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A clinicoepidemiological profile of lung cancers in India – Results from the National Cancer Registry Programme

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***Background & objectives*: Lung cancer is a significant public health concern in low- and middle-income countries such as India. The present article describes the epidemiology, and clinical profile of lung cancer in India, based on recent data from the National Cancer Registry Programme (NCRP).**

***Methods*: The latest data on lung cancer from the NCRP were collated from 28 population-based cancer registries and 58 hospital-based cancer registries across a five-year (2012-2016) reporting period.**

***Results*: The highest age-adjusted incidence rate and mortality (AAMR) was found amongst males and females in the Aizawl district of Mizoram. A significant increase in the annual per cent change of lung cancer incidence was observed in metropolitan cities from 1982 to 2016. About one-third of the cases (36.5%) in males and females (31.7%) were recorded in the age group of 55-64 yr. Adenocarcinoma accounted for about a third (34.3%) of the morphological type in males and half (52.7%) amongst females. Out of 22,645 recorded lung cancer cases, close to half (44.8%) of the patients presented with distant spread, while over one-third (35.3%) had loco-regional spread of disease at the time of diagnosis.**

***Interpretation & conclusions*: Our estimates suggest that the number of cases is expected to rise sharply to 81,219 cases amongst males and 30,109 in females in 2025. The rising incidence and delayed diagnosis of lung cancer in India are grave concerns. The findings of the present study call for scaling up and intensification of lung cancer-specific preventive, early diagnosis and control measures.**

Key words Incidence - India - lung cancer - morphology - registry

Lung cancer is the most frequently reported cancer globally, accounting for an estimated 2.2 million new cases and 1.8 million deaths in 2020[1]. Of the new cancer cases in 2020, lung cancer contributed to 11.4 per cent and 18 per cent of the cancer-related deaths[1]. The highest lung cancer rate has been reported amongst males in Turkey and females in Hungary[2]. In the Southeast Asia Region, lung cancer accounted for eight per cent of the new cases in 2018[3]. Lung cancer rates have remained stable over time in Finland, Norway, France and Spain[4]. Once diagnosed, the prognosis tends to be generally poor. Developing countries report a mean five-year survival of 15 per cent, which is three times lower than those reported from developed countries[5]. Inequalities in socioeconomic status and access to healthcare contribute to the differences in

lung cancer burden and mortality across the countries. The survival outcomes continue to be dismal, despite the several recent advances in diagnostic methods and treatment modalities.

The National Cancer Registry Programme (NCRP) of the Indian Council of Medical Research (ICMR) is implemented by the National Centre for Disease Informatics and Research (NCDIR), Bengaluru. The NCRP plays a vital role in cancer surveillance by collecting and compiling data on cancer occurrence, patterns, outcome and projections. An earlier report from the NCRP estimated a significant increase in the age-adjusted incidence rate (AAR) of lung cancer in both the genders since the early 1980s[6]. Understanding the epidemiologic and clinical profile of lung cancer is of utmost importance to gauge the impact of prevention and treatment programmes. It also enables in identifying gaps in cancer care services, planning and strengthening preventive actions and service provision. This article aims to present a descriptive epidemiology and clinical profile of lung cancer in India, based on the recent NCRP findings[7].

Material & Methods

The latest data from the NCRP have been collated from 28 population-based cancer registries (PBCRs) and 58 hospital-based cancer registries (HBCRs) and cover a five-year (2012-2016) reporting period. The 28 PBCRs have been grouped region wise as north, north east region (NER), east, central, west and south. The PBCRs obtain data on new cancer cases from various sources of registration such as hospitals, clinics, diagnostic centres and vital registration sources in a well-demarcated geographic area amongst persons who have been residing there for at least one year before diagnosis. The data generated from a PBCR provide vital information on the cancer incidence and changes in occurrence patterns over the time. An HBCR is based at a specific hospital and compiles data on cancer patients who avail care at different hospital departments. They furnish necessary information on the clinical presentation, treatment modalities and disease outcomes such as survivorship and mortality. The NCRP registers cancers with a behaviour code of 3 according to the definition of the International Classification of Diseases for Oncology[8].

The epidemiology of lung cancer is described in terms of the median age at presentation crude incidence rate (CR), AAR and age-adjusted mortality rate (AAMR) per 100,000 population using world standard population for all the 28 PBCRs[9]. The AAR trends were estimated from 1982 to 2016 for six PBCRs: Delhi, bengaluru, Mumbai, Chennai, Barshi and Bhopal: which had consistent data over time. However, Barshi rural reported fewer cases (<10) among both genders, while Bhopal reported less than ten cases in females and was excluded. Annual per cent change (APC) was calculated using Joinpoint trend analysis software by the National Cancer Institute for the said periods[10]. Other indices include cumulative risk, which is the likelihood of developing cancer of any anatomical site in the age group of 0-74 yr, in the absence of any other cause of death. The ranking of lung cancer amongst leading anatomical sites and the proportion of one relative to the other frequently reported cancer sites are enumerated for each PBCR site. The clinical profile is explained according to the age distribution, morphologic type (IC0-0-3 classification), broad method of diagnosis and the clinical extent of the disease. The clinical extent of disease includes localized (confined to the primary site), loco-regional (with spread to regional lymph nodes) and distant metastasis (spread to different parts of the body).

The projected number of lung cancer cases has been estimated using age-specific incidence rate (ASpR) data of 28 PBCRs from 2012-2016. At first, the State or Union Territory-wise population was estimated for 2025 using census growth rate (2001-2011) by different distribution methods for estimating five-year age group population, followed by region-wise collation/ representation of PBCR data for projecting the incident number of cancer cases in India. The ASpR, according to the anatomical sites and gender, was applied to the estimated population of a corresponding region to arrive at the ASpR and projected number of lung cancer cases for the year 2025[11].

Results

Incidence and cumulative risk of lung cancer: The highest crude incidence rate among males (27.1/100,000) was reported in Aizawl district, followed by Mizoram State (20.9/100,000), as shown in Table I. Similarly, crude incidence rate among females was highest in Aizawl district (27.9/100,000) followed by Mizoram State (18.0/100,000). The AAR and cumulative risk in both genders displayed a similar geographical trend, with the highest rates from Aizawl followed by Mizoram (Table I). Outside the NER, AAR in males was reportedly high in Kollam district (23.1/100,000), Kolkata (18.3/100,000) and Thiruvanthapuram

Table I. Number of lung cancer cases (n), incidence rate (cumulative risk) per 100,000, cumulative risk (0-74 yr age group), median age at presentation, mortality rate and reporting year for 28 population-based cancer registries under the National Cancer Registry Programme

PBCR	Male						Female					
	Incidence					Mortality AAMR	Incidence					Mortality AAMR
	n (%)	CR	AAR	Cumulative risk	Median age		n (%)	CR	AAR	Cumulative risk	Median age	
North												
Delhi	1083 (10.5)	11.8	16.7	1 in 47	61	3.3	321 (3.3)	4.0	5.1	1 in 161	60	1.0
Patiala district	75 (6.9)	7.0	7.7	1 in 101	60	1.2	27 (2.2)	2.8	2.8	1 in 304	58	0.6
South												
Hyderabad district	187 (10.9)	9.2	12.4	1 in 59	63	2.4	87 (4.1)	4.5	6.0	1 in 127	60	1.1
Kollam district	367 (18.5)	29.4	23.1	1 in 33	65	15.9	72 (3.7)	5.1	3.8	1 in 214	63	2.4
Thiruvanathapuram district	337 (12.5)	21.3	16.8	1 in 47	63	8.9	109 (3.8)	6.3	4.7	1 in 175	62	2.0
Bengaluru	445 (10.1)	9.8	13.0	1 in 59	64	5.5	199 (3.8)	4.7	5.8	1 in 143	60	2.3
Chennai	279 (9.7)	11.8	11.9	1 in 66	63	4.9	111 (3.3)	4.7	4.4	1 in 182	61	1.7
East												
Kolkata	510 (20.0)	22.0	18.3	1 in 42	65	9.7	151 (6.6)	7.0	5.9	1 in 142	62	2.9
West												
Ahmedabad urban	238 (8.1)	7.3	8.8	1 in 86	62	3.2	62 (2.8)	2.1	2.4	1 in 332	60	0.8
Aurangabad	43 (11.2)	6.4	8.8	1 in 83	60	3.1	16 (3.9)	2.5	3.2	1 in 243	60	1.0
Osmanabad and Beed	44 (4.9)	1.9	1.9	1 in 421	65	0.8	23 (2.1)	1.1	1.0	1 in 848	59	0.4
Barshi rural	5 (3.4)	1.9	1.8	1 in 448	60	1.3	5 (3.2)	2.1	1.9	1 in 458	58	1.5
Mumbai	639 (9.7)	9.5	11.0	1 in 73	65	9.2	348 (5.1)	6.0	5.9	1 in 143	65	4.8
Pune	147 (7.6)	5.1	6.7	1 in 113	65	3.8	90 (4.2)	3.5	4.0	1 in 204	61	2.4
Central												
Wardha district	34 (7.1)	5.0	4.6	1 in 179	62	3.6	17 (3.4)	2.6	2.3	1 in 147	59	1.8
Bhopal	98 (10.9)	9.1	12.0	1 in 64	62	7.4	29 (3.2)	2.9	3.6	1 in 220	58	2.2
Nagpur	74 (6.2)	5.5	6.1	1 in 121	62	1.5	35 (2.9)	2.7	2.7	1 in 299	55	0.5
North East												
Manipur State	140 (18.9)	8.9	12.9	1 in 58	68	6.1	130 (14.4)	8.3	11.8	1 in 63	65	5.2
Imphal West district	41 (18.2)	15.5	17.8	1 in 46	70	7.7	43 (14.3)	15.5	16.6	1 in 49	66	6.9
Mizoram State	124 (14.3)	20.9	32.1	1 in 26	66	23.1	106 (14.1)	18.0	27.6	1 in 29	67	17.2
Aizawl district	57 (13.2)	27.1	38.8	1 in 22	66	27.9	61 (16.0)	27.9	37.9	1 in 23	70	24.3
Sikkim State	17 (7.1)	4.9	6.5	1 in 127	69	5.2	15 (6.5)	4.9	7.1	1 in 118	66	5.7
Tripura State	221 (16.8)	11.3	14.5	1 in 54	63	10.4	53 (5.4)	2.8	3.4	1 in 226	60	2.3

Contd...

PBCR	Male						Female					
	Incidence					Mortality	Incidence					Mortality
	n (%)	CR	AAR	Cumulative risk	Median age	AAMR	n (%)	CR	AAR	Cumulative risk	Median age	AAMR
West Arunachal	16 (6.5)	3.7	7.0	1 in 110	54	2.1	9 (3.9)	2.2	5.0	1 in 51	55	1.4
Papum Pare district	8 (8.1)	7.6	20.1	1 in 38	55	3.6	4 (4.0)	4.2	12.8	1 in 366	60	2.4
Meghalaya	57 (6.1)	5.6	12.4	1 in 61	60	6.5	23 (4.1)	2.3	4.3	1 in 186	61	2.0
East Khasi Hills district	31 (5.3)	6.9	14.1	1 in 50	60	7.5	14 (4.0)	3.1	5.3	1 in 143	64	3.1
Nagaland	17 (6.0)	4.5	8.4	1 in 96	58	2.2	7 (3.7)	2.1	4.3	1 in 174	60	1.1
Pasighat	5 (7.8)	7.1	9.7	1 in 77	57	4.2	2 (3.0)	2.6	4.3	1 in 158	60	0.5
Cachar district	80 (8.6)	8.5	11.9	1 in 66	63	4.8	25 (3.2)	2.8	3.9	1 in 218	60	1.5
Dibrugarh district	27 (5.3)	3.9	5.1	1 in 155	60	1.6	10 (2.3)	1.5	2.0	1 in 393	60	0.6
Kamrup urban	99 (7.9)	15.1	18.1	1 in 44	64	8.0	36 (3.8)	5.7	6.7	1 in 128	56	2.3

CR, crude incidence rate; AAR, age-adjusted incidence rate; AAMR, adjusted incidence mortality rate; PBCR, population-based cancer registry

(16.8/100,000). The lowest AAR rates were observed among males in Barshi rural (1.8/100,000) and females in Osmanabad and Beed (1.0/100,000). The cumulative risk of developing cancer was the highest in Aizawl, with every one in 22 males and one in 23 females in the 0-74 yr age group, at risk of developing cancer in any given anatomical site.

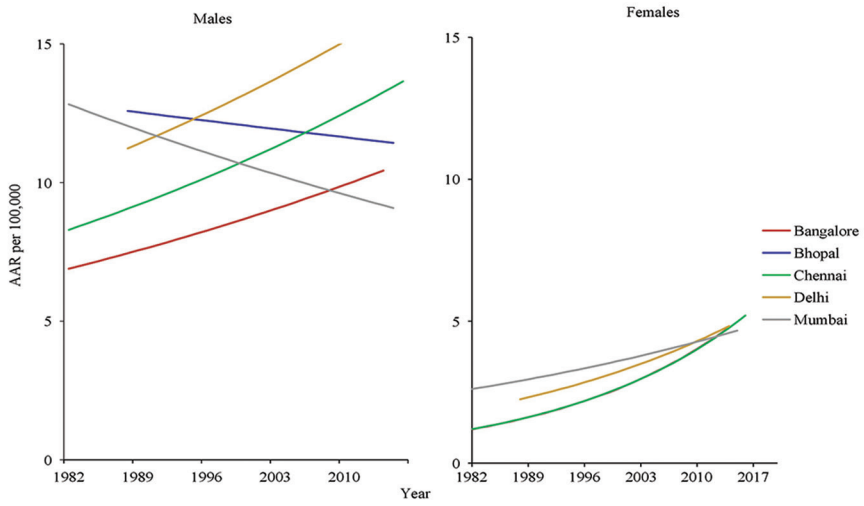
Median age at the time of diagnosis: The median age at diagnosis among the males ranged from 54 yr in West Arunachal to 70 yr in Imphal West district (Table I). The median age of 55 yr at diagnosis was the lowest among females in Arunachal Pradesh and highest in Aizawl (70 yr).

Lung cancer mortality: The AAMR in males was highest in Aizawl (27.9 per 100,000), followed by Mizoram (23.1 per 100,000), as seen from Table I. Among females, Aizawl recorded the highest AAMR (24.3 per 100,000) followed by Mizoram (17.1 per 100,000).

Trends in age-adjusted incidence rate (AAR) over time: The change in AAR is presented for males in five PBCRs and for females in four PBCRs. The AAR for incidence was observed to increase with statistically significant APC among males in Delhi (1.35), Bengaluru (1.30) and Chennai (1.48) (Fig. 1). In Mumbai, the AAR in males showed a downward trend, with a significant APC reduction (−1.04). Among females, the AAR showed a rising trend with a significant increase in APC in Bengaluru (4.43), Chennai (4.41), Delhi (1.98) and Mumbai (1.78). The actual points as well as fitted values of the joinpoint regression model are shown in Supplementary Figure.

Ranking of lung as a leading site cancer and relative proportion amongst tobacco-related cancers: In the NER, the lung constituted the leading site of cancer in males in Manipur (including Imphal West district) and Tripura. In other parts of the country, the lung ranked first as the leading cancer site amongst males in Delhi, Kollam, Thiruvanthapuram, Bengaluru, Chennai, Kolkata, Nagpur and Mumbai. Only Aizawl reported lung to be ranked as the first leading site in females. Lung cancers accounted for nearly two-thirds of the tobacco-related cancers amongst males in the NER and amongst females in the northern parts of the country.

Age distribution and morphologic type of lung cancer according to gender: The age-specific incidence rates



	Bangalore	Mumbai	Delhi	Bhopal	Chennai
Males	1.30°	-1.04°	1.35°	-0.35	1.48°
Females	4.43°	1.78°	2.98°	-	4.41°

Note: Bhopal reported less than ten cases in females and was therefore excluded. Also among females, the APC for Bangalore (4.43) and Chennai (4.41) is nearly the same, and hence are overlapping in the figure.

Fig. 1. Lung Cancer: Trends over time in age-adjusted rate 1982-2016.The annual per cent change among females, for Bengaluru (4.43) and Chennai (4.41) is nearly the same and hence is overlapping in the Figure.

of lung cancer for each of the 28 PBCRs are provided in Supplementary Tables I and II. A total of 22,645 lung cancer cases were recorded in the 58 HBCRs from 2012 to 2016, amongst which 17391 (76.7%) were reported in males. The highest proportion of cases (36.5%) in males and females (31.7%) were recorded in the age group of 55-64 yrs (Table II). Adenocarcinoma was the most frequent histologic type (34.3%), followed by squamous cell carcinoma (23.4%) in males. In females, adenocarcinoma comprised over half (52.7%) of the lung cancers and was the leading histologic type of lung cancer, while squamous cell carcinoma accounted for 11.5 per cent of the cases. Adenocarcinoma constituted the highest proportion of cancers in all the age groups up to 54 yr in males and 74 yr in females. The proportion of squamous cell carcinoma was higher beyond 75 yr as compared to adenocarcinoma in both genders. Fifteen cases were documented in the 0-14 yr age group of males, of which five (33.3%) were cases of a mesenchymal tumour. In females, only four cases were noted in the 0-14 yr age group.

Diagnostic method, clinical extent of disease at presentation and waiting time between diagnosis and treatment initiation: As many as 97.4 per cent of the lung cancers in males and 97.5 per cent in females had undergone a histopathological evaluation towards diagnosis. The proportion of those diagnosed by imaging (2.1%) and clinically (0.2%) was low. Close to half (44.8%) of the patients presented with a distant spread, while over one-third (35.3%) had loco-regional spread of the disease at the time of diagnosis (Fig. 2). Over one-third of the patients received treatment between days eight and 30 following diagnosis, regardless of the clinical extent of disease (Fig. 3).

Projected number of lung cancer cases and age-specific incidence rates: The number of cases is expected to rise sharply to 812, 19 cases among males and 30109 in females by 2025 (Fig. 4). The number of cases would be the highest in the 60-64 yr age group with about 15,759 among males and 4,779 in females. The projected age-specific incidence rate for 2025 would be highest in the 70-74 yr age group in males and the 75 yr plus age group in females.

Discussion

This is a comprehensive study on the epidemiological aspects of lung cancer in India based on an analysis from an extensive cancer registry network data. Aizawl district, followed by the entire State of Mizoram in the NER, recorded the highest incidence rate of lung cancer in both genders and is in accordance with the findings from the previous report[6]. The reported prevalence of tobacco use in Mizoram is

Table II. Age distribution and histologic type of lung cancer according to IC0-0-3 classification

Age group (yr)	Epithelial tumours-adenocarcinoma, n (%)	Epithelial tumours-squamous cell carcinoma, n (%)	Small cell carcinoma, n (%)	Non-small cell carcinoma, n (%)	Epithelial tumours-others, n (%)	Lymph histiocytic tumours, n (%)	Mesenchymal tumours, n (%)	Others*, n (%)	Total number of lung cancers, n (%)
				Males					
0-14	5 (0.1)	1 (0)	0	0	0	1 (3.6)	6 (13.0)	2 (0)	15 (0.1)
15-24	32 (0.5)	8 (0.2)	2 (0.1)	2 (0)	1 (0)	4 (14.3)	3 (6.5)	3 (0.2)	55 (0.3)
25-34	152 (2.5)	22 (0.5)	14 (0.8)	37 (1)	18 (2)	4 (14.3)	5 (10.9)	31 (1.7)	283 (1.6)
35-44	412 (6.9)	124 (3.0)	71 (4.0)	144 (5.3)	65 (7)	3 (10.7)	2 (4.3)	118 (6.5)	939 (5.4)
45-54	1293 (21.6)	613 (15.0)	364 (20.7)	512 (18.8)	186 (19)	4 (14.3)	7 (15.2)	436 (24.2)	3415 (19.6)
55-64	2098 (35.1)	1547 (37.9)	701 (39.9)	988 (36.2)	361 (37)	6 (21.4)	13 (28.3)	637 (35.3)	6351 (36.5)
65-74	1548 (25.9)	1319 (32.3)	486 (27.7)	792 (29.0)	259 (27)	4 (14.3)	9 (19.6)	454 (25.2)	4871 (28.0)
75+	439 (7.3)	449 (11.0)	117 (6.7)	252 (9.2)	79 (8)	2 (7.1)	1 (2.2)	121 (6.7)	1460 (8.4)
Total	5979 (100)	4083 (100)	1755 (100)	2727 (100)	970 (100)	28 (100)	46 (100)	1803 (100)	17,391 (100)
				Females					
0-14	1 (0.0)	0	0	1 (0.2)	1 (0.3)	0	1 (4.5)	0	4 (0.1)
15-24	14 (0.5)	3 (0.5)	7 (2.2)	4 (0.6)	3 (0.9)	0	1 (4.5)	1 (0.2)	33 (0.6)
25-34	117 (4.2)	12 (2.0)	11 (3.5)	21 (3.4)	13 (4.0)	0	5 (22.7)	19 (3.3)	198 (3.8)
35-44	363 (13.1)	53 (8.8)	37 (11.7)	56 (9.0)	38 (11.6)	2 (11.8)	3 (13.6)	82 (14.3)	634 (12.1)
45-54	715 (25.8)	123 (20.4)	72 (22.7)	143 (23.1)	93 (28.3)	4 (23.5)	6 (27.3)	143 (25.0)	1299 (24.7)
55-64	877 (31.6)	192 (31.8)	107 (33.8)	204 (33.0)	88 (26.7)	8 (47.1)	5 (22.7)	185 (32.3)	1666 (31.7)
64-74	525 (18.9)	182 (13.1)	63 (19.9)	143 (23.1)	71 (21.6)	3 (17.6)	1 (4.5)	115 (20.1)	1103 (21.0)
75+	161 (5.8)	39 (6.5)	20 (6.3)	47 (7.6)	22 (6.7)	0	0	28 (4.9)	317 (6.0)
Total	2773 (100)	604 (100)	317 (100)	619 (100)	329 (100)	17 (100)	22 (100)	573 (100)	5254 (100)

*Others, bronchioalveolar; large cell; adenosquamous; mesothelioma; carcinoma NOS. NOS, not otherwise specified

58.7 per cent, with a high rate of smoked tobacco use (25.1%) than other parts of the country[12]. Lung cancer incidence rates were lesser in Barshi, Osmanabad and Beed district in both genders and Wardha and Dibrugarh among males. This could be attributed to a current smoked tobacco prevalence rate of 3.8 per cent in Maharashtra; however, other factors such as poor treatment-seeking resulting in less reporting of cases need further exploration[12].

The use of smoked tobacco is coupled with using locally available forms such as '*tuibur*' (tobacco smoke-infused water), which appears to have a cultural context in NER and is commonly used by women[13]. Results on the association between smokeless tobacco use and lung cancer are found to be inconsistent[14].

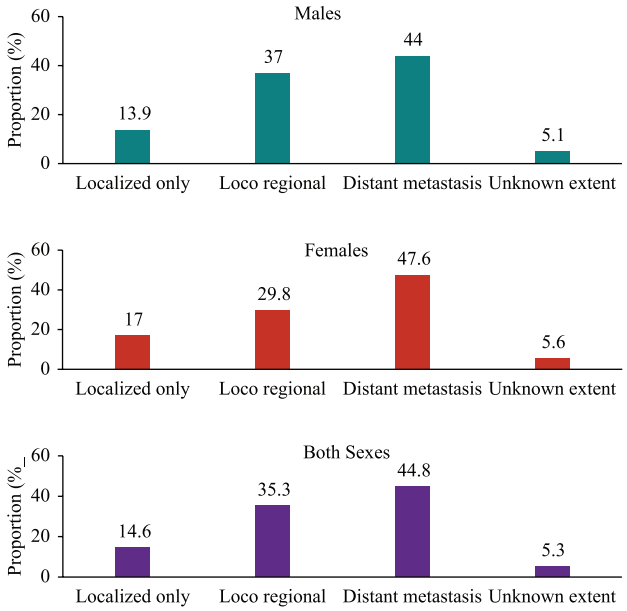


Fig. 2. Clinical extent of disease at presentation.

The rising trend in the AAR amongst males and females in the metro cities of Delhi, Bengaluru and Chennai over three decades is of concern, signifying the role of smoked tobacco, indoor and outdoor air pollution, but also could allude to an increased health-seeking behaviour for treatment, resulting in enhanced detection. Compared to GATS (Global Adult Tobacco Survey)-1 (2009-2010), the prevalence of tobacco use has decreased in GATS-2 (2016-2017)[12,15]. Hence, there is an increasing recognition of the role of air pollution in the causation of lung cancer[16,17]. According to recent findings of the National Non-Communicable Disease Monitoring Survey (NNMS), almost half (48.5%) of the adults reported exposure to second-hand smoke at home, workplace or travel[18]. The declining trend in lung cancer incidence in males and rising trend amongst females in Mumbai and Bhopal points towards a changing aetiology, which could be due to decreased smoking rates in men and increase in solid fuel exposure amongst women. Similar findings have been corroborated by other trend analysis studies on PBCR data[19-21]. These would, however, need further investigation to confirm the potential reasons for this pattern[19-21]. In the NNMS survey, over one-third (37.5%) of the women reported exposure to second hand smoke; in rural areas, the exposure occurred at home for 35.2 per cent of the participants[18].

The age-adjusted lung mortality rate was highest among males and females in Aizawl district, which also corresponds to the high incidence rate. Lung cancer mortality rates have been positively correlated

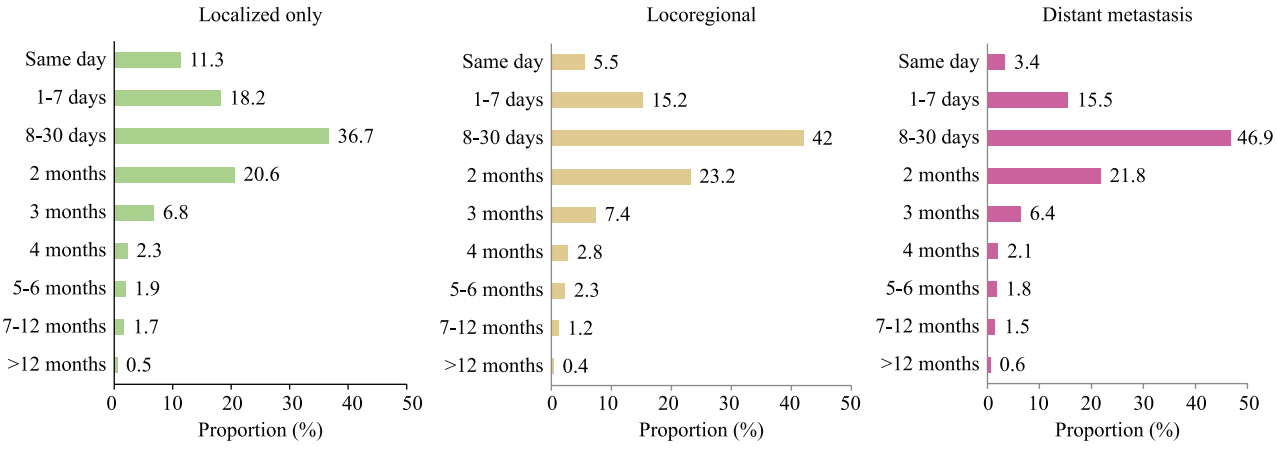


Fig. 3. Time between first diagnosis and commencement of cancer-directed treatment at reporting institution.

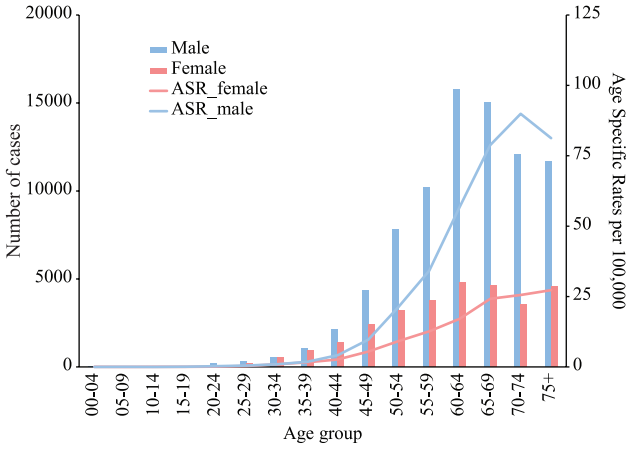


Fig. 4. Projected age-wise number and age specific incidence rate for Lung cancer cases (2025).

with cigarette smoking patterns[22,23]. This correlation is evident from the observed decline in mortality rates in the United States and the United Kingdom and rising rates in the BRIC (Brazil, Russia, India and China) countries[3]. Low survival rates often result from an advanced stage at presentation and deficiency in the availability and accessibility to quality healthcare[24].

Our analysis indicated that the median age at presentation ranged from 54 to 70 yr in different geographic areas. Compared to the western population, our median age of presentation tends to be a decade earlier in the Indian population. The mean age of presentation in patients presenting at a tertiary care hospital in North India was 57.9±11.3 yr[25].

The pathologic behaviour of lung cancer differs in males and females but lung cancer tends to display male preponderance[2]. In the present study, over two-third (76.7%) of the patients were males. Adenocarcinoma comprised over half of the lung cancers in females and about one-third of all cancers in males in our study. This is in tandem with other reports which have shown that the incidence of adenocarcinoma tends to be higher in females[26], and it is reportedly the most frequent histopathologic type of cancer among non-smokers[27].

Close to half of the patients had a distant spread of disease at the time of presentation in our analysis. Similar findings have been reported by studies from other Indian settings where most of the patients had Stage IV disease at the time of diagnosis[28,29]. In the Indian context, misdiagnosis of lung cancer as pulmonary tuberculosis is a frequently encountered reason for delayed diagnosis[30].

The present analysis was conducted on nationally representative data from 28 PBCRs and 58 HBCRs. It provides a comprehensive and descriptive profile of lung cancer epidemiology and clinical and histopathological profile of lung cancer in India through a systematic collection of robust data. However, the data on the number of cancer deaths compiled by registries are mostly insufficient. Most death certificates do not contain details on the underlying cause, which leads to under-reporting of mortality. Even if cancer is mentioned to be the cause of death, there are gaps in the information pertaining to the anatomical site and morphological type of cancer.

Overall, the findings on lung cancer and the projected increase in cases derived from the NCRP data analysis call for scaling up and intensifying lung cancer-specific preventive and control measures. It is suggested that while framing policies related to tobacco control in India, policymakers should consider the regionally relevant sociocultural factors. The role of exposure to environmental smoke in the causation of lung cancer should not be underestimated. Understanding the morphologic classification of lung cancer provides a background to explore novel treatment modalities regarding molecular targets. It is thus suggested that, capacity building of healthcare providers to ensure timely diagnosis and treatment will improve survivorship and prolong disease-free intervals. A robust mechanism of policy implementation, health system strengthening and research promotion in genetic risk factor profiling, improved diagnosis and novel targeted therapies are critical measures for lung cancer control in the country.

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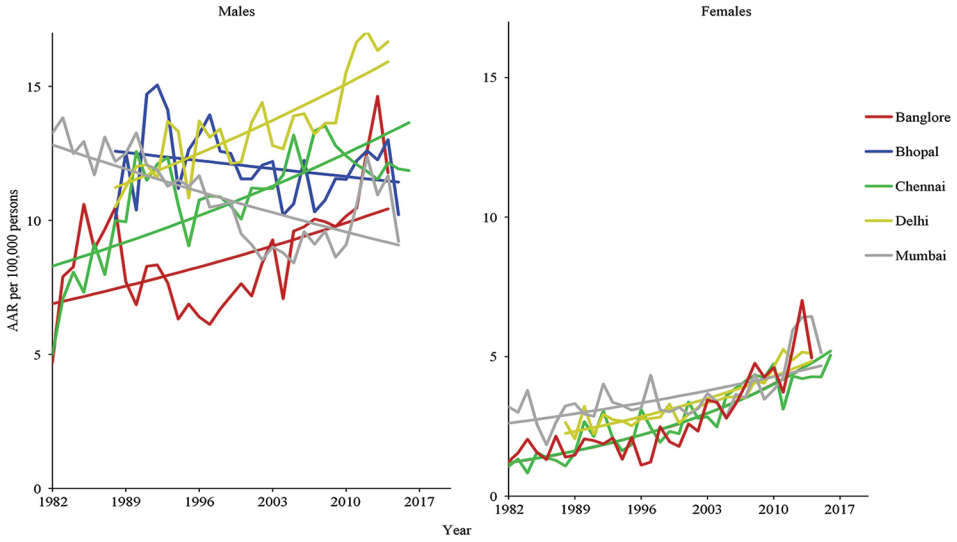

Supplementary Figure. Trends in age-adjusted rate showing actual points as well as fitted values.

Supplementary Table I. Age-specific incidence rate in males, according to the 28 population-based cancer registries

Region	Registry	Age Group															
		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+
North	Delhi	0.0	0.0	0.0	0.0	0.4	0.5	1.1	2.9	6.9	13.6	33.1	54.1	85.2	109.5	126.7	104.6
	Patiala District	0.0	0.2	0.0	0.0	0.4	0.4	0.5	1.9	2.4	9.5	23.5	27.7	44.8	32.9	53.9	32.3
South	Hyderabad District	0.0	0.0	0.0	0.0	0.2	0.7	1.8	1.9	6.7	10.0	18.6	28.7	59.2	90.5	121.5	76.1
	Kollam District	0.0	0.0	0.0	0.0	0.0	1.0	1.2	3.0	6.9	18.9	41.4	58.9	115.4	179.4	193.8	147.8
	Thi'puram District	0.0	0.0	0.0	0.0	0.3	0.9	1.1	4.0	6.1	15.8	29.5	44.7	91.3	116.0	122.2	113.8
	Bengaluru	0.1	0.1	0.1	0.3	0.2	0.5	1.0	2.4	3.6	8.3	22.5	40.2	58.0	100.8	104.6	92.3
	Chennai	0.0	0.1	0.0	0.2	0.4	0.3	1.6	0.7	4.5	10.0	20.4	38.4	53.3	85.0	89.7	86.8
East	Kolkata	0.0	0.0	0.0	0.0	0.6	0.9	1.0	2.1	5.7	12.7	36.0	56.5	85.4	118.4	158.9	136.2
West	Ahmedabad Urban	0.0	0.0	0.0	0.1	0.1	0.3	0.6	1.6	3.0	8.5	16.1	25.1	43.0	60.7	73.8	56.9
	Aurangabad	0.0	0.0	0.0	0.0	0.3	0.3	2.9	2.7	3.9	6.0	21.4	24.9	40.0	62.2	76.6	37.4
	Osmanabad & Beed	0.0	0.0	0.0	0.0	0.1	0.0	0.8	0.7	0.4	2.7	5.1	6.0	9.0	12.8	10.0	10.5
	Barshi Rural	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.5	3.0	5.2	9.1	4.4	12.8	7.7	7.7
	Mumbai	0.1	0.1	0.0	0.1	0.3	0.6	0.7	1.6	3.4	7.4	16.0	25.7	47.8	72.5	97.9	112.4
	Pune	0.0	0.0	0.0	0.0	0.1	0.1	0.5	0.8	1.8	4.6	10.3	17.8	31.0	51.3	59.0	50.7
Central	Wardha District	0.0	0.0	0.0	0.0	0.0	1.7	0.4	0.4	2.0	5.0	10.1	12.2	29.6	17.8	32.7	32.0
	Bhopal	0.0	0.3	0.0	0.2	0.2	0.2	0.9	2.9	5.3	12.1	26.8	44.5	48.6	76.1	97.7	67.1
	Nagpur	0.0	0.0	0.2	0.0	0.2	0.5	0.9	1.5	1.7	5.8	10.9	18.7	30.1	42.7	53.3	30.4
North East	Manipur State	0.0	0.0	0.0	0.0	0.3	0.3	1.0	0.7	2.5	4.5	13.7	26.1	41.8	96.9	159.1	143.4
	Imphal West District	0.0	0.0	0.0	0.0	0.0	0.0	1.8	1.9	2.2	4.9	13.6	41.2	61.2	124.0	192.8	241.3
	Mizoram State	0.3	0.0	0.0	0.0	0.0	0.4	2.4	3.1	7.5	16.7	44.3	78.1	144.4	224.6	274.8	343.3
	Aizawl District	1.0	0.0	0.0	0.0	0.0	0.0	2.1	2.7	12.8	23.7	50.7	79.6	187.7	309.7	277.8	408.0
	Sikkim State	0.0	0.0	0.0	0.0	0.0	0.0	0.6	1.6	2.8	6.9	5.3	7.3	32.2	29.4	71.7	81.1
	Tripura State	0.0	0.0	0.0	0.0	0.2	0.4	0.1	1.5	3.7	8.5	23.4	45.1	83.9	90.5	117.2	109.0
	West Arunachal	0.0	0.0	0.0	0.0	0.5	2.0	1.8	2.1	4.4	5.6	22.6	21.6	42.7	55.7	23.6	7.0
	Papumpare District	0.0	0.0	0.0	0.0	0.0	6.2	2.7	0.0	6.2	7.9	66.5	29.6	160.9	255.7	0.0	0.0
	Meghalaya	0.0	0.0	0.0	0.0	0.2	0.0	0.6	3.1	6.6	15.0	31.9	35.4	55.5	73.2	110.6	61.8
	East Khasi Hills District	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.1	10.2	16.2	32.8	41.9	47.6	68.4	181.1	76.9
	Nagaland	0.0	0.0	0.0	0.0	0.5	0.5	0.0	3.0	5.2	6.4	16.7	33.7	18.3	81.2	44.6	60.6
	Pasighat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.2	0.0	25.0	25.5	35.4	42.3	16.1	112.0	44.5
	Cachar District	0.2	0.0	0.0	0.0	0.5	0.0	0.0	1.8	3.7	9.4	19.4	33.7	62.5	63.2	112.9	100.5
	Dibrugarh District	0.0	0.0	0.0	0.0	0.0	1.2	0.0	1.1	2.1	5.9	12.7	9.2	20.3	37.9	38.7	38.4
	Kamrup Urban	0.0	0.0	0.0	0.0	0.3	0.3	1.1	2.7	6.1	11.5	25.9	55.7	67.0	108.7	181.1	182.7

Supplementary Table II. Age-specific incidence rate in females, according to the 28 population-based cancer registries

Region	Registry	Age Group															
		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+
North	Delhi	0.0	0.0	0.0	0.0	0.1	0.4	0.9	1.8	2.8	6.3	12.6	16.7	22.5	31.6	28.8	28.4
	Patiala District	0.0	0.0	0.0	0.0	0.0	0.2	0.8	1.7	2.7	2.0	7.5	16.1	6.8	15.3	12.9	17.5
South	Hyderabad District	0.0	0.0	0.0	0.0	0.1	0.0	1.8	1.3	3.6	6.5	12.3	23.1	34.1	39.7	35.3	20.1
	Kollam District	0.0	0.0	0.0	0.0	0.0	0.6	0.4	1.3	1.6	6.6	9.6	9.5	16.7	25.5	21.9	21.5
	Thi'puram District	0.0	0.0	0.0	0.0	0.1	0.4	1.4	1.0	3.3	6.1	12.1	13.4	18.8	28.9	29.4	28.3
	Bengaluru	0.0	0.0	0.1	0.0	0.1	0.4	0.8	1.8	3.9	8.3	13.9	19.5	23.7	29.4	38.7	37.7
	Chennai	0.0	0.0	0.0	0.0	0.0	0.3	1.2	2.2	2.2	5.2	10.0	14.1	19.0	25.7	30.3	28.0
East	Kolkata	0.0	0.0	0.0	0.0	0.0	0.6	0.9	3.5	3.3	9.3	12.4	17.3	24.8	33.7	35.3	37.7
West	Ahmedabad Urban	0.1	0.0	0.1	0.0	0.1	0.3	0.6	0.7	0.9	2.3	5.1	6.2	11.9	18.6	13.5	11.6
	Aurangabad	0.0	0.0	0.0	0.0	0.3	0.3	1.1	1.6	1.5	5.1	4.0	11.0	16.1	14.8	26.8	14.0
	Osmanabad & Beed	0.3	0.0	0.0	0.0	0.1	0.1	0.2	0.9	1.6	1.9	2.4	4.8	2.2	5.2	3.9	3.5
	Barshi Rural	0.0	0.0	0.0	0.0	0.0	1.1	1.2	1.2	3.9	1.6	5.7	6.7	5.5	14.0	2.8	5.3
	Mumbai	0.1	0.1	0.1	0.2	0.2	0.5	1.3	2.0	2.9	6.3	9.3	14.7	19.1	35.8	47.6	62.6
	Pune	0.0	0.1	0.1	0.1	0.1	0.3	0.6	1.9	3.0	5.8	7.5	8.2	20.9	29.1	20.8	23.3
Central	Wardha District	0.5	0.0	0.0	0.4	0.0	0.0	1.6	1.5	2.1	3.0	5.6	10.5	8.5	8.8	12.2	10.4
	Bhopal	0.0	0.0	0.0	0.0	0.0	0.2	1.2	1.3	2.7	7.4	9.5	13.5	14.7	19.3	21.4	10.0
	Nagpur	0.0	0.0	0.0	0.0	0.6	0.8	1.2	1.3	3.9	4.0	6.4	7.3	10.8	14.7	16.0	8.3
North	Manipur State	0.0	0.0	0.1	0.0	0.1	0.4	1.1	0.7	2.5	4.6	16.0	27.7	49.9	90.2	127.4	103.1
East	Imphal West District	0.0	0.0	0.0	0.0	0.8	0.0	0.8	0.9	5.2	9.6	31.5	39.4	64.5	104.4	156.7	179.7
	Mizoram State	0.0	0.0	0.0	0.4	0.3	0.0	2.0	2.1	5.2	8.1	30.1	69.4	107.8	191.7	290.8	318.6
	Aizawl District	0.0	0.0	0.0	1.0	0.0	0.0	3.9	3.8	4.7	7.8	27.9	94.1	110.6	252.9	400.6	569.8
	Sikkim State	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.8	0.0	8.1	9.9	16.2	26.9	47.3	60.2	81.4
	Tripura State	0.0	0.0	0.0	0.1	0.0	0.3	0.6	0.8	1.4	4.0	8.1	10.1	14.0	17.7	31.5	19.0
	West Arunachal	0.0	0.0	0.0	0.0	0.0	0.5	0.0	0.7	4.2	8.1	5.1	21.7	27.6	27.6	40.9	13.9
	Papumpare District	0.0	0.0	0.0	0.0	0.0	2.0	0.0	0.0	13.6	10.1	8.8	31.2	91.0	36.8	205.9	32.8
	Meghalaya	0.0	0.0	0.0	0.0	0.0	0.2	0.0	2.4	1.6	5.0	8.8	13.0	24.1	25.4	27.5	25.6
	East Khasi Hills District	0.0	0.0	0.0	0.0	0.0	0.0	0.0	2.7	0.8	6.0	4.0	13.5	34.4	41.2	37.6	33.7
	Nagaland	0.0	0.0	0.0	0.0	0.5	0.0	0.7	2.3	4.1	2.7	5.7	11.8	31.2	32.0	24.1	10.5
	Pasighat	0.0	0.0	0.0	0.0	0.0	0.0	0.0	0.0	4.8	0.0	9.1	14.0	22.8	50.7	25.5	0.0
	Cachar District	0.0	0.0	0.0	0.0	0.0	0.0	0.0	1.5	2.2	5.2	7.8	13.9	16.6	20.5	24.4	31.2
	Dibrugarh District	0.0	0.0	0.0	0.0	0.3	0.0	0.4	0.7	1.3	3.0	2.8	6.5	10.4	13.6	12.0	11.3
	Kamrup Urban	0.0	0.0	0.0	0.4	0.3	0.6	2.6	2.3	4.5	8.3	10.3	30.3	36.0	28.3	33.1	44.7