22.72 and 29.73 per 1000 live births respectively which is less than that in the year 1988

which were 71.74 and 58.28 in affected and control areas respectively(Annual report, BGDRC-1989). Infant mortality rate showed declining trend from 1996-2010, in both affected as well control areas. Neonatal as well as post-neonatal death rates were also observed to be higher in control area in comparison to that of the affected area. Infant mortality rate observed between 1996 to 2010 in every five year interval were 26.0,22.61,22.72 for affected area and for control area , it 41.19,41.55 and 29.73 per 1000 births which shows decline trend of infant mortality rate when we compared it to national urban infant mortality which was 31 per 1000 live births in 2010(Infant mortality rate in India ,SRS 1991-2013)
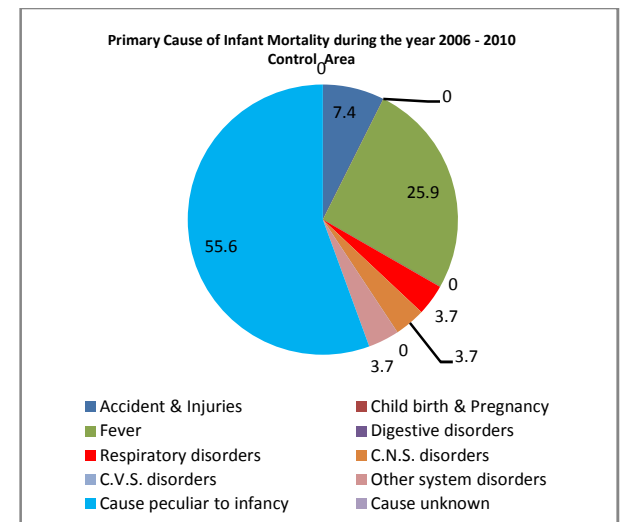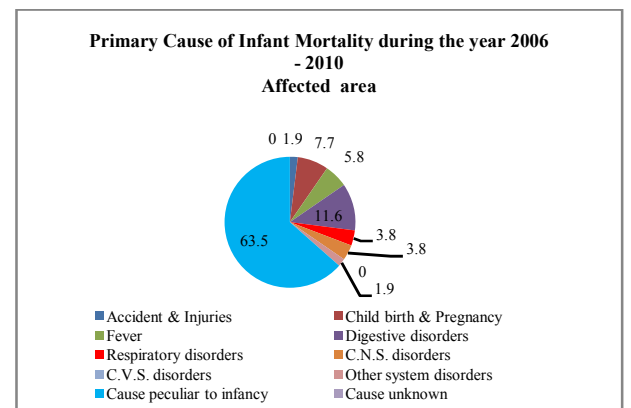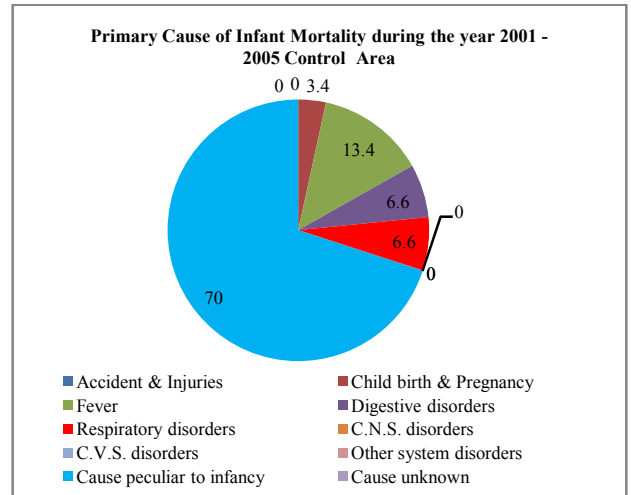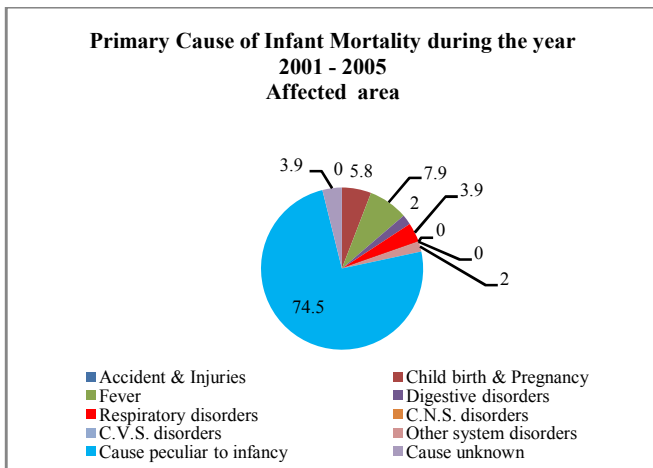
Primary Cause of Infant Mortality during the year 1996 - 2000 Affected area

Primary Cause of Infant Mortality during the year 1996 - 2000 Control Area

Primary Cause of Infant Mortality during the year 2001 - 2005 Affected area

Primary Cause of Infant Mortality during the year 2001 - 2005 Control Area

Primary Cause of Infant Mortality during the year 2006 - 2010 Affected area

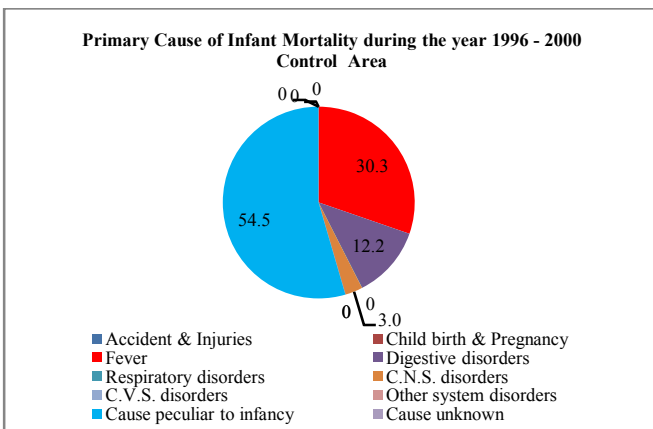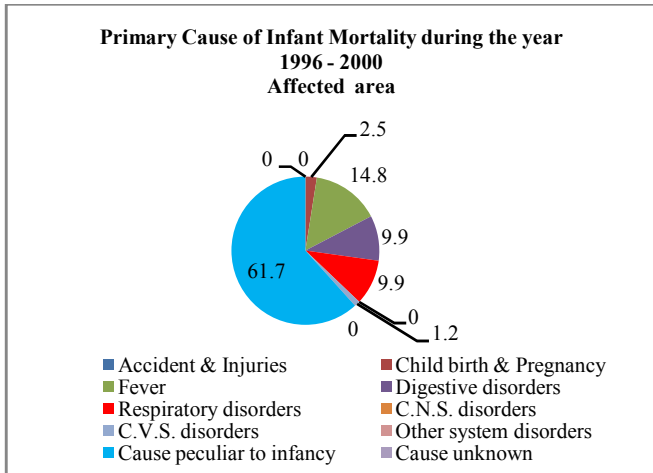**Primary Cause of Infant Mortality during the year 2006 - 2010 Control Area**

Figure 2 Primary cause of Infant mortality during 1986-2010

Primary cause of death

The information on causes of death was included since 1986: cause of death analysis is based on records collected during 1986-2010. Between the periods of 1986 to 2010 most common cause of death was observed to be respiratory in affected area followed by digestive and cerebro-vascular disorders [3]. In control area too respiratory disorders were the most common cause of death though with lesser frequency, followed by digestive disorders and fever.

Main cause of infant mortality, causes peculiar of infancy may be due to Diarrhoea and Malnutrition during 1996-2010. The causes for infant mortality were infancy(61-74%),fever(6-15%), digestive(2-10%), respiratory(4-10%),child birth and pregnancy (3-8%) in affected area where as in control area infancy (54-70%), fever(14-26%), digestive(0-13%), respiratory(0-6%), child birth and pregnancy(0-4%) respectively during 1996-2010.

DISCUSSION

This study is the longest running epidemiological study on toxic gas disaster. In 2010, December it completed 26 years to be precise 24 years of data collection. Operating study of this magnitude for such a long time has its own challenges, like holding cohort, studies operating on same methodology etc.

Socio economic and morbidity profile: Study noticed improvement in housing, per capita income and educational status of the population in affected as well in control population. However in smoking is a disturbing trend noticed in this study. In nut shell it may be said that all the morbidity levels have been fluctuating fewer than 20% since 1999.

Mortality: The mortality rates were high during the acute phase and later showed a decreasing trend with passage of time. In present study (1996-2010) mortality rates are less than the national crude death rate. Death rates observed during 2002-2009, bring out this fact more prominently. The study reveals main cause of mortality among gas affected as well control area as respiratory illness.

In another follow up study 2566 pregnant women exposed to toxic gas during pregnancy and other group of 1218 pregnant women in control area, it was observed that among babies born to the women of the two groups, infant mortality rate was 94.47 and 85.34% per thousand live birth respectively (BGDRC-ICMR, Annual report, 1987). Infant mortality rate in affected and control areas for the years 2006-2010 were 22.72 and 29.73 per 1000 live births respectively. During the year 1986 causes of infant death were respiratory infection of New Born(40%), Diarrhoea (25%) in affected area where as in control area Respiratory (7.14), diarrhoea (36%) respectively[Consolidated Report, BGDRC 1992]. It was observed that two causes accounted for 50% of all deaths at 1-59 months: pneumonia and diarrhoea[7].

In summary, it can be said that in general the socioeconomic status of the cohort has improved over the years. And smoking is seen increasing the cohort which is a disturbing trend and a risk factor in aggravating the morbidities in already respiratory symptomatic population or even in normal cohort. Finding of present study reveal that mortality of the affected cohort is equal to that of normal urban Indian population. We found that control area was very near to national urban infant mortality rate but affected area infant mortality rate were lower than the national figure in the year 2010.

It may be assumed that due to better health facilities for gas victims as well as implementation of better health facilities by State and Central Government like Janani Shishu Suraksha Yojana, Gas Rahat Hospital and other programme like National Rural Health Mission(NHRM) , which was launched in 2005 also helped to lower infant mortality rate. Similar trends, found for neonatal and post neonatal rate. It was found from the analysis that as the socio – economic status were improved, it contributed for lowering infant mortality rate (report 2014, NIPCD). The Government has increased access to minimum essential services at door step that would significantly reduce high infant mortality rate.

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