

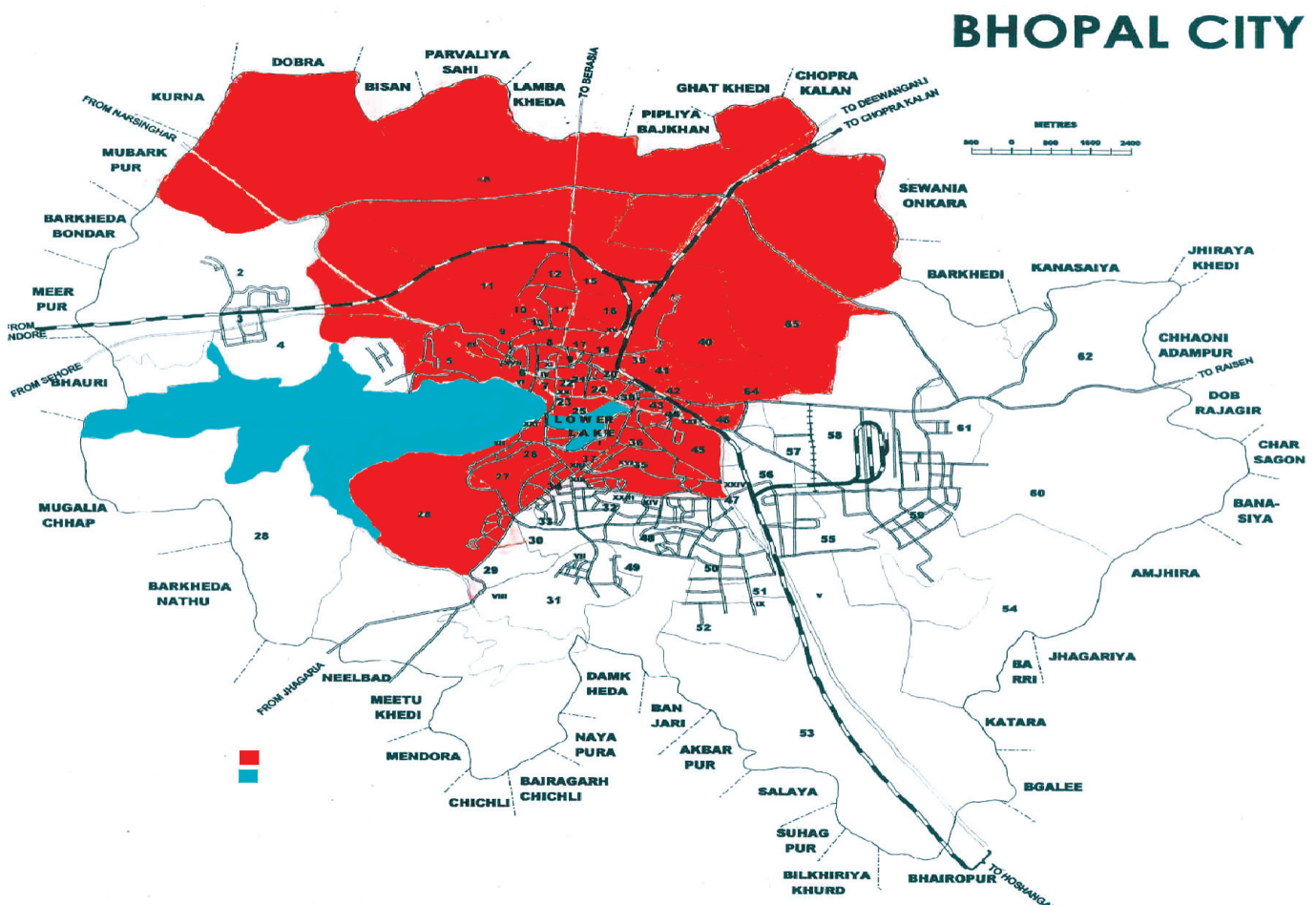
# Chapter 2

## MATERIAL AND METHODS

### Demarcation of MIC affected and unaffected area (wards) of Bhopal Urban Agglomerate

After the industrial gas catastrophe on the night of 3<sup>rd</sup> December 1984, Bhopal municipal area was divided into gas affected and unaffected areas. The demarcation of the region was based on the number of deaths in these localities between 3<sup>rd</sup> and 6<sup>th</sup> December 1984. Thus, the 56 municipal wards of Bhopal were categorized into 36 gas affected and 20 gas unaffected wards. The 36 affected wards were further classified into 2 severely affected, 5 moderately affected and 29 mildly affected wards. Table 2.1 gives the distribution of wards according to the degree of exposure.

Figure 2: Map of Bhopal showing the demarcation of MIC Affected & Unaffected Areas



**Table 2.1: Distribution of Municipal Wards According to Degree of Exposure - 1984**

Area	Municipal Wards	Total Wards
Severely affected	13, 20	2
Moderately affected	8, 11, 14, 45, 46	5
Mildly affected	1, 5, 6, 7, 9, 10, 12, 15, 16, 17, 18, 19, 21, 22, 23, 24, 25, 26, 27, 28, 29, 38, 39, 40, 41, 42, 43, 44, 47	29
Total affected	All mentioned above	36
Unaffected	2, 3, 4, 30, 31, 32, 33, 34, 35, 36, 37, 48, 49, 50, 51, 52, 53, 54, 55, 56	20

In the year 1994, some new areas were included in the municipal area and the larger wards were subdivided and redistribution was done. However, for this report, the initial classification of areas done in the year 1984 was retained. Further, the mild, moderately and severely affected areas shown in Table 2.1 are combined and designated as Area 1 while the MIC unaffected areas are designated as Area 2.

### Registration of Cancer Cases and Generation of Data Base

At the commencement of the cancer registry there were fifty four sources of registration of cancer cases. That number has now increased to sixty three. The sources include major hospitals that provide cancer directed treatment and diagnostic centres. The social investigators from the PBCR of Bhopal visit these sources to collect information in a prescribed form. The frequency of the visit to any source depends on the number of cases registered from that respective source. In addition, periodic visits are made to the HBCR at Tata Memorial Hospital, Mumbai and the cancer hospital at Indore. These visits are undertaken to collect information on cancer in residents of Bhopal, who are either referred directly by their family doctors or those of whom approach on their own for diagnosis and treatment to these cancer centres. Wherever possible, details of the cases are collected by personal interview of the patients/relatives and through abstraction of the medical records/case files.

Based on the identifying and residential information the proved cancers of the residents (minimum one year's residence in the city of Bhopal) of Bhopal are further classified according to their MIC exposure based on their residential ward. Data is entered onto a computer using the PBCR-DM-SW programme. Checks that are carried out using the software include range, consistency, histological family checks listed by IARC, duplicate verification and matching with mortality data. Finally, the Coordinating Unit of National Cancer Registry Programme does a global check before including the data base for tabulation and reporting.

Information on cancer deaths is collected from the registration units of births and deaths and also from the hospital mortality records/registers. Follow-up of cancer cases through house visits helps in supplementing the information on deaths. In addition to the house visits, data on cancer deaths is also collected from burial grounds and crematoriums. In more recent years, data on all deaths irrespective of the cause of death is obtained as a softcopy data base and the information is matched with the registry data. All matched cancer deaths are updated in the registry data. The unmatched cancer deaths and matched deaths where cause of death is other than cancer are followed back by house visits and scrutiny of medical records. Cases with no other details, other than those available on the death certificate, are registered as "Death Certificate Only" (DCO).

## Validation of Data – Checks for Ward Codes

In addition to the various routine checks on registry data as is done for other registries, the data of Bhopal PBCR was subjected to further checks for the ward codes. This was done to ensure the correct categorization of the cancer cases into Area 1 and Area 2 respectively. A random check to validate the residential status was also done through follow-up of cases from various years. No significant disparity was found in their categorization. Cancer incidence rate is generally expressed as age adjusted or age standardized (according to world standard population) incidence rates (AAR) per 100,000 persons. In order to derive such figures, the total as well as five year age group numbers of population for each year are required.

## Assumptions used in Analysis

1. In view of difficulty in identification of actual MIC affected cases because of migration of the population, an indirect approach was used for categorization of the cancer cases belonging to MIC affected (Area 1) and MIC unaffected (Area 2) areas. Based on the mortality rates observed from 3<sup>rd</sup> to 6<sup>th</sup> December 1984 in various municipal wards of Bhopal, the municipal area was divided into the two main areas. Thereafter all cancer cases who were residents of the MIC affected were considered as Area 1 and those cancer cases with residence in the MIC unaffected area as Area 2.
2. Data for the year 1986 and 1987 were excluded from the analysis as the registry data was in the process of stabilization.
3. Removal of effect of the age cohort (born after 1985): The cases born after the year 1985 were excluded from the analysis as this population was not exposed to the MIC gas. Further, inclusion of such cases could dilute the true differences existing in the cancer pattern of Area 1 and Area 2. The modified rates were calculated for the selected leading sites including all sites, after adjusting the effect of age cohort i.e. after removing the effect of those cases that were born after the year 1985 (including the fetus exposure). Suitable adjustments were made correspondingly in population figures by applying the appropriate weightages to arrive at modified populations to derive the above mentioned modified rates (Annexure III). Thus the AAR calculated by this exclusion is referred in the report as the modified AAR (AAR-M).
4. While calculating the AAR, an assumption is that there is uniform distribution of cases and population within each five year age group.

## Methods

**Wilcoxon Rank Sum Test:** As the age structure of the MIC affected and MIC unaffected areas were found to be different, the comparison of the cancer pattern in the two areas was done using AARs and Non-parametric test (Wilcoxon Rank Sum Test) for related samples. The SPSS 14.0 software programme was used to perform the test.

**Time Trend analysis using simple regression:** Simple regression analysis was done on the AARs for the years 1988 to 2007 and slopes were calculated separately for Area 1 and Area 2, to study whether these rates follow any trends in relation to time. Finding a significant slope of a regression line is the simplest method of assessing the presence of a linear trend in the data. A significant positive slope was interpreted as existence of an increasing trend in AAR while a significant negative slope was interpreted as existence of a decreasing trend in AAR.

**Time Trend analysis using Joinpoint Regression Program:** Joinpoint Regression Program, Version 3.4.2 is statistical software for the analysis of trends using Joinpoint models, that is, where several different regression lines are connected together at the “Joinpoints”. Cancer trends reported in NCI publications are calculated using the Joinpoint Regression Program to analyze rates calculated by the SEER. The software takes trend data (e.g. cancer rates) and fits the simplest Joinpoint model that the data allow. The user supplies the minimum and maximum number of Joinpoints. The program starts with the minimum number of Joinpoint (e.g. 0 Joinpoint, which is a straight line) and tests whether more Joinpoints are statistically significant and must be added to the model (upto that maximum number). This enables the user to test that an apparent change in trend is statistically significant. The tests of significance use a Monte Carlo Permutation method. The models may incorporate estimated variation for each point (e.g. when the responses are age adjusted rates) or use a Poisson model of variation. In addition, the models may also be linear on the log of the response (e.g. for calculating annual percentage rate change). The software also allows viewing one graph for each Joinpoint model, from the model with the minimum number of Joinpoints to the model with the maximum number of Joinpoints (Ref: <http://srab.cancer.gov/joinpoint>).

Annual Percentage Change (APC) in AARs was derived separately for MIC affected (Area 1) and MIC unaffected (Area 2) using Joinpoint Regression Program (*Kim et al, 2001*). This was mainly to study whether these rates follow any trends in relation to time. A significant positive APC value for the given period was interpreted as existence of an increasing trend in AAR while a significant negative APC value was interpreted as existence of a decreasing trend in AAR. Assuming cancer is a disease which does not show fluctuations in yearly time trend, one Joinpoint model was attempted. Based on the model suggested by the programme, APC0, APC1 and APC2 values are provided in the table indicating their significance.

**Small numbers and Time Trend:** While depicting the results of specific anatomical sites of cancer, those sites with fewer than 10 cases (separately for males and females) for any given year have been excluded.

Table 2.2 gives the number and relative proportion of cancers registered at various main sources of registration for the twenty year period.

**Table 2.2: Main Sources of Registration of Incident Cases of Cancer: 1988-2007**  
**Bhopal**

Name of the Institute	Number	%
J. L. N. Cancer Hospital	6091	35.4
Hamidia Hospital	5970	34.7
Sultania Zanana Hospital	1020	5.9
Kasturba Hospital	977	5.7
Navoday Cancer Hospital	744	4.3
Tata Memorial Hospital	513	3.0
D.C.O.	510	3.0
Peoples Hospital	463	2.7
Others	461	2.7
Bhopal Medical Centre	214	1.2
Parulkar Clinic	164	1.0
Blank Source	68	0.4
<b>Total</b>	<b>17195</b>	<b>100.0</b>

The details of estimation of population and statistical definitions/methods are given in Chapter 5.