

RESEARCH COMMUNICATION

Lifetime Risk and Trends in Lung Cancer Incidence in Greater Mumbai

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Abstract

Objective: To estimate the probability of developing lung cancer in the entire life span of the people of Greater Mumbai and variation according to age and sex. Information on cancer incidence trends in a community forms the scientific basis for planning and organising prevention, diagnosis and treatment. During the last 24 year period, a total of 11,458 lung cancer cases were registered (9,052 male and 2,406 female) by the Bombay Cancer Registry. Lung cancer accounts for 9.4% of all male cancers and 2.7% of those in females (6.2% of all cancers) in Greater Mumbai. The probability of developing cancer in the entire life span of the people of Greater Mumbai was estimated. **Methods:** A method based on the cumulative risk of cancer was used to estimate the probabilities using lung cancer data collected by the population-based Bombay Cancer Registry from the years 1982 to 2005. For evaluation of trends, a linear regression model based on the logarithm of the observed incidence rates was applied. The annual percentage change was also computed for the evaluation. The cumulative incidence rate percentage was calculated by adding up the age-specific incidence rates at single ages and then expressed as a percentage. **Results:** The results show that age-adjusted incidence rates of lung cancer during the period 1982 to 2005 showed a statistically significant decreasing trend in males and a statistically significant increasing trend among females. When these trends were examined across different age-groups (0-39, 40-64 and 65 or older), the rates showed a statistically significant decreasing trend from 0-64 years in males and a statistically significant increasing trend in females aged 65 years and older. The rates proved stable across the other age-groups. The probability estimates indicate that one out of every 74 men and one out of every 242 women will contract lung cancer at some time in their whole life in the absence of other causes of death, assuming that the current trends prevail over the time period. Most of them will acquire the disease after the age of 40 years, after which risk increases with time. **Conclusions:** The variation in age-adjusted incidence rate across different age-groups in both sexes clearly indicate that there has been a change in the etiology of lung cancer in Greater Mumbai over time. The most important reason for this would be decrease in smoking prevalence among males. The other reasons for this have to be explored through risk assessment studies, but these findings may be of general interest because changes in diagnostic practices are confounders in time trends of lung cancer in many developed countries, preventing inferences on changes in risk factors.

Key Words: Time trend - incidence - cumulative risk - lung cancer - Mumbai, India

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Introduction

Information on cancer incidence trends forms a scientific basis for planning and organizing prevention, diagnosis and treatment of cancer in a community. A trend, however, always represents a summary curve of changes that occur within different groups of people living under divergent conditions. A change in incidence and mortality figures to a large extent depends on the various factors like awareness about the disease, availability of health facilities, treatment seeking behaviour in the defined population. The new advancements in the diagnostic and treatment facilities also effect this change. Although cancer remains a significant cause of mortality at all ages and is the second most common cause of death after heart

disease, but its burden is felt disproportionately among older citizens (Kennedy et al., 1994). The majority of cancers occur in adults over the age of 65, with about 70 percent of all cancer deaths in this population (Greenlee et al., 2001).

Several studies have reported trends in cancer incidence for various sites in India: for brain cancer (Yeole, 2008d), non-Hodgkin's Lymphoma (Yeole, 2008e), prostate cancer (Yeole, 2008c), breast, cervix and ovary cancers in females (Yeole, 2008b) and esophagus, stomach colon rectum and liver in males (Yeole 2008a), head and neck cancer (Elango et al., 2006; Yeole 2007), cervical cancer (Murthy et al., 2005), breast cancer (Yeole and Kurkure, 2003) and kidney cancer (Mathew et al., 2002). Monitoring of trends helps us to understand not

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only the overall pattern of change in the incidence of the disease, but also helps us in comparing one time period to another, one geographical area to another and one population to other. It also helps us in making future projections. The information related to the trend of incidence and mortality explains the magnitude of problem in the society.

Materials and Methods

In the present study data during 1982-2005 from the oldest population based cancer registry of Mumbai covering the urban population has been used. During the last 24 years period a total of 11,458 lung cancer cases (9,052 male and 2,406 female) got registered in the registry. Lung cancer accounts for 9.4% of all male cancers and 2.7% of all female (6.2% of all cancers) in Greater Mumbai.

Population data are estimated from the 1981, 1991 and 2001 census reports (as on 1st March). The estimates for the years 1982 through 2001 (as on 1st July) are calculated using geometric rate of growth for each age-group and sex after smoothing the population. However, the population from 2002-2005 has been projected using Maharashtra urban abridge life table (due to the non-availability of district life table) for corresponding time period using MORTPAK software. Care has been taken about the difference in the definition of “resident” in census and that in Mumbai Cancer Registry by eliminating all migrants whose duration of residence in Mumbai was less than one year.

Age adjusted rates were computed using the world standard population given by Segi 1960 and modified by Doll et.al. 1966. For evaluation of incidence trends we used a linear regression analysis based on the logarithm of the observed incidence rates. Logarithmic transformation was preferred specifically because this facilitates the comparison of trends at varying incidence levels, i.e. the trends at different ages are examined. A model that fits this data well is the logarithm of $Y=AB^x$, which represented a linear regression model, where, ‘Y’ is the estimated incidence rate per 100,000 of the population; and ‘x’ is the calendar year minus the initial year (1982) for the current data. ‘A’ therefore represents the estimated rate of the initial year and $(B-1)*100$ gives the average annual percentage change in the incidence rate during the period.

The cumulative incidence rate is computed which is a summary measure of the experience of a population over a long time span or age-interval. It is obtained by summing up the age specific incidences for each year in the defined age interval and then expressed as a percentage. Since age specific incidence rates are usually computed for five year age intervals, the cumulative incidence rate between birth to 70+ years of age is 5 times the sum of the age specific incidence rates calculated over five year age groups. The cumulative incidence rate is directly standardized incidence rate and is a good approximation to the actuarial or cumulative risk. The reason of interest in the cumulative incidence rate is that it has a useful probabilistic interpretation. Another advantage is that as

a form of direct age standardization, the arbitrariness in choosing a standard population is removed. The probability of developing a specific cancer, expressed in terms of ‘one in every n persons’ is computed by reciprocating the estimated cumulative incidence rate expressed as a percentage.

Results

During the last 24 years period, 1982-2005, the average crude and age adjusted incidence rates for lung cancer were 6.48 and 10.78 among males and 2.13 and 3.38 among females respectively per 100,000 population. In order to see for the variation in the rates according to age-interval cumulative incidence rate was first computed by sex for the successive age intervals from 0 through age 70 for BCR data during last two decades (1986-2005) of Greater Mumbai (Figure 1). Age-specific lung cancer incidence rates and cumulative incidence rates rise quickly after age 40 in females and after age 44 in males. Hence, based on the cumulative incidence rate the age intervals were divided into 0-39, 40-64 and 65+ years to see for the variations if any.

When these rates were seen across different age-groups it was found that among males the rates were 0.42 and 0.35, 17.18 and 20.18, 78.53 and 76.33 respectively per 100,000 population and among females the rates were 0.23 and 0.20, 5.55 and 6.25, 23.6 and 24.1, respectively, per 100,000 population (Tables 1 and 2). Analysis of the trend in age-adjusted incidence rates of lung cancer showed a statistically significant decreasing trend in males and a statistically significant increasing trend among females. When these trends were seen across different age-groups (0-39, 40-64 and 65+), the rates showed a statistically significant decreasing trend in males and a statistically

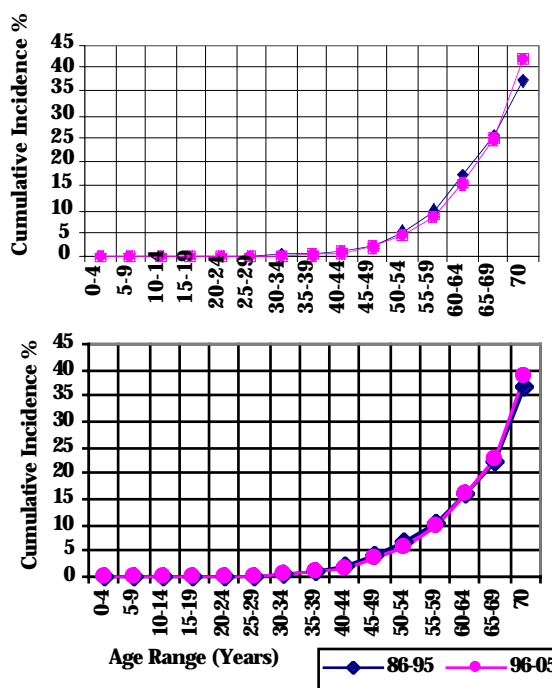


Figure 1. Cumulative Incidence Rates (lifetime risk) for ICS Data on Lung Cancer from 1986-2005 in Both Sexes

Table 3. Cumulative Incidence Rate Percent (CIRP) and Life Time Risk Expressed as One in Every ‘n’ Persons (LTR) for Different Age Groups for Lung Cancer Among Males, 1982-2005

Year	0-39		40-64		65+		Total	
	CIRP	LTR	CIRP	LTR	CIRP	LTR	CIRP	LTR
1982	0.035	2,862	3.00	33	11.26	9	1.56	64
1983	0.043	2,333	3.22	31	11.57	9	1.64	61
1984	0.040	2,503	2.69	37	11.55	9	1.51	66
1985	0.039	2,533	3.15	32	10.75	9	1.57	64
1986	0.024	4,238	2.49	40	11.17	9	1.42	70
1987	0.056	1,781	2.97	34	11.92	8	1.62	62
1988	0.030	3,380	2.99	33	10.30	10	1.49	67
1989	0.021	4,828	3.22	31	10.37	10	1.54	65
1990	0.029	3,405	3.13	32	11.66	9	1.62	62
1991	0.039	2,587	2.67	37	11.07	9	1.47	68
1992	0.024	4,237	2.90	35	10.02	10	1.44	69
1993	0.034	2,958	2.20	46	11.78	8	1.40	72
1994	0.026	3,838	2.33	43	11.88	8	1.43	70
1995	0.026	3,866	2.07	48	12.18	8	1.39	72
1996	0.023	4,283	2.63	38	11.05	9	1.45	69
1997	0.013	7,432	2.43	41	9.53	10	1.28	78
1998	0.031	3,220	1.90	53	11.20	9	1.28	78
1999	0.026	3,855	2.22	45	10.03	10	1.27	78
2000	0.020	5,007	1.73	58	9.97	10	1.14	87
2001	0.014	7,116	1.95	51	8.43	12	1.09	92
2002	0.018	5,573	1.58	63	14.19	7	1.40	71
2003	0.011	9,091	1.59	63	15.72	6	1.51	66
2004	0.025	4,022	1.70	59	13.82	7	1.41	71
2005	0.014	6,978	1.44	69	14.03	7	1.35	74
All	0.027	3,771	2.36	42	10.62	9	1.35	74

significant increasing trend limited to 65+ years among females. The rates proved stable across the other age-groups. Figure 2 shows the trends in AAR of lung cancer for different age groups by sex on a log-linear scale.

The probability estimates indicate that one out of every 74 men and one out of every 242 women will contract lung cancer at some time in their whole life. When these probability estimates were seen across different age-

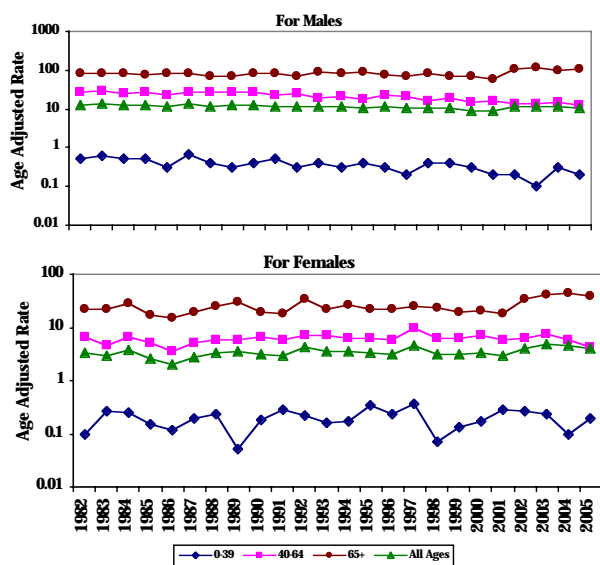


Figure 2. Trends in AAR of Lung Cancer Incidence/100,000 for Different Age-groups and Sex at all Ages During 1982-2005 in Greater Mumbai

Table 4. Cumulative Incidence Rate Percent (CIRP) and Life Time Risk Expressed as One in Every ‘n’ Persons (LTR) for Different Age Groups for Lung Cancer Among Females, 1982-2005

Year	0-39		40-64		65+		Total	
	CIRP	LTR	CIRP	LTR	CIRP	LTR	CIRP	LTR
1982	0.008	11849	0.74	135	3.02	33	0.40	249
1983	0.019	5214	0.50	200	3.05	33	0.35	285
1984	0.020	5072	0.79	127	3.92	25	0.49	206
1985	0.012	8202	0.56	178	2.46	41	0.32	312
1986	0.009	11157	0.39	257	1.94	51	0.24	418
1987	0.016	6343	0.55	183	2.74	37	0.34	295
1988	0.018	5595	0.64	157	3.49	29	0.42	240
1989	0.004	22771	0.64	156	3.97	25	0.44	227
1990	0.013	7756	0.69	145	2.67	37	0.37	272
1991	0.022	4589	0.64	155	2.54	39	0.35	283
1992	0.017	5832	0.76	132	4.60	22	0.52	191
1993	0.014	7320	0.80	125	2.98	34	0.42	240
1994	0.012	8058	0.71	141	3.60	28	0.44	229
1995	0.026	3790	0.66	151	3.00	33	0.39	254
1996	0.018	5705	0.64	157	3.10	32	0.39	257
1997	0.028	3633	1.09	92	3.33	30	0.52	191
1998	0.006	17527	0.67	149	3.14	32	0.39	255
1999	0.010	10397	0.71	141	2.72	37	0.37	267
2000	0.012	8005	0.76	132	2.79	36	0.39	255
2001	0.023	4278	0.69	145	2.47	40	0.36	277
2002	0.020	5085	0.69	146	4.61	22	0.51	197
2003	0.017	5906	0.82	123	5.54	18	0.60	166
2004	0.008	12782	0.67	149	5.91	17	0.59	171
2005	0.015	6618	0.47	213	5.12	20	0.49	206
All	0.015	6614	0.69	145	3.29	30	0.41	242

groups, it was found that one out of every 9 men will contract lung cancer after reaching 65 years while one out of every 42 men will contract lung cancer between 40-64 years and only one out of every 3,771 men will contract this cancer before his 40’s (Table 3). Among females, one out of every 30 women will contract lung cancer after reaching 65 years while one out of every 145 women will contract lung cancer between 40-64 years and only one out of every 6614 women will contract this cancer before her 40’s (Table 4).

From the estimated cumulative incidence rate percentages, it is found that 1.4% of the male population and 0.4% of the female population in Mumbai will get lung cancer at some time in their whole life span. However, when these variations were seen across the different age intervals, 10.6% of the male population and 3.3% of the female population belonging to the age of more than 65 years are at risk of lung cancer. Though these percentages seem to be very low, yet when it comes to absolute numbers the figures are quite large.

Discussion

Worldwide, lung cancer is the most common of all cancers accounting for about 1.4 million new cases being reported annually which amounts to 12.3 percent of total cancer cases and 1.2 million deaths (IARC, 2002). It is a leading cause not only because of its high incidence but also in terms of high number of deaths. It predominantly affects the middle and the older adults. The prognosis of

lung cancer is still poor, with 5-years survival rate of approximately 14 percent in the early stages and less than 5 percent in locally advanced stages (Montain 1986; Mghfoor & Michael 2005). About 80 percent of lung cancer cases in men and 50 percent in women are caused by tobacco smoking so it is primarily called the disease of smokers. Historically, more men than women die from lung cancer as a result of higher levels of smoking but now the male to female mortality ratio is showing signs of narrowing down (WHO, 2005). Even if the incidence rates in lung cancer were to remain unchanged, a large increase in absolute number of cases is a certainty because of the increase in population size and its ageing and poses a veritable time-bomb in public health terms, particularly for the developing countries. Prevention therefore can be considered to be one of the most important cancer-control strategies.

Trends in lung cancer incidence vary widely by geographical areas, age, sex and overtime. In men, the highest rates are observed in Europe (especially Eastern Europe) and North America. Moderately high rates are also seen in Australia/New Zealand and Eastern Asia (China and Japan) and the lowest in Western Africa. In women, incidence rates are comparatively low (globally the rate is 12.1 per 100,000 women compared to 35.5 per 100,000 in men) (Parkin et al., 2002). The highest rates are in North America and Northern Europe. It is to note that the incidence in China is rather high (ASR, 19.0 per 100,000), very much similar to that in Australia/New Zealand (17.4 per 100,000). Very low rates are observed in Middle and West Africa (0.6 per 100,000).

The 1990 global lung cancer incidence rate of 37.5 per 100,000, gave rise to 771800 cases, constituting 18% of all new cancer cases in men. The increase in the burden of lung cancer in men over 15 years has been 66% since 1975 (Notani, 2001; Parkin et al., 2002). Although the incidence rate in men is lower in the developing countries (24.1 per 100,000 in 1990) than the developed ones (62.6 per 100,000 in 1990) but it is to be noted that between 1985 and 1990, lung cancer burden of the developing countries went up by 25% (from 261,000 to 327,100), while that of the developed ones went up by only 7% (415,000 to 444,700). Thus, the global increase in lung cancer cases in men is now being fuelled by the cases from the developing countries.

In some parts of the world, lung cancer rates peaked among men, but rates among women were on the rise. Among men, incidence rates in the United States, Canada, England, Denmark and Australia have already peaked with more than 50 per 100,000 population, but they continued to rise in Spain, China and Japan ranging between 35-50 per 100,000 population and low incidence with less than 35 per 100,000 population countries included Utah (USA), Latin America, most Asian countries, Iceland, Norway and Sweden (Parkin, 1989). Among women, rates have been considerably lower, increase started a little later. Most western countries are still showing a rising trend in incidence and mortality among females, although in some this is recent and is affecting only recent generations (Spain), while for others (United Kingdom), it seems that the peak of risk may have been reached.

During 1977-86, the incidence and mortality of lung cancer ranked first among all sites in Beijing and has been on the increase from year to year (Wang 1991). The annual average crude incidence rate of cancer was 31.3 per 100,000 males during 1982-84 compared to a world standard rate of 33.0 per 100,000. Incidence due to lung cancer accounted for 20.3% of all male cancer cases and 16.1% among all female cancer cases. Female mortality rate due to lung cancer in Beijing was the highest compared to other countries of the world.

Devesa et al (2005) studied the varying trend in lung cancer by histologic type and sex using IARC and EUROCIIM data (European registry data) from 1980 to 1997. The results showed that among men, rates declined by 20–25% over virtually the entire time period in all areas except Iceland and France, where they were relatively stable and in Norway, Slovenia and Spain, where they increased. In contrast, rates among females rose rapidly in all areas over most of the time period; rates in the Netherlands and Norway more than doubled. Deceleration of the increase occurred in several areas, such as Canada, U.S. whites and Denmark; declines were suggested for U.S. blacks, in Switzerland and possibly Iceland. The male to female rate ratio was greater than 2 in every area except Iceland and ranged from 8 or more in Slovenia, Spain, France and Italy, to more than 14 in the Netherlands.

The overwhelming cause of lung cancer is cigarette smoking which is universally known but risk increases with early age at initiation, intensity and duration. There is a documented decline in incidence and mortality rates since 1991 in men in the US (Ries et al., 2000) and has been attributed to a decline in smoking prevalence. Several West European countries have also registered a decline, particularly in the younger cohorts of men (Coleman et al., 1993). Early case-control studies suggested that women were more susceptible than men to the adverse effects of cigarette smoking, but more recent cohort data have not supported pronounced sex differences in susceptibility (Patel et al., 2004; Bain et al., 2004).

Geographical variations in lung cancer patterns are noted not only throughout the world but also between various regions within the same country. In India too, lung cancer remains the leading site accounting for more than 41,000 cases and 38,000 deaths annually. It is estimated that there are around 48,000 people living with lung cancer alone in India at any given time (NCRP 2002). It is observed that lung cancer incidence is higher in men than in women, but these days the incidence in women is on the rise (MoHFW, 2002; ICS, 2001). Population as well as hospital based data from the Cancer Registry under the National Cancer Registry Programme (NCRP) and the Cancer Atlas Programme of the ICMR revealed that lung cancer has increased in India during the last few years. In India although 70 percent of the population reside in rural areas, but currently the available data on incidence and patterns are mainly from urban population available from the cancer registries. Even though the geographic area and population covered by these registries are quite small (about 20 percent urban and 1.5 percent rural), yet they give a fair idea of the cancer problem in selected parts of the country. However, results based on these fragmentary

statistics cannot be generalised for the whole country. Presently there are sixteen urban and four rural population based cancer registries functioning in India. Statistics of patients on cancer incidence and mortality are complete and reliable in all registries of India. The registries provide site wise information on incidence and mortality of cancer patients. It also provides information on their demographic, social, clinical and lifestyle factors which are essential for epidemiological research. Based on the data from the Population based cancer registries, overall among males, cancer of the lung is the number one cancer. Though the incidence rates are not as high as in some of the western countries, they vary from 6 to 18 per 100,000 in urban areas. Nonetheless, lung cancer is gaining in importance in certain registry areas of India, like Mumbai, Delhi, Bhopal and Imphal where it is the leading cancer site in men and is one of the five leading sites in all the other registries. In 1990, a third of all lung cancer cases were in women and it constituted 7% of all cancers that women developed. Incidence rates in Indian women are also quite low (1 to 5 per 100,000) (Parkin et al., 2007). Lung cancer ranks one of the 10 leading sites in nine registries of India including Mumbai.

The population based Bombay Cancer Registry is the oldest cancer registry in India established in the year 1963 as a unit of the Indian Cancer Society at Mumbai with the aim to obtain reliable morbidity data on cancer from a precisely defined urban population (approx. 12 million inhabitants). The majority of the hospitals in the city are maintained by the Municipal Corporation and the State Government which are basically responsible for conducting public health and medical services in the city. The diagnosis and treatment of cancer is centralized only to a certain extent in Mumbai. All malignant tumors either confirmed or suspected for a malignant chance based on pathology reports are registered. Cancer cases where the death certificate is the only source of information are also included in the list. Patients in whom cancer has been ruled out or has not yet been diagnosed are omitted from the case list. The cancer registry utilizes the coding system devised by the World Health Organization using code numbers C00.1-C98.9 as published in the manual of the International Classification of Diseases, Injuries and Causes of Death (WHO, 1977). The registry also utilizes the International Classification of Diseases for Oncology (ICDO-3) (WHO, 1976), simultaneously for coding the primary site. ICDO-3 gives histogenic and malignancy codes in conjunction with the primary site as suggested by the WHO. Validation checks are applied to avoid duplication of data entry in the computer. Quality control exercises are regularly undertaken to ensure the validity, reliability and completeness of the collected data. Two special studies (Yeole and Jussawalla 1988; Yeole 2001) have been carried out to evaluate the completeness and accuracy of the data. The inclusion of data in the IARC periodical publications itself states that the data quality is reliable.

Tobacco smoking in any form whether it is cigarettes, which has long been established as a major risk factor, or bidis which is smoked on the Indian subcontinent, are all causatively associated with lung cancer, depending on the

intensity of exposures, with 75% of new cases attributable to tobacco smoking (Pisani & Parkin, 1993). With the expansion of sale of cigarettes in the developing world, one can predict an explosion in the number of lung cancer cases from this part of the world. Only a complete elimination of this product would result in a substantial decline in the disease occurrence. Further, in non-smoking Indian women, indoor air pollution due to the use of bio-fuels for cooking is a significant risk factor. Apart from the increase in tobacco consumption, facts from (NFHS-3, 2005-06) data shows that, more than 700 million people in India (70.8% households) depend on solid fuels for cooking and other purposes. High exposure to indoor air pollution from the combustion of solid fuels have shown to cause serious health problems such as acute respiratory infections, chronic obstructive pulmonary disease, lung cancer, pulmonary tuberculosis and other respiratory diseases (Smith et al, 2000; Bruce et al, 2000, Ezzati and Kammen, 2002). Bio-fuel smoke contains the dangerous mixture of many pollutants including carbon monoxide and small particles but also nitrogen oxides, sulphur oxides, benzene, formaldehyde and many other health-damaging chemicals. Also in India where tuberculosis is a very common respiratory illness (NFHS-3) and has very similar symptoms to that of lung cancer so if only symptomatic investigation is done it may be misunderstood for TB and further delay in appropriate treatment may take place resulting in poor survival rates.

The age adjusted incidence rate of lung cancer in Mumbai is only 10.8 per 100,000 population among males and 3.4 per 100,000 population among females which is less than approximately one tenth of the rates in both sexes seen in the developed regions (Ferlay et.al. 2002; Parkin et.al. IARC 2007). Still lung cancer remains the leading site in age-adjusted incidence rates among all male cancers and it ranks 5th among females in Mumbai, India (BCR 2002-04).

Lung cancer is diagnosed in almost one seventh of the total population in the US (14% in males and 13% in females) and the probability estimates indicate that one in 12 men and one in 17 women will have lung cancer during their lifetime (Greenlee et al., 2001). In Mumbai, India, the present study showed that only one out of every 74 men and one out of every 242 women will be diagnosed with lung cancer during their lifetime. Hospital as well as population based registries show different patterns of the disease in different parts of the country. The variations in age-adjusted incidence rate across different age-groups in both sexes are clearly seen which indicates that there has been a change in the etiology of lung cancer in Greater Mumbai over time. The most important reason for this would be decrease in smoking prevalence among males. The other reasons for this have to be explored through risk assessment studies, but these findings may be of general interest because changes in diagnostic practices are confounders in time trends of lung cancer in many developed countries preventing inferences on changes in risk.

The major limitation in time trend analysis is that the estimates vary considerably from year to year, but our rates are based on most currently available incidence data,

however these data are three year old, at the time the estimates are calculated. Though the change may not be very large but it cannot be captured by our modelling efforts.

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