

NATIONAL CANCER REGISTRY PROGRAMME

Indian Council of Medical Research

Cancer in Bhopal: Comparison of Cancer Patterns in MIC Affected and Unaffected Areas (1988-2007)

Prepared by

**The Coordinating Unit
National Cancer Registry Programme, Bangalore**

in Collaboration with

**Population Based Cancer Registry
Gandhi Medical College, Bhopal**

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FOREWORD



I am happy to write this foreword for the report on “Cancer in Bhopal: Comparison of Cancer Patterns in MIC Affected and Unaffected Areas”. Soon after the tragic leakage of methyl isocyanate gas in Bhopal in 1984 the Indian Council of Medical Research commenced the Population Based Cancer Registry (PBCR) of Bhopal under ICMR’s National Cancer Registry Programme (NCRP).

This report of twenty years of data from 1988 to 2007 compares the magnitude and patterns of cancer between the MIC affected and unaffected areas of Bhopal. Over the years, the registry has seen changes in the Principal Investigators but the core staff responsible for data collection has remained the same. Further, data collection, checking, analysis etc. has been continuously monitored and coordinated by the NCRP of the ICMR. The Bhopal cancer registry data has been periodically published over the years as part of the PBCR reports under the NCRP.

The data presented here provides a valuable scientific document on the comparative incidence of cancer and its trends over time in the MIC affected and unaffected areas. It is important to note that a higher incidence of tobacco related cancers has been observed in MIC affected areas as compared to MIC unaffected areas. However, that significance was lost when the tobacco habits in the populations of the two areas were taken into account.

I am aware that the Coordinating Unit of NCRP located at Bangalore has laid special emphasis on quality of the data exercising internationally accepted norms. I am sure the readers will appreciate the quality of report. Support provided by the heads and staff of the PBCR and that of the contributing institutions also deserves mention. I hope that the report will stimulate in-depth investigations on various aspects of prevalent cancer in Bhopal so that the benefit of research reaches the people of Bhopal.

Dr V. M. Katoch

Secretary, Department of Health Research &
Director General, ICMR

PREFACE

On the night of 3rd December 1984, a chemical disaster occurred in Bhopal, the capital city of the state of Madhya Pradesh. A toxic gas, identified as Methyl Isocyanate, suddenly escaped in a gaseous form from the plant of Union Carbide, affecting a vast majority of the population of Bhopal. According to ICMR estimates, over sixty percent of the population suffered due to inhalation of the toxic fumes and approximately 2000 persons died within 72 hours of their exposure to the gas. A large number of survivors suffered acute multisystem morbidities – eyes and lung being the main target organs. Soon after the gas tragedy, based on the number of deaths in various localities, the municipal wards of the city were broadly divided into MIC affected and MIC unaffected areas.

Following the catastrophe, the Indian Council of Medical Research initiated many studies among the gas exposed population to evaluate the ill effects of the toxic gas. One of these was a Population Based Cancer Registry (PBCR) that was set up in the Department of Pathology, Gandhi Medical College, Bhopal. This was a special purpose registry to observe the effect of the gas in the occurrence of cancer in the affected and unaffected areas. The registry started working from 1st January 1986, registering all cancer cases of residents of Bhopal.

A number of research staff appointed under the Bhopal PBCR has made valuable contribution towards the collection of data. The Coordinating Unit of the National Cancer Registry Programme at Bangalore has played an important role in standardization of protocol, development of appropriate tools for collection, processing, analysis and interpretation of the data. Such painstaking efforts have culminated in this document on “Cancer in Bhopal: Comparison of Cancer Patterns in MIC affected and unaffected areas”.

The report has undergone considerable discussions at various expert committee meetings (both of the NCRP and that constituted specifically for the various studies on Bhopal MIC exposure), before the same was finalized and approved for printing. I am grateful for the efforts and inputs of all the experts and congratulate the Coordinating Unit of NCRP and the Bhopal PBCR in bringing out this scientific report.



Dr Bela Shah

Head, Division of Non-Communicable Diseases, ICMR

Cancer in Bhopal: Comparison of Cancer Patterns in MIC Affected and Unaffected Areas (1988-2007)

Executive Summary

Bhopal is the capital of the state of Madhya Pradesh in central India. A chemical disaster caused by the leakage of toxic gases from the factory of Union Carbide in Bhopal on the night of 3rd December 1984 led to massive mortality and morbidity in the city. Methyl isocyanate (MIC) was identified as the major ingredient of the toxic gas, which caused the catastrophe.

Soon after this tragedy, that received world-wide attention, the Indian Council of Medical Research (ICMR) initiated many studies to evaluate the ill effects of the toxic gas in the exposed population. One such study was the setting up of a Population Based Cancer Registry (PBCR) under the National Cancer Registry Programme of the ICMR.

McLennan has defined cancer registration as a process of continuing systematic collection of data on the occurrence and characteristics of reportable neoplasms (*McLennan et al, 1978*). Broadly there are two types of cancer registries – the Population Based and the Hospital Based. Registries could also be developed for a special purpose in relation to specific exposures, or, they could also be established for a specific anatomical site like Bone Tumour and Lymphoma registries. The Bhopal PBCR is an example of a special purpose PBCR.

The basic thrust of a PBCR is cancer in the community. PBCRs provide information on cancer incidence and mortality in a defined population, for a specific period of time. They also provide information on variation in incidence or mortality over time and with follow up, population based cancer survival rates. To initiate, establish and sustain population based cancer registries as per international norms requires meticulous planning, cooperation of medical institutions in the area, dedicated and committed personnel and adequate funding.

Cancer is not as yet a reportable disease in India. Therefore, methodology of data collection by the PBCRs is active, in that, staff of registry visit various sources of registration to collect information on cancers recorded in those institutions. Within a source of registration, there are several places for gathering information on cancer cases. These include pathology reports, medical records, radiology and radiotherapy departments and death certificates. The availability of up-dated investigation / diagnostic facilities in the registry area, well maintained medical records using International Classification of Diseases, together with an efficient death registration system are essential for completeness as well as good quality cancer registration. The advent of computing technology is gradually changing the method of working of cancer registries in India.

The Bhopal PBCR started working from 1st January 1986, registering all cancer cases with a diagnosis from that date and who were residing in Bhopal for at least one year prior to the date of diagnosis. The main objectives of the registry were to know the magnitude and patterns of cancer in Bhopal as a whole

and also observe whether any differences in the incidence rates or patterns over time were seen in the gas exposed population compared to those who were not exposed.

Registration of cancer cases started initially with fifty four sources which have now increased to sixty three sources of registration. The sources include diagnostic centres and hospitals that provide cancer directed treatment. The social investigators visit these sources to collect information in a prescribed format. Whenever possible, the information on cases is collected by interviewing the patients/relatives at the source, otherwise the details are noted down from the medical records/case files. The data submitted by the registry is subjected to various types of quality checks, which include duplicate checks and other consistency checks such as related to age, sex, site of cancer and morphology. One of the key items of information that was and is specifically collected by the Bhopal PBCR refers to whether the cancer patient's permanent place of residence is located in the area classified as "MIC affected" or "MIC unaffected".

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. Besides, the same data is required for both "MIC affected" and "MIC unaffected" areas. The Census of India (Census of India, 1981, 1991, 2001) population figures available for the years 1981, 1991 and 2001 were used. The Difference Distribution Method (*Takiar and Shobana, 2009*) was used to calculate the five year age group population estimates during the inter-census years for the two areas.

Chapter 1 introduces the reader to Bhopal and the events that led to the commencement of the cancer registry under the framework of the NCRP of the ICMR.

The Material and Methods that were used to derive the results are given in Chapter 2 with elaboration of the same in Chapters 5 and 6. This includes estimation of the population using the Difference Distribution Method.

Comparison of the cancer incidence rates in the MIC affected and unaffected areas are described in Chapter 3. For all anatomical sites of cancer in both males and females the overall AAR was higher in the affected area. In males, cancers of certain anatomical sites associated with the use of tobacco showed a higher incidence rate in the affected area compared to the unaffected area. Thus cancers of the tongue, mouth, hypopharynx, oesophagus and lung showed a higher incidence in the affected area compared to the MIC unaffected area. However, when the tobacco habits of the populations in the two areas were taken into account (Chapter 3) the higher rate observed in the MIC affected area was essentially neutralized. This suggests that the higher AAR observed in the MIC affected area was due to the higher proportion of the population consuming tobacco rather than due to the effect of the MIC exposure per se. Among females a higher incidence of cancer of the cervix was observed in the affected area and a higher incidence of cancer of the breast was seen in the unaffected area. Cancer of the cervix is known to have a higher incidence rate in the lower socioeconomic strata of society (*Teppo L, 1984*) and this is vice versa for cancer of the breast. Our surmise is, that, majority of the population of the affected area are from a lower socioeconomic group compared to the unaffected area, though we do not have hard data to substantiate the same.

Chapter 4 gives a description of the trends in AARs over the twenty year period in the two areas. Cancers of all sites in both males and females and in both affected and unaffected areas showed overall a statistically significant increasing trend in the AARs over the years – 1988 to 2007. This is in keeping with what is observed in other PBCRs (NCRP, 2009) under the NCRP. Among the specific anatomic sites, cancer of the lung in males showed a significant increase during the first eleven years (1988-1999) and thereafter a decline in the affected area only. There was no significant change in the AAR of lung cancer (in males) in the unaffected area. Among females, cancer of the breast showed a significant increase in AARs in both the areas and this is in tune with that observed in other urban PBCRs in India (NCRP, 2009).

The authenticity of the data depends on its quality, and with reference to the PBCRs, this would be both in terms of completeness of coverage of cancer cases in the geographic area as well as the reliability of the data. Registries routinely undertake various exercises to ensure that the data they collate and process is of high quality. A thorough check of data is also done before tabulation and international norms and definitions are meticulously followed. These aspects are dealt in detail in Chapter 6.

Cancer registration is a means to a purpose and not a purpose in itself. It is the forerunner of studies in descriptive epidemiology of cancer, which in turn generates specific scientific hypotheses for analytical studies. The cancer registry is central to any rational programme on cancer control (*Muir C.S., 1985*). The results of this report on a special purpose PBCR have provided a lead to set priorities for cancer research. Data needs to accrue for further years especially in certain anatomical sites where meaningful analysis or interpretation could not be carried out due to small numbers. This includes the lymphoid and haemopoietic malignancies, soft tissue tumours and so on. The former have been shown to have a higher incidence in the atomic bomb survivors of Hiroshima and Nagasaki (*Prestone et al, 1994*).

Despite the meticulous effort put in by the Bhopal Cancer Registry and the staff therein, in data collection and the quality control exercises carried out further by the Coordinating Unit of NCRP certain unavoidable limitations remain. These include misclassification of cancer cases between the two areas on account of migration between the two areas, incorrect address etc. though care has been taken to randomly check the authenticity of residence of cancer cases. A second limitation is that the worst affected cases due to the MIC exposure have died almost instantly, and the data available is only of those who have survived. Lastly, the system of registration and certification of cause of death in our country does not provide complete and accurate information on cancer mortality. In more recent years all cause mortality data is matched with the incident cases improving the Mortality Incidence ratio. Since such data was not available for earlier years data or interpretation on cancer mortality has not been provided in this report. Despite these limitations the report has provided scientific results of the effect of MIC exposure on the occurrence of cancer in Bhopal.

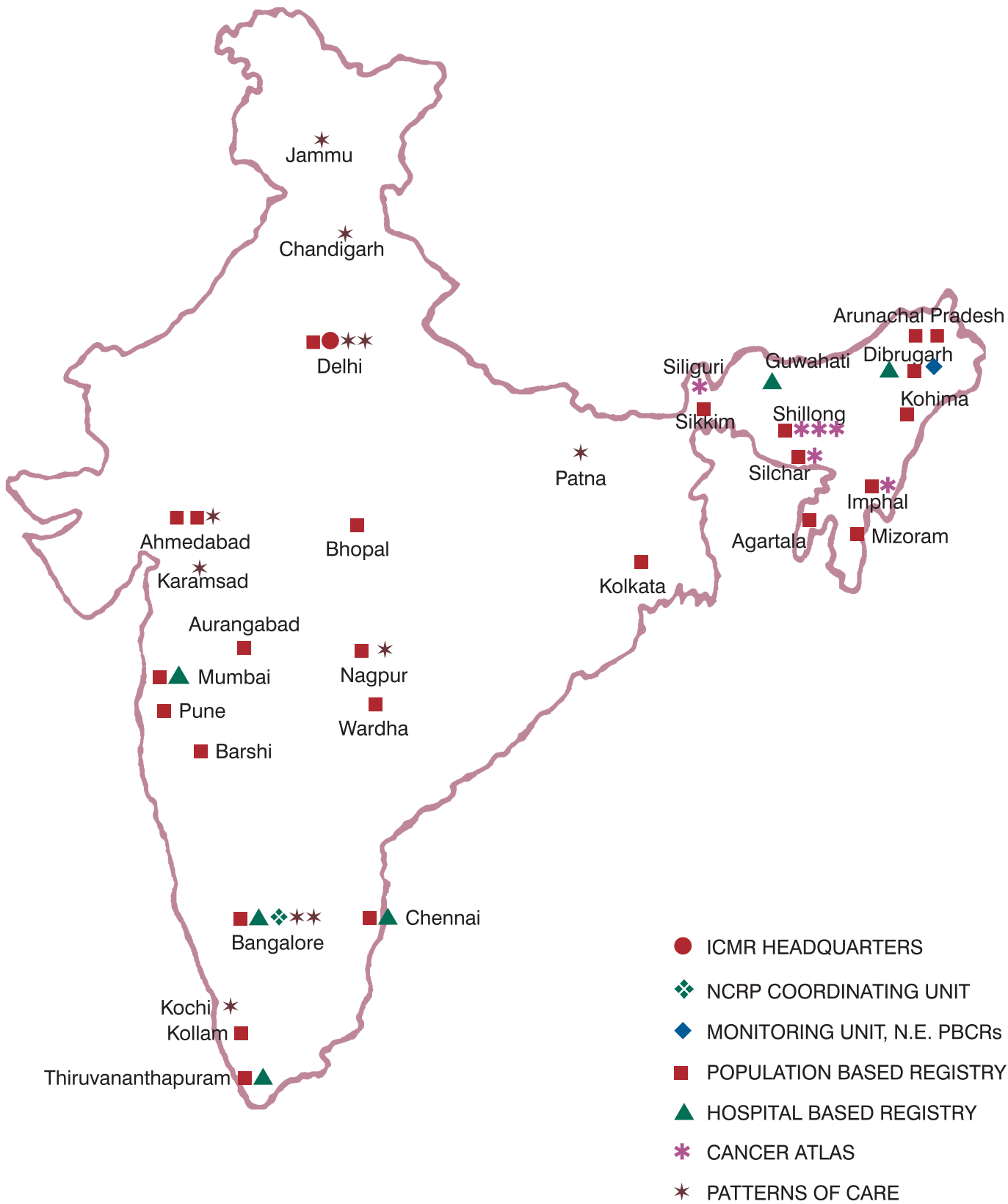


Dr A. Nandakumar
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NATIONAL CANCER REGISTRY PROGRAMME

(Indian Council of Medical Research)

Figure 1.1: NCRP Network



Chapter 1

INTRODUCTION

Madhya Pradesh was created as a state of India in 1956 with the city of Bhopal as the capital. The city is located in the centre of India on the Arera hills at an altitude of 505 metres above mean sea level. Geographically it is placed at latitude of 23.07° North and longitude 77.12° East. The city area is 284.90 Sq. km. The density of population as per 2001 Census is 4755.46/Sq. Km.

Bhopal today presents a multifaceted profile. The city is divided into old and new Bhopal. The old city with its crowded market places, ancient structures such as mosques and palaces still bear the aristocratic imprint of its former rulers. Equally impressive is the new city with its vibrant exquisitely laid out parks, shopping complexes, and broad vibrant avenues. Bhopal, which is also known as the city of lakes, is dominated by its two lakes namely Lower Lake and Upper Lake, which are its centre of attraction. The city receives its water supply partially from the Upper Lake and from the Kolar dam.

The city has a moderate climate with temperature varying from a minimum of 5°C in month of January to a maximum of 46°C in the month of May. The average annual rainfall recorded in the city is 1200 mm.

National Cancer Registry Programme

The National Cancer Registry Programme (NCRP) was commenced by the Indian Council of Medical Research (ICMR) with a network of cancer registries across the country in December 1981. The main objectives of this Programme were: 1. To generate reliable data on the magnitude and patterns of cancer; 2. Undertake epidemiological studies based on results of registry data; 3. Help in designing, planning, monitoring and evaluation of cancer control activities under the National Cancer Control Programme (NCCP); 4. Develop training programmes in cancer registration and epidemiology.

With these objectives, three Population Based Cancer Registries (PBCRs) at Bangalore, Chennai and Mumbai and three Hospital Based Cancer Registries (HBCRs) at Chandigarh, Dibrugarh and Thiruvananthapuram were commenced from 1 January 1982 (NCRP, 2008). A PBCR at Bhopal (see below) was started soon after the industrial accident that resulted in leakage of methyl isocyanate gas into the atmosphere. The PBCRs have gradually expanded over the years and as of now there are 24 PBCRs and 6 HBCRs under the NCRP network and these are illustrated in Figure 1.1.

The NCRP is a long term activity of the ICMR and the office of the NCRP is located in Bangalore. It is assisted by a Steering Committee and a Monitoring Committee that meets periodically to oversee and guide its functioning. A review meeting is held annually where the Principal Investigators and staff of the registries present results and participate in the discussions. The meeting is preceded by a workshop.

Cancer registration in India is active and staff of all registries visit hospitals, pathology laboratories and all other sources of registration of cancer cases on a routine basis. Death certificates are also scrutinized from the municipal corporation units and information collected on all cases where cancer is mentioned on the death certificates.

The information that is collected on a core form that is computer ready is subsequently entered into a computer. Over the years, the registries and the office of the NCRP have used modern advances in electronic information technology to not only enter the data but also help in specific activities that involves checking of the data, verification of duplicates and matching mortality and incidence records. A PBCR data management software (PBCR-DM-SW) has now been developed by the Coordinating Unit and is now being used by most of the 24 PBCRs. Data quality and completeness of coverage is a prime requisite for good cancer registration. This is ensured to the best possible extent by the NCRP through this software.

Over the years, the staff from registries and the NCRP have benefited from both short term and long term training fellowships in established institutions in developed countries. This has helped the working of the cancer registries and also to evolve epidemiological studies. Data from the NCRP registries is regularly published in succeeding volumes of Cancer Incidence in Five Continents published by the International Agency for Research on Cancer - the cancer research arm of the World Health Organization (WHO).

Population Based Cancer Registry – Bhopal

A chemical accident caused by the leakage of toxic gas from the factory of Union Carbide in Bhopal on the night of 3rd December 1984 led to massive mortality and morbidity in the city. Methyl isocyanate (MIC) was supposed to be the major content of the toxic gas. Subsequent to the mishap the mortality data was categorized according to different municipal wards. Based on this information, the Bhopal municipal area was divided into MIC affected and MIC unaffected areas. The affected area was further divided into severely, moderately and mildly affected areas (ICMR, Technical Report, 2009).

Immediately after this industrial disaster, the Indian Council of Medical Research initiated many studies to evaluate the ill effects of the toxic gas among the gas exposed population. Along with these studies, a PBCR was established at Bhopal to ascertain the magnitude of cancer problem and to evaluate the carcinogenic effects of MIC, if any, on the gas exposed population. The main objectives of the registry are:

1. Registration of all cancer cases of residents of the geographic area of the city of Bhopal and generate a data base.
2. To observe and compare the incidence rate of cancer (all sites) in MIC affected and unaffected areas of Bhopal.
3. To assess the time trend in the incidence of various types of cancer in the two areas.

The registry started working from 1st January 1986, registering all cancer cases of residents of Bhopal.

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 3rd 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 3rd and 6th 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

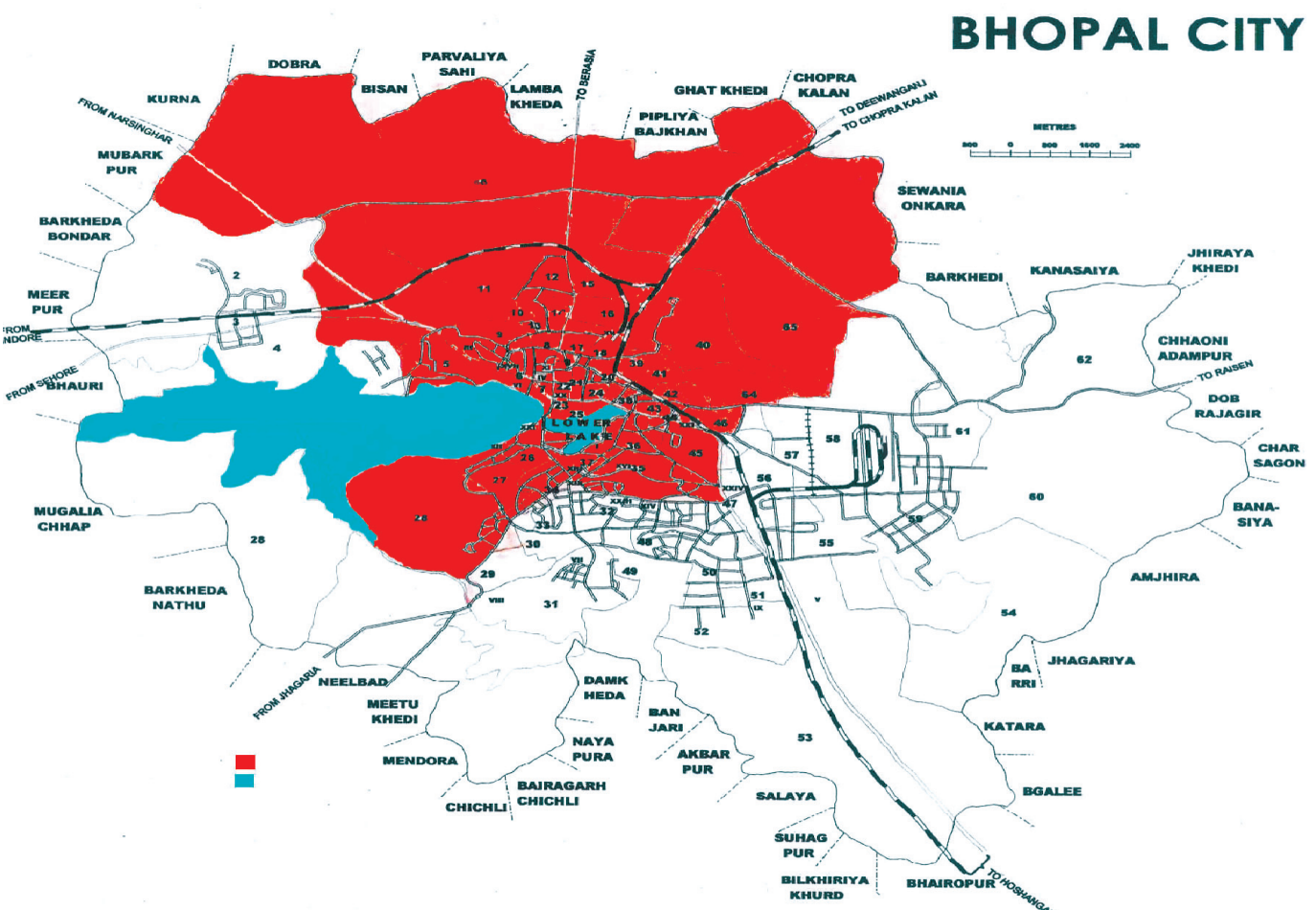


Table 2.1: Distribution of Municipal Wards According to Degree of Exposure - 1984

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 3rd to 6th 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
Total	17195	100.0

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

Chapter 3

COMPARISON OF INCIDENCE RATES

The leading sites of cancer with their modified CR (CR-M) and AAR (AAR-M) in Area 1 and Area 2 and the results of their comparisons by Wilcoxon test (Non-parametric test) are summarized in Table 3.1. The corresponding year-wise rates for all anatomical sites of cancer and selected leading sites, with the results of the comparison between the two areas are shown in Tables 3.2–3.14.

Cancer of All sites:

For both males and females, the modified AARs for all sites of cancer were higher in Area 1 as compared to Area 2.

Males:

The modified AARs of cancers of the tongue, mouth, hypopharynx, oesophagus and lung showed significantly higher incidence rates in Area 1 as compared to Area 2.

Females:

The modified AARs of cancers of the mouth and cervix were higher in Area 1. However, the modified AAR of cancer breast was higher in Area 2.

Comparison of Incidence Rates of Tobacco Related Cancers

The results above suggest that AARs of cancers of some (tongue, mouth, oesophagus, lung) anatomical sites associated with use of tobacco (TRCs) are apparently higher in the affected Area 1 as compared to unaffected Area 2. Further, the comparison between the areas in the AARs of all TRCs over the years (Table 3.15) showed a significantly higher AAR of TRCs in Area 1 as compared to Area 2.

In view of this, the tobacco habits of the population in the two areas were examined. In the year 2005, a random sample survey was carried out on 2000 households covering approximately 10,000 populations in each of the Areas 1 and Area 2. Besides the tobacco habits, the survey also provided information on the age distribution of the population in the two areas. The results of the survey showed that 50.7% of males (above 21 years of age) in Area 1 as opposed to 34.2% of males of the same age group in Area 2 were tobacco users (Annexure II). Likewise, the corresponding figures in females were 15.5% and 5.9% in Area 1 and 2 respectively.

Since the information on tobacco habits was available for the year 2005 through NCRP survey 2005, it was thought logical to relate them to TRC incidence of the year 2005 in Area 1 and Area 2, respectively. As a first step, the TRC incidence to tobacco habit ratio was obtained for both the areas. Under the assumption that both the areas have common tobacco habits, the pooled tobacco habit was obtained using weighted average and then the pooled TRC incidence to Tobacco habit ratio was obtained which was used to obtain the expected TRC incidence by multiplying it with the tobacco habit. The Expected TRC incidence cases

Table 3.1: Comparison between Area 1 and Area 2 of Modified CR and AAR Bhopal (1988-2007)**Males**

	CR-M		AAR-M	
	Z value	P-value	Z value	P-value
All sites	3.435	<0.01	3.472	<0.01
Tongue	3.621	<0.01	3.883	<0.01
Mouth	3.211	<0.01	3.323	<0.01
Hypopharynx	2.501	<0.01	2.688	<0.01
Oesophagus	3.173	<0.05	3.323	<0.01
Stomach	0.112	NS	0.299	NS
Larynx	2.315	<0.05	1.829	NS
Lung	2.128	<0.05	2.464	<0.05
Prostate	-1.493	NS	-1.083	NS
Brain NS	-1.493	NS	-1.680	NS
NHL	0.040	NS	0.724	NS
Myeloid leukaemia	-0.262	NS	-0.201	NS

Females

	CR-M		AAR-M	
	Z value	P-value	Z value	P-value
All sites	-0.373	NS	2.576	<0.05
Mouth	1.755	NS	3.024	<0.05
Oesophagus	1.207	NS	1.736	NS
Stomach	0.161	NS	0.336	NS
Gall bladder	-1.027	NS	-0.597	NS
Lung	-0.821	NS	-0.485	NS
Breast	-3.920	<0.01	-3.883	<0.01
Cervix	3.397	<0.01	3.808	<0.01
Corpus uteri	-0.467	NS	-0.672	NS
Ovary	-1.269	NS	-0.971	NS
Brain NS	-0.885	NS	-0.915	NS
Myeloid leukaemia	0.762	NS	-1.167	NS

were calculated by multiplying the Expected TRC incidence to respective populations and then dividing it by 100,000. It gave the expected number of TRC incidence cases under the assumption that both the areas have common tobacco habits. The Chi-square was used to test the significant difference between observed and expected number of cases.

Table 3.2: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - All sites of Cancer (ICD10: C00-C96) - Bhopal (1988-2007)

Year	MALES				FEMALES			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	54.24	44.27	95.86	87.76	50.80	55.61	89.56	95.95
1989	59.22	49.46	105.26	91.04	57.98	45.49	97.95	78.83
1990	62.92	46.85	110.70	83.99	62.15	56.96	94.32	89.69
1991	66.32	55.22	114.02	99.51	64.18	56.99	102.92	89.81
1992	65.36	61.93	114.68	104.34	65.36	66.08	104.96	100.30
1993	67.09	67.27	114.16	111.12	63.34	73.58	101.91	110.29
1994	74.87	66.41	124.11	109.29	67.81	75.96	107.40	110.92
1995	73.26	74.96	122.29	119.52	69.59	67.33	112.29	101.25
1996	77.23	72.19	127.72	119.09	70.01	82.83	113.71	120.00
1997	80.18	78.02	130.29	122.49	74.49	88.80	120.73	126.06
1998	80.21	79.72	132.92	122.49	73.28	83.20	114.43	114.85
1999	91.35	75.22	150.95	114.60	79.53	87.76	124.97	118.86
2000	94.32	78.75	148.31	123.78	84.43	91.46	132.30	122.25
2001	96.84	83.81	155.25	122.88	85.26	94.53	133.66	126.79
2002	105.58	84.06	161.61	126.59	96.03	97.89	150.57	126.39
2003	108.33	94.18	162.29	129.96	95.60	96.07	144.80	113.54
2004	114.86	91.55	167.78	134.84	110.51	100.60	173.81	155.15
2005	119.34	105.29	174.40	156.00	109.18	101.73	167.20	161.64
2006	109.50	118.15	152.86	169.10	118.37	98.66	179.44	157.42
2007	122.42	118.14	164.82	157.23	132.00	113.13	192.39	174.97
Wilcoxon Z	3.435		3.472		-0.373		2.576	
P value	<0.01		<0.01		NS		<0.01	

The results (Table 3.15) show that the differences in the incidence of TRC cancers between the areas when adjusted for the tobacco habits of the population became comparable. Thus the differences in AARs of all TRCs can be explained due to differences in tobacco habits of the population and not due to their exposure status per se. The incidence rates of specific anatomical sites: mouth, tongue, oesophagus and hypopharynx were also compared between the areas (Area 1 and Area 2) after adjusting for the tobacco habits. The incidence rates were found to be again comparable suggesting that the differences in AARs of these sites between Area 1 and 2 are again due to the differences in the tobacco habits of the population in the two areas (Tables 3.16–3.20).

However, one limitation of this exercise is that the information on tobacco habits among cancer cases from PBCR areas was not available, throughout the period of the study.

Table 3.3: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Tongue and Mouth (ICD10: C01-C02 & C03-06) Bhopal - Males (1988-2007)

Year	TONGUE (ICD10: C01-C02)				MOUTH (ICD10: C03-06)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	7.25	0.00	13.33	0.00	4.94	3.67	9.03	8.67
1989	6.46	7.12	12.40	12.43	5.17	4.58	10.26	7.92
1990	7.27	5.43	13.77	11.69	1.26	2.96	2.51	4.76
1991	5.73	3.43	11.21	5.37	2.87	0.98	4.87	1.84
1992	6.70	2.42	12.87	5.41	3.83	4.83	6.95	7.77
1993	5.44	4.76	10.49	7.79	5.12	6.19	8.34	8.82
1994	6.41	4.70	10.55	8.90	6.41	5.64	11.03	9.56
1995	6.43	4.63	10.81	7.38	8.35	6.48	13.97	9.95
1996	7.74	4.10	13.51	6.63	7.74	5.46	12.85	8.14
1997	7.12	6.27	12.54	10.44	8.74	6.72	13.34	8.95
1998	6.83	5.29	12.36	8.17	7.48	7.50	11.46	12.01
1999	9.47	7.38	15.25	11.07	8.17	4.34	11.72	6.87
2000	8.54	6.42	12.93	9.57	8.87	4.28	12.76	6.47
2001	10.25	8.02	17.00	11.20	9.92	5.06	14.80	8.20
2002	11.66	5.00	17.31	7.32	10.00	5.00	14.26	7.19
2003	11.48	8.18	18.01	11.29	9.43	8.18	14.00	10.44
2004	14.27	7.74	21.73	11.10	16.31	4.48	20.52	6.32
2005	13.41	9.28	19.34	12.92	16.85	6.05	23.81	8.46
2006	12.58	14.30	19.60	17.35	14.67	10.04	19.94	14.52
2007	12.09	10.81	16.52	14.70	11.38	10.01	14.70	12.90
Wilcoxon Z	3.621		3.883		3.211		3.323	
P value	< 0.01		< 0.01		< 0.01		< 0.01	

Table 3.4: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Hypopharynx and Oesophagus (ICD10: C12-13 & C15) Bhopal - Males (1988-2007)

Year	HYPOPHARYNX (ICD10: C12-13)				OESOPHAGUS (ICD10: C15)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	1.98	3.67	3.82	8.15	3.30	2.62	5.05	6.29
1989	5.17	2.54	9.65	5.28	4.52	2.54	8.19	5.97
1990	5.69	3.45	10.85	6.30	6.96	2.96	13.31	5.99
1991	4.46	2.94	7.27	4.86	4.14	3.43	8.56	6.81
1992	4.47	5.31	8.81	9.72	5.11	1.93	9.14	3.48
1993	5.44	4.29	10.49	7.96	5.44	2.38	10.37	4.90
1994	4.81	5.17	8.22	9.51	5.77	5.17	10.62	7.99
1995	5.14	2.78	9.68	4.50	3.86	6.48	6.90	9.85
1996	3.55	5.01	6.74	8.78	5.16	5.92	9.25	9.59
1997	5.82	3.14	10.46	5.01	6.47	6.27	11.90	10.56
1998	5.20	3.97	9.40	7.05	7.15	6.17	11.75	10.41
1999	4.90	5.21	8.72	8.87	7.84	5.21	14.24	8.31
2000	6.24	3.00	10.25	4.73	8.22	4.71	14.42	6.77
2001	5.62	5.06	10.14	8.17	7.94	4.22	13.43	6.38
2002	5.67	4.58	9.78	7.21	7.33	6.66	11.63	11.10
2003	5.50	5.97	9.65	8.46	7.86	4.72	13.05	7.50
2004	5.78	5.29	9.30	8.52	6.12	6.19	9.90	9.53
2005	4.47	4.03	6.95	6.39	5.50	3.63	8.99	5.54
2006	8.73	6.43	13.53	10.06	11.88	6.02	18.71	8.59
2007	8.18	3.60	12.70	5.87	7.11	5.61	10.21	8.46
Wilcoxon Z	2.501		2.688		3.173		3.323	
P value	<0.01		<0.01		<0.01		<0.01	

Table 3.5: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Lung and Prostate (ICD10: C33-34 & C61) Bhopal - Males (1988-2007)

Year	LUNG (ICD10: C33-34)				PROSTATE (ICD10: C61)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	4.61	6.29	9.60	11.99	0.99	0.52	2.25	1.05
1989	6.14	7.12	12.39	15.32	2.91	1.53	6.40	3.25
1990	7.59	3.95	14.30	5.97	2.85	2.96	6.50	6.85
1991	7.65	7.83	15.61	15.34	2.55	2.94	5.87	6.74
1992	9.89	7.25	18.84	11.98	2.55	2.42	4.91	5.90
1993	7.99	8.58	14.88	16.94	3.52	2.38	7.58	4.26
1994	8.33	7.04	14.54	10.96	2.56	1.88	5.40	4.63
1995	9.00	8.33	16.13	14.12	2.25	3.70	4.54	7.23
1996	10.96	7.28	18.95	12.71	2.58	5.01	5.30	9.19
1997	11.65	8.51	19.48	14.77	4.21	3.58	7.61	6.87
1998	10.73	6.61	20.70	10.49	4.55	6.17	9.05	11.12
1999	12.41	6.95	20.65	11.27	3.92	5.21	7.45	9.52
2000	11.50	6.85	19.39	10.86	3.94	5.99	7.47	11.32
2001	12.90	6.75	21.80	10.37	2.98	5.06	5.88	9.29
2002	10.00	12.50	16.54	19.13	4.33	5.42	8.63	8.97
2003	11.16	11.95	18.31	18.30	4.25	3.46	8.02	5.39
2004	12.23	8.55	18.59	12.45	5.44	4.48	9.54	7.09
2005	11.01	12.91	16.22	19.72	4.47	6.86	7.90	11.55
2006	19.22	14.46	29.67	20.30	7.34	6.43	12.10	10.77
2007	11.38	14.82	17.53	20.78	4.27	6.41	7.27	9.96
Wilcoxon Z	2.128		2.464		-1.493		1.083	
P value	<0.05		<0.01		NS		NS	

Table 3.6: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Stomach and Larynx (ICD10: C16 & C32) Bhopal - Males (1988-2007)

Year	STOMACH (ICD10: C16)				LARYNX (ICD10: C32)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	1.98	2.62	3.74	5.08	2.97	3.15	4.91	6.47
1989	2.91	0.51	5.12	1.65	1.29	1.02	2.37	2.51
1990	3.16	2.47	4.95	5.38	1.90	1.48	2.61	2.50
1991	2.87	3.92	4.23	6.32	1.91	2.94	3.12	6.39
1992	2.87	0.97	4.70	1.77	2.55	2.42	4.22	3.74
1993	1.28	1.91	2.71	3.38	1.60	2.38	2.81	5.00
1994	3.20	0.94	5.44	1.58	3.20	1.88	5.47	3.40
1995	0.96	3.24	1.73	5.51	2.57	2.78	4.44	4.75
1996	3.22	1.37	4.67	2.79	3.55	2.73	6.90	5.56
1997	2.59	2.69	4.38	3.52	2.59	4.48	3.88	7.78
1998	0.98	3.97	2.02	6.08	5.20	4.41	8.65	6.79
1999	2.29	0.87	3.62	1.74	4.57	4.34	8.25	6.71
2000	1.64	3.42	2.71	5.32	4.27	3.42	7.36	5.25
2001	1.98	0.84	3.43	1.24	4.96	3.80	8.68	6.07
2002	1.33	2.08	2.10	2.71	5.00	3.75	8.94	6.35
2003	1.89	2.20	2.50	2.94	4.87	4.72	7.93	6.36
2004	2.04	2.44	3.13	3.49	7.82	3.26	12.05	4.87
2005	2.75	3.63	3.64	5.19	6.88	3.23	10.54	5.25
2006	4.89	4.02	6.70	6.39	6.29	4.02	9.44	5.69
2007	2.13	2.40	3.01	3.90	6.76	4.41	10.15	6.18
Wilcoxon Z	0.112		0.299		2.315		1.829	
P value	NS		NS		<0.05		NS	

Table 3.7: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Brain NS and NHL (ICD10: C70-72 & C82-85, C96) Bhopal - Males (1988-2007)

Year	BRAIN NS (ICD10: C70-72)				NHL (ICD10: C82-85, C96)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	0.99	0.00	1.51	0.00	0.33	1.57	0.39	2.83
1989	1.94	2.04	3.10	2.52	0.65	0.51	0.80	0.42
1990	1.26	0.49	2.27	1.38	1.90	1.97	2.30	2.86
1991	3.19	1.86	3.86	2.19	0.32	1.47	0.86	1.66
1992	3.06	2.42	3.68	4.05	1.60	0.97	2.33	1.57
1993	2.24	5.24	3.51	6.65	3.20	1.43	4.38	2.58
1994	1.03	3.76	0.86	5.13	1.67	0.94	2.82	1.44
1995	2.57	3.70	2.45	4.23	2.25	1.85	3.48	1.78
1996	2.26	4.01	2.99	5.41	1.55	1.37	1.71	2.02
1997	1.62	1.61	2.14	1.28	2.14	3.40	2.89	4.92
1998	2.08	3.26	2.52	3.76	2.60	1.76	4.22	2.52
1999	1.63	3.56	1.63	4.61	3.59	1.74	5.41	1.75
2000	2.96	2.57	3.75	3.57	4.27	3.85	5.76	6.11
2001	2.58	5.49	3.43	6.69	2.25	2.95	2.71	5.36
2002	2.53	2.50	3.06	3.49	4.33	2.92	4.39	4.37
2003	3.30	3.46	3.79	4.67	0.00	0.00	0.00	0.00
2004	3.74	1.63	5.30	1.80	4.49	5.38	4.93	7.59
2005	0.69	2.82	0.79	4.36	3.44	3.63	4.59	4.88
2006	2.38	1.61	2.44	2.32	3.84	4.42	5.40	6.41
2007	1.14	4.00	1.05	4.66	3.20	6.41	3.89	8.41
Wilcoxon Z	-1.493		-1.680		0.040		0.724	
P value	NS		NS		NS		NS	

Table 3.8: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Myeloid Leukaemia (ICD10: C92-94) Bhopal - Males (1988-2007)

Year	CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2
1988	1.12	2.62	1.42	2.30
1989	0.65	1.02	0.56	0.76
1990	1.26	0.49	1.26	0.39
1991	2.48	0.98	3.17	1.49
1992	1.47	3.38	1.84	3.08
1993	3.52	3.34	3.64	3.43
1994	3.53	0.47	3.97	0.33
1995	1.29	0.46	1.10	0.32
1996	0.97	2.28	0.94	2.56
1997	1.62	3.14	1.71	3.22
1998	1.63	3.53	1.50	4.09
1999	1.31	2.17	1.80	1.93
2000	3.29	1.71	4.37	2.10
2001	1.52	5.06	1.56	5.71
2002	3.00	2.75	4.23	2.82
2003	0.00	0.00	0.00	0.00
2004	2.45	1.22	2.62	1.70
2005	5.16	3.63	5.95	4.61
2006	3.35	1.93	3.32	2.71
2007	1.85	2.80	2.13	2.97
Wilcoxon Z	-0.262		-0.201	
P value	NS		NS	

Table 3.9: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Cervix and Corpus Uteri (ICD10: C53 & C54) Bhopal (1988-2007)

Year	CERVIX (ICD10: C53)				CORPUS UTERI (ICD10: C54)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	13.31	13.04	21.09	23.38	1.85	1.19	3.26	2.46
1989	14.82	10.31	25.64	15.99	3.25	0.00	6.09	0.00
1990	15.89	10.51	24.69	17.01	1.06	1.11	1.77	1.40
1991	17.08	14.27	28.75	21.99	1.78	0.55	2.67	0.98
1992	16.73	13.00	25.57	19.36	2.49	0.54	4.12	0.94
1993	15.68	17.62	24.58	24.71	1.07	1.60	1.73	2.66
1994	18.18	16.31	27.78	22.96	0.71	1.05	1.04	1.72
1995	18.91	13.47	28.27	19.85	0.36	1.55	0.54	2.50
1996	18.59	16.79	28.75	24.59	1.07	1.02	1.89	1.51
1997	19.36	17.00	29.97	23.39	0.72	2.00	0.93	2.79
1998	19.78	14.75	30.85	19.42	1.44	1.48	2.55	2.27
1999	18.76	17.90	30.96	25.19	2.17	1.94	3.38	2.95
2000	19.57	18.10	32.12	23.27	2.90	0.95	4.82	1.86
2001	17.09	19.69	28.32	25.25	2.91	0.94	5.55	1.22
2002	25.21	13.40	41.18	16.51	0.00	1.39	0.00	1.94
2003	24.06	11.64	38.44	14.15	0.31	2.36	0.38	2.41
2004	25.89	15.53	40.38	25.35	3.33	1.85	4.81	2.66
2005	22.73	12.67	36.02	19.47	1.49	4.10	2.45	7.19
2006	23.80	16.62	37.31	26.59	3.40	1.13	5.46	1.87
2007	27.61	18.41	37.53	26.45	2.30	3.83	4.03	6.32
Wilcoxon Z	3.397		3.808		0.467		0.672	
P value	<0.01		<0.01		NS		NS	

Table 3.10: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Mouth and Oesophagus (ICD10: C03-06 & C15) Bhopal - Females (1988-2007)

Year	MOUTH (ICD10: C03-06)				OESOPHAGUS (ICD10: C15)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	2.22	2.37	4.92	3.71	4.81	2.96	8.14	5.43
1989	4.70	1.15	8.33	2.22	2.17	2.29	4.43	4.66
1990	3.18	1.66	5.55	2.55	2.12	1.66	3.94	3.61
1991	1.42	2.75	3.01	5.40	2.49	2.20	3.69	3.55
1992	3.56	3.25	7.88	5.27	2.85	2.71	5.92	5.66
1993	3.21	3.20	5.53	5.50	3.21	4.27	5.72	7.35
1994	3.92	3.16	7.64	4.98	4.28	2.63	7.84	5.10
1995	3.93	2.59	6.98	4.32	5.35	0.52	10.12	0.84
1996	3.58	4.58	6.79	6.47	3.58	3.56	6.04	6.87
1997	5.02	4.00	9.43	5.87	4.30	2.50	9.02	4.49
1998	5.03	5.41	9.24	7.27	2.52	1.97	4.16	2.84
1999	3.97	6.77	7.02	9.84	2.53	3.87	4.81	5.13
2000	5.44	5.72	10.23	9.30	2.90	2.38	4.95	3.72
2001	4.73	3.75	8.44	5.52	3.64	2.81	6.54	3.81
2002	6.58	2.77	11.33	3.80	2.56	4.16	4.50	5.73
2003	5.82	4.72	10.12	5.80	4.09	3.77	6.53	5.15
2004	6.29	2.96	10.31	4.38	3.70	3.70	7.43	6.58
2005	3.73	5.59	6.04	8.57	5.59	3.73	10.22	6.31
2006	6.42	3.40	11.20	4.21	4.91	5.67	8.54	9.07
2007	8.82	4.22	14.35	6.79	6.52	8.82	10.46	13.65
Wilcoxon Z	1.755		3.024		1.207		1.736	
P value	NS		<0.01		NS		NS	

Table 3.11: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Stomach and Gall bladder (ICD10: C16 & C23-24) Bhopal - Females (1988-2007)

Year	STOMACH (ICD10: C16)				GALL BLADDER (ICD10: C23-24)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	1.11	0.00	2.13	0.00	1.85	2.37	3.87	5.44
1989	0.36	1.15	0.63	1.53	1.08	4.01	2.72	8.66
1990	0.35	1.11	0.29	1.73	0.71	1.11	1.26	2.61
1991	3.20	0.55	5.46	0.98	1.07	0.55	1.90	0.97
1992	1.78	0.00	3.40	0.00	0.71	2.17	1.19	3.85
1993	0.36	1.60	0.64	3.07	2.14	1.60	3.60	3.11
1994	1.78	0.53	2.77	0.82	1.78	0.00	3.01	0.00
1995	1.43	1.04	1.94	1.62	2.85	2.59	5.26	3.81
1996	1.43	2.04	2.54	2.39	1.79	3.56	3.64	5.98
1997	1.08	1.00	1.91	1.97	1.43	4.50	3.08	7.46
1998	1.44	1.97	1.82	2.69	1.80	2.95	3.39	4.86
1999	1.44	0.48	2.47	0.67	2.89	3.39	4.25	4.66
2000	0.72	2.38	1.33	3.48	3.62	5.72	7.59	8.76
2001	1.82	1.88	3.19	2.69	3.27	4.69	5.31	6.09
2002	0.73	0.92	0.78	1.34	4.02	4.62	6.29	6.21
2003	0.79	1.42	1.11	2.25	5.82	3.77	9.08	5.56
2004	0.74	0.74	1.11	1.21	4.81	4.07	8.07	6.30
2005	1.12	0.75	2.27	1.37	5.22	4.10	8.79	6.76
2006	0.76	3.02	1.37	5.35	4.53	2.64	7.08	4.30
2007	1.92	0.38	3.95	0.71	4.83	5.75	7.06	10.12
Wilcoxon Z	0.161		0.336		-1.027		-0.597	
P value	NS		NS		NS		NS	

Table 3.12: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Lung and Breast (ICD10: C33-34 & C50) Bhopal - Females (1988-2007)

Year	LUNG (ICD10: C33-34)				BREAST (ICD10: C50)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	0.37	1.19	1.03	1.78	9.98	13.04	17.06	22.03
1989	0.72	2.29	1.56	4.76	10.84	12.61	19.17	21.83
1990	1.06	0.00	1.89	0.00	11.30	15.49	18.32	23.67
1991	0.36	1.10	0.77	1.89	12.81	13.18	21.93	20.11
1992	2.49	0.54	5.16	1.13	12.10	18.42	17.71	29.21
1993	1.78	2.67	2.92	3.37	13.18	19.22	20.44	29.20
1994	1.43	2.10	2.90	3.93	12.84	21.04	19.81	30.32
1995	1.78	3.63	4.07	6.33	12.13	20.72	17.77	29.72
1996	2.15	2.04	3.43	2.50	14.66	19.84	21.54	27.16
1997	1.79	2.00	3.19	3.05	12.91	24.50	19.16	33.55
1998	0.36	2.46	0.71	4.67	15.46	25.08	23.65	34.37
1999	1.44	0.48	2.52	0.71	14.43	30.00	21.39	38.36
2000	2.90	2.38	5.34	3.27	18.84	25.25	26.21	33.77
2001	1.82	3.28	2.80	4.91	17.46	28.14	24.29	36.91
2002	1.46	2.31	2.11	3.45	19.73	30.51	29.46	37.93
2003	0.79	0.94	1.50	1.51	21.23	30.82	31.12	35.94
2004	2.22	1.11	4.38	1.92	21.82	30.33	32.47	45.04
2005	1.49	3.73	2.34	6.64	29.81	30.18	41.27	46.53
2006	3.02	0.76	4.77	1.41	28.71	29.08	39.64	45.92
2007	3.45	3.07	5.34	5.82	26.69	29.53	35.81	43.36
Wilcoxon Z	-0.821		-0.485		-3.920		3.883	
P value	NS		NS		<0.01		<0.01	

Table 3.13: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Ovary and Brain NS (ICD10: C56 & C70-72) Bhopal - Females (1988-2007)

Year	OVARY (ICD10: C56)				BRAIN NS (ICD10: C70-72)			
	CR-M		AAR-M		CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2	Area 1	Area 2
1988	1.48	3.56	2.06	6.67	0.00	0.59	0.00	1.09
1989	3.61	2.86	5.81	4.78	1.08	0.80	1.63	0.67
1990	4.24	2.21	5.98	3.31	1.77	1.66	2.45	1.36
1991	2.85	6.04	3.68	9.71	2.49	1.65	3.29	3.14
1992	6.76	4.87	9.90	5.21	0.71	1.08	0.56	1.61
1993	2.99	5.34	4.93	7.63	1.07	1.60	1.69	1.79
1994	3.21	5.79	4.03	8.47	1.07	3.79	1.55	4.07
1995	4.64	5.18	7.51	7.43	0.71	0.52	0.60	0.78
1996	4.29	3.56	7.00	5.28	1.00	1.02	0.79	0.75
1997	4.01	5.00	5.42	6.40	1.08	1.00	1.80	1.16
1998	3.60	5.90	5.40	7.20	1.44	2.16	1.81	2.75
1999	4.33	2.90	8.10	4.02	2.17	1.94	1.91	2.59
2000	3.99	3.81	5.31	4.77	1.09	1.43	1.31	1.33
2001	5.46	6.00	7.41	8.21	1.45	0.47	1.86	0.35
2002	4.75	8.78	7.35	10.69	1.46	1.39	2.12	1.40
2003	5.03	6.45	4.70	8.98	1.10	1.89	0.00	1.19
2004	6.36	12.20	9.01	17.49	2.96	2.22	3.63	2.63
2005	6.71	7.45	9.50	10.86	1.12	1.86	1.51	2.24
2006	9.06	7.86	13.93	13.32	1.81	1.81	2.54	3.14
2007	11.35	6.52	16.39	9.96	0.77	2.30	0.51	2.91
Wilcoxon Z	-1.269		-0.971		-0.885		0.915	
P value	NS		NS		NS		NS	

Table 3.14: Comparison between Area 1 and Area 2 of yearwise modified CR and AAR - Cancer of Myeloid Leukaemia (ICD10: C92-94) Bhopal - Females (1988-2007)

Year	CR-M		AAR-M	
	Area 1	Area 2	Area 1	Area 2
1988	0.00	1.78	0.00	1.30
1989	0.36	1.15	0.30	0.83
1990	0.71	1.66	0.85	1.24
1991	1.07	0.00	0.93	0.00
1992	1.78	0.54	1.84	0.41
1993	1.92	1.60	2.72	1.34
1994	1.14	0.53	1.47	0.87
1995	1.43	0.52	2.86	0.42
1996	1.79	1.02	3.18	1.46
1997	1.79	1.50	1.94	1.96
1998	2.30	2.16	2.33	2.08
1999	2.53	1.06	3.02	1.23
2000	1.09	2.38	1.25	2.87
2001	1.45	3.75	1.83	4.15
2002	1.10	0.92	0.85	0.75
2003	0.00	0.00	0.00	0.00
2004	2.29	1.85	3.14	3.76
2005	3.35	1.49	4.27	2.53
2006	1.13	0.76	1.36	0.63
2007	1.53	1.53	1.95	2.16
Wilcoxon Z	0.762		-1.167	
P value	NS		NS	

Table 3.15: Comparison of TRC and Non-TRC Incidence rates in Area 1 and Area 2 - Bhopal (1988-2007)

Year	TRC-Incidence		Non TRC-Incidence	
	Area 1	Area 2	Area 1	Area 2
1988	24.05	20.02	27.44	21.48
1989	27.81	23.64	26.92	21.78
1990	29.53	19.80	27.83	22.44
1991	25.36	21.29	33.16	27.25
1992	29.37	22.96	26.93	30.34
1993	27.34	24.88	28.93	32.38
1994	30.57	27.38	31.35	27.76
1995	29.33	28.20	30.09	32.97
1996	31.84	26.81	30.35	30.69
1997	34.68	29.90	25.77	30.58
1998	33.38	28.14	27.03	31.74
1999	36.71	27.10	29.60	28.36
2000	34.71	22.76	31.80	34.90
2001	37.37	25.43	29.94	34.49
2002	34.98	26.18	34.34	32.94
2003	34.97	32.80	33.93	27.11
2004	38.40	27.94	32.51	35.25
2005	31.73	26.91	36.48	39.73
2006	34.06	36.57	33.09	39.23
2007	31.92	30.55	36.07	47.81
Wilcoxon-Z	3.73		0.336	
P-values	< 0.01		NS	

Fig. 3.1: Comparison of TRC incidence rates in Area 1 and Area 2 in Bhopal (1988-2007)

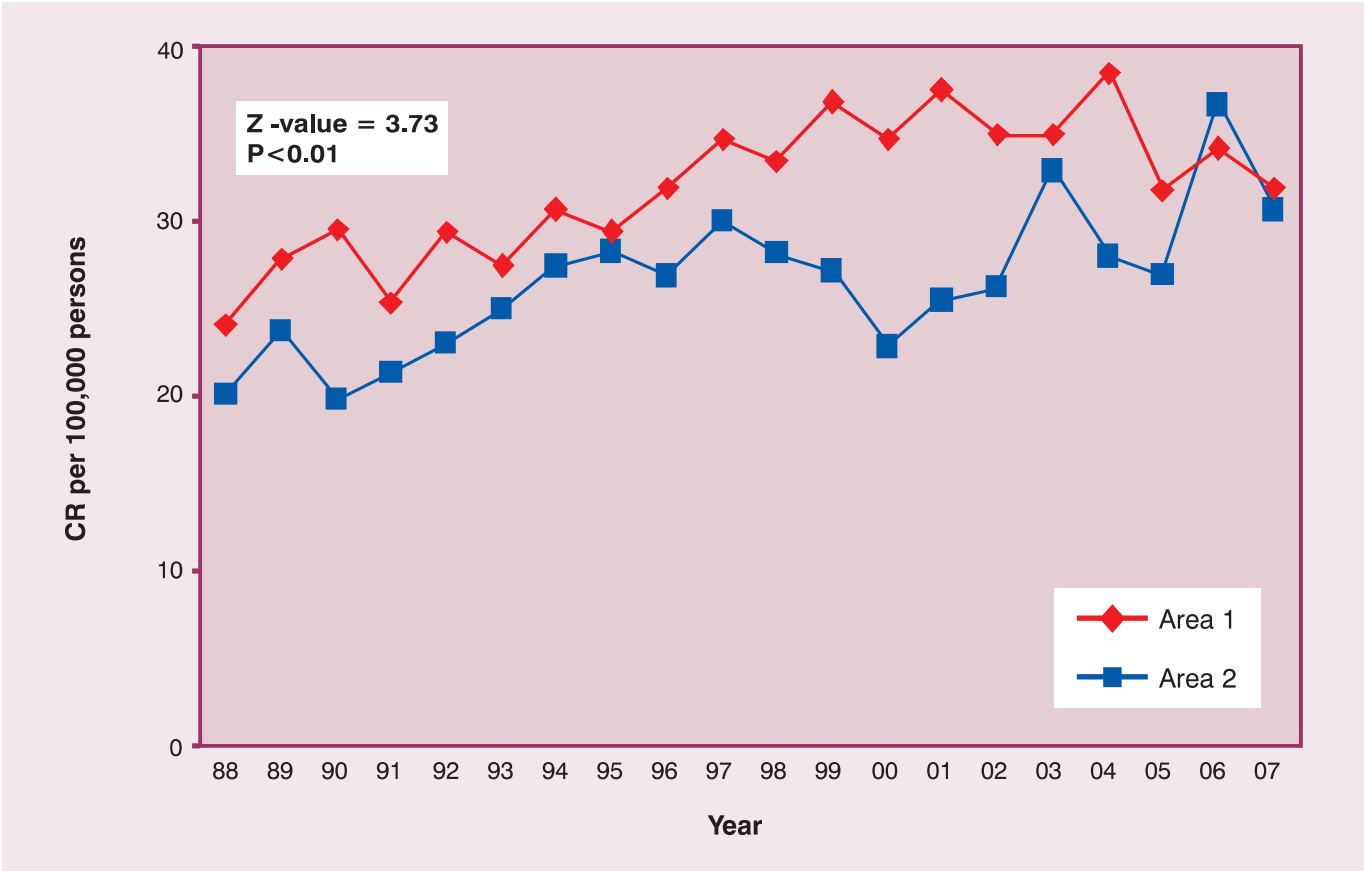


Fig. 3.2: Comparison of Non-TRC incidence rates in Area 1 and Area 2 in Bhopal (1988-2007)

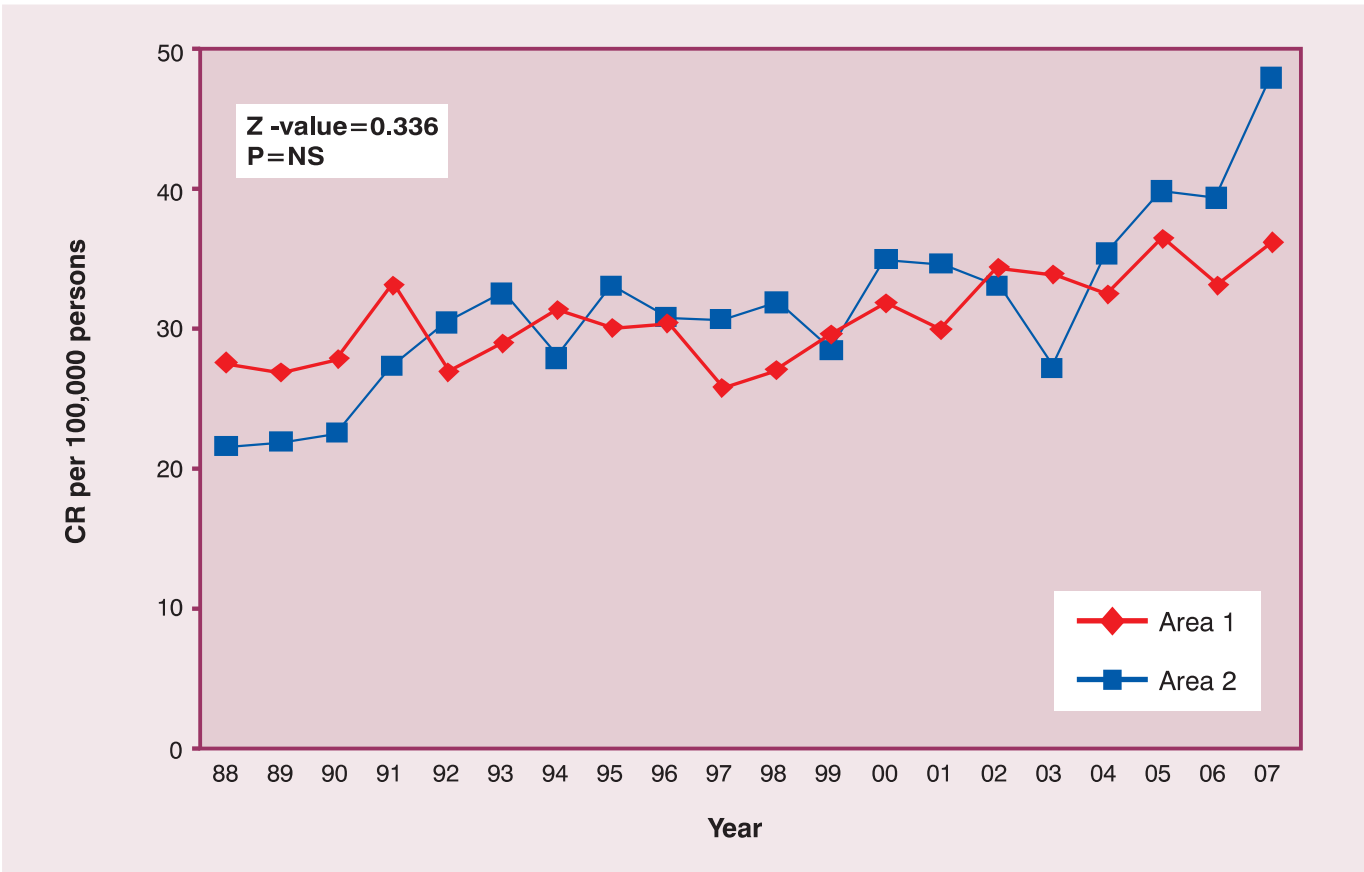


Table 3.16: Adjustment of TRC incidence by Tobacco habits and Area in Bhopal - Males - TRC Cases - 2005

Variable name	Affected	Unaffected	Total / Average
Cases = a	145	98	243
Population = b	504325	397686	902011
TRC Inc (a/b)*100000 = K	28.75	24.64	26.94
Total covered = d	3048	3474	6522
No. of Tobacco users = c	1544	1188	2732
Tobacco habit* = (c/d)*100 = L	50.7	34.2	41.9
(TRC Inc/Tobacco habit) ratio = (K/L) = M	0.57	0.72	0.64
Expected TRC Inc = (L* avg. M) = N	32.58	21.99	26.94
Expected TRC cases (b * N) /100000)	164.30	87.46	243.00
Chi square value	2.267	1.270	3.537
P-value	0.132	0.260	0.171
Significance	NS	NS	NS

* - Based on NCRP Survey 2005; NS – Non-significant.

Table 3.17: Adjustment of incidence by Tobacco habits and Area in Bhopal - Males - Mouth - 2005

Variable name	Affected	Unaffected	Total / Average
Cases = a	40	14	54
Population = b	504325	397686	902011
TRC Inc (a/b)*100000 = K	7.93	3.52	5.99
Total covered = d	3048	3474	6522
No. of Tobacco users = c	1544	1188	2732
Tobacco habit* = (c/d)*100 = L	50.7	34.2	41.9
(TRC Inc/Tobacco habit) ratio = (K/L) = M	0.16	0.10	0.14
Expected TRC Inc = (L* avg. M) = N	7.24	4.89	5.99
Expected TRC cases (b * N) /100000)	36.51	19.44	54.00
Chi square value	0.333	1.520	1.854
P-value	0.564	0.218	0.396
Significance	NS	NS	NS

* - Based on NCRP Survey 2005; NS – Non-significant.

**Table 3.18: Adjustment of incidence by Tobacco habits and Area in Bhopal
Males - Tongue - 2005**

Variable name	Affected	Unaffected	Total / Average
Cases = a	28	21	49
Population = b	504424	397874	902298
TRC Inc (a/b)*100000 = K	5.55	5.28	5.43
Total covered = d	3048	3474	6522
No. of Tobacco users = c	1544	1188	2732
Tobacco habit* = (c/d)*100 = L	50.7	34.2	41.9
(TRC Inc/Tobacco habit) ratio = (K/L) = M	0.11	0.15	0.13
Expected TRC Inc = (L* avg. M) = N	6.57	4.43	5.43
Expected TRC cases (b * N) /100000)	33.13	17.64	49.00
Chi square value	0.793	0.640	1.434
P-value	0.373	0.424	0.488
Significance	NS	NS	NS

* - Based on NCRP Survey 2005; NS – Non-significant.

**Table 3.19: Adjustment of incidence by Tobacco habits and Area in Bhopal
Males - Oesophagus - 2005**

Variable name	Affected	Unaffected	Total / Average
Cases = a	14	10	24
Population = b	504325	397686	902011
TRC Inc (a/b)*100000 = K	2.78	2.51	2.66
Total covered = d	3048	3474	6522
No. of Tobacco users = c	1544	1188	2732
Tobacco habit* = (c/d)*100 = L	50.7	34.2	41.9
(TRC Inc/Tobacco habit) ratio = (K/L) = M	0.05	0.07	0.06
Expected TRC Inc = (L* avg. M) = N	3.22	2.17	2.66
Expected TRC cases (b * N) /100000)	16.23	8.64	24.00
Chi square value	0.306	0.215	0.520
P-value	0.580	0.643	0.771
Significance	NS	NS	NS

* - Based on NCRP Survey 2005; NS – Non-significant.

**Table 3.20: Adjustment of incidence by Tobacco habits and Area in Bhopal
Males - Hypopharynx - 2005**

Variable name	Affected	Unaffected	Total / Average
Cases = a	9	4	13
Population = b	504325	397686	902011
TRC Inc (a/b)*100000 = K	1.78	1.01	1.44
Total covered = d	3048	3474	6522
No. of Tobacco users = c	1544	1188	2732
Tobacco habit* = (c/d)*100 = L	50.7	34.2	41.9
(TRC Inc/Tobacco habit) ratio = (K/L) = M	0.04	0.03	0.03
Expected TRC Inc = (L* avg. M) = N	1.74	1.18	1.44
Expected TRC cases (b * N) /100000)	8.79	4.68	13.00
Chi square value	0.005	0.099	0.104
P-value	0.943	0.754	0.9495
Significance	NS	NS	NS

* - Based on NCRP Survey 2005; NS – Non-significant.

Chapter 4

TRENDS OVER TIME IN INCIDENCE RATES (AAR) OF AREA 1 AND AREA 2

The time trend analysis was done using actual AAR values rather than the modified AAR values as the trends depending on actual AAR values gives the true trend existing in the data. The trend analysis was also done with modified AAR values but not provided in the report, as the comparison of trends over time in the two areas using these values were not too different from that of the actual AARs.

The leading sites of cancer for either sex with statistical results of slope (b), S.E. (b), t values and p-values of Area 1 and Area 2 are shown in Tables 4(a) to 4(d). The trend graphs of both Linear Regression and Joinpoint Regression are shown in Figures 4.1 to 4.8. The model fitted values along with respective APC values are also shown for each figure in the table below the Joinpoint Regression graph. The APC0 values in JPRM refers to slope of linear regression when log values are considered. The APC1 and APC2 of the JPRM refer to the significance of trends over time for earlier and latter years respectively. Wherever, significant, the AAR values of the corresponding years have been indicated in bold.

Cancer of All Sites

Cancers of all sites in both males and females and in Areas 1 and 2, showed a statistically significant increasing trend in the AARs over the years 1988 to 2007. This significant increase was observed through the Linear Regression Method (LRM) as well as by Joinpoint Regression method (JPRM). However, the latter method showed a more pronounced increase for the earlier years 1988-2003 in males in Area 1 and Area 2 and in females in Area 1 after the year 1999.

Males

Tongue: For Areas 1 and 2, the LRM and the overall JPRM (APC0) showed no significant changes in AARs. The JPRM showed an increasing trend (APC=4.00) for the period 1994-2007 in Area 1.

Mouth: In Area 1, the LRM and the JPRM showed a similar increasing trend (APC=3.80) in AARs for the period 1988-2007. No significant increase or decrease in AARs was observed in Area 2.

Lung: In both Areas 1 and 2 the LRM and the overall JPRM did not show significant variations in the AARs for the entire period 1988-2007. However, in Area 1, the JPRM showed an increasing trend (APC=3.20) from 1988-1998 followed by a decreasing trend (APC=-4.40) for the period 1998-2007.

Females

Breast: In both the Areas 1 and 2 the LRM and the overall JPRM showed an increasing trend. Further, the JPRM showed a higher increasing trend in AARs for both Area 1 and 2 for the period 2002-2007.

Cervix: In Area 1 no significant trend in AARs was observed by both the methods. In Area 2 an overall significant decline was seen.

Ovary: In Area 1 LRM and JPRM (APC0 = 3.0) showed an increasing trend in AARs while no change in AARs was observed in Area 2.

**Table 4(a): Summary Results of Time Trend Analysis of Selected Leading Sites of Cancer
- Area 1- Bhopal - Males (1988-2007)**

Linear Regression Method				
Sites	Slope (b)	S.E.(b)	t value	p-value
All sites	0.626	0.148	4.215	<0.01
Tongue	0.027	0.057	0.477	NS
Mouth	0.261	0.085	3.051	<0.01
Hypopharynx	-0.080	0.055	-1.454	NS
Oesophagus	-0.050	0.070	-0.713	NS
Stomach ^{\$}	-0.123	0.032	-3.820	<0.01
Larynx	0.204	0.040	5.067	<0.01
Lung	-0.048	0.076	-0.634	NS
Prostate ^{\$}	0.007	0.044	0.169	NS
Brain NS ^{\$}	-0.029	0.030	-0.958	NS
NHL ^{\$}	0.105	0.047	2.254	<0.05
Myeloid Leukaemia ^{\$}	0.011	0.042	0.256	NS

^{\$} Sites with small number of cases (<10).

Joinpoint Regression Method			
Sites	APC0	APC1	APC2
All sites	0.60*	1.00*	-1.90
Tongue	0.30	-6.50*	4.00*
Mouth	3.80*		
Hypopharynx	-0.90		
Oesophagus	-0.50		
Stomach ^{\$}	-4.20*		
Larynx	5.00*		
Lung	-0.40	3.20*	-4.40*
Prostate ^{\$}	0.50		
Brain NS ^{\$}	-1.90		
NHL ^{\$}	-0.90		
Myeloid Leukaemia ^{\$}	-6.00		

APC - Annual percent change;

* represents the significant APC ($p < 0.05$) values.

^{\$} Sites with small number of cases (<10).

Table 4(b): Summary Results of Time Trend Analysis of Selected Leading Sites of Cancer- Area 2 - Bhopal - Males (1988-2007)

Linear Regression Method				
Sites	Slope (b)	S.E.(b)	t value	p-value
All sites	0.603	0.223	2.704	< 0.05
Tongue	0.106	0.089	1.190	NS
Mouth	-0.002	0.072	-0.034	NS
Hypopharynx ^{\$}	-0.098	0.053	-1.840	NS
Oesophagus	-0.026	0.056	-0.455	NS
Stomach ^{\$}	-0.067	0.053	-1.266	NS
Larynx ^{\$}	-0.021	0.043	-0.497	NS
Lung	-0.020	0.098	-0.208	NS
Prostate ^{\$}	0.133	0.063	2.108	< 0.05
Brain NS ^{\$}	0.008	0.059	0.140	NS
NHL ^{\$}	0.143	0.051	2.789	< 0.01
Myeloid Leukaemia ^{\$}	0.024	0.041	0.577	NS

^{\$} Sites with small number of cases (<10).

Joinpoint Regression Method			
Sites	APC0	APC1	APC2
All sites	0.70*	2.50*	-1.80
Tongue	3.40		
Mouth	0.50		
Hypopharynx ^{\$}	-1.70		
Oesophagus	-0.43	4.09	-4.15
Stomach ^{\$}	-1.80		
Larynx ^{\$}	0.00		
Lung	0.00		
Prostate ^{\$}	3.90*	34.60*	0.00
Brain NS ^{\$}	4.00	99.80*	-5.50
NHL ^{\$}	-1.20		
Myeloid Leukaemia ^{\$}	-3.80		

APC - Annual percent change;

* represents the significant APC ($p < 0.05$) values.

^{\$} Sites with small number of cases (<10).

Table 4(c): Summary Results of Time Trend Analysis of Selected Leading Sites of Cancer- Area 1 - Bhopal - Females (1988-2007)

Linear Regression Method				
Sites	Slope (b)	S.E.(b)	t value	p-value
All sites	1.277	0.198	6.449	<0.01
Mouth	0.082	0.052	1.569	NS
Oesophagus ^{\$}	-0.020	0.060	-0.339	NS
Stomach ^{\$}	-0.075	0.039	-1.901	NS
Gall bladder	0.167	0.038	4.353	<0.05
Lung ^{\$}	0.025	0.040	0.632	NS
Breast	0.698	0.192	3.628	<0.01
Cervix	0.062	0.072	0.851	NS
Corpus uteri ^{\$}	-0.042	0.054	-0.766	NS
Ovary	0.145	0.067	2.157	<0.05
Brain NS ^{\$}	0.007	0.025	0.278	NS
Myeloid Leukaemia ^{\$}	0.029	0.031	0.934	NS

^{\$} Sites with small number of cases (<10).

Joinpoint Regression Method			
Sites	APC0	APC1	APC2
All sites	1.30*	0.30	3.00*
Mouth	1.60		
Oesophagus ^{\$}	-0.20		
Stomach ^{\$}	-14.20	3.90	-76.80*
Gall bladder	5.90*		
Lung ^{\$}	1.80		
Breast	3.10*	0.50	22.10*
Cervix	0.30		
Corpus uteri ^{\$}	-7.60		
Ovary	3.00*		
Brain NS ^{\$}	13.90		
Myeloid Leukaemia ^{\$}	8.30		

APC - Annual percent change;

* represents the significant APC ($p < 0.05$) values.

^{\$} Sites with small number of cases (<10).

Table 4(d): Summary Results of Time Trend Analysis of Selected Leading Sites of Cancer - Area 2 - Bhopal - Females (1988-2007)

Linear Regression Method				
Sites	Slope (b)	S.E.(b)	t value	p-value
All sites	0.683	0.267	2.559	<0.05
Mouth [§]	0.020	0.051	0.389	NS
Oesophagus [§]	0.036	0.061	0.585	NS
Stomach [§]	0.027	0.033	0.799	NS
Gall bladder [§]	0.019	0.070	0.270	NS
Lung [§]	0.001	0.057	0.013	NS
Breast	0.842	0.187	4.490	<0.01
Cervix	-0.307	0.111	-2.779	<0.01
Corpus uteri [§]	0.065	0.033	1.990	NS
Ovary	0.115	0.076	1.522	NS
Brain NS [§]	0.014	0.028	0.497	NS
Myeloid Leukaemia [§]	0.033	0.028	1.172	NS

[§]Sites with small number of cases (<10).

Joinpoint Regression Method			
Sites	APC0	APC1	APC2
All sites	0.80*		
Mouth [§]	0.70	6.3*	-7.6
Oesophagus [§]	0.80		
Stomach [§]	21.90		
Gall bladder [§]	5.60		
Lung [§]	2.40		
Breast	3.00*	1.3*	15.3*
Cervix	-2.10*		
Corpus uteri [§]	15.40		
Ovary	1.90		
Brain NS [§]	1.10		
Myeloid Leukaemia [§]	4.00		

APC - Annual percent change;

* represents the significant APC ($p < 0.05$) values.

[§] Sites with small number of cases (<10).

Fig. 4.1(a): ALL SITES (ICD-10: C00-C96) – Males
Trends over time (1988-2007) in AAR (Linear Regression)

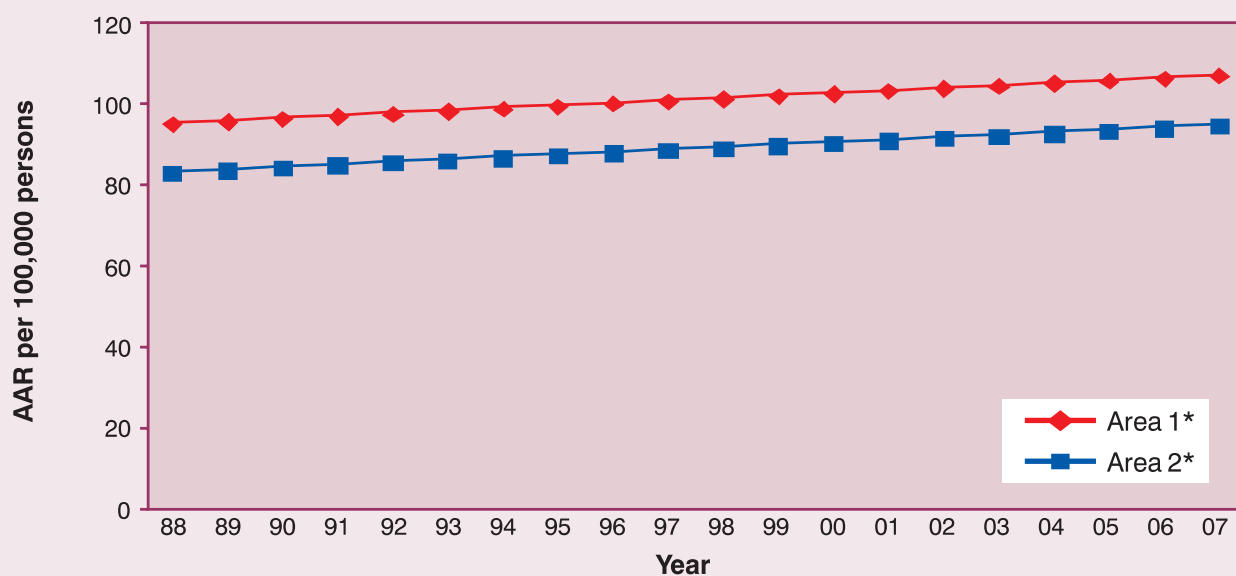


Table 4.1(a): Yearwise Cases and AARs

Year	Area 1		Area 2	
	Cases	AAR	Cases	AAR
1988	167	89.8	85	81.8
1989	185	95.7	98	82.7
1990	202	98.4	96	74.4
1991	210	98.6	114	86.1
1992	207	96.9	130	88.4
1993	212	94.2	145	92.7
1994	239	100.8	145	88.9
1995	235	97.4	167	95.0
1996	252	100.6	163	92.4
1997	251	97.7	178	92.6
1998	257	98.9	183	89.7
1999	289	109.2	176	82.0
2000	297	104.4	190	87.5
2001	308	107.4	205	84.6
2002	325	107.2	210	85.3
2003	331	105.5	221	84.8
2004	323	107.5	210	86.5
2005	305	107.5	246	96.6
2006	348	100.5	309	102.1
2007	359	99.2	317	99.7
b(Slope)		0.626		0.603
p-value		< 0.01		< 0.01

Fig. 4.1(b) : ALL SITES (ICD-10: C00-C96) – Males
Trends over time (1988-2007) in AAR (Joinpoint Regression)

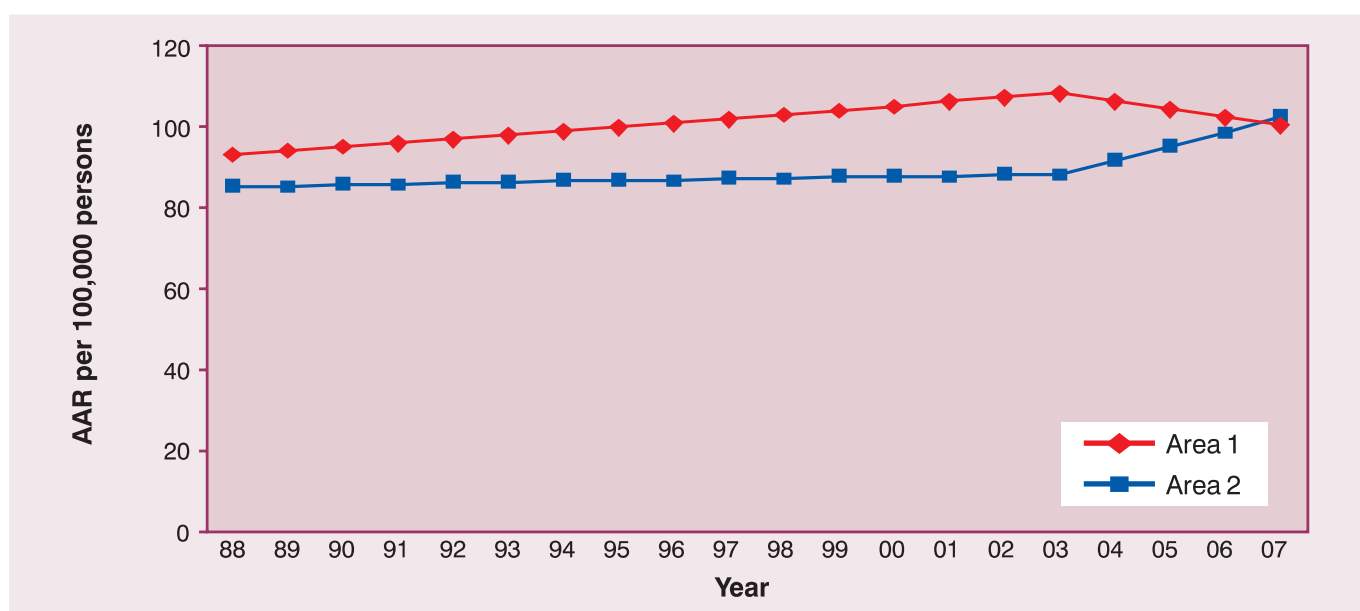


Table 4.1(b): Value of Joinpoint AARs with Annual Percent Change (APC)

Year	Area 1	Area 2
1988	93.00	85.02
1989	93.93	85.22
1990	94.86	85.42
1991	95.81	85.62
1992	96.77	85.82
1993	97.73	86.02
1994	98.71	86.22
1995	99.69	86.43
1996	100.69	86.63
1997	101.69	86.83
1998	102.70	87.03
1999	103.73	87.24
2000	104.76	87.44
2001	105.81	87.64
2002	106.86	87.85
2003	107.93	88.05
2004	105.92	91.37
2005	103.95	94.81
2006	102.02	98.37
2007	100.12	102.08
APC0	0.60*	0.70*
APC1	1.00*	2.50*
APC2	-1.90	-1.80

Values of years where a shift in trend is observed is highlighted; * represents significant joinpoint model and APC ($p < 0.05$) values.

Fig. 4.2(a): ALL SITES (ICD-10: C00-C96) – Females
Trends over time (1988-2007) in AAR (Linear Regression)

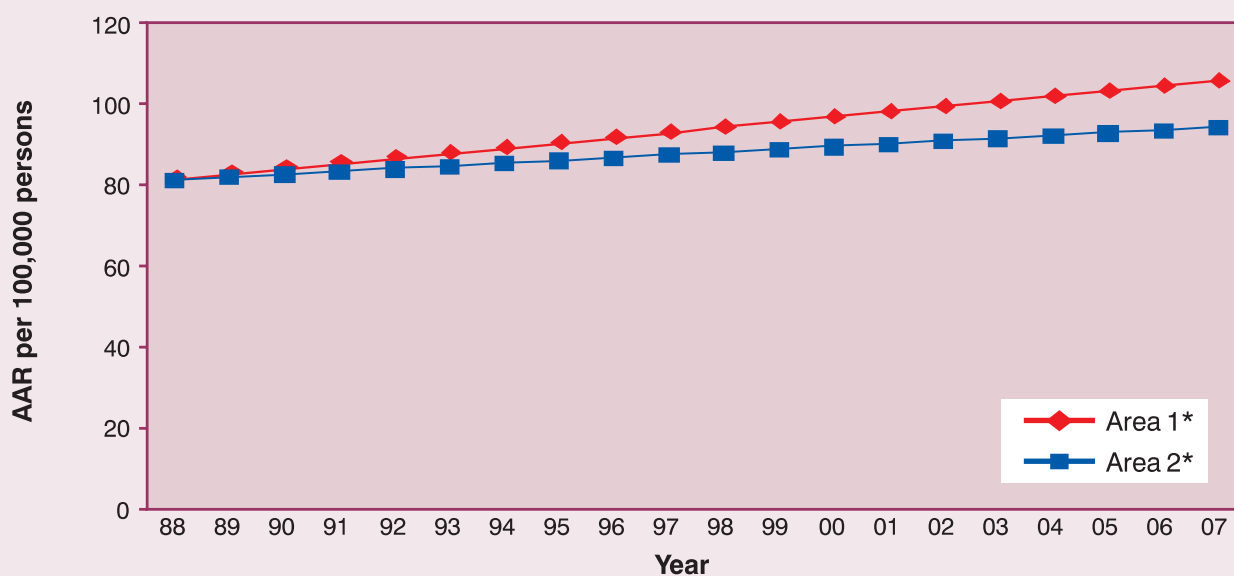


Table 4.2(a): Yearwise cases and AARs

Year	Area 1		Area 2	
	Cases	AAR	Cases	AAR
1988	138	83.3	95	89.7
1989	162	89.1	81	72.2
1990	178	83.7	103	78.9
1991	183	89.4	104	77.3
1992	185	88.6	122	84.3
1993	182	84.9	139	90.9
1994	193	86.8	146	89.3
1995	198	88.4	133	80.2
1996	198	87.3	166	92.7
1997	214	91.5	181	95.3
1998	209	84.4	174	85.4
1999	225	89.7	186	85.7
2000	239	92.8	197	86.0
2001	239	90.7	210	88.2
2002	269	99.8	222	86.4
2003	262	94.3	206	75.3
2004	286	109.4	246	100.6
2005	278	103.6	251	99.7
2006	330	107.9	268	89.8
2007	367	113.7	305	97.2
b(Slope)		1.277		0.683
p-value		<0.01		<0.05

Fig. 4.2(b): ALL SITES (ICD-10: C00-C96) – Females
Trends over time (1988-2007) in AAR (Joinpoint Regression)

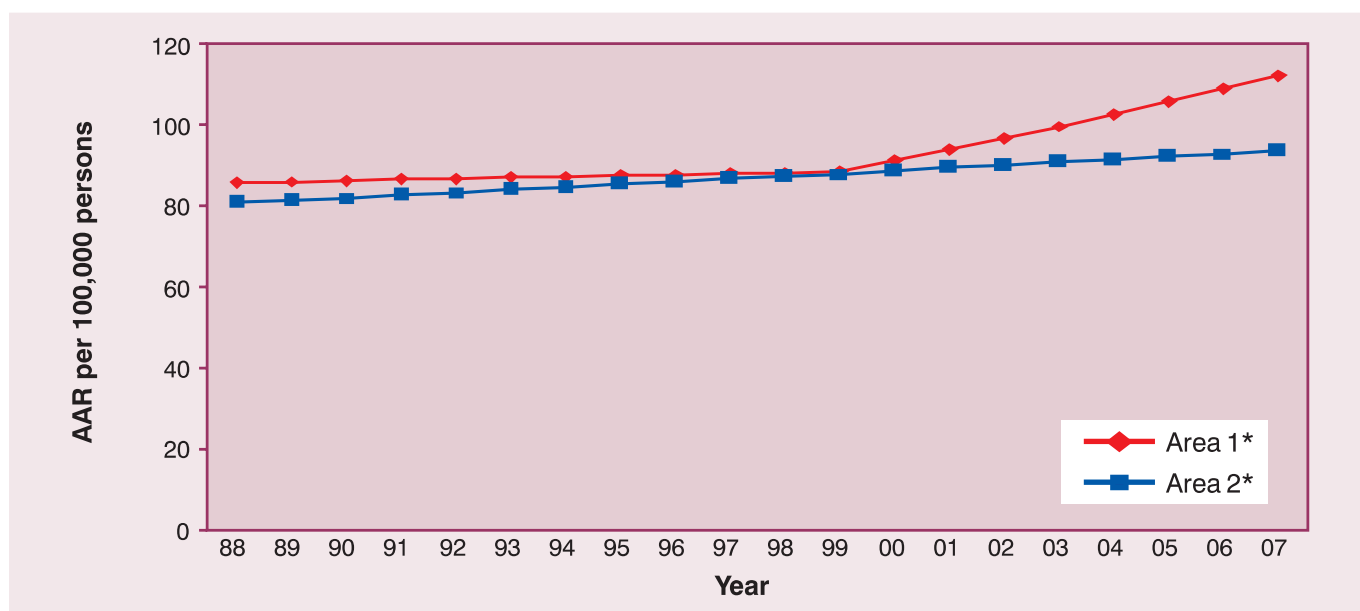


Table 4.2(b): Value of Joinpoint AARs with Annual Percent Change (APC)

Year	Area 1	Area 2
1988	85.86	80.69
1989	86.10	81.32
1990	86.34	81.96
1991	86.58	82.60
1992	86.82	83.25
1993	87.07	83.90
1994	87.31	84.56
1995	87.55	85.23
1996	87.80	85.89
1997	88.04	86.57
1998	88.29	87.25
1999	88.53	87.93
2000	91.22	88.62
2001	93.98	89.32
2002	96.83	90.02
2003	99.77	90.72
2004	102.80	91.44
2005	105.90	92.15
2006	109.10	92.88
2007	112.40	93.60
APC0	1.30*	0.80*
APC1	0.30	
APC2	3.00*	

Values of years where a shift in trend is observed is highlighted; * represents significant joinpoint model and APC ($p < 0.05$) values.

Fig. 4.3(a): TONGUE (ICD-10: C01-C02) – Males
Trends over time (1988-2007) in AAR (Linear Regression)

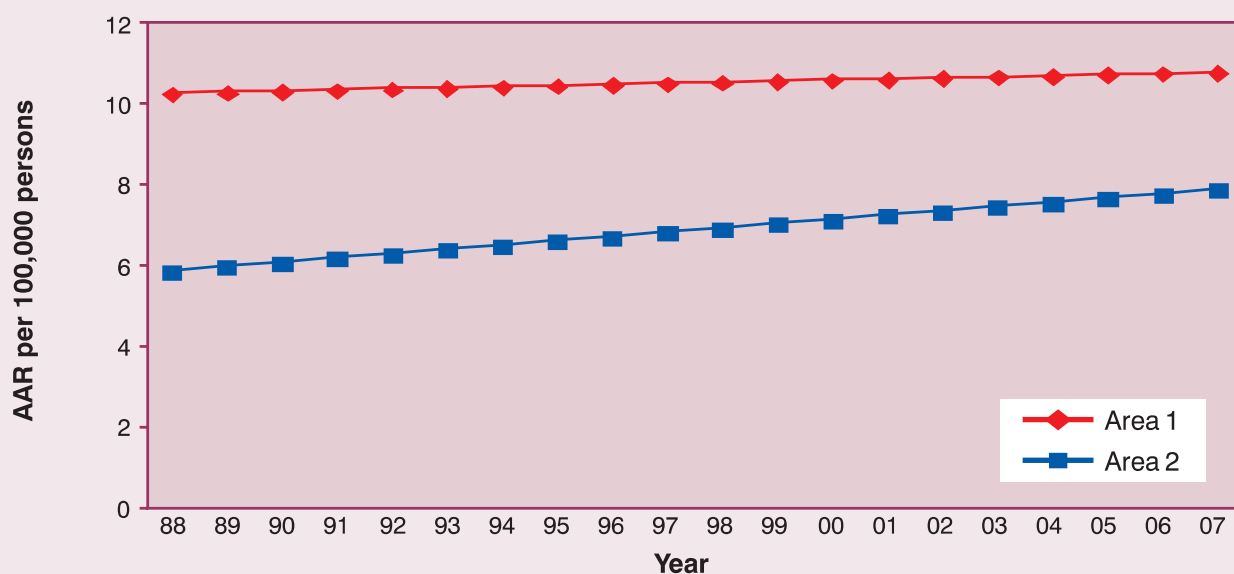


Table 4.3(a): Yearwise Cases and AARs

Year	Area 1		Area 2	
	Cases	AAR	Cases	AAR
1988	22	12.4	0	1.0
1989	20	11.2	14	11.24
1990	23	12.1	11	10.29
1991	18	9.6	7	4.62
1992	21	10.8	5	4.55
1993	17	8.6	10	6.39
1994	20	8.4	10	7.12
1995	20	8.4	10	5.76
1996	24	10.3	9	5.05
1997	22	9.3	14	7.77
1998	21	9.0	12	5.93
1999	29	10.8	17	7.84
2000	26	8.9	15	6.6
2001	31	11.4	19	7.52
2002	35	11.3	12	4.79
2003	35	11.5	19	7.2
2004	39	13.4	16	6.86
2005	28	11.6	21	7.75
2006	40	10.9	36	10.2
2007	34	9.4	27	8.3
b(Slope)		0.027		0.106
p-value		NS		NS

Fig. 4.3(b): TONGUE (ICD-10: C01-C02) – Males
Trends over time (1988-2007) in AAR (Joinpoint Regression)

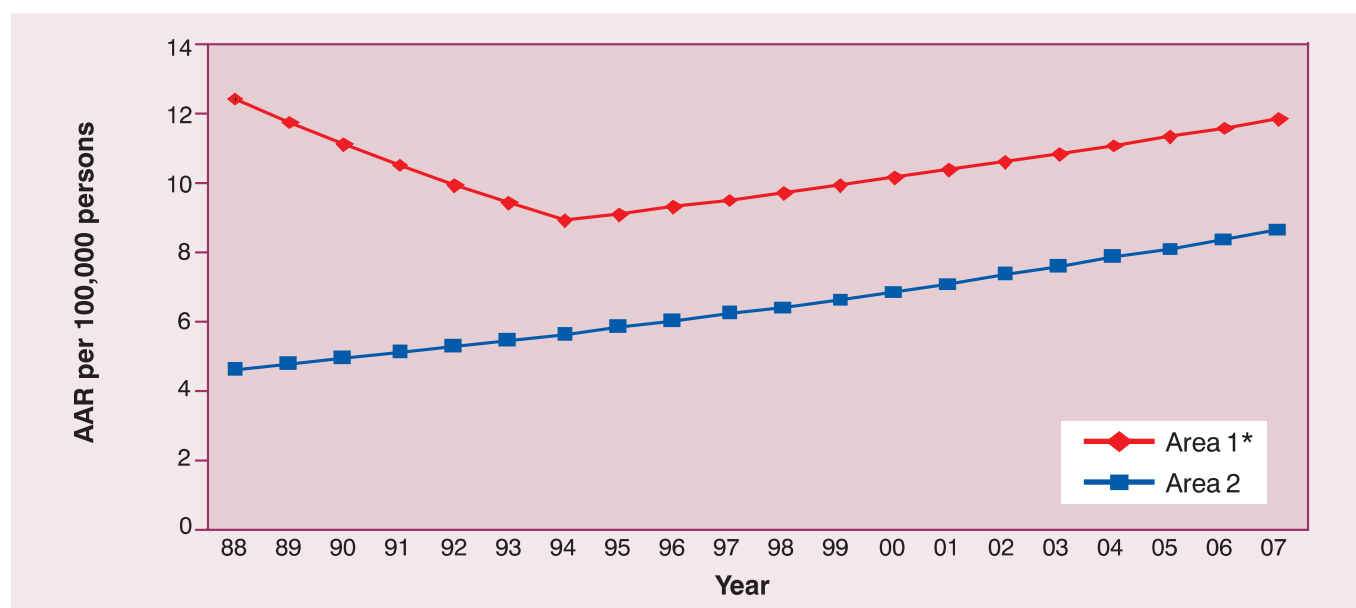


Table 4.3(b): Value of Joinpoint AARs with Annual Percent Change (APC)

Year	Area 1	Area 2
1988	12.36	4.57
1989	11.69	4.72
1990	11.06	4.88
1991	10.46	5.05
1992	9.89	5.22
1993	9.36	5.40
1994	8.85	5.58
1995	9.05	5.77
1996	9.25	5.96
1997	9.45	6.17
1998	9.66	6.38
1999	9.88	6.59
2000	10.10	6.82
2001	10.32	7.05
2002	10.55	7.29
2003	10.78	7.53
2004	11.02	7.79
2005	11.27	8.05
2006	11.52	8.33
2007	11.77	8.61
APC0	0.30	3.40
APC1	-6.50*	
APC2	4.00*	

Values of years where a shift in trend is observed is highlighted; * represents significant joinpoint model and APC ($p < 0.05$) values.

Fig. 4.4(a): MOUTH (ICD-10: C03-C06) – Males
Trends over time (1988-2007) in AAR (Linear Regression)

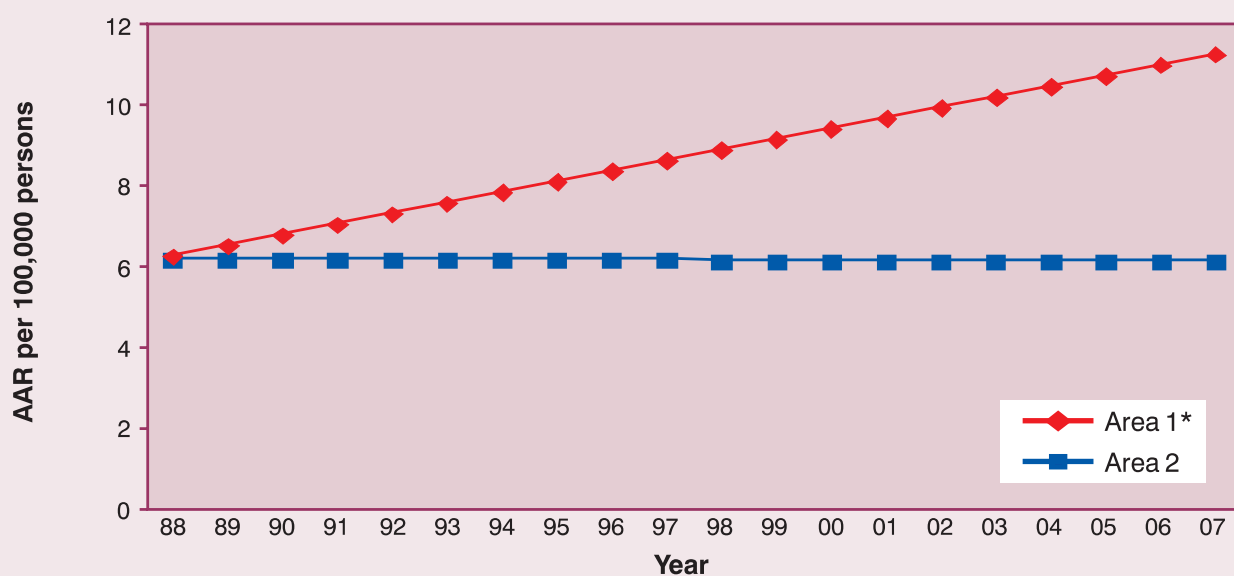


Table 4.4(a): Yearwise Cases and AARs

Year	Area 1		Area 2	
	Cases	AAR	Cases	AAR
1988	15	8.4	7	8.0
1989	16	9.3	9	7.2
1990	4	2.2	6	4.2
1991	9	4.2	2	1.6
1992	12	5.8	10	6.5
1993	16	6.8	13	7.2
1994	20	8.8	12	7.7
1995	26	10.9	14	7.8
1996	24	9.8	12	6.2
1997	27	9.9	15	6.7
1998	23	8.3	17	8.7
1999	25	8.3	10	4.9
2000	27	8.8	10	4.5
2001	30	10.0	12	5.5
2002	30	9.3	12	4.7
2003	29	8.9	19	6.6
2004	45	12.7	11	3.9
2005	40	14.3	14	5.1
2006	37	9.7	25	8.5
2007	32	8.4	25	7.3
b(Slope)		0.261		-0.002
p-value		<0.01		NS

Fig. 4.4(b): MOUTH (ICD-10: C03-C06) – Males
Trends over time (1988-2007) in AAR (Joinpoint Regression)

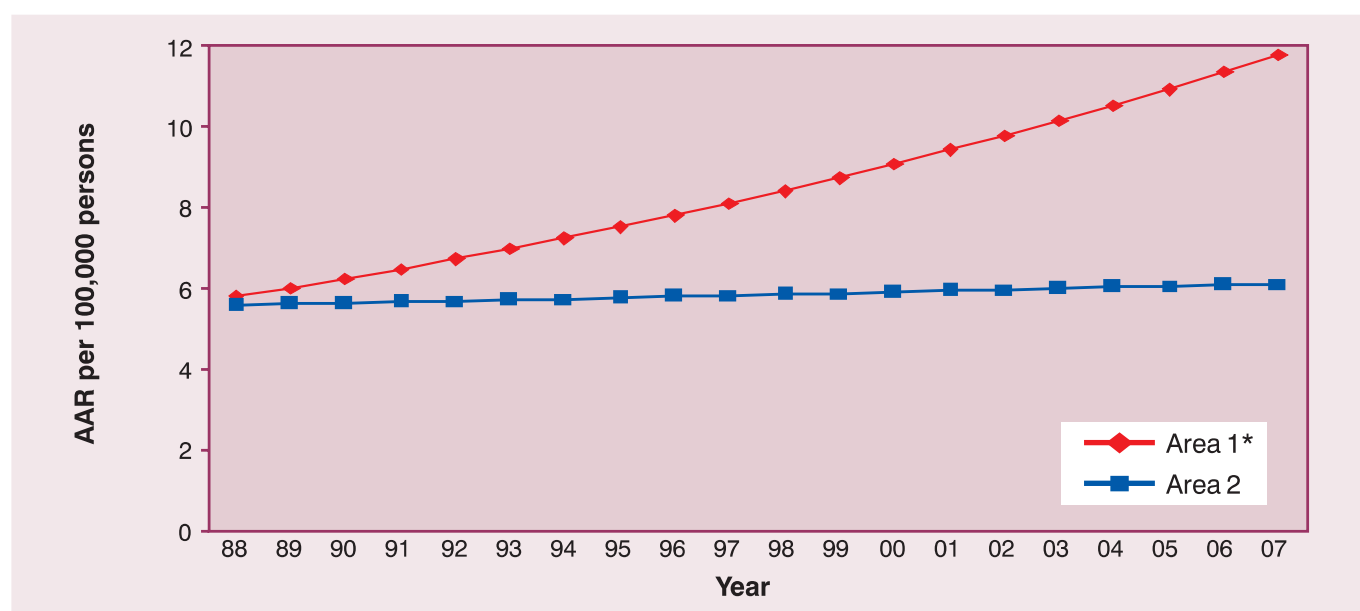


Table 4.4(b): Value of Joinpoint AARs with Annual Percent Change (APC)

Year	Area 1	Area 2
1988	5.75	5.53
1989	5.97	5.56
1990	6.20	5.58
1991	6.44	5.61
1992	6.68	5.64
1993	6.94	5.67
1994	7.20	5.69
1995	7.48	5.72
1996	7.76	5.75
1997	8.06	5.78
1998	8.37	5.81
1999	8.69	5.83
2000	9.02	5.86
2001	9.36	5.89
2002	9.72	5.92
2003	10.09	5.95
2004	10.47	5.98
2005	10.87	6.01
2006	11.29	6.04
2007	11.72	6.06
APC0	3.80*	0.50
APC1		
APC2		

* represents significant joinpoint model and APC ($p < 0.05$) values.

Fig. 4.5(a): LUNG (ICD-10: C33-C34) – Males
Trends over time (1988-2007) in AAR (Linear Regression)

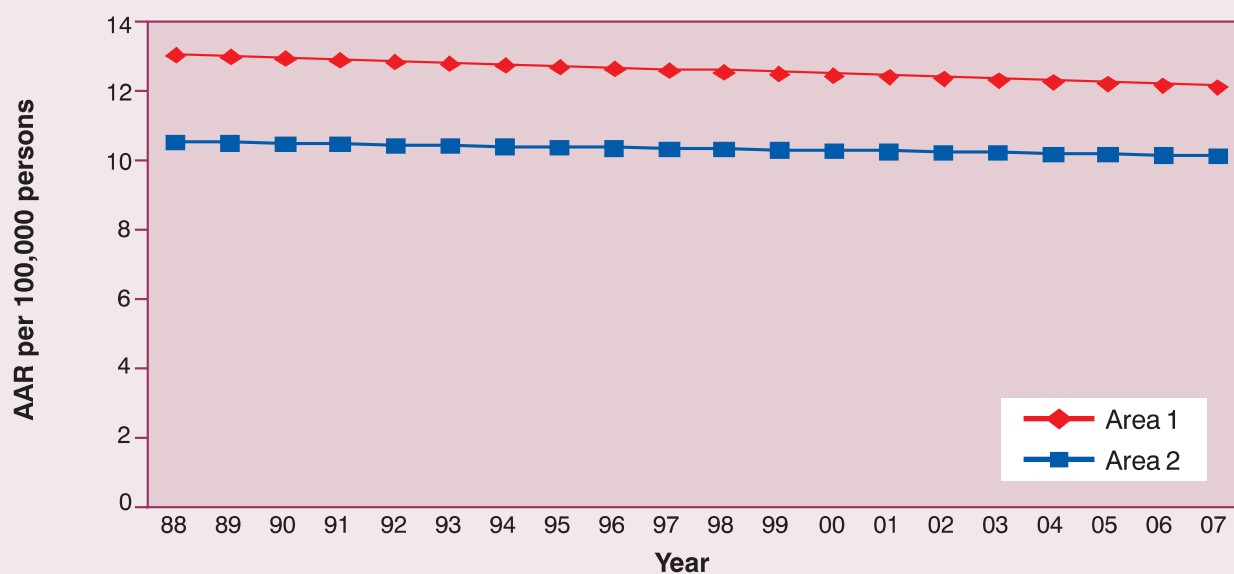


Table 4.5(a): Yearwise Cases and AARs

Year	Area 1		Area 2	
	Cases	AAR	Cases	AAR
1988	14	8.9	12	11.1
1989	19	11.2	14	13.9
1990	24	12.6	8	5.3
1991	24	13.4	16	13.2
1992	31	15.8	15	10.1
1993	25	12.2	18	13.9
1994	26	11.6	15	8.8
1995	28	12.6	18	11.0
1996	34	14.4	16	9.7
1997	36	14.5	19	11.0
1998	33	15.0	15	7.6
1999	38	14.6	16	8.0
2000	35	13.4	16	7.5
2001	39	14.7	16	7.0
2002	30	10.8	30	12.5
2003	34	11.7	28	11.6
2004	34	11.5	19	7.7
2005	28	9.7	30	11.8
2006	38	12.1	36	11.9
2007	32	10.0	37	11.8
b(Slope)		-0.05		-0.02
p-value		NS		NS

Fig. 4.5(b): LUNG (ICD-10: C33-C34) – Males
Trends over time (1988-2007) in AAR (Joinpoint Regression)

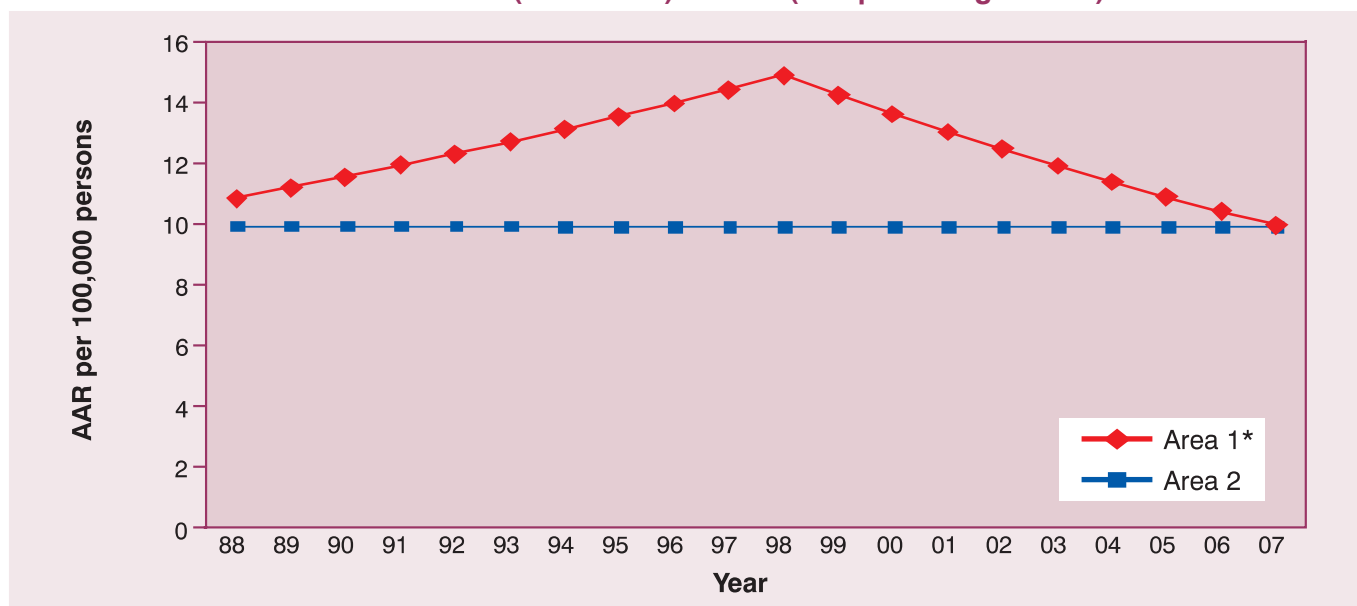


Table 4.5(b): Value of Joinpoint AARs with Annual Percent Change (APC)

Year	Area 1	Area 2
1988	10.88	9.98
1989	11.23	9.97
1990	11.59	9.97
1991	11.97	9.97
1992	12.35	9.97
1993	12.75	9.97
1994	13.17	9.96
1995	13.59	9.96
1996	14.03	9.96
1997	14.48	9.96
1998	14.95	9.96
1999	14.30	9.95
2000	13.67	9.95
2001	13.07	9.95
2002	12.50	9.95
2003	11.95	9.95
2004	11.43	9.94
2005	10.93	9.94
2006	10.45	9.94
2007	9.99	9.94
APC0	-0.40	0.00
APC1	3.20*	
APC2	-4.40*	

Values of years where a shift in trend is observed is highlighted; * represents significant joinpoint model and APC ($p < 0.05$) values.

Fig. 4.6(a): BREAST (ICD-10: C50)
Trends over time (1988-2007) in AAR (Linear Regression)

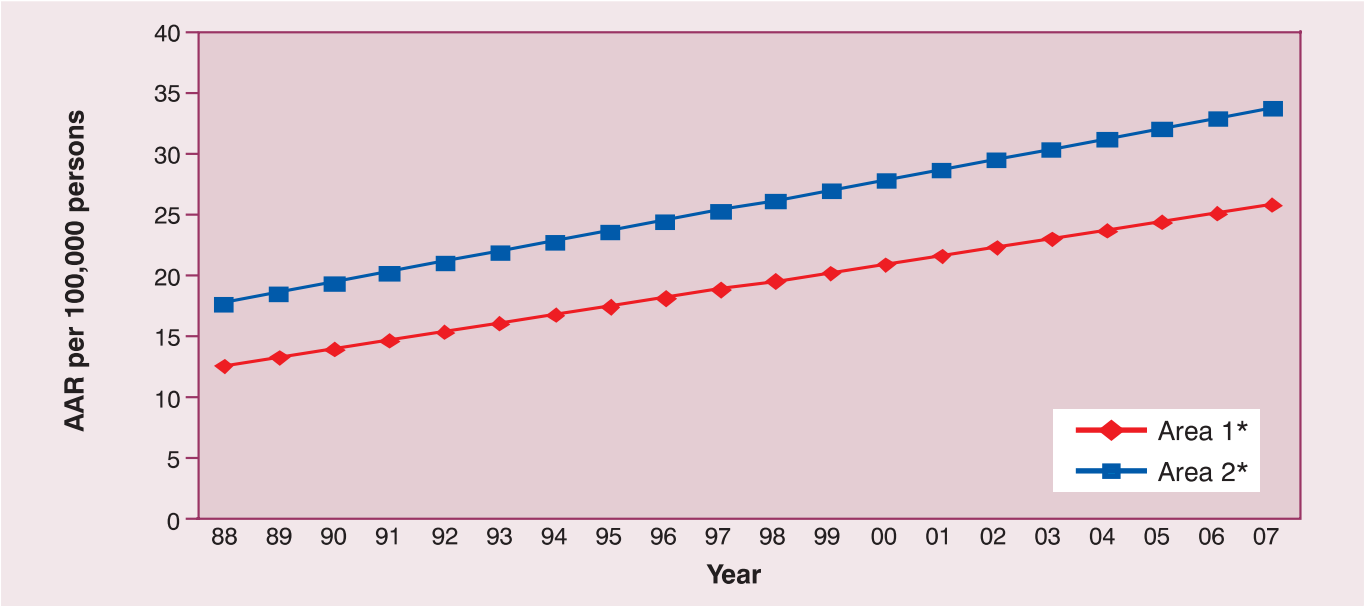


Table 4.6(a): Yearwise Cases and AARs

Year	Area 1		Area 2	
	Cases	AAR	Cases	AAR
1988	27	15.8	22	20.5
1989	30	17.3	22	19.7
1990	32	16.1	28	20.8
1991	36	18.9	24	17.3
1992	34	14.9	34	24.5
1993	37	16.8	36	24.0
1994	36	15.9	40	24.3
1995	34	13.9	40	23.2
1996	41	16.4	39	20.7
1997	36	14.3	49	25.0
1998	43	17.2	51	25.0
1999	40	15.1	62	27.2
2000	52	18.1	53	23.3
2001	48	16.3	60	24.8
2002	54	19.3	66	24.8
2003	58	19.8	66	22.8
2004	56	20.1	73	28.7
2005	78	24.8	69	27.6
2006	76	29.1	77	41.6
2007	70	41.3	77	46.0
b(Slope)		0.698		0.842
p-value		<0.01		<0.01

Fig. 4.6(b): BREAST (ICD-10: C50)
Trends over time (1988-2007) in AAR (Joinpoint Regression)

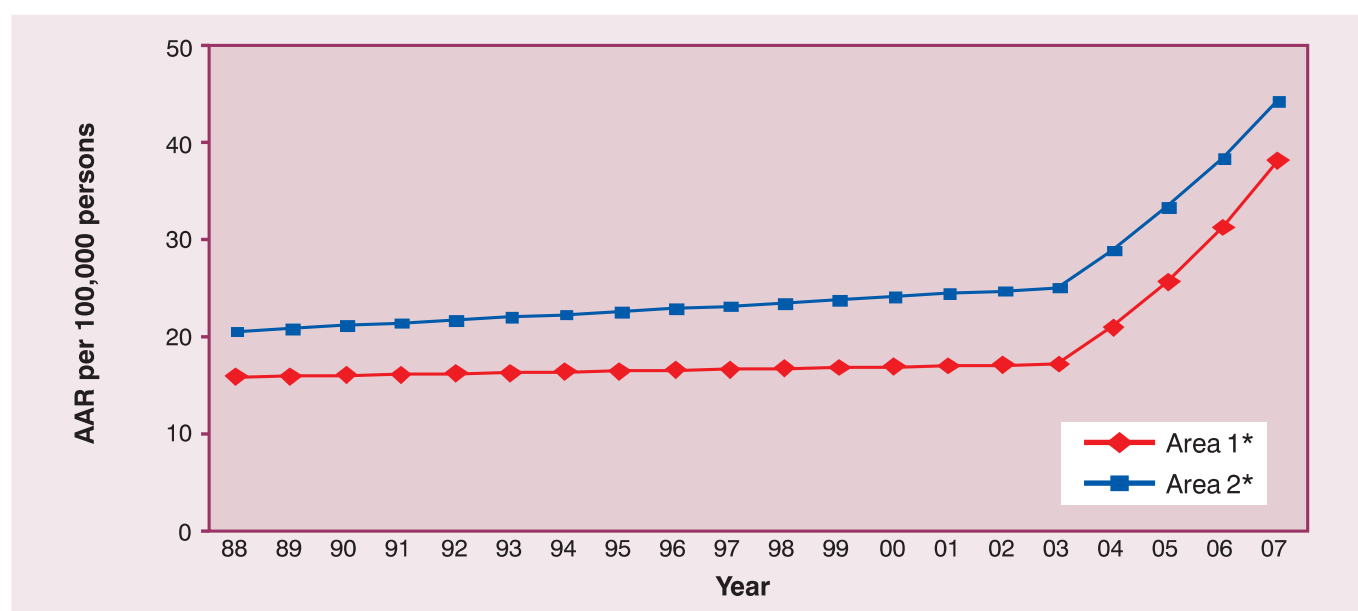


Table 4.6(b): Value of Joinpoint AARs with Annual Percent Change (APC)

Year	Area 1	Area 2
1988	15.82	20.58
1989	15.91	20.85
1990	15.99	21.13
1991	16.08	21.41
1992	16.17	21.70
1993	16.25	21.98
1994	16.34	22.28
1995	16.43	22.57
1996	16.52	22.87
1997	16.61	23.17
1998	16.70	23.48
1999	16.79	23.79
2000	16.88	24.11
2001	16.97	24.43
2002	17.06	24.75
2003	17.15	25.08
2004	20.95	28.92
2005	25.58	33.34
2006	31.23	38.44
2007	38.13	44.32
APC0	3.10*	3.00*
APC1	0.50	1.30*
APC2	22.10*	15.30*

Values of years where a shift in trend is observed is highlighted; * represents significant joinpoint model and APC ($p < 0.05$) values.

Fig. 4.7(a): CERVIX (ICD-10: C53)
Trends over time (1988-2007) in AAR (Linear Regression)

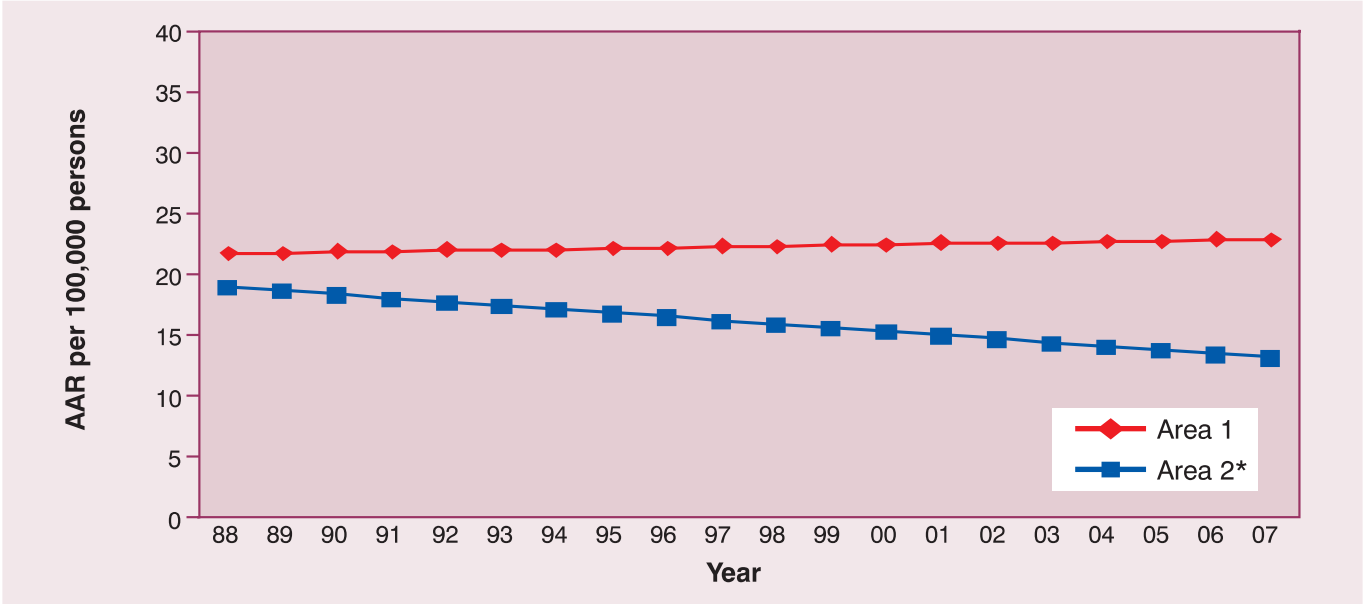


Table 4.7(a): Yearwise Cases and AARs

Year	Area 1		Area 2	
	Cases	AAR	Cases	AAR
1988	36	19.6	22	21.7
1989	41	23.2	18	14.5
1990	45	21.7	19	15.0
1991	48	24.7	26	18.9
1992	47	21.5	24	16.3
1993	44	20.2	33	20.3
1994	51	22.2	31	18.4
1995	53	22.1	26	15.5
1996	52	21.9	33	18.7
1997	54	22.3	34	17.4
1998	55	22.4	30	14.1
1999	52	21.9	37	17.8
2000	54	22.2	38	16.1
2001	47	19.0	42	17.0
2002	69	26.9	29	10.8
2003	66	24.4	25	7.4
2004	63	25.0	36	16.3
2005	57	21.6	32	11.7
2006	63	21.8	44	14.8
2007	72	21.3	48	14.6
b(Slope)		0.062		-0.307
p-value		NS		<0.01

Fig. 4.7(b): CERVIX (ICD-10: C53)
Trends over time (1988-2007) in AAR (Joinpoint Regression)

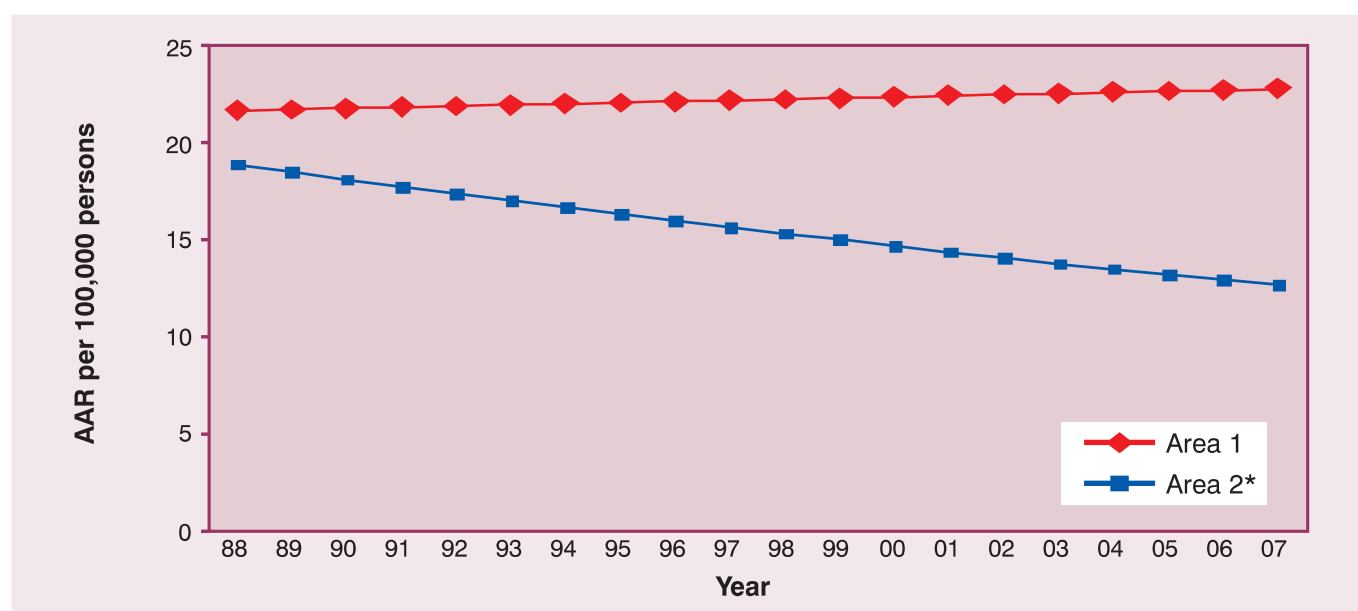


Table 4.7(b): Value of Joinpoint AARs with Annual Percent Change (APC)

Year	Area 1	Area 2
1988	21.66	18.90
1989	21.72	18.50
1990	21.78	18.12
1991	21.84	17.74
1992	21.90	17.37
1993	21.95	17.01
1994	22.01	16.65
1995	22.07	16.30
1996	22.13	15.96
1997	22.19	15.63
1998	22.25	15.31
1999	22.31	14.99
2000	22.37	14.67
2001	22.43	14.37
2002	22.49	14.07
2003	22.55	13.77
2004	22.61	13.49
2005	22.67	13.20
2006	22.73	12.93
2007	22.79	12.66
APC0	0.30	-2.10*
APC1		
APC2		

* represents significant joinpoint model and APC ($p < 0.05$) values.

Fig. 4.8(a): OVARY (ICD-10: C56)
Trends over time (1988-2007) in AAR (Linear Regression)

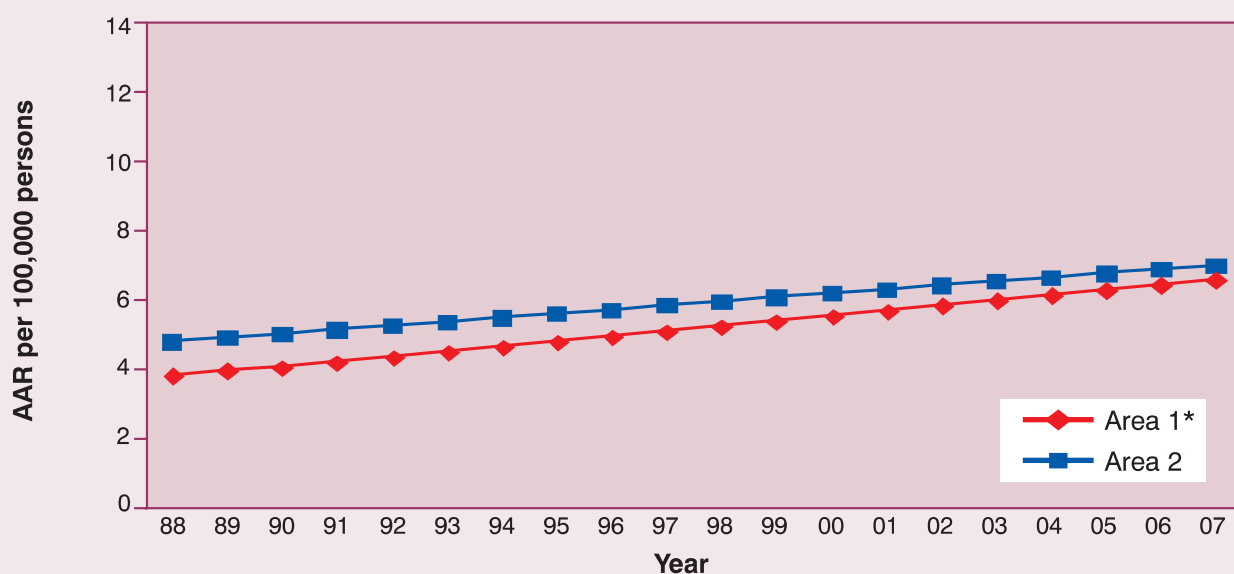


Table 4.8(a): Yearwise Cases and AARs

Year	Area 1		Area 2	
	Cases	AAR	Cases	AAR
1988	4	1.9	6	6.2
1989	10	5.2	5	4.3
1990	12	5.3	4	2.9
1991	8	3.2	11	8.3
1992	19	8.3	9	4.4
1993	9	4.2	10	6.3
1994	9	3.2	11	6.8
1995	13	5.9	10	5.8
1996	12	5.3	8	4.5
1997	13	4.5	11	5.3
1998	10	3.9	12	5.2
1999	12	5.7	6	2.8
2000	11	3.7	9	3.6
2001	16	5.2	13	5.6
2002	13	4.8	21	7.7
2003	14	3.3	14	5.7
2004	18	5.71	29	11.5
2005	14	5.7	17	6.8
2006	26	8.5	21	7.7
2007	31	9.5	18	5.8
b(Slope)		0.145		0.115
p-value		< 0.05		NS

Fig. 4.8(b): OVARY (ICD-10: C56)
Trends over time (1988-2007) in AAR (Joinpoint Regression)

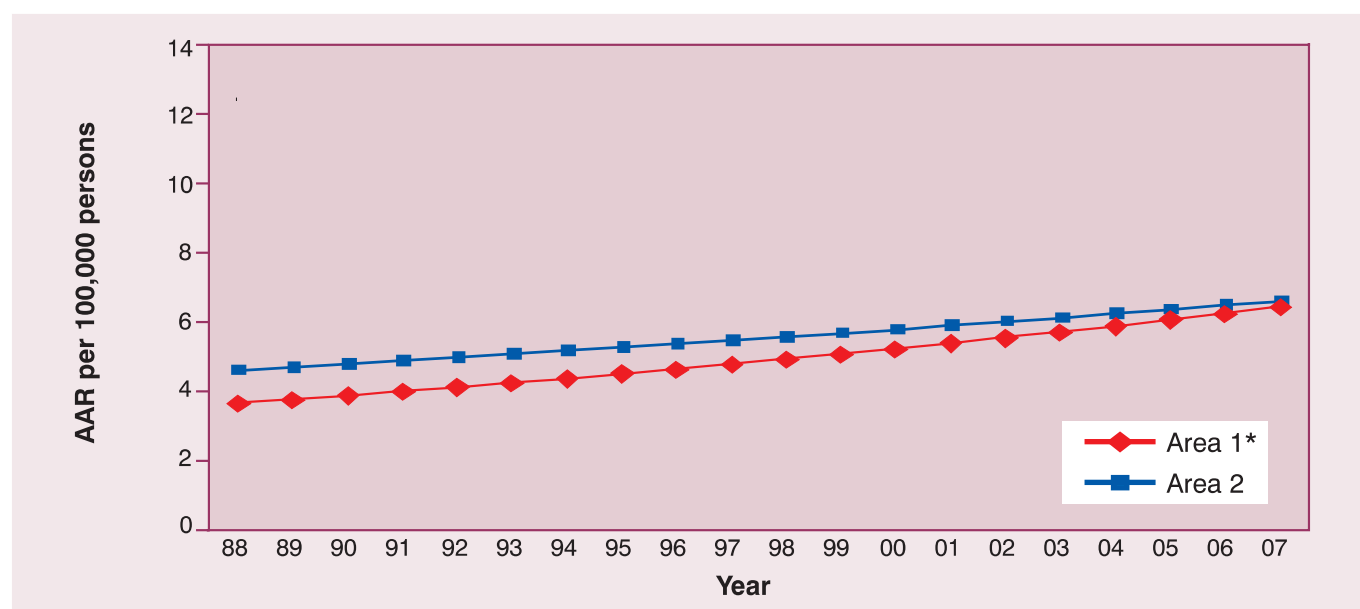


Table 4.8(b): Value of Joinpoint AARs with Annual Percent Change (APC)

Year	Area 1	Area 2
1988	3.63	4.63
1989	3.74	4.72
1990	3.86	4.81
1991	3.97	4.90
1992	4.09	5.00
1993	4.22	5.09
1994	4.35	5.19
1995	4.48	5.29
1996	4.61	5.39
1997	4.75	5.49
1998	4.90	5.60
1999	5.05	5.70
2000	5.20	5.81
2001	5.36	5.92
2002	5.52	6.04
2003	5.69	6.15
2004	5.86	6.27
2005	6.04	6.39
2006	6.22	6.51
2007	6.41	6.63
APC0	3.00*	1.90
APC1		
APC2		

* represents significant joinpoint model and APC ($p < 0.05$) values.

Chapter 5

POPULATION ESTIMATION AND STATISTICAL DEFINITIONS/METHODS

Estimation of Population

In India, the census is providing population figures once in every 10 years. However, based on the Cancer Incidence data, to provide various rates for inter-census years, the calculation of the relevant population estimates, assumes importance.

Population of Bhopal Urban Agglomerate

Bhopal, a small town of 1901, started flourishing soon after receiving the status of state capital in 1956. New areas were included in the Bhopal Municipal Corporation. In 1971, Bhopal became a district place. A large number of migratory populations came and settled here. As per the census data, Bhopal had the maximum growth of 7.4% during the decade 1961-1971. As revealed by the 2001 census, the city had a growth rate of 2.98% for males and 3.04% for females during the decade 1991-2001.

Population and Growth Rates of Area 1 and Area 2

Census data on ward wise population was utilized to arrive at total population of MIC affected and MIC unaffected areas (Area 1 and Area 2) for the year 1981, 1991 & 2001 correspondingly the average annual growth rates were also calculated for males and females separately and shown Table 5.1.

Table 5.1: Population & Growth Rate of Area 1 and Area 2 for years 1981, 1991 & 2001

Year	Male		Female	
	Area 1	Area 2	Area 1	Area 2
1981	230256	132730	201606	114220
1991	347386	223381	311387	198648
2001	442994	325396	397504	292520
Average Annual Growth Rate (1981-1991)	4.2	5.2	4.4	5.7
Average Annual Growth Rate (1991-2001)	2.5	3.8	2.6	3.9

It was observed that the growth rate differed significantly between the Area 1 and Area 2 for the period 1981-1991 & 1991-2001. In view of this the age distribution provided by the census for Bhopal Urban Agglomerate cannot be used for two areas. It may be mentioned that the age distribution for the ward wise population is not available for any of the census. This necessitated the calculation of five yearly age group populations of the two areas. The following data were used in estimation of five yearly age group population:

1. The growth rates of 1981-1991; 1991-2001 of Area 1 and Area 2.
2. Age and sex distribution of ICMR cohort of 1985.
3. Age and sex distribution of NCRP survey 2005 carried out in Area 1 and Area 2.

The details of the ICMR cohort 1985 and the NCRP survey 2005 are provided in Tables 5.2 and 5.3. A significant difference was observed in age distribution of the two areas among males as well as females. This confirmed the fact that a common age distribution cannot be used for both the areas.

Table 5.2: Age & Sex Distribution of Area 1 and Area 2 of ICMR Cohort 1985

Age Group	Male				Female			
	Area 1		Area 2		Area 1		Area 2	
	No.	%	No.	%	No.	%	No.	%
0-4	4903	11.68	1094	12.75	4560	12.08	953	12.94
5-9	5614	13.38	1265	14.74	5063	13.41	1202	16.33
10-14	5302	12.63	965	11.25	4808	12.74	864	11.74
15-19	4491	10.70	774	9.02	4295	11.38	631	8.57
20-24	4496	10.71	789	9.20	4458	11.81	903	12.27
25-29	3696	8.81	843	9.83	3661	9.70	815	11.07
30-34	3132	7.46	779	9.08	2509	6.65	629	8.54
35-39	2526	6.02	686	8.00	2005	5.31	399	5.42
40-44	2096	4.99	463	5.40	1577	4.18	272	3.69
45-49	1659	3.95	310	3.61	1334	3.53	173	2.35
50-54	1421	3.39	219	2.55	1091	2.89	155	2.11
55-59	763	1.82	109	1.27	623	1.65	89	1.21
60-64	979	2.33	138	1.61	920	2.44	152	2.06
65-69	333	0.79	48	0.56	315	0.83	47	0.64
70-74	326	0.78	60	0.70	297	0.79	41	0.56
75+	231	0.55	38	0.44	236	0.63	37	0.50
Total	41968	100.00	8580	100.00	37752	100.00	7362	100.00

METHOD FOR ESTIMATION OF POPULATION

Difference distribution method (*Takiar & Shobana, 2009*) was used to calculate the five yearly age group population estimates for inter-census years. The method of calculation is shown in Annexure I. The following steps were used in estimation:

1. The total populations were arrived separately for Area 1 and Area 2 utilizing the respective decadal growth rates.
2. Utilizing the five yearly percentage distribution of ICMR cohort 1985 the five yearly age group populations for the year 1985 of Area 1 and Area 2 were arrived.
3. Similarly, utilizing the five yearly percentage distributions of NCRP survey 2005 the five yearly age group populations for the year 2005 of Area 1 and Area 2 were arrived.

Table 5.3: Age & Sex Distribution of Area 1 and Area 2 - NCRP Survey 2005

Age Group	Male				Female			
	Area 1		Area 2		Area 1		Area 2	
	No.	%	No.	%	No.	%	No.	%
0-4	475	8.22	455	7.41	429	8.23	452	7.97
5-9	633	10.95	591	9.63	537	10.30	518	9.13
10-14	665	11.50	660	10.75	583	11.19	573	10.10
15-19	675	11.68	667	10.87	574	11.01	593	10.46
20-24	707	12.23	664	10.82	645	12.38	655	11.55
25-29	497	8.60	593	9.66	524	10.05	576	10.16
30-34	440	7.61	470	7.66	444	8.52	484	8.53
35-39	434	7.51	460	7.49	386	7.41	434	7.65
40-44	326	5.64	376	6.13	307	5.89	317	5.59
45-49	265	4.58	301	4.90	221	4.24	279	4.92
50-54	182	3.15	225	3.67	149	2.86	220	3.88
55-59	145	2.51	226	3.68	131	2.51	160	2.82
60-64	130	2.25	156	2.54	110	2.11	180	3.17
65-69	88	1.52	137	2.23	64	1.23	105	1.85
70-74	64	1.11	97	1.58	57	1.09	70	1.23
75+	55	0.95	60	0.98	51	0.98	55	0.97
Total	5781	100.00	6138	100.00	5212	100.00	5671	100.00

4. The difference (2005-1985) in each of the five yearly age group populations was arrived and their percentage contribution to total growth (1985 to 2005) was calculated.
5. To estimate the five yearly age group population for a given year its growth in relation to the year 1985 was distributed according to the percentage distribution arrived in step 4 and subsequently added to the base population of the year 1985.
6. The estimated population totals and the 5 yearly age group distributions for 1988 to 2005 of Area 1 and Area 2 are shown in Annexure I.

Definitions, Statistical Terms and Method Used in Calculations

Cancer Case: All neoplasms with a morphology behaviour code of '3' as defined by the International Classification of Diseases - Oncology, (Third edition) are considered reportable and therefore registered.

Age-Group: According to WHO, the following five yearly age groups are in use for reporting the cancer incidences:

0-4, 5-9, 10-14, ...,75+.

Incidence Cases: This refers to new cancer cases diagnosed during a year in a given population.

Rates: Cancer is a rare disease hence its various incidence rates are expressed per 100,000 populations.

Crude Incidence Rate (CR): This is the ratio of the number of new cases to the estimated mid year population (mid-year), multiplied by 100,000.

$$CR = \frac{\text{New cases of cancer of a particular year}}{\text{Estimated mid year population of the same year}} \times 100,000$$

Age Specific Rate (ASpR): This is the ratio of the number of new cases of a particular age group to the estimated mid year population of the same age group, multiplied by 100,000.

$$ASpR = \frac{\text{New cases of cancer of a particular year in the given age group}}{\text{Mid year population of the same year for the given age group}} \times 100,000$$

Age Adjusted or Age Standardized Rate (AAR): Mostly occurrence of cancer increases as age increases. Therefore a higher proportion of older population implies a higher number of cancers. Most developed western countries have a higher proportion of older population. So in order to make rates of cancer comparable between developed and developing countries, a hypothetical world standard population (Table 5.4) was used to arrive at the age adjusted or age standardized rates. The world standard population approximates the proportional age distribution of the world and is given below:

Table 5.4: Distribution of World Standard Population

Age Group	World Standard Population
0-4	12,000
5-9	10,000
10-14	9,000
15-19	9,000
20-24	8,000
25-29	8,000
30-34	6,000
35-39	6,000
40-44	6,000
45-49	6,000
50-54	5,000
55-59	4,000
60-64	4,000
65-69	3,000
70-74	2,000
75 +	2,000
All Ages	100,000

$$AAR = \frac{\sum_{i=1}^A a_i w_i}{\sum_{i=1}^A w_i}$$

Where:

a_i is the age specific rate(AspR) in age class i ;

w_i is the world standard population in age class i ;

A (=16) represents the number of age intervals

or expressed in more simpler term thus:

$$AAR = \frac{\sum (ASpR) \times (\text{No. of persons in Std. world population in that 5 yr. age group})}{100,000}$$

Chapter 6

DATA QUALITY AND INDICES OF RELIABILITY

The cancer registry is a source of information. Quality is a property of the data and a product of the techniques used to create them. The quality of information is a product of the quality of the data and the quality of their presentation. The five main areas of consideration of quality in a PBCR are,

1. **Completeness of coverage:** to obtain information on all cancers diagnosed in the population so as to ensure a high degree of case ascertainment;
2. **Adequacy of data:** to have certain core and critical items of patient information on all cases;
3. **Accuracy of data:** to ensure that data are free from erroneous abstraction, coding, data entry etc.;
4. **Comparability of data:** to adopt information techniques in coding, classification etc., that would assure comparability internally and externally;
5. **Reliability of data:** to ensure reliability of data through periodic audits.

Along with the above objectives, the registries routinely undertake various exercises to ensure that the data they gather and process is of high quality. Based on the publication “Comparability and Quality Control in Cancer Registration” published by the International Agency for Research on Cancer (*Parkin et al, 1994*) and suitably modified so as to be practically applicable for the set-up of the cancer registries under the NCRP, these exercises include:

1. **Details of Sources of Registration:** To minimize duplicate registrations at an early stage and identify number of cases whose residential status including duration of stay remains unknown, a comprehensive account of the various sources of registration is obtained. The latter helps in pinpointing sources and the channels of referral of these resident unknown cases where greater efforts are made to minimize such cases. This exercise also helps in knowing the number of sources of registration per case - an index to assess coverage.
2. **Notification per case:** By notification per case is meant, the different types of reports confirming the diagnosis of cancer in a given case. For example, a patient with a lump in the breast could initially have fine needle aspiration cytology, followed by a biopsy and finally a mastectomy specimen, with all three reports having evidence of malignancy. Notifications per case give an idea of the diagnostic work-up and mechanics of reporting while also providing an indirect measure of completeness of coverage.
3. **Re-abstraction of Random Sample:** All registries regularly re-abstract a ten percent random sample of cases. This is done by supervisory staff, and the core proforma is completed afresh for all these cases, without reference to the original abstracts. Differences between original and re-abstracted data are tabulated and categorized into minor and major disagreements, justifiable disagreements and errors. The above tabulations are prepared by all registries and presented and discussed in the

NCRP workshops every year. Overall such re-abstraction errors have been less than five percent.

4. Range and Consistency Checks: Besides data entry and other checks carried out by the registries, the Coordinating Unit has developed a comprehensive software programme which checks the quality of the data online. This quality control involves range checks, consistency checks, duplicate checks and unknown primary site checks.

Apart from the above steps, within the data itself, there are certain indices of reliability. These include the proportion of microscopic verification, the proportion of cases categorized as “Death Certificate Only” and the Mortality Incidence Ratio.

Proportion of microscopic verification

This is an indicator of the validity of diagnostic information (*Parkin et al, 1994*).

Death Certificate Only

These are cases for which there is no other information other than a death certificate with cancer mentioned as a cause of death. These cases are obtained through the death registration units etc and cannot be matched with any of the registered cases. To some extent the proportion of these cases reflect the proportion of cancer cases that could possibly be missed by the registry. Generally such cases should be minimal.

Annexure Tabulation

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Annexure-I

POPULATION ESTIMATION

The Difference Distribution Method for Estimation of Populations by Five Yearly Age Groups and its Validity

In India, the Census is providing the population figures once in every 10 years starting from the year 1951. The latest Census was conducted in the year 2001. Thus, for cancer incidence data, to provide various rates for a given year, lying between any two-census years, the calculation of population estimates assumes importance.

For the estimation of the mid year population usually the Exponential Growth Rate Method is used and the formulae that are used in this method are shown below:

$$r = (P_t / P_0)^{1/t} - 1, \dots\dots\dots (1)$$

$$P_x = P_0 * (1 + r)^x \text{ when } 0 < x < t \dots\dots\dots (2)$$

$$P_x = P_t * (1 + r)^x \text{ when } x > t \dots\dots\dots (3)$$

The population growth rate is assumed to remain the same after the time x.

Five yearly age groups considered for providing the age specific rates:

In Cancer Epidemiology, the following five yearly age groups are usually considered to calculate the various age specific rates:

0-4; 5-9; 10-14; 15-19; 20-24; 25-29; 30-34; 35-39; 40-44; 45-49; 50-54; 55-59; 60-64; 65-69; 70-74; 75 & above. These age groups are referred with the help of $i = 1, 2, 3 \dots 16$. For example for $i = 1 \Rightarrow$ the 0-4 years age group is referred; for $i = 2$ the 5-9 years.

The Difference Distribution Method:

This method makes use of the five yearly age distributions of immediately preceding two Census years. Assume that for a given area a^{i91} and a^{i01} denotes the population of i^{th} five yearly age group for $i = 1, 2, 3 \dots 16$ for the Census years 1991 and 2001, respectively. Then, calculate the difference (d^{i0191}) in the population for each age group and express it as the proportion (p^{i0191}) of the overall change in the population (D^{0191}). Thus, in notations:

$$d^{i0191} = a^{i01} - a^{i91} \quad \forall i = 1, 2, 3 \dots 16. \quad D^{0191} = \sum d^{i0191}$$

$$p^{i0191} = (d^{i0191} / D^{0191}) \quad \forall i = 1, 2, 3 \dots 16$$

To estimate the five yearly age groups populations for the year x, the Difference Distribution Methods requires the knowledge of the following two populations: 1) Base population (P_{1991}) and 2) The population (P_x) at time x which can be estimated using the formula (1), (2) or (3). Then, proceed as follows:

Case I: When $1991 < x < 2001$

Let $D_{x91} = (P_x - P_{91})$ then

$$a_{ix} = a_{i91} + (D_{x91} * p_{i0191}) \quad \forall i = 1, 2, 3 \dots 16$$

Case II: When $x > 2001$

Let $D_{x01} = (P_x - P_{01})$ then

$$a_{ix} = a_{i01} + (D_{x01} * p_{i0191}) \quad \forall i = 1, 2, 3 \dots 16$$

It is assumed here that the difference distribution remains the same after the year 2001.

The Table 1 demonstrates the application of the above method for the estimation of five yearly age group populations using the Census data of Chennai PBCR area for males for the year 2003. The five yearly age group populations for the Census years of 1991 (a_{i91}) and 2001 (a_{i01}) are shown in column 2 & 3, respectively. Their differences (d_{i0191}) and the corresponding difference proportions (p_{i0191}) are shown in column 4 & 5, respectively. The estimated growth and the estimates of five yearly age group populations for the year 2003 are provided in column 6 & 7, respectively. The population estimates of 0-4 years and 5-9 years have shown a decreasing trend while the other age groups have shown an increasing trend as compared to the populations of the year 2001.

It is shown that the proposed Difference Distribution Method, unlike the Proportion Method, is able to maintain both the negative as well as the positive growth in different five yearly age group populations. It has maintained the negative growth in 0-4 years and 5-9 years and maintained the positive growth in other five yearly age groups. The proposed method also maintains the overall growth rate unlike seen in the case of Individual Exponential Growth Rate Method. Thus, the proposed method scores over both the current methods, which are in use in the projection of the five yearly age group population.

(Ref: *Takiar R, Shobana B: Cancer Incidence Rates and Problem of Denominators – A New Approach in Indian Cancer Registries; Asian Pacific J Cancer Prev. Vol 10, 209; 123-126.*)

Table ANX 1.1: Population Estimation by Five Yearly Age Groups, using Difference Distribution Method - Chennai (India) - 2003

Age Group	Census 1991 (a_{i91})	Census 2001 (a_{i01})	Difference $d_{i0191} = (a_{i01} - a_{i91})$	Difference proportion $p_{i0191} =$ (d_{i0191}/D_{0191})	Estimated growth by 2003 $g_{i0301} =$ $(D_{0301} * p_{i0191})$	Estimated Population by age group $a_{i03} = a_{i01} + g_{i0301}$
(1)	(2)	(3)	(4)	(5)	(6)	(7)
0-4	167407	156443	-10964	-0.047	-2343	154101
5-9	191025	174686	-16339	-0.07	-3491	171195
10-14	195524	200575	5052	0.0217	1079	201655
15-19	198581	216803	18222	0.0781	3894	220697
20-24	216844	231618	14774	0.0633	3157	234775
25-29	200616	226999	26383	0.1131	5637	232636
30-34	168146	197627	29482	0.1264	6299	203927
35-39	151786	181515	29729	0.1274	6352	187867
40-44	125427	148448	23020	0.0987	4919	153367
45-49	98541	130115	31575	0.1354	6747	136862
50-54	81152	104987	23835	0.1022	5093	110080
55-59	62384	70861	8477	0.0363	1811	72672
60-64	52094	64215	12122	0.052	2590	66805
65-69	31846	44587	12741	0.0546	2722	47309
70-74	22924	32622	9697	0.0416	2072	34694
75+	21982	37437	15455	0.0663	3302	40739
Total	1986278	2219539	233261	1.0000	49842	2269381
$D_{0191} = \sum(d_{i01}) = 233261$ $P_{03} = 2269381;$ $P_{01} = 2219539;$ $D_{0301} = P_{03} - P_{01} = 49842$						

Table ANX 1.2(a): Estimated Population of Area 1 of Bhopal (1988-2007)**MALES**

Year	Age Group (years)																Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+	
1988	34871	41273	39993	35562	36074	28384	24337	20823	16763	13373	10775	6500	7494	3210	2808	2135	324373
1989	35368	42329	41357	37327	38011	29517	25400	22112	17647	14110	11161	6965	7785	3548	3018	2337	337991
1990	35886	43429	42778	39166	40030	30697	26508	23456	18567	14879	11564	7450	8088	3900	3237	2547	352181
1991	36128	43944	43444	40028	40977	31251	27027	24085	18999	15239	11752	7677	8231	4065	3339	2645	358831
1992	36451	44629	44328	41173	42233	31986	27716	24921	19572	15717	12003	7979	8419	4284	3475	2776	367662
1993	36781	45330	45234	42345	43520	32738	28423	25778	20159	16207	12259	8288	8613	4509	3615	2910	376710
1994	37119	46049	46163	43547	44840	33510	29146	26656	20761	16709	12522	8605	8811	4739	3758	3047	385981
1995	37466	46785	47114	44778	46191	34300	29888	27555	21377	17224	12791	8930	9014	4975	3904	3187	395480
1996	37821	47539	48089	46040	47576	35110	30648	28477	22009	17751	13067	9263	9222	5217	4054	3331	405213
1997	38185	48312	49087	47332	48995	35940	31426	29421	22656	18291	13350	9603	9435	5464	4208	3479	415185
1998	38558	49104	50111	48657	50449	36790	32224	30388	23319	18844	13640	9953	9654	5718	4366	3630	425403
1999	38940	49916	51159	50014	51938	37661	33041	31380	23998	19411	13936	10310	9878	5978	4527	3785	435872
2000	39331	50747	52233	51404	53465	38554	33879	32395	24694	19992	14240	10677	10107	6244	4693	3944	446599
2001	39732	51599	53334	52828	55028	39468	34737	33436	25407	20587	14552	11053	10342	6517	4862	4106	457589
2002	40143	52472	54462	54288	56631	40405	35616	34502	26138	21197	14871	11438	10583	6796	5036	4273	468851
2003	40564	53367	55617	55784	58272	41365	36516	35595	26887	21822	15198	11832	10829	7083	5214	4444	480389
2004	40996	54283	56801	57316	59954	42349	37439	36714	27654	22462	15534	12236	11082	7376	5396	4619	492211
2005	41438	55222	58014	58886	61678	43357	38385	37861	28440	23118	15877	12650	11341	7677	5583	4798	504325
2006	41891	56184	59257	60495	63444	44390	39354	39036	29245	23790	16229	13074	11606	7985	5774	4982	516736
2007	42355	57170	60530	62143	65253	45448	40347	40240	30071	24479	16589	13509	11878	8301	5971	5170	529454

Table ANX 1.2(b): Estimated Population of Area 2 of Bhopal (1988-2007)**MALES**

Year	Age Group (years)																Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+	
1988	23586	27228	22431	19237	20081	20299	18308	16195	11155	8092	5930	3423	4123	1830	1715	1186	204817
1989	24046	27744	23438	20505	21548	21440	19195	17003	11783	8743	6469	3866	4606	2144	1897	1338	215762
1990	24531	28288	24499	21841	23093	22641	20129	17854	12445	9429	7037	4332	5114	2474	2088	1497	227291
1991	24849	28645	25197	22719	24109	23430	20744	18414	12880	9879	7410	4638	5448	2692	2213	1602	234870
1992	25228	29070	26025	23762	25316	24368	21473	19078	13397	10415	7854	5002	5844	2950	2362	1727	243874
1993	25621	29511	26886	24845	26569	25342	22231	19769	13934	10971	8314	5380	6256	3218	2517	1856	253222
1994	26030	29969	27779	25970	27870	26354	23018	20485	14492	11549	8792	5772	6684	3497	2678	1991	262929
1995	26453	30444	28707	27138	29221	27404	23835	21229	15070	12148	9288	6180	7128	3786	2845	2130	273008
1996	26894	30938	29670	28351	30624	28494	24683	22002	15671	12771	9804	6603	7590	4086	3018	2275	283473
1997	27351	31450	30670	29610	32080	29626	25564	22804	16295	13417	10339	7042	8068	4398	3198	2426	294339
1998	27825	31983	31709	30917	33593	30802	26479	23637	16943	14088	10894	7498	8566	4722	3385	2582	305622
1999	28318	32535	32787	32275	35163	32022	27428	24502	17616	14785	11471	7972	9082	5058	3579	2744	317337
2000	28829	33109	33906	33684	36794	33289	28414	25401	18315	15509	12070	8464	9618	5407	3780	2913	329502
2001	29361	33705	35069	35148	38486	34605	29438	26333	19040	16260	12692	8974	10175	5769	3989	3088	342132
2002	29912	34323	36276	36667	40244	35972	30501	27302	19793	17040	13338	9504	10753	6145	4206	3269	355247
2003	30485	34966	37529	38245	42070	37390	31605	28307	20575	17851	14009	10055	11353	6536	4432	3458	368865
2004	31080	35633	38831	39884	43965	38863	32751	29351	21387	18692	14705	10627	11976	6942	4666	3654	383007
2005	31697	36325	40182	41585	45933	40393	33941	30435	22230	19565	15428	11220	12623	7363	4909	3857	397686
2006	32338	37044	41585	43351	47976	41981	35177	31561	23105	20472	16179	11836	13295	7800	5161	4068	412929
2007	33004	37791	43042	45186	50098	43630	36460	32729	24014	21414	16958	12476	13992	8255	5424	4287	428760

Table ANX 1.2(c): Estimated Population of Area 1 of Bhopal (1988-2007)**FEMALES**

Year	Age Group (years)																Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+	
1988	31876	36333	35634	32656	34658	28374	20761	17074	13481	10805	8344	5476	6794	2734	2526	2096	289624
1989	32302	37147	36819	34013	36344	29726	22165	18372	14522	11467	8707	5942	7012	2957	2718	2280	302492
1990	32746	37997	38055	35431	38105	31139	23633	19728	15608	12158	9086	6429	7240	3190	2918	2472	315932
1991	32936	38361	38585	36038	38859	31744	24261	20309	16073	12455	9248	6637	7337	3290	3003	2555	321691
1992	33199	38864	39317	36877	39901	32580	25129	21111	16716	12864	9472	6925	7472	3427	3121	2669	329643
1993	33468	39379	40067	37737	40968	33436	26019	21933	17375	13283	9702	7220	7610	3568	3242	2785	337791
1994	33744	39907	40835	38617	42062	34313	26930	22775	18050	13712	9938	7522	7751	3713	3367	2905	346140
1995	34027	40448	41622	39519	43183	35213	27864	23638	18741	14152	10179	7831	7896	3861	3494	3027	354695
1996	34317	41003	42429	40444	44332	36134	28821	24523	19450	14604	10426	8149	8044	4013	3624	3153	363463
1997	34614	41571	43255	41392	45508	37078	29802	25429	20176	15066	10679	8474	8196	4169	3758	3281	372446
1998	34918	42153	44102	42363	46715	38046	30807	26357	20920	15539	10939	8807	8352	4328	3894	3413	381652
1999	35230	42750	44970	43358	47950	39037	31836	27309	21683	16025	11205	9148	8512	4491	4035	3548	391086
2000	35549	43361	45860	44377	49217	40053	32892	28284	22464	16522	11477	9498	8675	4659	4178	3686	400752
2001	35877	43987	46771	45422	50514	41094	33973	29284	23265	17031	11756	9856	8843	4830	4326	3828	410658
2002	36212	44629	47705	46493	51844	42161	35081	30308	24085	17554	12042	10224	9015	5006	4477	3973	420808
2003	36556	45287	48662	47590	53207	43254	36216	31357	24926	18089	12336	10600	9191	5186	4631	4122	431210
2004	36908	45961	49643	48714	54603	44374	37380	32432	25787	18637	12636	10986	9371	5371	4790	4275	441868
2005	37269	46652	50648	49866	56034	45522	38572	33534	26670	19199	12944	11381	9556	5560	4952	4431	452790
2006	37639	47360	51678	51046	57500	46698	39794	34663	27575	19775	13260	11786	9745	5754	5118	4591	463982
2007	38018	48085	52733	52256	59003	47903	41046	35820	28502	20365	13583	12201	9940	5952	5289	4755	475451

Table ANX 1.2(d): Estimated Population of Area 2 of Bhopal (1988-2007)**FEMALES**

Year	Age Group (years)																Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+	
1988	20806	26374	20789	16623	21527	19380	15053	10809	7854	5477	4559	3372	3968	1918	1498	1137	181145
1989	21157	26867	21824	17915	22534	20271	15776	11736	8667	6174	5053	3936	4266	2267	1738	1273	191453
1990	21528	27387	22918	19279	23598	21212	16540	12716	9526	6909	5576	4532	4580	2636	1990	1417	202346
1991	21770	27727	23631	20170	24292	21826	17039	13356	10087	7389	5917	4921	4785	2877	2155	1511	209452
1992	22059	28132	24483	21233	25121	22559	17634	14119	10756	7962	6324	5385	5030	3164	2352	1623	217939
1993	22359	28554	25370	22340	25984	23322	18254	14914	11453	8559	6747	5869	5285	3463	2557	1740	226770
1994	22672	28993	26293	23491	26882	24116	18898	15741	12177	9179	7188	6372	5550	3774	2771	1861	235958
1995	22998	29449	27253	24689	27816	24942	19569	16601	12931	9825	7647	6895	5826	4098	2993	1988	245519
1996	23337	29924	28252	25936	28788	25802	20267	17496	13716	10497	8124	7439	6114	4435	3224	2119	255468
1997	23689	30419	29291	27233	29799	26696	20993	18427	14532	11196	8620	8006	6412	4785	3464	2256	265819
1998	24056	30933	30372	28582	30851	27627	21748	19396	15382	11923	9137	8596	6723	5150	3714	2398	276590
1999	24438	31469	31498	29986	31946	28595	22535	20405	16266	12680	9674	9209	7047	5529	3974	2547	287797
2000	24835	32026	32668	31448	33085	29603	23353	21454	17185	13468	10234	9847	7384	5924	4245	2701	299459
2001	25248	32605	33887	32968	34270	30651	24204	22546	18142	14287	10816	10511	7734	6335	4526	2861	311593
2002	25678	33208	35154	34550	35504	31742	25090	23681	19138	15140	11421	11202	8098	6763	4820	3028	324218
2003	26125	33836	36473	36196	36787	32877	26011	24863	20174	16027	12051	11921	8478	7208	5124	3201	337355
2004	26591	34489	37846	37909	38123	34058	26970	26093	21252	16950	12707	12670	8872	7670	5442	3382	351025
2005	27075	35168	39274	39691	39512	35287	27968	27373	22374	17911	13389	13448	9283	8152	5772	3570	365248
2006	27579	35875	40760	41545	40958	36566	29006	28705	23541	18911	14099	14258	9710	8653	6116	3766	380048
2007	28103	36610	42306	43475	42462	37896	30087	30090	24756	19951	14837	15101	10155	9175	6473	3969	395447

Annexure-II

**Table ANX 2.1: Distribution of Population according to their type of Tobacco habits
(All Age Group) – Bhopal - NCRP Survey 2005**

Type of Habit	Male				Female			
	Affected		Unaffected		Affected		Unaffected	
	No.	%	No.	%	No.	%	No.	%
Non user	4115	71.2	4890	79.7	4650	89.2	5471	96.5
User	1666	28.8	1248	20.3	562	10.8	200	3.5
Chewer	1184	20.5	827	13.5	456	8.7	196	3.5
Smoker	817	14.1	556	9.1	14	0.3	4	0.1
Both	335	5.8	135	2.2	8	0.2	0	0.0
Total	5781	100.0	6138	100.0	5212	100.0	5671	100.0

**TABLE: ANX 2.2: Distribution of Population according to their Tobacco habits
(for age > 21 years) – Bhopal - NCRP Survey 2005**

Type of Habit	Male				Female			
	Affected		Unaffected		Affected		Unaffected	
	No.	%	No.	%	No.	%	No.	%
Non user	1504	49.3	2286	65.8	2411	84.5	3048	94.1
User	1544	50.7	1188	34.2	443	15.5	191	5.9
Chewer	1077	35.3	770	22.2	436	15.3	187	5.8
Smoker	789	25.9	550	15.8	11	0.4	4	0.1
Both	322	10.6	132	3.8	7	0.2	0	0.0
Total	3048	100.0	3474	100.0	2854	100.0	3239	100.0

Annexure-III

Table ANX 3.1: Population Weightages considered for calculation of Modified CR (CR-M) and Modified AAR (AAR-M) - Bhopal (1988-2007)

Year	Age Group (years)															
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+
1988	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1989	0.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1990	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1991	0.0	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1992	0.0	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1993	0.0	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1994	0.0	0.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1995	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1996	0.0	0.0	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1997	0.0	0.0	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1998	0.0	0.0	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
1999	0.0	0.0	0.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2000	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2001	0.0	0.0	0.0	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2002	0.0	0.0	0.0	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2003	0.0	0.0	0.0	0.4	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2004	0.0	0.0	0.0	0.2	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2005	0.0	0.0	0.0	0.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2006	0.0	0.0	0.0	0.0	0.8	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0
2007	0.0	0.0	0.0	0.0	0.6	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0	1.0

Table ANX 3.2: Modified Population considered for calculation of Modified CR (CR-M) and Modified AAR (AAR-M) by using appropriate weightages - Area 1 - Bhopal (1988-2007)

Males

Year	Age Group (years)																Modified Total	Actual Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75 +		
1988	13948	41273	39993	35562	36074	28384	24337	20823	16763	13373	10775	6500	7494	3210	2808	2135	303452	324373
1989	7074	42329	41357	37327	38011	29517	25400	22112	17647	14110	11161	6965	7785	3548	3018	2337	309698	337991
1990	0	43429	42778	39166	40030	30697	26508	23456	18567	14879	11564	7450	8088	3900	3237	2547	316296	352181
1991	0	35155	43444	40028	40977	31251	27027	24085	18999	15239	11752	7677	8231	4065	3339	2645	313914	358831
1992	0	26777	44328	41173	42233	31986	27716	24921	19572	15717	12003	7979	8419	4284	3475	2776	313359	367662
1993	0	18132	45234	42345	43520	32738	28423	25778	20159	16207	12259	8288	8613	4509	3615	2910	312730	376710
1994	0	9210	46163	43547	44840	33510	29146	26656	20761	16709	12522	8605	8811	4739	3758	3047	312024	385981
1995	0	0	47114	44778	46191	34300	29888	27555	21377	17224	12791	8930	9014	4975	3904	3187	311228	395480
1996	0	0	38471	46040	47576	35110	30648	28477	22009	17751	13067	9263	9222	5217	4054	3331	310236	405213
1997	0	0	29452	47332	48995	35940	31426	29421	22656	18291	13350	9603	9435	5464	4208	3479	309052	415185
1998	0	0	20044	48657	50449	36790	32224	30388	23319	18844	13640	9953	9654	5718	4366	3630	307676	425403
1999	0	0	10232	50014	51938	37661	33041	31380	23998	19411	13936	10310	9878	5978	4527	3785	306089	435872
2000	0	0	0	51404	53465	38554	33879	32395	24694	19992	14240	10677	10107	6244	4693	3944	304288	446599
2001	0	0	0	42262	55028	39468	34737	33436	25407	20587	14552	11053	10342	6517	4862	4106	302357	457589
2002	0	0	0	32573	56631	40405	35616	34502	26138	21197	14871	11438	10583	6796	5036	4273	300059	468851
2003	0	0	0	22314	58272	41365	36516	35595	26887	21822	15198	11832	10829	7083	5214	4444	297371	480389
2004	0	0	0	11463	59954	42349	37439	36714	27654	22462	15534	12236	11082	7376	5396	4619	294278	492211
2005	0	0	0	0	61678	43357	38385	37861	28440	23118	15877	12650	11341	7677	5583	4798	290765	504325
2006	0	0	0	0	50755	44390	39354	39036	29245	23790	16229	13074	11606	7985	5774	4982	286220	516736
2007	0	0	0	0	39152	45448	40347	40240	30071	24479	16589	13509	11878	8301	5971	5170	281155	529454

Table ANX 3.3: Modified Population considered for calculation of Modified CR (CR-M) and Modified AAR (AAR-M) by using appropriate weightages - Area 1 - Bhopal (1988-2007)

Females

Year	Age Group (years)																Modified Total	Actual Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75 +		
1988	12750	36333	35634	32656	34658	28374	20761	17074	13481	10805	8344	5476	6794	2734	2526	2096	270496	289624
1989	6460	37147	36819	34013	36344	29726	22165	18372	14522	11467	8707	5942	7012	2957	2718	2280	276651	302492
1990	0	37997	38055	35431	38105	31139	23633	19728	15608	12158	9086	6429	7240	3190	2918	2472	283189	315932
1991	0	30689	38585	36038	38859	31744	24261	20309	16073	12455	9248	6637	7337	3290	3003	2555	281083	321691
1992	0	23318	39317	36877	39901	32580	25129	21111	16716	12864	9472	6925	7472	3427	3121	2669	280899	329643
1993	0	15752	40067	37737	40968	33436	26019	21933	17375	13283	9702	7220	7610	3568	3242	2785	280697	337791
1994	0	7981	40835	38617	42062	34313	26930	22775	18050	13712	9938	7522	7751	3713	3367	2905	280471	346140
1995	0	0	41622	39519	43183	35213	27864	23638	18741	14152	10179	7831	7896	3861	3494	3027	280220	354695
1996	0	0	33943	40444	44332	36134	28821	24523	19450	14604	10426	8149	8044	4013	3624	3153	279660	363463
1997	0	0	25953	41392	45508	37078	29802	25429	20176	15066	10679	8474	8196	4169	3758	3281	278961	372446
1998	0	0	17641	42363	46715	38046	30807	26357	20920	15539	10939	8807	8352	4328	3894	3413	278121	381652
1999	0	0	8994	43358	47950	39037	31836	27309	21683	16025	11205	9148	8512	4491	4035	3548	277131	391086
2000	0	0	0	44377	49217	40053	32892	28284	22464	16522	11477	9498	8675	4659	4178	3686	275982	400752
2001	0	0	0	36338	50514	41094	33973	29284	23265	17031	11756	9856	8843	4830	4326	3828	274938	410658
2002	0	0	0	27896	51844	42161	35081	30308	24085	17554	12042	10224	9015	5006	4477	3973	273666	420808
2003	0	0	0	19036	53207	43254	36216	31357	24926	18089	12336	10600	9191	5186	4631	4122	272151	431210
2004	0	0	0	9743	54603	44374	37380	32432	25787	18637	12636	10986	9371	5371	4790	4275	270385	441868
2005	0	0	0	0	56034	45522	38572	33534	26670	19199	12944	11381	9556	5560	4952	4431	268355	452790
2006	0	0	0	0	46000	46698	39794	34663	27575	19775	13260	11786	9745	5754	5118	4591	264759	463982
2007	0	0	0	0	35402	47903	41046	35820	28502	20365	13583	12201	9940	5952	5289	4755	260758	475451

Table ANX 3.4: Modified Population considered for calculation of Modified CR (CR-M) and Modified AAR (AAR-M) by using appropriate weightages - Area 2 - Bhopal (1988-2007)

Males

Year	Age Group (years)																Modified Total	Actual Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75 +		
1988	9434	27228	22431	19237	20081	20299	18308	16195	11155	8092	5930	3423	4123	1830	1715	1186	190667	204817
1989	4809	27744	23438	20505	21548	21440	19195	17003	11783	8743	6469	3866	4606	2144	1897	1338	196528	215762
1990	0	28288	24499	21841	23093	22641	20129	17854	12445	9429	7037	4332	5114	2474	2088	1497	202761	227291
1991	0	22916	25197	22719	24109	23430	20744	18414	12880	9879	7410	4638	5448	2692	2213	1602	204291	234870
1992	0	17442	26025	23762	25316	24368	21473	19078	13397	10415	7854	5002	5844	2950	2362	1727	207015	243874
1993	0	11804	26886	24845	26569	25342	22231	19769	13934	10971	8314	5380	6256	3218	2517	1856	209892	253222
1994	0	5994	27779	25970	27870	26354	23018	20485	14492	11549	8792	5772	6684	3497	2678	1991	212925	262929
1995	0	0	28707	27138	29221	27404	23835	21229	15070	12148	9288	6180	7128	3786	2845	2130	216109	273008
1996	0	0	23736	28351	30624	28494	24683	22002	15671	12771	9804	6603	7590	4086	3018	2275	219708	283473
1997	0	0	18402	29610	32080	29626	25564	22804	16295	13417	10339	7042	8068	4398	3198	2426	223269	294339
1998	0	0	12684	30917	33593	30802	26479	23637	16943	14088	10894	7498	8566	4722	3385	2582	226790	305622
1999	0	0	6557	32275	35163	32022	27428	24502	17616	14785	11471	7972	9082	5058	3579	2744	230254	317337
2000	0	0	0	33684	36794	33289	28414	25401	18315	15509	12070	8464	9618	5407	3780	2913	233658	329502
2001	0	0	0	28118	38486	34605	29438	26333	19040	16260	12692	8974	10175	5769	3989	3088	236967	342132
2002	0	0	0	22000	40244	35972	30501	27302	19793	17040	13338	9504	10753	6145	4206	3269	240067	355247
2003	0	0	0	15298	42070	37390	31605	28307	20575	17851	14009	10055	11353	6536	4432	3458	242939	368865
2004	0	0	0	7977	43965	38863	32751	29351	21387	18692	14705	10627	11976	6942	4666	3654	245556	383007
2005	0	0	0	0	45933	40393	33941	30435	22230	19565	15428	11220	12623	7363	4909	3857	247897	397686
2006	0	0	0	0	38381	41981	35177	31561	23105	20472	16179	11836	13295	7800	5161	4068	249016	412929
2007	0	0	0	0	30059	43630	36460	32729	24014	21414	16958	12476	13992	8255	5424	4287	249698	428760

Table ANX 3.5: Modified Population considered for calculation of Modified CR (CR-M) and Modified AAR (AAR-M) by using appropriate weightages - Area 2 - Bhopal (1988-2007)

Females

Year	Age Group (years)																Modified Total	Actual Total
	0-4	5-9	10-14	15-19	20-24	25-29	30-34	35-39	40-44	45-49	50-54	55-59	60-64	65-69	70-74	75+		
1988	8322	26374	20789	16623	21527	19380	15053	10809	7854	5477	4559	3372	3968	1918	1498	1137	168660	181145
1989	4231	26867	21824	17915	22534	20271	15776	11736	8667	6174	5053	3936	4266	2267	1738	1273	174528	191453
1990	0	27387	22918	19279	23598	21212	16540	12716	9526	6909	5576	4532	4580	2636	1990	1417	180816	202346
1991	0	22182	23631	20170	24292	21826	17039	13356	10087	7389	5917	4921	4785	2877	2155	1511	182138	209452
1992	0	16879	24483	21233	25121	22559	17634	14119	10756	7962	6324	5385	5030	3164	2352	1623	184624	217939
1993	0	11422	25370	22340	25984	23322	18254	14914	11453	8559	6747	5869	5285	3463	2557	1740	187279	226770
1994	0	5799	26293	23491	26882	24116	18898	15741	12177	9179	7188	6372	5550	3774	2771	1861	190092	235958
1995	0	0	27253	24689	27816	24942	19569	16601	12931	9825	7647	6895	5826	4098	2993	1988	193073	245519
1996	0	0	22602	25936	28788	25802	20267	17496	13716	10497	8124	7439	6114	4435	3224	2119	196559	255468
1997	0	0	17575	27233	29799	26696	20993	18427	14532	11196	8620	8006	6412	4785	3464	2256	199994	265819
1998	0	0	12149	28582	30851	27627	21748	19396	15382	11923	9137	8596	6723	5150	3714	2398	203376	276590
1999	0	0	6300	29986	31946	28595	22535	20405	16266	12680	9674	9209	7047	5529	3974	2547	206693	287797
2000	0	0	0	31448	33085	29603	23353	21454	17185	13468	10234	9847	7384	5924	4245	2701	209931	299459
2001	0	0	0	26374	34270	30651	24204	22546	18142	14287	10816	10511	7734	6335	4526	2861	213257	311593
2002	0	0	0	20730	35504	31742	25090	23681	19138	15140	11421	11202	8098	6763	4820	3028	216357	324218
2003	0	0	0	14478	36787	32877	26011	24863	20174	16027	12051	11921	8478	7208	5124	3201	219200	337355
2004	0	0	0	7582	38123	34058	26970	26093	21252	16950	12707	12670	8872	7670	5442	3382	221771	351024
2005	0	0	0	0	39512	35287	27968	27373	22374	17911	13389	13448	9283	8152	5772	3570	224039	365247
2006	0	0	0	0	32766	36566	29006	28705	23541	18911	14099	14258	9710	8653	6116	3766	226097	380048
2007	0	0	0	0	25477	37896	30087	30090	24756	19951	14837	15101	10155	9175	6473	3969	227967	395447

Annexure-IV

Table ANX 4.: Distribution of population surveyed according to the history of MIC Exposure in Affected and Unaffected areas - Bhopal - NCRP Survey 2005

Affected Area												
Age Group	Male						Female					
	Exposed		Unexposed		Total		Exposed		Unexposed		Total	
	No.	%	No.	%	No.	%	No.	%	No.	%	No.	%
0-4	0	0.0	475	100.0	475	8.2	0	0.0	429	100.0	429	8.2
5-9	0	0.0	633	100.0	633	10.9	0	0.0	537	100.0	537	10.3
10-14	0	0.0	665	100.0	665	11.5	0	0.0	583	100.0	583	11.2
15-19	0	0.0	675	100.0	675	11.7	0	0.0	574	100.0	574	11.0
20-24	390	55.2	317	44.8	707	12.2	300	46.5	345	53.5	645	12.4
25-29	357	71.8	140	28.2	497	8.6	239	45.6	285	54.4	524	10.1
30-34	299	68.0	141	32.0	440	7.6	210	47.3	234	52.7	444	8.5
35-39	300	69.1	134	30.9	434	7.5	224	58.0	162	42.0	386	7.4
40-44	246	75.5	80	24.5	326	5.6	233	75.9	74	24.1	307	5.9
45-49	217	81.9	48	18.1	265	4.6	185	83.7	36	16.3	221	4.2
50-54	152	83.5	30	16.5	182	3.1	126	84.6	23	15.4	149	2.9
55-59	119	82.1	26	17.9	145	2.5	99	75.6	32	24.4	131	2.5
60-64	107	82.3	23	17.7	130	2.2	90	81.8	20	18.2	110	2.1
65-69	74	84.1	14	15.9	88	1.5	51	79.7	13	20.3	64	1.2
70-74	53	82.8	11	17.2	64	1.1	44	77.2	13	22.8	57	1.1
75+	47	85.5	8	14.5	55	1.0	39	76.5	12	23.5	51	1.0
Total	2361	40.8	3420	59.2	5781	100.0	1840	35.3	3372	64.7	5212	100.0
Unaffected Area												
0-4	0	0.0	455	100.0	455	7.4	0	0.0	452	100.0	452	8.0
5-9	0	0.0	591	100.0	591	9.6	0	0.0	518	100.0	518	9.1
10-14	0	0.0	660	100.0	660	10.7	0	0.0	573	100.0	573	10.1
15-19	0	0.0	667	100.0	667	10.8	0	0.0	593	100.0	593	10.5
20-24	62	9.3	602	90.7	664	10.8	52	7.9	603	92.1	655	11.5
25-29	58	9.8	535	90.2	593	9.6	43	7.5	533	92.5	576	10.2
30-34	48	10.2	422	89.8	470	7.6	38	7.9	446	92.1	484	8.5
35-39	45	9.8	415	90.2	460	7.5	38	8.8	396	91.2	434	7.7
40-44	45	12.0	331	88.0	376	6.1	53	16.7	264	83.3	317	5.6
45-49	52	17.3	249	82.7	301	4.9	47	16.8	232	83.2	279	4.9
50-54	46	20.4	179	79.6	225	3.6	35	15.9	185	84.1	220	3.9
55-59	40	17.7	186	82.3	226	3.7	17	10.6	143	89.4	160	2.8
60-64	23	14.7	133	85.3	156	2.5	21	11.7	159	88.3	180	3.2
65-69	16	11.7	121	88.3	137	2.2	17	16.2	88	83.8	105	1.9
70-74	10	10.3	87	89.7	97	1.6	11	15.7	59	84.3	70	1.2
75+	6	10.0	54	90.0	60	1.0	9	16.4	46	83.6	55	1.0
Total	481	7.8	5687	92.2	6168	100.0	381	6.7	5290	93.3	5671	100.0

Annexure-V

PATTERN OF CANCER IN HAMIDIA HOSPITAL (1983-1984)

Table ANX 5.1: Pattern of Cancer Cases reported at Hamidia Hospital, Bhopal (1983-984)

Males

ICD10	Site	1983	1984
C00-C14	LIP, ORAL CAVITY, PHARYNX		
C00	Lip	1	0
C01	Tongue	15	23
C03	Alvelous	1	2
C05	Palale	1	5
C06	Cheek	18	32
C09	Tonsils	6	4
C10	Epiglottis	4	3
C12	Pyri fossa	5	1
C14	Pharynx	3	2
	Total	54	76
C15-C26	DIGESTIVE SYSTEM		
C15	Oesophagus	7	14
C16	Stomach	1	1
C17	Duodem	0	1
C18	Colon	3	2
C20	Rectum	4	10
C21	Anal canal	1	5
C22	Liver (primary)	1	4
	Metastasis	4	
C25	Pancreas	0	1
	Total	21	38
C30-C39	RESPIRATORY SYSTEM		
C30	Nasuc cary	2	6
C31	Maxillary Anlum	1	2
C32	Larynx	11	22
C34	Lung	3	6
C38	Pleura	2	0
	Total	19	36
C40	BONE	2	4
C44	SKIN	11	18
C49	CONNECTIVE TISSUE	8	10
C50	BREAST	2	2
C60-63	MALE GENITAL TRACT		
C60	Penis	11	8
C61	Prostate	3	6
C62	Testis	4	3
	Total	18	17
C64-68	URINARY TRACT		
C64	Kidney	3	1
C67	Bladder	4	3
	Total	7	4
C77	LYMPH NODE		
C77	Primary	7	7
	Melustasis	15	9
	Total	22	16
C48	PERITONIUM	1	0

**Table ANX 5.2: Pattern of Cancer Cases reported
at Hamidia Hospital, Bhopal (1983-1984)**

Females

ICD10	Site	1983	1984
C00-C14	LIP, ORAL CAVITY, PHARYNX		
C00	Lip	0	1
C01	Tongue	2	4
C03	Alveolus	1	1
C05	Palate	2	1
C06	Cheek	5	20
C08	Salivary gland	1	0
C09	Tonsils	0	2
C12	Pyri fossa	3	0
C14	Pharynx	0	1
	Total	14	30
C15-C26	DIGESTIVE SYSTEM		
C15	Oesophagus	1	6
C16	Stomach	1	0
C18	Colon	1	1
C20	Rectum	2	4
C21	Anal canal	1	2
C22	Liver	0	2
C23	Gall bladder	1	0
C25	Pancreas	1	1
	Total	8	16
C30-C39	RESPIRATORY SYSTEM		
C30	Nasuc cary	0	1
C31	Maxillary Anlum	2	1
C32	Larynx	0	0
C38	Pleura	1	1
	Total	3	3
C44	SKIN	9	7
C49	CONNECTIVE TISSUE	5	7
C48	OMEXLUM	1	1
C50	BREAST	34	33
C51-58	FEMALE GENITAL TRACT		
C51	Vulva	0	0
C52	Vagina	2	1
C53	Cervix	22	79
C54	Uterus	6	7
C55	Ovary	6	9
	Total	36	96
C77	LYMPH NODE		
C77	Primary	4	9
	Melustasis	2	8
	Total	6	17
C73	Thyroid	1	2
C91	Brain	1	1
C40	Bone	1	2
	Total	3	5

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