

3.5

Key Selected Studies and Estimation of the Number of Tobacco Users

In this section, key studies selected as a basis for estimation of the number of tobacco users are described and an estimate of this number is attempted.

Key selected studies

The major source material used for this study is tabulated data from the special report: *Consumption of tobacco in India, 1993–1994* of the National Sample Survey Organization (NSSO).⁴⁸ This nationwide survey was undertaken as the 50th round of the National Sample Survey (NSS), using statistical sampling techniques. A total of 115,354 households located in 6951 villages and 4650 urban blocks were visited and information on tobacco use including product types were obtained for all members aged 10 years and above residing in each surveyed household. In the survey, tobacco use among a total of 432,393 individuals of all ages was recorded. This information was obtained from one member of the household, usually the male head. The NSSO tabulated the survey results for urban and rural residents gender-wise and age-wise for 32 states and union territories. In the report the age groupings were as follows: 10–14, 15–29, 30–44, 45–60 and 60+ years. The NSSO report also contains prevalence by type among various social groups.

The second National Family Health Survey (NFHS-2) was also a nationwide household survey conducted according to strict statistical sampling procedures during 1998–1999, on health-related practices and behaviour in 26 states. Over 90,000 households were surveyed

and information on *paan*/tobacco chewing and tobacco smoking were obtained for 315,597 persons aged 15 years and above. Information was collected from the female head on members aged 15 years and above on tobacco use, and tabulated data are presented as tobacco chewers and tobacco smokers in the report. Data are not presented on the prevalence of combined use in that report, thus there is an overlap and the prevalence of chewing and smoking cannot be added together. However, some combined data have been published elsewhere.⁴⁹ In the NFHS-2 report, the age categorization adopted was 15–19, 20–24, 25–29, 30–39, 40–49, 50–59 and 60 years and above. These data were obtained from 25 states in the country.

Other than the above two nationwide survey reports, the results of a complete rural population survey have also been used to estimate the national prevalence in this section. This survey was conducted in the entire Karunagappally population located in Kollam district of Kerala during 1990–1998. These results were also used for estimating prevalence as this was a complete population survey conducted by face-to-face interviews with results tabulated for 5-year age groups by gender, which made it possible to obtain age-specific prevalence rates for males and females. This area is ‘rural’ according to the government census. The survey was undertaken to obtain the prevalence of lifestyle factors associated with cancer occurrence (personal communication Dr P. Jayalekshmi, P. Gangadharan and V.S. Binu, Karunagapally Cancer Registry).⁹³

In Table 3.7 the number of persons interviewed in the NSS are shown gender-wise and according to urban–rural residence. The rural population was only 62% of the total studied.

Table 3.7 Number of persons covered in the NSS, 50th round (1993–1994) of all ages⁴⁸

	Rural	Urban	Total
Male	137,265	86,144	223,409
Female	130,357	78,627	208,984
Total	267,622	164,771	432,393

Source: National Sample Survey Organization, 1998–1999

Table 3.8 Percentage of household members above 10 years of age who regularly use tobacco, by gender 1993–1994 (NSSO 50th round)⁴⁸

Residence	Males			Females		
	Chewers	Smokers	Any form	Chewers	Smokers	Any form
Rural	19.3	29.3	43.0	9.3	2.3	10.9
Urban	9.9	20.2	27.7	4.3	0.7	4.7

Source: National Sample Survey Organization, 1998–1999

In the survey of the rural Karunagappally population, information was obtained by interviewing 117,240 men and 138,883 women above 15 years of age.

Overall urban and rural prevalence

According to the NSSO report, overall in India in the population aged 10 years and above, 43% of rural males and 28% of urban males are regular tobacco users (Table 3.8). Among females the prevalence in rural areas was 11% and in urban areas it was 5%. It is evident that rural prevalence is higher than urban prevalence for both males and females and that male prevalence is higher than female prevalence overall.

Table 3.9 shows the observed prevalence rates of the NFHS-2 in rural and urban areas for tobacco chewing and smoking among males and females.

The prevalence in rural areas was 50% higher than in urban areas for both males and females, and for chewing tobacco and smoking. Smoking prevalence among rural females compared to urban females was more than 3 times higher. On an all-India level, the NFHS-2 estimated that 21% of persons aged 15 years and above chew *paan masala* or tobacco and only 3% of the women are reported to have ever smoked but 29% of men are current smokers. This survey also noted higher rates among rural and less educated men and women compared to urban residents.

In the rural Karunagappally population, current tobacco use prevalence figures in the population 15 years of age and above were 53.8% among males and 14.2% among females.

Table 3.9 Percentage of household members above 15 years of age who currently chew tobacco or smoke by gender 1998–1999 (NFHS-2)⁹⁴

Residence	Male		Female	
	Chew tobacco	Currently smoke	Chew tobacco	Currently smoke
Rural	31.3	32.6	13.8	3.1
Urban	20.8	21.4	8.8	0.9
Total	28.3	29.4	20.5	16.2

Source: International Institute for Population Sciences, 2000

Age-specific prevalence

Table 3.10 shows that the prevalence increased with age. Among males the rates decreased after 60 years but not in females.

Table 3.10 Age-specific prevalence (%) among males and females of regular tobacco users in rural and urban areas (NSS 1993–1994)⁴⁸

Age group (years)	Male		Female	
	Rural	Urban	Rural	Urban
10–14	1.3	0.4	0.9	0.2
15–24	19.1	8.7	4.6	1.2
25–44	61.3	40.7	12.2	4.5
45–59	72.3	50.9	20.4	11.4
60+	65.0	39.5	21.2	13.0
Total	43.0	27.7	10.9	4.7

Source: National Sample Survey Organization, 1998–1999

A similar pattern is seen in the age-specific prevalence distribution from the NFHS-2, as shown in Table 3.11.

Table 3.11 Age-specific prevalence of tobacco use in males and females (NFHS-2)⁹⁴

Age group (years)	Male		Female	
	Chew tobacco	Currently smoke	Chew tobacco	Currently smoke
15–19	9.4	4.4	2.1	0.2
20–24	20.3	13.7	4.3	0.6
25–29	28.0	25.1	8.0	1.1
30–39	34.1	37.6	12.3	2.2
40–49	35.6	45.0	18.6	4.0
50–59	35.4	45.3	22.8	5.7
60+	37.6	38.6	25.0	5.3
Total	28.3	29.4	20.5	16.2

Source: International Institute for Population Sciences, 2000

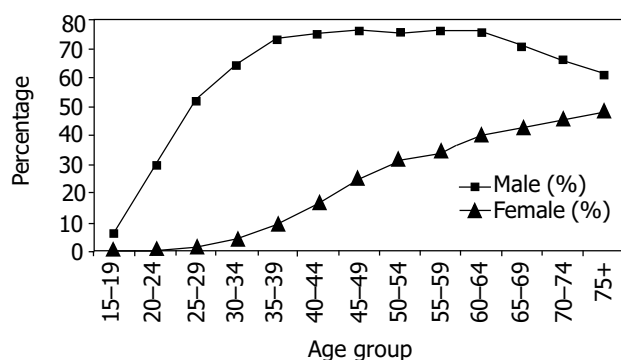


Fig. 3.4 Age-specific prevalence rates among current tobacco users in Karunagappally taluk, 1990–1998

Table 3.12 Prevalence of tobacco use in any form by ever-users per 1000 rural and urban males and females (10+ years of age), States and Union Territories, India, NSS, 1993–1994⁴⁸

State	Male		Female	
	Rural tobacco users (%)	Urban tobacco users (%)	Rural tobacco users (%)	Urban tobacco users (%)
Andhra Pradesh	43.9	26.2	12.3	4.1
Arunachal Pradesh	47.9	37.5	28.8	16.2
Assam	52.7	44.6	11.1	5.3
Bihar	47.6	33.0	6.0	3.6
Goa	22.0	23.8	5.5	4.2
Gujarat	42.9	28.6	9.1	3.5
Haryana	46.8	33.7	6.2	2.1
Himachal Pradesh	41.7	28.1	3.8	3.1
Jammu and Kashmir	38.2	19.8	3.2	0.5
Karnataka	36.6	24.0	9.6	3.2
Kerala	34.6	31.5	6.7	4.6
Madhya Pradesh	54.0	33.6	12.0	7.2
Maharashtra	45.4	25.4	24.0	8.0
Manipur	45.5	35.4	21.5	13.2
Meghalaya	62.2	53.2	31.9	13.1
Mizoram	69.8	66.9	63.2	57.4
Nagaland	31.9	34.1	1.7	–
Orissa	56.2	41.8	44.8	24.1
Punjab	12.8	18.0	0.3	0.3
Rajasthan	45.8	31.4	4.8	3.8
Sikkim	52.6	36.2	4.6	0.6
Tamil Nadu	28.4	23.4	9.2	4.0
Tripura	56.1	50.7	21.1	24.6
Uttar Pradesh	47.6	31.5	7.7	3.0
West Bengal	52.7	44.4	10.6	6.6
Andaman and Nicobar	53.3	43.4	19.9	9.7
Chandigarh	38.1	30.2	1.3	1.3
Dadra and Nagar Haveli	56.7	28.2	5.6	3.1
Daman–Diu	26.8	21.0	7.2	0.5
Delhi	43.4	25.2	3.5	1.4
Lakshadweep	38.3	43.5	21.4	14.9
Pondicherry	23.2	16.6	4.8	2.1
All India	45.3	29.9	11.8	5.1

Source: National Sample Survey Organization, 1998–1999

In Fig. 3.4, the age-specific prevalence curves plotted against age for males and females are shown for the population of Karunagappally taluk, Kollam district, Kerala. Among males, the prevalence was above 70% in the age range of 35–69 years. As in the NFHS-2 and the NSS-50th round, the prevalence declined at older ages in men but not in women.

State-wise prevalence

In Table 3.12, the prevalence of tobacco use per 1000 individuals (not percentage) aged 10 years and above in each state and territory is given. The variations in tobacco use prevalence that exist between states are evident. Among rural males in Punjab, the prevalence was 12.8% but it was 69.8% in Mizoram. Among urban males, the lowest rate was seen in Pondicherry at 16.6% and the highest prevalence of 66.9% was noted again in Mizoram. Similar variations in prevalence were noted among women also. Among the rural and urban women of Punjab only 0.3% were tobacco users but the prevalence among rural females in Mizoram was 63.2% and urban 57.4%. The higher prevalence in rural areas and among males is true for most states and territories. Only in Goa, Nagaland, Punjab and Lakshadweep, the rates in urban males were higher than in rural males. In Tripura, urban females had a higher rate than rural ones.

Estimation of tobacco use prevalence

Methods

A simple method is adopted for estimating the number of tobacco users in India for the year 2004. It was thought sufficient to consider only three variables: rural versus urban residence, age and gender. State-wise differences and socioeconomic differences were not considered in the estimation procedure for the whole country, given the difficulties involved. The available rates were projected onto the 2004 population estimated for India in the Registrar General's report 1996.⁹⁵ In this report, the

estimated population of India (all ages) on 1 March 2004 was 547,556,000 males and 512,468,000 females. The distribution of the population by 5-year age groups is also given in the publication. This estimated population was proportionately assumed to be composed of 27% urban and 73% rural in each age group and the urban and rural age distribution was obtained.

The prevalence of tobacco use for rural and urban areas of residence obtained from the NSSO age-specific rates were directly used to estimate the number of users. These were obtained separately for males and females in each age group. A similar compilation was also done using the Karunagappally age-prevalence rates of tobacco users for comparison purposes.

Estimations

By using the NSSO age-specific rates, regular consumers of tobacco (aged 10 years and above) were 186,482,598 in rural India and 49,337,216 in urban areas. Thus, the total number of tobacco users was 235,819,814 in 2004.

Age-specific estimation based on the Karunagappally 5-year age-specific prevalence rates of current tobacco use yields a total of 195,446,246 male users and 44,607,056 female users in 2004, totalling 240,053,302 users in India. It is essential to mention here that the Karunagappally rates are obtained for the age groups of 15 years and above, whereas the NSSO reports are for the ages of 10+ years and above. Thus, the Karunagappally rates would be lesser by the number of male and female users in the 10–14 years age group, which would be 4–5 million.

A further estimation was done of the number of tobacco users (smokers, chewers) among persons aged 30 years and above (Table 3.13). This was used to estimate chronic disease burdens.

Discussion

Table 3.13 All-India tobacco use prevalence and estimated number of users (chewers, smokers) in the 30+ age group⁹⁴

Men		Women	
Chewers	Smokers	Chewers	Smokers
35.4%	41.2%	18.2%	3.9%
75,479,712	87,873,798	36,762,373	7,833,853

Source: National Family Health Survey-2 age-specific data from International Institute for Population Sciences, 2000

Prevalence studies of tobacco use in India have shown wide variations between urban and rural areas, regions, age, gender, education, and other sociodemographic variables across the country. Urban–rural differences are an especially important consideration for estimation, as several surveys have shown that the prevalence of tobacco use is higher in rural populations compared to urban areas and, in India, 73% of the population lives in rural areas. Also, tobacco use is more common among men than women (NSSO, NFHS-2).^{48,49}

The two estimates of prevalence of the number of users differ by around 10 million when the age considered is 10+; thus, the estimated number indicates that in 2004 there are about 250 million users aged 10+ years in the country.

The NSSO is a nationwide study and is thus important for such national estimation. The NSSO estimates gave the number of tobacco users as 235.8 million.

The Karunagappally area is rural, hence using this the prevalence may have inflated the estimated number. However, it must be pointed out that in Kerala there is no ‘rural’ area as seen in other parts of the country. Sometimes the entire state is termed as an extended suburban area. It may also be underscored that there was a high literacy rate—more than 85% in Karunagappally, which is unusual in a rural setting. The prevalence of tobacco use was also high. Using the age-specific prevalence of Karunagappally, the estimated number is 250 million users in 2004 in the 10+ years age group.

By a direct estimation using the prevalence

percentage of the NFHS-2, Rani *et al.*⁴⁹ estimated that the total number of users were 195 million—154 million men and 41 million women, probably using the base year 1998–1999.⁴⁹ The NSSO survey was done earlier in 1993–1994 and the Karunagappally population survey was undertaken during 1990–1998. Because it was based on house-to-house visits and face-to-face interviews it took 8 years to complete.

An earlier estimate made for 1996 was 184 million tobacco users (150 million males and 34

million females).⁹⁶

It is clear that the estimates obtained here suffer from limitations. The most important limitation is that the surveys were not designed to collect information on tobacco use. Surrogate responses were used, which can introduce inaccuracies and biases. Also, the household was used as a sampling unit rather than an individual, and it was not possible to make appropriate statistical adjustments for that while doing the estimation. It is thus imperative that national-level surveys be undertaken periodically with the objective of finding out the prevalence of tobacco use in India.

3.5 KEY SELECTED STUDIES AND ESTIMATION OF THE NUMBER OF TOBACCO USERS

KEY MESSAGES

- There are currently an estimated 250 million tobacco users aged 10 years and above in India.
- There are currently about 240 million tobacco users aged 15 years and above (195 million male users and 45 million female users) in India.
- The prevalence of tobacco use is higher in rural population compared to that in urban areas; 73% of the population lives in rural India.

Appendix

Chemistry and Toxicology of Tobacco Products used in India

Chemistry of tobacco

Both tobacco and tobacco smoke contain a large variety of chemicals. Nearly 3000 chemical constituents have been identified in smokeless tobacco, while close to 4000 are present in tobacco smoke. These include alkaloids such as nicotine, nornicotine, cotinine, anatabin, anabasin; aliphatic hydrocarbons present in the waxy leaf coating and hundreds of isoprenoids that give the aroma to tobacco. Phytosterols such as cholesterol, campesterol, etc. and alcohols, phenolic compounds, chlorogenic acid, rutin, carboxylic acids and several free amino acids are present in tobacco.⁹⁷ In addition, a wide range of toxic metals including mercury, lead, cadmium, chromium and other trace elements have been found in Indian tobacco.⁹⁸

Dependency on tobacco use is related to the pharmacological effects of nicotine present in tobacco leaves and in tobacco smoke. There are at least 15 additional alkaloids that are structurally related to nicotine. Nornicotine and

anabasin have a similar pharmacological action to that of nicotine but only 20%–75% potency. The alkaloids nicotine and nornicotine give rise to carcinogenic N-nitrosornicotine (NNN), while another potent carcinogen 4-methyl-nitrosamino-1-(3pyridyl)-1-butanone (NNK) is derived from nicotine. N-nitrosoanatabin (NAT) and N-nitrosoanabasin are other N-nitrosamines derived from the alkaloids anabasin and anatabin, respectively. Secondary amines are also known to combine with nitrites to form carcinogenic nitrosamines. N-nitrosamines are formed during the fermentation and curing of tobacco, i.e. during processing, as well as storage. Both NNN and NNK are present in high concentrations in smokeless tobacco and tobacco smoke.

Estimation of moisture content, pH, nitrite, nitrate, nicotine and other tobacco-specific alkaloids in various smokeless tobacco products (*zarda*, *Pandharpuri*, and three types of *masheri* and *rawa* tobacco [tobacco dust]), tobacco used for *beedi* manufacture and tobacco fillers from *beedis* and cigarettes, revealed that the nicotine content of *Pandharpuri* tobacco was the maximum followed by *zarda* tobacco as shown in Table 3.14.⁹⁹ These two types also showed a high content of nornicotine which is converted to carcinogenic NNN during curing. Alkaloid levels were also two-fold higher in *beedi* tobacco fillers than in cigarette fillers or processed *beedi* tobacco. The nitrite content was two-fold higher in cigarette tobacco. Nair *et al.*¹⁰⁰ examined total nitrosamine content and tobacco-specific nitrosamines (TSNAs) including NNN, NAT and NNK in *masheri*, a pyrolysed form of tobacco used commonly in Maharashtra as a dentifrice.

Table 3.14 Moisture, pH and alkaloid content of chewing tobacco products⁹⁹

Tobacco product	Moisture (%)	pH	Nitrate (mg/g)	Nitrite (µg/g)	UP-SP Nicotine (mg/g)	Nicotine* (mg/g)	Nornicotine* (mg/g)	Anabasin* (mg/g)	Anatabin* (mg/g)	Cotinine* (mg/g)
<i>Pandharpuri</i>	3.99	5.15	4.66	23.05	55.25	54.77	17.11	0.31	0.63	0.37
<i>Zarda</i>	11.58	5.02	5.00	30.80	25.79	26.20	10.23	0.09	0.92	0.15
<i>Masheri</i> Br. 1	7.69	6.33	6.49	11.07	5.52	6.02	0.46	0.05	0.04	0.10
<i>Masheri</i> Br. 2	5.80	7.12	2.26	9.25	18.90	23.08	3.66	0.07	0.38	0.43
<i>Rawa</i> tobacco	9.52	5.18	8.56	9.01	14.35	16.91	4.23	0.72	0.91	0.09
<i>Rawa masheri</i>	4.29	5.89	4.49	16.40	5.60	4.99	0.34	0.74	0.09	0.11

UV-SP: ultraviolet spectrophotometry; *GC-FID: gas chromatography-flame ionization detection

Source: Pakhale *et al.* 1997

The total nitrosamine content of brown and black *masheri* samples was higher than that of the tobacco used for their preparation. NNN levels were higher in *masheri* than in the tobacco from which it was prepared. Nair *et al.*¹⁰¹ detected high amounts of NNN and NNK in snuff. Analysis of TSNAs in cigarette, *chutta*, cigar and *beedi* tobacco fillers showed minimum amounts of NNN, NAT and NNK in tobacco fillers of a filtered cigarette but the levels were higher in non-filtered cigarette fillers. One of the *chutta* tobacco fillers had the highest amount of TSNAs among the smoking products.¹⁰¹ Another study¹⁰² reported higher levels of nicotine, nornicotine, anabasin, anatabin and cotinine in *beedi* and *chutta* tobacco fillers than in cigarette fillers.

Tobacco smoke is known to be rich in naphthalene and polycyclic aromatic hydrocarbons (PAH). In studies from India, high levels of benzopyrene were reported in *masheri*, snuff and two samples of chewing tobacco.^{100,103} Other tumorigenic agents isolated from smokeless tobacco and tobacco smoke and identified by chemical analysis were volatile aldehydes including formaldehyde, acetaldehyde and crotonaldehyde, volatile N-nitrosamines, N-nitrosamino acids, lactones, polycyclic aromatic hydrocarbons, some metals and polonium-210, which is radioactive.

Pakhale *et al.*⁹⁹ analysed the levels of nitrate, nitrite, and tobacco-specific alkaloids in processed *beedi* tobacco used for *beedi* manufacture, and tobacco fillers obtained from ready to smoke *beedis* and cigarettes sold in the market. The nitrate content of the three tobacco varieties

was similar while the nitrite content was two-fold higher in cigarette tobacco (Table 3.15).

Information on the chemicals present in tobacco smoke is based on machine smoking of *beedis* and cigarettes under standard laboratory conditions. Tobacco smoke is composed of a volatile gaseous and a particulate phase. Some 500 gaseous compounds including nitrogen, oxygen, hydrogen, methane, carbon monoxide, carbon dioxide, ammonia, hydrogen cyanide and benzene have been identified in the volatile phase of cigarette smoke, which account for about 95% of the weight of cigarette smoke; the other 5% is accounted for by particulate matter. At an alkaline pH, nicotine is detected in the gaseous phase also, which seems to aid its absorption. The vapour phase also contains volatile carcinogenic aldehydes, ketones, nitric oxides and volatile nitrites along with additional minor constituents.

There are about 3500 different compounds in the particulate phase, of which the major one is the alkaloid nicotine. Other alkaloids include nornicotine, anatabin and anabasin. Particulate matter without its alkaloid and water content is called tar. Many carcinogens, including polycyclic aromatic hydrocarbons, N-nitrosamines including TSNAs and aromatic amines have been identified in tobacco smoke. Chlorinated hydrocarbon insecticides, N-alkylcarbazols, fluoranthenes, benzofluorones, phenylindane, pyrenes and cyclopenteno-phenanthrenes have been detected in a subfraction of smoke tar. The major carcinogens present in the particulate phase of tobacco smoke are polonium-210, volatile/non-volatile N-nitrosamines and

Table 3.15 Moisture, pH, nitrate, nitrite and alkaloid content of *beedi*/cigarette fillers⁹⁹

Tobacco product	Moisture (%)	pH	Nitrate (mg/g)	Nitrite (µg/g)	UV-SP Nicotine (mg/g)	Nicotine* (mg/g)	Nornicotine* (mg/g)	Anabasin* (mg/g)	Anatabin* (mg/g)	Cotinine* (mg/g)
<i>Beedi</i> filler	8.21	5.07	2.28	16.89	40.75	42.05	3.70	0.35	1.65	0.19
Cigarette tobacco	12.81	5.00	1.64	38.55	16.23	14.19	1.56	0.03	0.22	0.05
<i>Beedi</i> /tobacco	10.26	5.09	1.15	13.43	37.70	35.15	3.41	0.10	1.53	0.16

UV-SP: ultraviolet spectrophotometry; *GC-FID: gas chromatography-flame ionization detection

Cigarette/*beedi*/tobacco: tobacco collected from cigarette/*beedi*, *Beedi* filler: tobacco used for preparation of *beedis*

Source: Adapted from Pakhale *et al.* 1997

TSNAs. In addition, co-carcinogenic agents such as pyrene, fluoranthene, dichlorostilbene and catechols have been identified in the particulate phase of cigarette smoke.

Toxic effects of tobacco

The toxic effects of tobacco include mutagenicity, carcinogenicity and genetic damage, as shown by various assays, cell culture studies, animal experiments and tests on humans who either use tobacco or work in processing it.

Mutagenicity

An ethanolic extract of the *Pandharpuri* brand of chewing tobacco and *masheri*,^{103,104} extracts of *beedi* tobacco¹⁰⁵ and *beedi*/cigarette smoke condensates^{106,107} were mutagenic in the Ames assay that uses *Salmonella typhimurium* strains for detecting the mutagenic activity of chemicals. Urine samples from *masheri* users,¹⁰⁸ tobacco chewers¹⁰⁴ and *beedi* industry workers,¹⁰⁵ and gastric fluid from tobacco chewers¹⁰⁹ were also mutagenic. The levels of PAH-induced DNA adducts that can lead to mutations were higher in the skin of mice administered total particulate matter from the smoke of *beedis*.¹¹⁰

Beedi/cigarette smoke condensates, and an ethanol extract of *Pandharpuri* tobacco induced mutation in Chinese hamster V79 cells and increased micronucleated cell frequency in mouse bone marrow cells.¹⁰⁶ An extract of snuff inhibited the growth of mouse tongue epithelial cells in culture.¹¹¹ A single, 24-hour treatment of hamster tracheal epithelial cells in culture with an extract of *beedi* tobacco decreased the growth rate of cells, with respect to untreated control cells, increased the rate of DNA synthesis, ornithine decarboxylase activity and the number of cells in the DNA synthesis phase. Repeated exposure to the extract, however, led to a significant increase in cell number, suggesting

that chronic inhalation of tobacco dust among *beedi* industry workers may stimulate proliferation of the tracheal cells and thereby increase the risk for the development of pulmonary disorders including cancer.¹¹²

Carcinogenicity

In a study that attempted to induce cheek pouch tumours in hamsters, snuff application alone resulted in a high incidence of tumours in the forestomach but not cheek pouches of treated animals.¹¹¹ Other studies in mice revealed that application of an extract of *masheri* to the skin of the back induced skin tumours in 20% of mice,¹¹³ while application of an extract of *beedi* tobacco promoted the growth of skin papillomas induced by a tumour-initiating carcinogen.¹¹⁴ Tumours were induced in the liver, forestomach and oesophagus of mice treated with *beedi* smoke condensate in another study.¹¹⁵

Genetic damage in humans

Cytogenetic studies in tobacco users and non-users have shown that the frequency of chromosomal damage denoted by chromatid breaks and gap type aberrations is significantly higher among those who chew tobacco with other ingredients such as betel nut,^{116,117} or tobacco with lime,¹¹⁸ *masheri* users,¹¹⁸ and those who chew tobacco containing betel quid or *gudhaku*, a tobacco-containing chewing product.¹¹⁹ Chronic use of tobacco was associated with a significantly diminished ability to detoxify foreign chemicals including those present in tobacco.^{118,120} Chromosomal damage is known to occur at a higher frequency in the lymphocytes of smokers, workers employed in cigarette factories¹²¹ and those engaged in processing of tobacco for the manufacture of *beedis*.^{120,122} Micronucleated cells are more commonly seen in the buccal epithelial cells of tobacco users or those with occupational exposure to tobacco.^{123,124}

APPENDIX: CHEMISTRY AND TOXICOLOGY OF TOBACCO PRODUCTS USED IN INDIA

KEY MESSAGES

- Nearly 3000 chemical constituents have been identified in smokeless tobacco, while close to 4000 are present in tobacco smoke, many of them harmful.
- Tobacco contains tobacco-specific nitrosamines (TSNAs) formed during fermentation and curing of tobacco, which are carcinogenic.
- Dependency on tobacco use is related to the pharmacological effects of nicotine and related alkaloids present in tobacco leaves and tobacco smoke.
- Tobacco smoke is known to be rich in naphthalene and polycyclic aromatic hydrocarbons (PAH), which are known carcinogens. Studies from India report high levels of benzopyrene in *masheri*, snuff and two samples of chewing tobacco.
- There are about 3500 different compounds in the particulate phase of tobacco smoke, of which the major one is the alkaloid nicotine. Particulate matter in tobacco smoke without its alkaloid and water content is called tar. Many carcinogens, including PAH, N-nitrosamines such as TSNAs and aromatic amines have been identified in cigarette tar.
- The toxic effects of tobacco include mutagenicity, carcinogenicity and genetic damage, as shown by various assays, cell culture studies, animal experiments and tests on humans who either use tobacco or work in processing it.

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3.1 Tobacco use practices

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