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Burden of Tobacco-related Cancers in India and its States, 2015-2025

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Abstract

Tobacco use is a significant contributor to the cancer burden, which is preventable. It relates to around a quarter to two-third of cancers in males and up to half in females. For planning and effective implementation of anti-tobacco programmes, the knowledge of burden of tobacco-related cancers (TRCs) is essential. This paper assesses and projects the burden of TRCs in India and its States for the period 2015-2025 by using the data of National Cancer Registry Programme (NCRP) of Indian Council of Medical Research (ICMR). Cancer incidence rates generated by Population-Based Cancer Registries under the NCRP and population of India and its States as projected by the Registrar General of India formed the sources of data for this study. The best possible assessment of incidence rates was made for the States and Union Territories using the limited data available. The regression method was applied to assess the trend and project the rates for the study period. Overall burden of TRCs in India was estimated at about 365 thousand in 2015 and projected to increase to 506 thousand by 2025, an increase of more than one-third. A sizeable portion of this burden is due to tobacco use in men. Analysis showed regional diversity in the burden of diverse types of TRCs. There is an urgent need to initiate focused tobacco prevention measures to combat this threat.

Keywords: PBCR, tobacco-related cancers, State-wise projection, India.

I. Introduction

Globally, cancer is the second leading cause of death preceded only by cardiovascular disorders (Jemal et al., 2007). It accounts for nearly 23 per cent and 7 per cent of deaths in the USA and India respectively. The world's population is likely to reach 7.9 billion by 2020, and it is predicted that almost 15 million new cancer cases will be diagnosed, and nearly 12 million cancer patients will die annually (Bray & Moller, 2006).

Tobacco use is associated with a wide range of major diseases, including several types of cancer, heart and lung diseases. In addition to sharing the same health risks as men, women who use tobacco also have trouble in becoming pregnant and are at an increased risk of infertility, pregnancy complications, premature births, low-birth-weight infants, still births and infant deaths (USDHHS, 2004). Multiple scientific investigations have also confirmed the association of smoking with various diseases and provided evidence that associates cigarette smoking with a variety of neoplasms, including cancer of the larynx, lung, oral cavity, esophagus, urinary bladder, pancreas, cervix and more recently of hematopoietic system (USDHHS, 1989).

Heart diseases are strongly associated with the use of tobacco (Gupta et al., 1997; Rani et al., 2003; Shimkhada & Peabody, 2003). Sixty per cent of persons suffering from them under 40 years of age may attribute their condition to tobacco use (Gupta et al., 1997). A distinguishing characteristic of tobacco-related morbidity is that the incidence of oral cancer in India exceeds that

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of lung cancer and is one of the highest in the world (Gupta, 1999). In India, one-third of all cancers are reported as oral cancer, ninety per cent of which are among tobacco users (Gupta, 1999; Shimkhada & Peabody, 2003).

In India, oral cancer has a direct association with the increase in consumption of a broad range of tobacco products (Sankaranarayanan et al., 2005). Previous studies have confirmed the use of smokeless tobacco as a cause of oral cancer, esophageal cancer (when chewed with betel quid) and cardiovascular diseases. Two large hospital-based case-control studies in India reported a two-fold increase in the risk of oral cancer (Gavarasana et al., 1991; WHO, 1997; Arora & Reddy, 2005; Sharma et al., 2011). Another Indian research on oral cancer suggested that current users of nasal snuff had about four times the risk for cancer of the gingival (Sankaranarayanan et al., 1989). A case-control study showed a significant relative risk of laryngeal cancer for occasional paan-tobacco chewers (Rao et al., 1989).

India has the fastest rate of increase in the quantum of deaths attributable to tobacco in the first two decades of the current century. Most of the deaths are in the productive years of an adult victim's life (Reddy & Gupta, 2004). The magnitude of cancer incidence for India as a whole has been estimated according to the site, age and sex based on different methods till the years 2016 (Murthy et al., 2008) and 2020 (Takiar et al., 2010). However till recently, no published study was available that estimated, directly or indirectly, the incidence of cancer in all States/Union Territories (UTs) of India. Moreover, past studies had used single (pooled/average) incidence rates assuming that the risk of occurrence of cancer is the same throughout India. This assumption was hardly tenable in view of the vast heterogeneity in the country. Therefore, there was need of a better approach to estimate the State-wise burden of cancers in India so that proactive actions may be taken in the future. Prasad & Dhar (2018) addressed this gap and estimated and projected overall burden of cancer in the country. Present study was undertaken to assess and project the burden of tobacco-related cancers (TRCs) taken individually as well as combined for India and States/UTs by sex and place of residence.

II. Methods

Data on cancer incidence

National Cancer Registry Programme (NCRP) was started in 1980 by the Indian Council of Medical Research (ICMR). It is the only major and reliable source of information on cancer in the country. Cancer registration in NCRP started in 1982 with only three Population Based Cancer Registries (PBCRs) covering only three States and only less than three per cent of the population. Over the period of about four decades, however, the registration coverage has been expanded considerably. For the present study, cancer incidence rates were obtained from the published reports of PBCRs under NCRP. The latest report of NCRP dealing with the data from PBCRs is available for the period 2012-14, which contains 27 PBCRs (NCRP, 2016). In addition, four PBCRs (SAS Nagar, Mansa, Sangrur and Chandigarh) were added in 2013 by the Tata Memorial Center, Mumbai (TMC, 2017[a]; TMC, 2017[b]; TMC, 2017[c]; TMC, 2017[d]). Thus, there were altogether 31 PBCRs representing 16 States and two UTs of the country. There were six PBCRs in Maharashtra, three each in Assam and Punjab, two each in Kerala, Gujarat and Arunachal Pradesh, and one each in the remaining 11 States/UTs. The population covered by these 31 registries was around 15 per cent of India's total population.

Data on population

Census is the only source of data on population in the developing countries in general and in India in particular. It is conducted at a gap of 10 years. In India, there is the practice of National Commission on Population (NCP), a body under Registrar-General of India (RGI), constituting Technical Group on Population Projections (TGPP) from time to time with the objective of projecting the annual population of India and its States/UTs beyond the latest census year. Thelatest

report of TGPP provides projected annual population till 2026 by quinquennial age group and sex. The present study utilized the data on population from the same.

Tobacco-related cancers

There is a plethora of analytical observational studies looking into associations between consumption of different forms of tobacco and different cancer sites during the second half of the last century. Establishment of the association, however, requires the fulfillment of Hill's criteria (Hill, 1965). Thus, there may not be a universally acceptable exhaustive list of tobacco-related cancer sites. NCRP, however, considers 10 sites as tobacco-related cancers based on the list of TRCs by International Agency for Research on Cancer (IARC), a leading international organization in cancer research. The present study has adopted the same definition for the projection of TRCs. A list of these tobacco-related sites along with codes according to the ninth and tenth revision of ICD is given in Table 1.

Table 1: Topography codes of 10 cancer sites according to ICD-09/ICD-10

Sites	ICD-09	ICD-10
Lip	140	C00
Tongue	141	C01-C02
Mouth	144-145	C03-C06
Oropharynx	146	C10
Hypopharynx	148	C12-C13
Pharynx unspecified	149	C14
Esophagus	150	C15
Larynx	161	C32
Lung	162	C33-C34
Urinary bladder	188	C67

Assessment and projection of cancer incidence rates

Methods for the assessment and projection are basically similar to that in our recent publication on the projection of burden of cancer in India (Prasad & Dhar, 2018). The same is described in detail for the benefit of the researchers not directly associated with cancer registries, and availability of cancer incidence data in India.

Assessment of cancer incidence rates for a particular State and its projection for the future period was based on the availability and duration of PBCR in the State. Based on the availability of PBCR, the States/UTs were divided into following three categories.

I. States/UTs with at least one PBCR for long duration: Delhi, Karnataka, Madhya Pradesh, Maharashtra and Tamil Nadu.

II. States/UTs with at least one PBCR but not for long duration: Assam, Arunachal Pradesh, Chandigarh, Gujarat, Kerala, Nagaland, Manipur, Meghalaya, Mizoram, Punjab, Sikkim, West Bengal and Tripura.

III. States/UTs without any PBCR: Uttar Pradesh, Bihar, Jharkhand, Uttaranchal, Chhattisgarh, Andhra Pradesh, Pondicherry, Goa, Rajasthan, Haryana, Himachal Pradesh, Chandigarh, Orissa, Lakshadweep, Jammu and Kashmir, Dadra and Nagar Haveli, Daman and Diu, and Andaman and Nicobar Islands.

States/UTs in category I: Crude cancer incidence rates were obtained from 1997 or the period when a registry commenced whichever was later, till the latest time period for which report was published. It included all available information on the respective sites for assessing trends from 2015

onwards and a load of cancer cases (NCRP, 2002; NCRP, 2005; NCRP, 2006; NCRP, 2008, NCRP, 2010; NCRP, 2013, NCRP, 2016). In case of more than one registry in a State, the rates of different PBCRs for a particular time period were pooled. For assessing the trend, however, inferences from the regression method were drawn to determine the significance of the trend (Jensen, 1991). In the case of a significant trend during the observed period, the same was applied to project the rates for 2015, 2020 and 2025. For the sites with no significant trend, pooled rates were considered and assumed to remain the same for the whole study period.

States/UTs in category II: In case of more than one registry in a State, the rates of different PBCRs for a particular time period were pooled to arrive at a single rate for the State. This rate was assumed to remain the same for the whole study period.

States/UTs in category III: The incidence rates from the neighbouring or nearest State/UT with PBCR were obtained. The pooling of the rates in case of more than one PBCR, assessment of trend and projections were made as described above.

Procedure for estimation of the number of cancer cases

The respective age and sex-specific rates (projected or pooled as described above) were multiplied by the corresponding projected age and sex-specific population to project the number of incident cases of cancer by place of residence at five-year periods (for the years 2015, 2020 and 2025) for each of the States/UTs. In addition, the number of estimated cancer cases for India was obtained for the years 2015, 2020 and 2025 by summing the number of cancer cases of all States/UTs.

Assumptions

There were three basic assumptions pertaining to the assessment of State/UT wise cancer incidence and projection of the same over the projection period.

1. A State/UT is uniform enough for the rate observed in PBCR (pooled in the case of more than one) to apply for the State.

2. For a State/UT with no PBCR, the rate observed in PBCR in neighbouring State/UT (pooled in the case of more than one) applies for that State.

3. Linear trend in the incidence rates during the observation period will hold good for the projection period.

III. Results

Overall State/UT wise burden of TRCs

The burden of TRCs in India was estimated to be around 365 thousand in 2015 and expected to cross half-million mark by 2025, an increase of about 40 per cent in ten years. The increase is projected to be almost similar during two 5-year periods 2015-2020 and 2020-2025. The contribution from different States/UTs to the national burden was on the lines of population size. In the national burden in 2015, the contribution was the highest from Uttar Pradesh (58 thousand), followed by Bihar (45 thousand) and West Bengal (40 thousand). During 2015-2020, the increase was the highest for Daman & Diu where it was expected to become one and half times during the five-year period. This UT was followed by Pondicherry, Jharkhand, Bihar, Delhi and West Bengal with an increase of about one-third during the same time period. During 2020-2025 also, the pattern of increase was similar but quantitatively, however, it was lower.

Table 2: Projected number of tobacco-relatedcancers (TRCs) during 2015-2025 with percentage change during each 5 year period in India and its States/UTs

State/UT	No. of TRCs			% change during	
	2015	2020	2025	2015-20	2020-25
Jammu & Kashmir	2488	2606	2695	4.7	3.4
Himachal Pradesh	1415	1470	1518	3.9	3.3
Punjab	5921	6188	6414	4.5	3.7
Chandigarh	344	435	519	26.5	19.3
Uttaranchal	2824	3345	3873	18.4	15.8
Haryana	7429	7965	8452	7.2	6.1
Delhi	5818	7500	9500	28.9	26.7
Rajasthan	17305	18468	19576	6.7	6.0
Uttar Pradesh	58217	69632	81367	19.6	16.9
Bihar	44944	58176	71907	29.4	23.6
Sikkim	121	134	149	10.7	11.2
Arunachal Pradesh	150	157	165	4.7	5.1
Nagaland	416	438	457	5.3	4.3
Manipur	387	409	427	5.7	4.4
Mizoram	511	626	748	22.5	19.5
Tripura	820	862	899	5.1	4.3
Meghalaya	1064	1119	1167	5.2	4.3
Assam	9642	10314	10953	7.0	6.2
West Bengal	40446	51754	63450	28.0	22.6
Jharkhand	14494	18911	23536	30.5	24.5
Orissa	18240	23271	28437	27.6	22.2
Chhattisgarh	3717	4177	4727	12.4	13.2
Madhya Pradesh	21255	24432	27621	14.9	13.1
Gujarat	19733	25014	30462	26.8	21.8
Daman & Diu	112	174	240	55.4	37.9
Dadra & Nagar Haveli	106	133	150	25.5	12.8
Maharashtra	20653	23029	26552	11.5	15.3
Andhra Pradesh	13638	14918	16832	9.4	12.8
Karnataka	14823	16889	18931	13.9	12.1
Goa	394	490	598	24.4	22.0
Lakshadweep	30	33	32	10.0	-3.0
Kerala	13646	14327	15083	5.0	5.3
Tamil Nadu	23297	25538	27657	9.6	8.3
Pondicherry	573	760	959	32.6	26.2
A & N Islands	185	219	254	18.4	16.0
India	365158	433914	506307	18.8	16.7

Trend in the burden of TRCs by sex and urban/rural setting

Among men in 2015, over 250 thousand new TRCs were estimated. They were expected to rise to about 400 thousand by 2025, mainly due to an increase in the population. It is considerably higher in the rural areas (nearly twice that in urban areas). Looking at the numbers State-wise, Uttar Pradesh, Tamil Nadu, West Bengal, Maharashtra, and Gujarat are the leading States in order in urban areas, and Uttar Pradesh, Bihar, West Bengal, Madhya Pradesh and Orissa in the rural areas. Lakshadweep had the lowest burden of TRCs among all States/UTs for the period under study. By 2025, it was projected to increase by more than half in urban area and by more than a quarter in rural area. Cases of TRCs in urban areas are continuously increasing in the States of Uttar Pradesh, West Bengal, Maharashtra, Tamil Nadu and Gujarat. In the rural areas, the highest rise between 2015 and

2025 is expected in Bihar, West Bengal and Uttar Pradesh. In other States and Union Territories, the number of cases was expected to be either stable or increase slightly.

Table 3a: Projected number of tobacco-related cancers among males by place of residence in India and its States/UTs, 2015-25

Regions	2015		2020		2025	
	Urban	Rural	Urban	Rural	Urban	Rural
Jammu & Kashmir	523	1260	571	1291	674	1247
Himachal Pradesh	130	872	145	898	163	915
Punjab	1792	2533	1995	2535	2399	2305
Chandigarh	249	31	320	40	406	30
Uttaranchal	674	1495	836	1737	1113	1869
Haryana	2092	3677	2414	3777	2962	3612
Delhi	4465	180	5811	189	7484	130
Rajasthan	3745	9267	4039	9850	4808	9926
Uttar Pradesh	10318	34884	12700	41347	16700	46415
Bihar	3581	29440	4585	37564	5986	45570
Sikkim	11	66	13	73	16	80
Arunachal Pradesh	40	67	49	63	59	58
Nagaland	59	288	61	304	70	311
Manipur	59	181	61	193	72	193
Mizoram	194	164	247	194	340	189
Tripura	126	513	139	532	162	537
Meghalaya	157	621	166	652	193	659
Assam	1780	5352	2003	5608	2306	5761
West Bengal	8555	21053	10841	26532	15040	30314
Jharkhand	2561	8058	3349	10326	4661	12192
Orissa	2365	10863	3122	13526	4189	15952
Chhattisgarh	1067	1547	1278	1657	1607	1705
Madhya Pradesh	4549	11465	5292	12952	6783	13676
Gujarat	7676	8408	9312	11132	12405	12470
Daman & Diu	19	80	21	136	28	190
Dadra & Nagar Haveli	47	36	67	36	80	34
Maharashtra	9574	5109	10985	5404	13918	4928
Andhra Pradesh	4447	5083	5016	5429	6324	5444
Karnataka	3697	5836	4396	6485	5717	6495
Goa	215	63	287	67	382	57
Lakshadweep	6	16	6	18	7	16
Kerala	2516	7452	2689	7878	3253	7883
Tamil Nadu	9941	7059	11915	6887	14736	5782
Pondicherry	306	133	431	176	628	165
A & N Islands	57	80	73	89	100	91
India	87591	183231	105234	215577	135770	237205

In women, the estimated annual numbers were 90 thousand, 110 thousand and 130 thousand for the years 2015, 2020 and 2025 respectively. The main contributory States/UTs to this burden were on the lines similar to that in men. The total number of TRCs in urban women was likely to go up from 31 thousand in 2015 to about 50 thousand in 2025. In the rural areas, it was expected that the numbers might increase from 63 thousand to 85 thousand. Among urban females, there may be an increase during 2015 to 2025 in Maharashtra, Tamil Nadu and West Bengal. Among rural women, Bihar and West Bengal will contribute the most to the number of TRCs during the same time period.

Table 3b: Projected number of tobacco-related cancers among females by place of residence in India and its States, 2015-25

Regions	2015		2020		2025	
	Urban	Rural	Urban	Rural	Urban	Rural
Jammu & Kashmir	182	523	198	546	234	540
Himachal Pradesh	42	371	45	382	50	390
Punjab	630	966	692	966	827	883
Chandigarh	58	6	68	7	78	5
Uttaranchal	182	473	226	546	298	593
Haryana	579	1081	660	1114	807	1071
Delhi	1127	46	1452	48	1853	33
Rajasthan	1114	3179	1201	3378	1426	3416
Uttar Pradesh	2860	10155	3509	12076	4614	13638
Bihar	1219	10704	1643	14384	2219	18132
Sikkim	7	37	8	40	10	43
Arunachal Pradesh	16	27	20	25	25	23
Nagaland	12	57	13	60	15	61
Manipur	38	109	40	115	47	115
Mizoram	84	69	105	80	143	76
Tripura	36	145	40	151	47	153
Meghalaya	63	223	69	232	81	234
Assam	647	1863	741	1962	857	2029
West Bengal	3085	7753	4153	10228	5970	12126
Jharkhand	903	2972	1258	3978	1811	4872
Orissa	860	4152	1209	5414	1678	6618
Chhattisgarh	480	623	596	646	769	646
Madhya Pradesh	1464	3777	1769	4419	2338	4824
Gujarat	1854	1795	2237	2333	2978	2609
Daman & Diu	6	7	7	10	10	12
Dadra & Nagar Haveli	14	9	21	9	26	10
Maharashtra	4033	1937	4669	1971	5949	1757
Andhra Pradesh	2079	2029	2370	2103	3013	2051
Karnataka	2022	3268	2400	3608	3108	3611
Goa	93	23	115	21	143	16
Lakshadweep	4	4	4	5	4	5
Kerala	1597	2081	1623	2137	1869	2078
Tamil Nadu	3689	2608	4284	2452	5143	1996
Pondicherry	94	40	109	44	132	34
A & N Islands	20	28	26	31	33	30
India	31194	63142	37581	75522	48603	84729

Individual sites related to tobacco by urban/rural setting

Lung cancer was the leading TRC among men in urban as well as rural India. Its incidence is especially higher in urban, 16 per cent higher than the next leading site (mouth cancer). By 2025, cases of lung cancer are expected to double from about 20 thousand to approximately 40 thousand in urban men. In rural men also, it is expected to increase by one-third, from 60 thousand in 2015 to about 80 thousand in the year 2025.

Among females also, lungs were the leading TRC site in both rural (20,025 cases) and urban (9,322 cases) areas in 2015. These figures are expected to rise to 31 thousand and 17 thousand respectively by 2025. The number of any TRC in urban men is expected to increase from 88 thousand in 2015 to 136 thousand in 2025. Similarly, among rural men, it is expected to rise from 183 thousand

to 237 thousand respectively during the same period. Cancers of the lungs, mouth, tongue, esophagus, larynx and urinary bladder were obviously much higher among men than women.

Table 4a: Projected number of cancer incidence among males for tobacco-related sites, India, 2015-2025

Site of Cancer	2015		2020		2025	
	Urban	Rural	Urban	Rural	Urban	Rural
Lip	813	1722	978	1960	1260	2096
Tongue	13095	26257	16213	32271	21405	36611
Mouth	19166	33399	24955	42134	34462	48839
Oropharynx	1739	2812	2093	3133	2679	3274
Hypopharynx	4942	10900	5310	11294	6158	11023
Pharynx Unsp.	991	2070	1086	2301	1291	2393
Esophagus	9114	19376	9899	20700	11577	20795
Larynx	8438	18350	9306	19752	11120	20048
Lung	22900	55312	27996	67753	36590	77311
Urinary Bladder	6393	13033	7398	14280	9229	14816
All TRCs No.	87591	183231	105234	215577	135770	237205

Table 4b: Projected number of cancer incidence among females for tobacco-related sites, India, 2015-2025

Site of Cancer	2015		2020		2025	
	Urban	Rural	Urban	Rural	Urban	Rural
Lip	354	731	421	813	540	859
Tongue	4180	8724	5023	10481	6483	11774
Mouth	6871	12931	8326	15608	10848	17615
Oropharynx	263	519	322	684	419	829
Hypopharynx	1281	1927	1406	1976	1659	1906
Pharynx Unsp.	372	587	438	651	553	678
Esophagus	5693	11905	6204	12930	7309	13325
Larynx	1150	2451	1259	2559	1489	2547
Lung	9322	20025	12229	26211	16883	31489
Urinary Bladder	1708	3342	1955	3609	2419	3706
All TRCs No.	31194	63142	37581	75522	48603	84729

Among females also, lungs were the leading TRC site in both rural (20,025 cases) and urban (9,322 cases) areas in 2015. These figures are expected to rise to 31 thousand and 17 thousand respectively by 2025. The number of any TRC in urban men is expected to increase from 88 thousand in 2015 to 136 thousand in 2025. Similarly, among rural men, it is expected to rise from 183 thousand to 237 thousand during the same period. Cancers of the lungs, mouth, tongue, esophagus, larynx and urinary bladder were obviously higher among men than women.

IV. Discussion

Tobacco has been recognized as the number one enemy of quality and quantity of human life in the developing world. Its multidimensional effect on human health causing poor health and early death is well established. In spite of wide awareness of these facts, elimination of tobacco use appears close to impossible. On the one hand, it attracts the adolescents as a fancy practice and on the other, its addictive property makes for a person almost impossible to quit it once addicted. This is the reason why the success of anti-tobacco programmes is not seen in spite of wide-spread efforts nationally and internationally. The use of tobacco is the most significant and preventable cause of cancer. It is potentially associated with several types of cancers such as cancer of lung, larynx, oral cavity,

esophagus, urinary bladder, stomach, pancreas, cervix and more recently of haematopoietic system (USDHHS, 1989). Tobacco is also significantly associated with many other major health problems like coronary artery disease, obstructive airway disease, peripheral vascular disease and pregnancy complications (including intra-uterine growth, retardation and variety of neoplasms).

In India, the prevalence of tobacco use increased from the period 1998-99 (second round of NFHS) to the period 2005-06 (third round of NFHS). Later on (fourth round of NFHS), however, there are indications of its decline. Men aged 15−49 years are more prone to tobacco use than women in the same age group. Tobacco use is visibly higher among the poor, those living in rural areas and the illiterate as compared respectively with the wealthy, urban residents and educated (IIPS, 2017). The problem of NCDs in general and cancer in particular worsened with the rapid changes in lifestyle during the last quarter of the twentieth century at least in part due to increased tobacco consumption. There is an expected increase in the burden of non-communicable diseases of which cancer is going to be a major component. Within the burden of cancer, a sizeable proportion is due to tobacco and, therefore, completely preventable. Registry data from various States and UTs show that TRCs are responsible for 24 to 64 per cent of cancers in men and about 7 to 42 per cent of cancers in women (NCRP, 2016). Planning an extension of measures to control the incidence and spread of cancer requires accurate estimation of the burden of TRCs. Therefore, this study was conducted to present a detailed profile of TRCs in India.

Unlike developed countries, the developing nations, including India, do not have national-level cancer registries. This lacuna makes an assessment of the national burden of any type of cancer difficult. Some authors in the developed countries have used advanced and sophisticated methods like age period cohort model to predict the burden of cancer at community level (Clark, 1995; Verdecchia et al., 2002; Olsen et al., 2008). This approach is not feasible in developing countries in general and India in particular due to lack of sufficient data. In India, there have been some attempts in the past using different models and approaches to project the burden of cancer (Nair et al., 2005; Marimuthu, 2008; Murthy et al., 2008; Takiar et al., 2010). These studies however used single (pooled or average) rates for assessing cancer risk in all the States and linear regression methods for examining the trend and ascertaining the rates at different points of time in the future. The underlying assumption in those studies was that the pooling or averaging the rates gives good estimates of overall risk. This appears to be hardly tenable due to diverse geography, culture, habits, living conditions and environment. Hence, Prasad and Dhar (2018) tried to capture the regional diversity in the occurrence of cancer by assessing the rates State/UT wise. Detailed descriptions of their method along with involved assumptions are available in 'Methods and materials' section of this communication. Their method appears to capture the variation in the risk of cancer at least in principle. However, it practically depends on whether we have enough and scientifically located cancer registries to capture the variation. As recommended by Dhar (2018), expansion of cancer registration accounting for etiological diversity may be the key to capture diversity in the risk of cancer.

This study has estimated that TRCs will rise from an estimated 365 thousand in 2015 to about 506 thousand in 2025. Attempts were also made in the past to make such projections (Murthy et al., 2008; Takiar et al., 2010). However, those studies arrived at lower estimates of TRC cases, mainly because they used data from fewer registries. In addition, the assumptions involved in those studies may be relatively less tenable. The increase in incidence cases is not only because of increase in population size, but also due to a decline in the incidence of communicable diseases and the resultant rise in life expectancy.

Men in the age group of 15−49 years are more prone to tobacco use than women in the same age group. An estimated 57 per cent of men and 11 per cent of women used some form of tobacco (IIPS, 2007), resulting in more estimated incidences of cancer in males than females in the period 2015−25. Tobacco chewing is more prevalent than smoking in many areas (Reddy & Gupta, 2004). Another study conducted by Prasad and Dhar (2017) shows higher number of tobacco users in males. The trend in burden of tobacco consumption is increasing in urban areas. Moreover, the detailed

analysis showed regional diversity in the burden of smoking and smokeless tobacco consumption, which results in the extra burden of oral cancers. Some of the studies indicate that one-third of reported cancers are oral cancers and 90 per cent of oral cancer patients are tobacco users (Gupta, 1999; Shimkhada & Peabody, 2003).

TRCs are the highest in the rural areas of Bihar, Uttar Pradesh and West Bengal, while in urban settings the highest numbers are in the States of Maharashtra, Tamil Nadu, West Bengal and Uttar Pradesh for the period under study. The number of cancer cases is more in rural males (increasing from about 183,000 in 2015 to 237,000 in 2025). The next highest numbers are expected to be for urban men, followed by rural females. Tobacco use is the leading cause of lung cancer followed by cancer of the mouth, esophagus, etc. in both urban and rural areas of India. WHO indicated that about 71 per cent of lung cancer cases are due to smoking and that the prevalence of smoking among men is higher in lower-middle income countries (WHO, 2011).

A substantial proportion of TRCs can be prevented by anti-tobacco programmes. It is necessary to target teenaged people because the tobacco habit is picked up at this stage of life. Legislation in India prohibits the advertisement of tobacco products and their sale to under-aged people. Cigarette packages carry graphic warnings of the dangers smoking such as lung, mouth and other tobacco-related cancers. However, the legislation does not appear to have made the necessary impact due to various reasons — political, environmental and social. The result is that the burdens of lung, mouth, and tongue cancers are showing an increasing trend. By 2025, it is predicted that there will be about 162,000, 111,000, and 76,000 cases of these cancers respectively.

To conclude, a considerable proportion of the cancer burden in India is because of tobacco use, the prevalence of which is higher among men than women. Cancers of the lung, mouth, tongue, and esophagus are leading TRCs in both rural and urban India. Their burden during the period 2015−2025 in rural areas was estimated to be higher in the States of Bihar, Uttar Pradesh and West Bengal. In urban areas, the States of Maharashtra, Tamil Nadu, West Bengal and Uttar Pradesh are projected to have the highest TRCs in the same period. Analysis showed substantial variations across regions for several types of cancers. In view of the increasing burden of TRCs, there is an urgent need to initiate focused tobacco prevention measures. Findings of the present study may also be utilized in the allocation of resources based on the magnitude of the problem in different States/UTs.

Limitations of the study

India has progressed considerably in cancer registration and control during the last four decades. However, coverage of the population by Indian PBCRs is still limited due to vast population. Hence, one of the inherent limitations with the studies on burden and pattern of cancer is the non-availability of data that may thoroughly capture the geographical diversity in the occurrence of cancer. The present study also made possible an assessment of incidence rate at the State/UT level. However, the accuracy of figures arrived at depends to some extent on the tenability of underlying assumptions.

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