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Tobacco associated mortality in Mumbai (Bombay) India. Results of the Bombay Cohort Study

Prakash C Gupta,[1] Mangesh S Pednekar,[1]* DM Parkin[2] and R Sankaranarayanan[2]

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Background Little is known about the excess mortality from forms of tobacco use other than cigarette smoking that are widely prevalent in India, such as bidi smoking and the various forms of smokeless tobacco use. We report on absolute and relative risks of mortality among various kinds of ever tobacco users vs never-users in the city of Mumbai, India.

Methods Using the Mumbai voters' list as the selection frame, 99 570 individuals aged ⩾35 years were interviewed at their homes during 1992–94. At active follow-up (during 1997–99) after 5.5 years, 97 244 (97.7%) were traced. Among these, 7531 deaths (4119 men, 3412 women) were recorded, of which 89% died within study area. It was possible to abstract cause of death information from the records of the municipal corporation for 5470 deaths. These were coded using ICD 10.

Results The adjusted relative risk was 1.37 (95% CI 1.23–1.53) for (men) cigarette smokers and 1.64 (95% CI 1.47–1.81) for bidi smokers, with a significant dose–response relationship for number of bidis or cigarettes smoked. Women were essentially smokeless tobacco users; the adjusted relative risk was 1.25 (95% CI 1.15–1.35). The risk of deaths from respiratory diseases (RR 2.12, 95% CI 1.57–2.87), tuberculosis (RR 2.30, 95% CI 1.68–3.15), and neoplasms (RR 2.60, 95% CI 1.78–3.80) were significantly high in male smokers than never tobacco users.

Conclusions Bidi is no less hazardous than cigarette smoking, and smokeless tobacco use may also result in significantly increased mortality.

Keywords Cause of death, cohort study, India, smoking, mortality, smokeless tobacco

Introduction

The World Health Organization has estimated the excess premature mortality attributable to tobacco use (almost all of it in the form of cigarette smoking) as 4.9 million per year. Specific estimates are available for industrialized countries. Peto *et al.*[1] estimated smoking attributable deaths in developed countries in 1995 as 2 million.

After China (where tobacco accounted for ~12% of male deaths at ages 35–69 in 1990[2]), India is the second most populous country and the second largest producer and consumer of tobacco in the world. India has a long history of tobacco use, including smokeless tobacco use and many forms of smoking, of which cigarette smoking forms only a minor part.[3] All forms of tobacco use can carry serious health consequences,[4] so the burden of deaths and diseases from tobacco use in India may be greater than those included in global estimates that are based mainly on cigarette smoking.[5]

Some attempts had been made to estimate tobacco attributable mortality in India. The first one was on the basis of cohort studies conducted in rural areas of Ernakulam District, Kerala[6] and Srikakulam District, Andhra Pradesh.[7] In these studies, cohorts of over 10 000 villagers were followed-up for 10 years through a house-to-house approach, yielding accurate estimates of all-cause mortality, and the relative risks for different kinds of tobacco use were estimated. Using conservative numbers and using 1986 mortality data for the

[1] Healis, Sekhsaria Institute for Public Health, 601/B, Great Eastern Chambers, Plot No. 28, Sector 11, CBD Belapur, India.

[2] Descriptive Epidemiology Unit, International Agency for Research on Cancer, Lyon, France.

* Corresponding author. E-mail: pednekarmangesh@rediffmail.com

whole of India, tobacco attributable mortality was estimated as 630 000 deaths per year.[8] Since the cause of death was not available in those studies, cause-specific mortality was not calculated.

A case–control study on the relative risk of smoking for all-cause mortality in southern India found relative risks of 1.6 for rural and 2.1 for urban areas at ages 25–69. Cause-specific relative risks were high for tuberculosis, other respiratory diseases, and cancer.[9]

A cohort study was undertaken in Mumbai with a view to obtaining cause-specific tobacco attributable mortality in India. The baseline[10] and interim[11] follow-up results have been reported earlier. In this paper we report on complete follow-up results including cause-specific relative risks for various types of tobacco use from this cohort study.

Methods

Mumbai (formerly Bombay) is a large, densely populated metropolitan city (density 16 461 inhabitants per km^2) with a population of 9.93 million (1991 census). It is divided into three parts: the main (island) city, suburbs, and extended suburbs. This cohort study was conducted in the island city of Mumbai, which comprises 11.6% of the greater metropolitan area (603 sq km) but has a population of 3.42 million at the 1991 census. The endpoint of the prospective cohort study was mortality. A total of 99 570 individuals age ⩾35 years were recruited into the cohort, by personal interviews through house-to-house visits. The voters' lists were used as the sampling frame. These lists provided name, age, sex, and address of all the individuals aged ⩾18 years. The lists were fairly complete, since almost everyone is entitled to vote and registration is not necessary; lists are updated before every major election through house-to-house visits. These lists were organized according to polling stations, each station containing ~1000–1500 voters. Once a list corresponding to a polling station was selected, all individuals aged ⩾35 years in the list were approached by investigators for interview. The selection of lists, however, was not random. The survey population largely consisted of individuals belonging to middle, lower-middle, and lower class. Apartment complexes that housed upper-middle and rich classes were not included. The reasons were: difficulty to approach owing to security precautions and a lack of cooperation from these individuals, as they did not perceive any material gain from participation. The proportion excluded varied from area to area. Sometimes individuals not listed on the voters' list were also interviewed and included in the sample when they insisted that they were permanent residents of the place. Such individuals formed ~5% of the sample. The interviews were conducted by trained field investigators using hand-held computers (electronic diaries) from February 1992 to May 1994. Details of recruitment procedures have been described earlier.[10]

An active house-to-house follow-up was conducted ~5–6 years after the initial survey. The field investigators were provided with list of names and addresses of cohort members and were asked to revisit each person. If the person was alive and available, a face-to-face re-interview was conducted. If the person was reported dead, the date and place of death were recorded as accurately as feasible. Permanently moving out of the city of the study area was considered to be withdrawal from the study, and the date of moving out was noted. The re-interviews were conducted during July 1997 and November 1999. Interim results were described elsewhere.[11]

Cause of death

Under a uniform system of registration of births and deaths, reporting and registration of births and deaths is compulsory. The quality of registration varies across the country but in Mumbai, almost all the deaths get registered. Almost all deaths are medically certified.

The cause of death was sought not from household members but from the municipal corporation death records. For all deaths over 27 years of age in those records, details (including demographic information on the decedent, and the underlying cause(s) of death) were computerized by project personnel—amounting to over 20 000 deaths per year within the study area. The deaths recorded during the follow-up of the cohort were matched with the dataset from the corporation. The matching was done using age, sex, name, address, and date of death. The most important variables for matching were name and address, since the spelling could be very different in two datasets most of the matching was done manually. For matched deaths, the cause of death was coded according to ICD 10. For 1685 matched deaths an independent trained field supervisor was sent to the household. In all the 1685 revisited deaths matching was found to be 100% correct.

Statistical analysis

Person-years were calculated using the date of recruitment and the date of withdrawal (defined as the date of death; re-interview; migration; or ascertainment). In cases where the exact date of death (2.6% deaths) or migration (1.4% migrations) was not available, mid-point between date of recruitment and date of ascertainment was used. The information on age, sex, and details of tobacco use was abstracted from the baseline data. The age increment for calculating age-specific person-years was given annually and each record was replicated for the number of years each individual contributed in cohort. Direct age-adjustment was done using overall 5 year age-specific person-years as weights. In separate analysis, relative risks adjusted for age and education (as a surrogate for socioeconomic status) and 95% confidence intervals (95% CIs) were calculated by using Cox model.

The tobacco use analysis was restricted to three categories: those who did not report using tobacco in any smokeless or smoking form; those who reported using smokeless tobacco only; and, those who reported smoking (some of them could also be smokeless tobacco users). The results for smokers and mixed (smoker as well as smokeless) were generally similar; therefore, for the sake of simplicity were considered as a single category, as smoker, throughout the analysis. The prevalence of past users was small, 2.2% among women (almost all smokeless tobacco users) as compared with 57.5% current users and 4.5% among men (2.8% smokers and 1.7% smokeless tobacco users) compared with 69.3% current users[10] and they were combined with current users and referred as ever-users. Different categories of tobacco use were mutually exclusive. Education level included illiterate, primary school (up to 5 years of education), middle school (6–8 years), secondary school (9–12 years), and college (any).

In addition to cigarette (9.9%), bidi (11.9%) smoking was common among smokers (men) in the cohort.[10] Bidi is a cheap smoking stick hand-made by rolling a dried, rectangular piece of temburni leaf (*Diospyros melanoxylon*) with 0.15–0.25 g of sun-dried, flaked tobacco into a conical shape and securing the roll with a thread. The length of a bidi varies from 4 to 7.5 cm. A variety of smokeless tobacco habits were common, the most frequent being use of mishri (pyrolized tobacco in the form of dry, black powder, 35.7%). Rather infrequently other forms of smoked tobacco, e.g. chilum and hooka were also reported (<0.5%) and these were combined with bidi smokers. Some men reported bidi as well as cigarette smoking (1.4%) and they were combined with bidi smoking. Details of tobacco use in the cohort and tobacco habits prevalent in India are available elsewhere.[3,10]

Results

Of the 99 570 cohort members some 2326 persons could not be traced; the most common reason was the demolition of their residential building (1748 persons). In Mumbai, many old buildings are demolished when they get too dangerous to live in, or for redevelopment. Table 1 shows the follow-up results for the remaining 97 244 subjects. Face-to-face interviews were conducted for 74 517 individuals and 7531 deaths were reported. Some 11 091 had migrated outside the study area and for them the date of migration corresponded to the date of withdrawal from the study. The remaining 4105 individuals, although assessed to be alive and traceable, were not available for face-to-face interview and for them; the last date of attempted follow-up was the withdrawal date. The main reason was that they were temporarily not available for interview even after multiple visits. For 155 migrated individuals and 195 deaths, the date of migration or death could not be determined and the mid-point was used as the date of withdrawal. It was possible to code the cause of death for 5470 deaths. A lack of matching with the municipal death records (1042 deaths) and the death occurring outside the study area (815 deaths) were the major reasons for not coding the remaining deaths.

Table 2 shows the number of person-years and the death rates by sex and tobacco use. A total of 533 445 person-years were observed. Of the total person-years contributed by men (210 129), 27.4% were by smokers, 46.1% by smokeless tobacco users, and 26.5% by never tobacco users. For women, among 323 316 person-years, 0.4% were smokers, 59.3% smokeless tobacco users, and 40.3% never tobacco users. For men, the age-adjusted death rate (per 1000 person-years) among smokers (based on 1478 deaths) was 23.3, whereas among never-users of tobacco (854 deaths) it was 13.6. The relative risk adjusted for age and education was 1.55 (95% CI 1.42–1.69). Although very few women smoked, the relative risk appeared to be similar to men (1.40, 95% CI 0.99–1.97). Smokeless tobacco use was high among men as well as women, the age and education adjusted relative risks were 1.16 (95% CI 1.06–1.26) among men and 1.25 (95% CI 1.15–1.35) among women.

Table 3 shows the death rates among men with the two major types of smoking habits prevalent in Mumbai: cigarette and bidi. The adjusted relative risk was 1.37 (95% CI 1.23–1.53) for cigarette and 1.64 (95% CI 1.47–1.81) for bidi. A significant dose–response relationship was observed for bidi (P-value for trend <0.00001) as well as cigarette (P-value for trend <0.00001).

Table 1 Follow-up details in the Mumbai Cohort Study

Followed-up	97 244	100%
Re-interviewed	74 517	76.6%
Deaths	7531	7.7%
Matched and coded deaths	5470	5.6%
Migrated	11 091	11.4%
Alive but not re-interviewed	4105	4.2%
Not followed-up[a]	2326	

[a] The most common reason for a lack of follow-up was demolition of the building where the subject was recorded to be staying (1748 persons).

Table 2 Relative risks for all-cause mortality for tobacco use by sex in Mumbai Cohort Study

	Total	Never tobacco use	Smokeless tobacco[a]	Smoking
Men				
Person-years	210 129	55 717	96 884	57 528
Deaths	4119	854	1787	1478
Mortality rate (per 1000 person-years)				
Crude	19.6	15.3	18.4	25.7
Age-adjusted				
All ages	17.9	13.6	17.3	23.3
Ages 35–69[b]	–	12.9	15.8	22.9
Relative risk[c]				
All ages	NA	1.0	1.16	1.55
Ages 35–69			1.14	1.66
95% CI				
All ages	NA	NA	1.06–1.26	1.42–1.69
Ages 35–69			1.03–1.26	1.49–1.84
Women				
Person-years	323 316	130 294	191 625	1398
Deaths	3412	907	2470	35
Mortality rate (per 1000 person-years)				
Crude	10.6	7.0	12.9	25.0
Age-adjusted				
All ages	11.4	8.9	12.7	17.1
Ages 35–69[b]		7.4	11.6	14.6
Relative risk[c]				
All ages	NA	1.0	1.25	1.40
Ages 35–69			1.30	1.53
95% CI				
All ages	NA	NA	1.15–1.35	0.99–1.97
Ages 35–69			1.18–1.43	0.97–2.42

NA = not applicable.
[a] Non-smokers only.
[b] Averaged for 5 year age group.
[c] Age and education adjusted RR by using Cox model.

Table 4 shows the mortality rates by the type of smokeless tobacco use among women and men. Among women the relative risks were significant for the use of mishri, mishri with other forms of tobacco and chewing tobacco or tobacco containing product; these categories showed adjusted relative risks of 1.21

Table 3 Relative risks for all-cause mortality by type and number of bidis or cigarettes smoking habit among cohort study men, Mumbai

	Person-years	Deaths	Age-adjusted mortality rate (per 1000 person-years)	RR[a]	95% CI
Bidi[b]					
All ages	31 376	982	26.5	1.64	1.47–1.81
Ages 35–69	28 324	676	26.4[c]	1.82	1.62–2.05
Age 35–49	13 681	161	–	2.84	2.22–3.62
Age ⩾ 50	17 695	821	–	1.47	1.32–1.63
Cigarette					
All ages	26 152	496	18.9	1.37	1.23–1.53
Ages 35–69	24 217	335	17.9[c]	1.43	1.25–1.64
Age 35–49	14 190	93	–	1.89	1.47–2.45
Age ⩾ 50	11 962	403	–	1.28	1.13–1.45
Number of bidis[b] **(per day)**[d]					
1–5	6658	177	23.1	1.42	1.20–1.68
6–10	5594	182	25.8	1.59	1.35–1.87
11–15	5838	184	26.8	1.62	1.37–1.91
⩾16	12 865	427	29.1	1.78	1.57–2.02
Number of cigarettes (per day)[d]					
1–5	11 709	177	17.5	1.20	1.02–1.42
⩾6	14 444	319	20.5	1.50	1.32–1.71
Never tobacco use	55 717	854	13.6	1.00	–

[a] Age and education adjusted relative risk (RR) by using Cox model.
[b] Includes bidi and bidi plus other smoking.
[c] Averaged for 5 year age group.
[d] Chi-squared for trend is significant, $P < 0.00001$.

(95% CI 1.10–1.34); 1.36 (95% CI 1.24–1.48); and 1.37 (95% CI 1.09–1.73), respectively. Among men, the relative risks were significant for the use of mishri with other forms of tobacco (RR 1.18, 95% CI 1.07–1.31) and chewing tobacco or tobacco containing product that mostly comprised of tobacco and lime (RR 1.24, 95% CI 1.08–1.41). Interestingly betel-quid or areca nut (without the use of tobacco) did not show a significant relative risk among men or women.

Table 5 shows the relative risks for major causes of death among men and women. Smoking among men increased the risk of deaths from respiratory diseases (RR 2.12, 95% CI 1.57–2.87), tuberculosis (RR 2.30, 95% CI 1.68–3.15), circulatory diseases (RR 1.21, 95% CI 1.04–1.40), and for all neoplasms (RR 2.60, 95% CI 1.78–3.80). Within respiratory diseases, the increase in risk was significant for pneumonia (RR 2.46, 95% CI 1.40–4.30) and COPD (RR 2.13, 95% CI 1.45–3.14), and, within neoplasms, for oropharyngeal (RR 19.69, 95% CI 2.65–146.17) and respiratory (RR 4.05, 95% CI 1.51–10.85) neoplasms. Deaths from diseases of the digestive system (5%) and other causes (16%), mainly senility, did not show significant associated with smoking. Within diseases of circulatory system, cardiovascular deaths were associated with smoking (RR 1.54, 95% CI 1.09–2.19) whereas ischaemic heart disease (IHD) failed to reach statistical significance (RR 1.17, 95% CI 0.99–1.39). In addition, smoking also increased the risk of dying from accidents (RR 2.65, 95% CI 1.43–4.90); however, confounding from alcohol has not been taken into consideration.

Table 4 Relative risks for all-cause mortality by type of smokeless tobacco habit in Mumbai Cohort Study

	Person-years	Deaths	Age-adjusted mortality rate (per 1000 person-years)	RR[a]	95% CI
Women					
Mishri	88 002	743	12.3	1.21	1.10–1.34
Mishri + oth.	71 817	1323	14.1	1.36	1.24–1.48
Betel-quid	20 153	236	9.8	0.96	0.83–1.11
Other tob[b]	5020	80	14.1	1.37	1.09–1.73
Areca nut	6633	88	9.9	1.05	0.84–1.31
Never tobacco use	130 294	907	8.9	1.00	–
Men					
Mishri	14 658	226	16.1	1.14	0.97–1.33
Mishri + oth	38 981	782	18.3	1.18	1.07–1.31
Betel-quid	24 368	436	16.2	1.10	0.98–1.24
Other tob[b]	17 039	316	18.5	1.24	1.08–1.41
Areca nut	1838	27	11.5	0.83	0.56–1.21
Never tobacco use	55 717	854	13.6	1.00	–

[a] Age and education adjusted relative risk (RR) by using Cox model.
[b] Generally tobacco plus lime.

The relative risks for smokeless tobacco users although higher than unity, did not reach statistical significance ($P < 0.05$) except for all neoplasms (RR 1.57, 95% CI 1.16–2.13), all diseases of circulatory system (RR 1.19, 95% CI 1.02–1.38), and, within diseases of circulatory system, IHD (RR 1.25, 95% CI 1.05–1.49) among women and deaths from respiratory diseases (RR 1.50, 95% CI 1.12–2.03) and tuberculosis (RR 1.46, 95% CI 1.07–2.00) among men.

Discussion

This cohort study has several characteristics that are different from similar studies reported from industrialized countries. Most important perhaps is the active house-to-house follow-up for determining the subject's status (alive, dead, or migrated). In industrialized countries, follow-up is generally done by linkage with death and/or population registers. Such an approach although less expensive and cumbersome, was not feasible in Mumbai.

The house-to-house approach provided exact information on the fact of death for the 97.7% of the original cohort that was followed-up. Abstraction of cause of death could be done only after matching, which was possible for deaths occurring within the study area. No specific index variable (such as social security number) was available for matching. The recording of age is not exact and there is no standard format or spelling for recording name and address. Still it was possible to match 84.5% of deaths. Almost all the matched deaths were coded (96.4%) using ICD 10. The date of migration (available for 98.6% migrated individuals) enabled accurate estimation of person-years of observation. We compared the tobacco use distribution among those who migrated with those who did not. The percentage of tobacco use was 66.7% among those who migrated and 65.2% among those who did not. The difference was not significant even after taking age and the type of tobacco use into the account (result not

Table 5 Number of deaths and relative risks by cause of death and tobacco habit among men and women

Cause of death[a]	Never tobacco use	Smokeless	Smoker
Men			
Diseases of Respiratory [J00-J99]			
Deaths	63	169	148
RR[b] (95% CI)	1.0	1.50 (1.12–2.03)	2.12 (1.57–2.87)
Pneumonia [J18]			
Deaths	18	43	44
RR[b] (95% CI)	1.0	1.50 (0.85–2.63)	2.46 (1.40–4.30)
COPD [J42-46]			
Deaths	38	102	96
RR[b] (95% CI)	1.0	1.42 (0.96–2.08)	2.13 (1.45–3.14)
TB [A15-19]			
Deaths	58	160	152
RR (95% CI)	1.0		
All ages		1.46 (1.07–2.00)	2.30 (1.68–3.15)
Ages 35–69		1.55 (1.10–2.18)	2.48 (1.76–3.50)
Neoplasms [C00-C97]			
Deaths	40	91	103
RR (95% CI)	1.0	1.40 (0.95–2.06)	2.60 (1.78–3.80)
Oral and pharynx neoplasms [C00-C14]			
Deaths	1	7	22
RR (95% CI)	1.0	3.72 (0.46–30.26)	19.69 (2.65–146.17)
Respiratory neoplasms [C30-C39]			
Deaths	6	19	21
RR (95% CI)	1.0	2.23 (0.82–6.04)	4.05 (1.51–10.85)
Diseases of circulatory [I00-I99]			
Deaths	323	535	430
RR[b] (95% CI)	1.0	0.94 (0.82–1.09)	1.21 (1.04–1.40)
IHD [I10-I11,13,21,24,25,46,50]			
Deaths	251	380	317
RR[b] (95% CI)	1.0	0.89 (0.75–1.05)	1.17 (0.99–1.39)
CVD [I61-64,66,67]			
Deaths	50	130	93
RR[b] (95% CI)	1.0	1.32 (0.94–1.84)	1.54 (1.09–2.19)
Digestive [K00-93]			
Deaths	35	61	53
RR[b] (95% CI)	1.0	0.93 (0.61–1.42)	1.35 (0.87–2.08)
Accidents [X00-99]			
Deaths	14	45	42
RR[b] (95% CI)	1.0	1.71 (0.93–3.14)	2.65 (1.43–4.90)
Others			
Deaths	110	233	154
RR[b] (95% CI)	1.0	1.18 (0.93–1.49)	1.26 (0.98–1.61)
Women			
Diseases of respiratory [J00-J99]			
Deaths	107	292	4
RR[b] (95% CI)	1.0	1.04 (0.82–1.31)	1.15 (0.42–3.15)
Pneumonia [J18]			
Deaths	31	84	1
RR[b] (95% CI)	1.0	1.30 (0.86–1.97)	1.26 (0.20–7.87)
COPD [J42-46]			
Deaths	69	183	3
RR[b] (95% CI)	1.0	0.96 (0.72–1.28)	1.26 (0.39–4.04)
TB [A15-19]			
Deaths	46	123	5
RR (95% CI)	1.0	1.40 (0.99–2.00)	5.92 (2.31–15.17)
Neoplasms [C00-C97]			
Deaths	65	177	2
RR (95% CI)	1.0	1.57 (1.16–2.13)	1.85 (0.45–7.60)
Oral and pharynx neoplasms [C00-C14]			
Deaths	1	11	
RR (95% CI)	1.0	2.74 (0.60–12.40)	
Diseases of circulatory [I00-I99]			
Deaths	283	735	7
RR[b] (95% CI)	1.0	1.19 (1.02–1.38)	0.84 (0.37–1.88)
IHD [I10-I11,13,21,24,25,46,50]			
Deaths	197	544	4
RR[b] (95% CI)	1.0	1.25 (1.05–1.49)	0.57 (0.18–1.79)
CVD [I61-64,66,67]			
Deaths	59	147	2
RR[b] (95% CI)	1.0	1.15 (0.84–1.59)	1.46 (0.35–6.01)
Digestive [K00-93]			
Deaths	10	18	
RR[b] (95% CI)	1.0	0.95 (0.42–2.14)	
Accidents [X00-99]			
Deaths	20	31	
RR[b] (95% CI)	1.0	0.76 (0.42–1.38)	
Others			
Deaths	140	372	6
RR[b] (95% CI)	1.0	1.26 (1.02–1.55)	1.57 (0.69–3.58)

[a] Coded as per ICD 10.
[b] Age and education adjusted relative risk (RR) by using Cox model.

shown). The major reason for migration is that the industrial areas within the main city are changing to commercial areas. Also the island city is very densely populated leading to high real estate prices forcing many people to move out to suburbs.

A high relative risk for overall mortality in cigarette smokers compared with non-smokers has been found in cohort studies from several parts of the world. The present study with RR = 1.37 for cigarette smokers demonstrates that Indians are no different in that respect, although this RR is on the lower side probably owing to lower frequency of number of cigarettes smoked per day.[10] The excess annual mortality among 35–69 year old male smokers (average for 5 year age group) in developed countries is reported as 701 per 100 000.[1] The comparable estimate from the

present study is 996 per 100 000 (Table 2) despite the fact that the number of bidis or cigarettes smoked per day in this study was quite low (median 5 cigarettes or 12 bidis[10]). The entire difference, however, is due to bidi smoking, the comparable estimate for bidi smoking was 1350 per 100 000 and for cigarette smoking 503 per 100 000 (Table 3).

Bidi smoking is the dominant form of smoking in India, especially in rural areas. Being a large metropolitan city, in this cohort bidi and cigarette were equally common but in the country as a whole, 7–8 times more bidis are consumed than cigarettes. Bidi smoking is also practised in neighbouring countries and there are recent reports of its availability and popularity in the USA as well, especially among youth.[12] The results for bidi smoking is, therefore, important not only for India but also for many other countries.

Bidi smoking showed a high relative risk (1.64) that was not entirely unexpected. In an earlier cohort study in Ernakulam district, Kerala State, men smokers (90% of them bidi smokers) showed age-adjusted relative risk of overall mortality as 1.5.[6] In another cohort study from Pune district in Maharashtra, the relative risk for bidi smokers compared with tobacco chewers was 1.6.[13] Although a bidi contains a much smaller amount of tobacco (~0.2 g) than a cigarette (~1 g), a bidi delivers a comparable or higher amount of tar and nicotine.[4]

Age-specific mortality rates among smokers showed a greater difference in younger age groups: the relative risk for cigarette smokers at age 35–49 years was 1.9 (*vs* 1.3 for ⩾50 years) and for bidi smokers at age 35–49 years, 2.8 (*vs* 1.5 for ⩾50 years, Table 3). Number of bidis or cigarettes smoked didn't explain this difference, as it was slightly lower at ages 35–50 (66% smoking ⩾6 per day) than over age 50 (71% smoking 6 or more per day). Another noteworthy finding was a relatively high RR (1.42) at a low level of exposure among bidi smokers (1–5 bidis per day) compared with cigarette smokers (RR 1.20 for 1–5 cigarettes per day).

Results for smokeless tobacco use seem a little less clear. The relative risk for chewing betel-quid was not significant, but the risks associated with use of mishri with other forms of tobacco, and the use of tobacco plus lime were significant for both men and women. In an earlier study from Kerala,[6] the RR among male smokeless tobacco users was 1.2 (not significant) and among women it was 1.3 (significant). Annual excess mortality among women smokeless tobacco users in the 35–69 years age group in the present study was 250 per 100 000 (Table 2). No comparable number for women smokeless tobacco users is available but among women smokers in developed countries the excess mortality was reported as 312.[1] It is, therefore, highly likely that, like smoking, smokeless tobacco use is resulting in an excess overall mortality. In a cohort study of Swedish construction workers, the relative risk for cardiovascular diseases among smokeless tobacco users was 1.4.[14]

The estimation of tobacco attributable mortality for 35–69 years age group has been reported from the case–control study in Chennai[9] and we can attempt similar estimation from our study. No countrywide estimates of prevalence of smoking or tobacco use are available but summary estimates made by the WHO can be used.[15] Considering prevalence of smoking in India as 40% (30% bidi, RR 1.82, 95% CI 1.62–2.05; 10% cigarette, RR 1.43, 95% CI 1.25–1.64) in men, and with an additional 15% smokeless tobacco users (RR 1.14, 95% CI 1.03–1.26), a total of 23.7% of deaths among men aged 35–69 years can be attributed to tobacco use. This translates to 527 500 deaths every year (taking all-cause deaths in the 30–69 years age group to 2 229 000 [16]). Gajalakshami *et al*.[9] estimated that about a quarter of male bidi or cigarette smokers at ages 25–69 years are killed by their smoking, and overall smoking causes 552 000 deaths among men aged 25–69 years. Taking the prevalence of smokeless tobacco use among women in India to be 15% (RR 1.30, 95% CI 1.18–1.43) and of smoking to be 3% (RR 1.53, 95% CI 0.97–2.42); ~5.7% deaths among women, 35–69 years old, can be attributed to tobacco use. This translates into 83 000 deaths per year (taking all-cause deaths in the 30–69 years age group to 1 453 000[16]).

Although tobacco use is causing excess mortality in India, the pattern of causes seems to be different from that in industrialized countries. Tuberculosis is a major cause of morbidity and mortality in developing countries, including India. In 1990, the estimated number of deaths from tuberculosis in the world was 1.96 million of which ~40% were from India. By 2020, the global burden of tuberculosis is estimated to be 2.30 million of which 99% will be in developing countries.[15]

The possible association between smoking and tuberculosis has not received much attention so far, even though there have been several cross-sectional and case–control studies[17–20] reporting on this association. This association was not visible in cohort studies from industrialized countries where tuberculosis is rather rare. A recent cohort study from Hong Kong,[21] however, demonstrated adjusted hazard ratio 2.87 (95% CI 2.00–4.11) among current cigarette smokers (*vs* never smokers) for pulmonary tuberculosis with a significant dose–response relationship. The Mumbai Cohort Study shows a similar association of smoking with tuberculosis (RR 2.30, 95% CI 1.68–3.15).

WHO has estimated 630 000 annual tuberculosis deaths among men in India at all ages and 400 000 between 30–69 years.[16] Taking the relative risk from this study for tuberculosis deaths (RR 2.48, 95% CI 1.76–3.50) and 40% smoking prevalence in India, ~37.2% of deaths among men (aged 35–69 years) can be attributed to smoking. This translates into 149 000 tuberculosis deaths per year as being due to smoking. Gajalakshami *et al*.[9] arrived at an estimate of 140 000 tuberculosis deaths among men at ages 25–69 years attributable to smoking although they used a different set of figures.

Although the city of Mumbai has one of the best death registering systems in India, the causes of deaths information seems to have limitations. Among total coded deaths (5470), 15% were recorded as acute myocardial infarction, and 19% were other causes (mainly senility 22%). These seem to be rather non-specific, indicating a variable quality in the recording of causes of deaths. Around 27% of total deaths could not be matched as they occurred outside study area. Thus the cause-specific death rates were underestimates and the cause-specific relative risks may have variability associated with them in addition to sampling variability.

Another limitation of the study is that the sample was not random or representative of the population. In cohort studies this may not be a specific limitation, but we excluded individuals who resided in upper-middle-class and upper-class housing complexes that were not accessible to us as a result of security issues. So the result may not apply to that particular stratum of the society that, however, forms only a small part of the Indian population. Also, the migration rate in this study was high (11%)

even though the average follow-up period was only 5.5 years. It is known that a large follow-up period provides better insights into the risks,[22,23] but in Mumbai long follow-up may be associated with higher migration and additional uncertainties.

Improved recording of cause of death information in India can clearly help in further clarifying the pattern of causes of excess mortality among tobacco users.

Contributors

Dr P.C.G. conceptualized the study, evolved field instruments and procedures, directed the field work, data management and data analyses, interpreted the results, and contributed towards the writing of the paper at all stages. Mr M.S.P. supervised the field work, was responsible for the data management, data analyses and the statistical procedures and tests, interpreted the results, and contributed towards the writing of the paper at all stages. Dr D.M.P. and Dr R.S. were responsible for helping in the conceptualization of the study, finalization of methods, interpretation of results, and the writing of the paper.

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KEY MESSAGES

- Bidi smoking is at least as harmful as cigarette smoking. Low intensity of every day use may also cause excess all-cause mortality. For smokers, smoking ⩽5 bidis per day, the relative risk was 42% higher compared with never-users of tobacco.
- The relative risk for all-cause mortality among bidi smokers was 64% higher and cigarette smokers 37% higher compared with never-users of tobacco.
- Smokeless tobacco use may also results in excess all-cause mortality. The relative risk for all-cause mortality among women for a specific category of smokeless tobacco use was 37% higher as compared with never-users of tobacco.
- Deaths from respiratory diseases, TB, and neoplasms were more than doubled among male smokers as compared with never-users of tobacco.
- Around 149 000 male TB deaths per year in India can be attributed to smoking.

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