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Nested multilevel modelling study of smoking and smokeless tobacco consumption among middle aged and elderly Indian adults: distribution, determinants and socioeconomic disparities

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Abstract

Introduction The Global Adult Tobacco Survey (GATS) shows a drop in tobacco use worldwide. Despite the drop, there still continues to be a significant number of tobacco users in India. Research on tobacco use among young persons is commonly prioritised in India, while studies on tobacco use among middle-aged (45–59 years) and elderly (≥ 60 years) adults are noticeably lacking. We have conducted this study with objective to estimate the distribution, determinants and socioeconomic inequalities of smoking (SM) and smokeless tobacco (SLT) consumption across Indian states and union territories.

Methods This study was based on 66,606 participants aged ≥ 45 years using Longitudinal Aging Study in India (LASI)-1 (2017–2018) data. Distribution of tobacco consumption (any form, smoking (SM), smokeless (SLT) and both) was documented as per Indian states and union territories with spatial distribution by Indian map. Demographic, socioeconomic, health related and behavioural determinants were established using nested multilevel regression modelling. Socioeconomic disparities were documented using concentration curve. P-value < 0.05 was considered as statistically significant.

Results Overall, 36.78% participants documented using any form of tobacco; with higher consumption of SLT (19.88%) than smoking/SM (13.92%). Only 2.98% consumed both. Mizoram had highest consumption of tobacco in any form (78.21%) and smoking (35.18%). Elderly participants had higher odds of consuming tobacco (any 1.23 (1.18–1.28), SM 1.99 (1.14–1.27), SLT 1.08 (1.03–1.14) and both 1.27 (1.14–1.40 times) than middle aged participants. Females, OBC (other backward castes), urban residence had lower odds in all the categories, while being widow/separated/ divorced, belonging to Muslim community, having clerical and skilled occupation, poor self-rated health, comorbidity and multimorbidity had higher odds. With decrease in the wealth index, educational status and frequency of physical activity the odds of tobacco consumption increased. The odds of higher tobacco consumption were documented from northeast region (2.56 (2.37–2.76) higher than north). Alcohol consumption had the highest odds (4.94 (4.69–5.21)). Participants exposed to media had lower odds (11% lower) of consuming tobacco. The

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socioeconomic inequalities in tobacco consumption were significantly distributed more among the poorest (any -0.064 (-0.072 to -0.056) and SLT -0.069 (-0.072 to -0.056)).

Conclusion Prioritising tobacco prevention and increasing availability and accessibility of cessation programmes that are suited with unique requirements and circumstances, even for elderly population, are essential focusing on the higher determinants across poorest section in the country.

Keywords Tobacco, Smoke, Smoking, Smokeless, SM, SLT, Middle aged, Elderly, LASI, Model

Introduction

Beyond national, ethnic, and social borders, tobacco smoking is becoming a more significant worldwide public health concern [1, 2]. The pervasive usage of various tobacco products is a source of concern in low- and middle-income countries (LMICs). Data points to about 1.3 billion tobacco users worldwide, 80% of whom reside in LMICs, where tobacco-related morbidities and deaths are most prevalent [3]. India is 2nd-largest consumer of tobacco products among LMICs and continues to be a major producer of the commodity. India's tobacco environment is diverse and complex [4, 5]. Around 267 million tobacco users in India were above the age of 15, according to the Global Adult Tobacco Survey-2 (GATS-2, 2016–17). Of them, approximately 42.4% were males and 14.2% were women [6].

There are two main ways that people consume tobacco: smokeless and smoking (SM). In India, the usage of smokeless tobacco (SLT)—which includes chewing tobacco, gutkha, khaini, betel quid with tobacco, gul, mishri and gudakhu etc.) is quite common because of its social acceptability. Additional forms include using tobacco products of any kind, such as cigarettes, hookahs, and bidis, and smoking cigarettes. These actions also increase the chance of developing oral submucous fibrosis (OSMF), a premalignant condition that has the potential to progress to oral cancer [7]. There is proof that smoking causes health problems with the respiratory and cardiovascular systems. Smoking has negative social and economic effects in addition to high morbidity. The overall monetary cost of tobacco usage in India for all ailments among those above 35 years in 2017 was around INR 177 billion [8].

It is critical to comprehend the tobacco usage among middle aged (45–59 years) and elderly (≥60 years) adults in India. India faces particular difficulties due to its ageing population since non-communicable illnesses are more common as people gets older [9]. Examining the relationship between tobacco use and health issues, impairments, and higher healthcare use is crucial given the significant effects smoking has on this ageing population with demographic, socioeconomic and cultural challenges [10, 11].

India has made great efforts to combat tobacco smoking, but middle-aged and elderly adults have received less scientific attention than younger population [12, 13]. Despite the well-established negative effects of tobacco use, there is a significant deficiency of thorough study on the consumption of tobacco among middle- and elderly-aged adults in LMICs like India [14]. This study was conducted to unveil the curtain form this important public health problem with following objectives:

Among middle aged and elderly Indian adults:

1. To estimate the distribution of smoking (SM) and smokeless tobacco (SLT) consumption across Indian states and union territories.
2. To identify different demographic, socioeconomic; health related and behavioural determinants.
3. To estimate the socio-economic disparities across the wealth index.

Methods

Study design

The Longitudinal Ageing Study in India, wave 1 (LASI-2017–18) data was utilised in this study. In all the Indian states and union territories, 73,396 participants (≥45 years), along with their spouses, made up the survey's nationally representative sample. To choose the final units of observation, LASI used a multistage stratified area probability cluster sampling strategy. The sample unit consisted of households with one or more members who were 45 years of age or older. All individuals 45 years of age and older who were married or not, as well as their spouses, were questioned for the data in a subset of homes. The information offers solid scientific support on biomarkers, employment, chronic health, symptom-based health problems, household economics, and demography. Comprehensive details are documented in the LASI Wave-1 Report [15]. Upon excluding the individuals under 45 years, our final sample size was 66,606.

Outcome variable

The outcome variable was self-reported tobacco consumption. The participants were asked- "Have you ever

smoked tobacco (cigarette, bidi, cigar, hookah, Cheroot) or used smokeless tobacco (such as chewing tobacco, gutka, pan masala, etc.)?" Answers were recorded in dichotomous format- "no, yes" and considered as consumption of any form of tobacco. They have also asked- "What type of tobacco product have you used or consumed?" Followings were the options for answering- "smoke tobacco"/ smoking, "smokeless tobacco (such as chewing tobacco, gutka, pan masala, etc.)" and "both smoke and smokeless tobacco."

Explanatory variables

These variables were categorised into age group (45–59, > 60 years), gender (male, female), demographic and socioeconomic, health related and behavioural factors. Under demographic and socioeconomic factors, we have included- religion (Hindu, Muslim, Christian and others), caste (scheduled caste (SC), scheduled tribe (ST), other backward caste (OBC) and others), MPCE (monthly per capita expenditure- poorest, poorer, middle, richer, richest) quintile/ wealth index, education (illiterate, less than primary. primary completed, middle completed, secondary school, higher secondary, and diploma/ graduate), marital status (unmarried, married/ in live-in, widow/ separated/ divorced), residence (rural, urban), health insurance (no, yes), occupation (unemployed, professional and semi-professional- 'legislators and senior officials, professionals, technicians and associate professionals', clerical and skilled- 'clerks, service workers and shopkeepers, skilled agriculture and fishery workers, craft and related trade worker, plant and machine operator', unskilled), living alone (no, yes) and region (north, central, east, northeast, west and south). Under health-related factors, we have included- physical activity (everyday, once per week, 1–3 times per week, once per month, never), self-rated health (excellent, very good, good, fair, poor), tobacco abuse (no, yes), comorbidity (no, yes) and multimorbidity (no, yes). Following chronic health conditions were considered- diabetes, hypertension, cancer, diabetes, chronic lung diseases (e.g.- chronic obstructive pulmonary disease, asthma, chronic bronchitis, other chronic lung problems), stroke, chronic heart disease (e.g.- congestive heart failure, myocardial infarction, heart attack, other chronic heart diseases), dyslipidaemia (high cholesterol), thyroid disorders, musculoskeletal disorder (MSD e.g.- rheumatism, arthritis, osteoporosis, other chronic joint or bone disorders), visual impairment chronic renal failure, and hearing impairment. The interviewer asked proper questions related to chronic health conditions with dichotomous answers (no/ yes)- "Has any health professional ever diagnosed you with the following chronic conditions or diseases?" Participants having at least one and two chronic health conditions were described as comorbidity and multimorbidity, respectively. Under behavioural factors we have included alcohol consumption (no, yes) and media (television/ radio/ mobile) exposure (no. yes).

Data analysis

Data was analyzed using STATA v17 (StataCorp LLC, College Station, TX) [16]. Bivariate analysis was conducted to document the consumption of tobacco: any form, smoking, smokeless and both with respect to various demographic, socio-economic and health related factors. Appropriate survey weights were used. Chi-square p-value was estimated. Indian states and union territories were categorised into low/L (0 to 33rd percentile), medium/M (34 to 66th percentile) and high/H (67 to 100th percentile) as per tobacco consumption. We have produced Indian map to document these categories with Microsoft excel.

We have applied nested multilevel regression modelling to show the association between tobacco consumption and explanatory variables. We have used total 4 models. In the Model-1, we have included age group and gender. In the Model-2, Model-3 and Model-4; we have subsequently added demographic and socioeconomic factors; health related; and behavioural factors. We have also documented pseudo R^2, log-likelihood, likelihood ratio, AIC (Akaike Information Criterion) and BIC (Bayesian Information Criterion) to evaluate the best fit model. P-value < 0.05 were considered as statistically significant.

The socioeconomic inequalities in tobacco consumption among middle aged (45–59 years) and elderly (≥ 60 years) Indian adults were disaggregated as per wealth index at national level using concentration index [17]. Detailed methods have been described elsewhere [18, 19]. The area between the concentration curve and the line of equality was computed by first plotting the cumulative proportion of the population ranked by wealth quintile against the cumulative proportion of tobacco consumption. A concentration index of zero indicating no socioeconomic inequality. A positive value depicts that tobacco consumption is distributed more among the richest while a negative value depicts that the distribution more among poorest. Higher value shows greater inequality (both in negative and positive directions). Following STATA command was used to calculate the concentration index "conindex variable, rank(wealth_index) truezero bounded limits(0 1) erreygers graph loud" where erreygers correction were included [20].

Ethics

In compliance with Human Subjects Protection, the survey agencies that carried out the field survey for the data collection obtained prior informed consent (signed and

oral) from eligible respondents as well as from the legal guardians of illiterates for both the biomarker testing and interviews. The Indian Council of Medical Research (ICMR)'s Central Ethics Committee on Human Research (CECHR) granted ethical permission for the LASI survey [21].

Results

Tobacco consumption in any form was 36.78% in India, which was higher among elderly (39.72%) than middle aged (33.82%) participants. Consumption of SM, SLT and both were 13.92%, 19.88% and 2.98, respectively. Tobacco consumption was highest among males (19.11%), Muslims (39.13%), schedule caste (46.02%), poorer (40.19%), illiterate (46.08%), married/ in live-in (38.67%), rural (42.36%), clerical and skilled occupation (48.02%), living alone (36.90%), northeast region (54.29%), never indulged in physical activity (47.17%), poor self-reported health (42.82%), having comorbidity (41.35%), multimorbidity (39.64%), alcohol consumption (79.89%) and not exposed to media (40.81%). Almost similar pattern was documented among SM, SLT and both types of tobacco consumers (Table 1).

Mizoram had highest consumption of tobacco in any form (78.21%) and smoking (35.18%); where Punjab (11.36%) and Jharkhand (2.81%) had lowest consumption of any form of tobacco and smoking, respectively. The highest and lowest consumption of SLT was documented in Odisha (51.89%) and Himachal Pradesh (1.21%), respectively. Manipur (12.62%) and Puducherry (0.08%) had highest and lowest consumption of both. Overall, northeast states had relatively higher consumption of tobacco (Table 2, Fig. 1).

Nested multilevel regression modelling shows Model-4 to be the best fit model with significant p-value. Elderly participants had higher odds of consuming tobacco (any 1.23 (1.18–1.28), SM 1.99 (1.14–1.27), SLT 1.08 (1.03–1.14) and both 1.27 (1.14–1.40 times) than middle aged participants. Females, OBC, urban residence had lower odds in all the categories, while Muslims, widow/ separated/ divorced participants, having clerical and skilled occupation, poor self-rated health, having comorbidity and multimorbidity had higher odds. With decreasing in the wealth index, educational status and frequency of physical activity the odds of tobacco consumption increased. had higher odds. The odds of higher tobacco consumption was documented from northeast region (2.56 (2.37–2.76) higher than north). Alcohol consumption had the highest odds (4.94 (4.69–5.21)). Participants exposed to media had lower odds (11% lower) of consuming tobacco (Table 3, 4).

Overall, the socioeconomic inequalities in tobacco consumption among middle aged and elderly Indian adults were significantly distributed more among the poorest (any -0.064 (-0.072 to -0.056) and SLT -0.069 (-0.072 to -0.056)) (Fig. 2).

Discussion

This research documented distribution and determinants of tobacco consumption among middle aged and elderly Indian adults in LASI-1(2017–2018). Overall, 36.78% participants documented using any form of tobacco; with higher consumption of SLT (19.88%) than smoking/SM (13.92%). Only 2.98% consumed both. Tobacco consumption in all categories were higher among elderly than middle aged participants. These findings were much lower (SM = 28.6%, SLT = 23.5%, 45–60 years) than Global Adult Tobacco Survey (GATS)-2 (2016–2017) suggesting decreasing trend in this age group [6]. However, strikingly the percentage of smoker in the elderly age group, above 60 years of age is 15.38% is more as compared to the percentage reported in above 65 years group in GATS-2 (11.8%), highlighting the importance of focussing on the geriatric population in India in awareness and treatment-seeking process [6]. The percentage of tobacco consumption reported in the current study is otherwise lower as compared that documented in a study on tribal population (40–65 years) in India (48.1%) [22]. Community based researches documented the tobacco consumption ranging from 31 to 42% among elderly [23, 24].

Mizoram had the highest reported consumption of tobacco in any form (78.21%) and smoking (35.18%); while Punjab (11.36%) and Jharkhand (2.81%) had the lowest consumption of any form of tobacco and smoking, respectively. The highest and lowest consumption of SLT was documented in Odisha (51.89%) and Himachal Pradesh (1.21%), respectively. Manipur (12.62%) and Puducherry (0.08%) had highest and lowest consumption of both. Overall, northeast states had relatively higher consumption of tobacco, which is similar to the findings of GATS-2 [6]. Participants residing in northeast had the highest odds of tobacco consumption. Tobacco is mostly used in smokeless form in the northeast. Men over the age of 15 are more likely than women to consume tobacco (smokeless or smoked) at 47% vs 14% [25]. Patterns of tobacco use are influenced by historical background, cultural traditions, and local practices. In these areas, it is thus common to come across the use of smokeless tobacco (such as gutka, khaini, and zarda). The northeastern states continue to have a significant tobacco-related health burden despite the overall nationwide success in lowering tobacco use. Enforcing stricter tobacco laws is still essential for public health [26].

Table 1 Distribution of various factors as per tobacco consumption among middle aged and elderly Indian adults

Variables	Weighted proportion			
	Tobacco (any) (SM or SLT)	Smoking (SM)	Smokeless Tobacco (SLT)	Tobacco (both) (SM + SLT)
Demographic and socio-economic factors				
Age-group in years				
45–59 (middle aged)	33.82*	12.45*	18.70*	2.67*
≥60 (elderly)	39.72*	15.38*	21.06*	3.28*
Gender				
Male	57.58*	26.60*	24.93*	24.93*
Female	19.11*	3.14*	15.59*	15.59*
Religion				
Hindu	37.33*	14.06*	20.24*	3.03*
Muslim	39.13*	15.60*	20.46*	3.07*
Christian	28.52*	12.11*	14.06*	2.36*
Others	23.48*	6.79*	14.72*	1.97*
Caste				
Schedule caste	46.02*	17.86*	27.55*	3.60*
Schedule tribe	44.03*	14.41*	22.44*	3.17*
OBC	33.50*	12.72*	18.08*	2.68*
Others	34.21*	12.98*	18.60*	2.64*
Wealth index				
Poorest	38.95*	12.88*	22.88*	3.28
Poorer	40.19*	14.11*	23.30*	2.77
Middle	37.29*	14.45*	19.65*	3.17
Richer	36.89*	15.03*	18.71*	3.15
Richest	29.57*	13.11*	13.88*	2.57
Education				
Illiterate	46.08*	17.89*	23.13*	5.02*
Less than primary	41.06*	15.59*	21.33*	4.14*
Primary completed	41.02*	16.85*	20.65*	3.53*
Middle completed	36.79*	13.48*	20.81*	2.50*
Secondary school	30.48*	12.41*	15.57*	2.52*
Higher secondary	28.08*	10.19*	15.93*	1.96*
Diploma/ Graduate	19.05*	7.43*	10.26*	1.37*
Marital status				
Unmarried	31.62*	14.34*	16.68*	5.60*
Married/ in live -in	38.67*	15.67*	19.67*	3.32*
Widow/ separated/ divorced	38.20*	8.72*	20.66*	1.82*
Residence				
Rural	42.36*	15.83*	22.88*	3.64*
Urban	24.64*	9.77*	13.34*	1.53*
Health Insurance				
No	36.73	13.87*	19.89*	2.97
Yes	38.93	16.21*	19.63*	3.08
Occupation				
Unemployed	27.83*	9.97*	16.01*	1.84*
Professional and semi-professional	18.79*	7.82*	9.68*	1.29*
Clerical and skilled	48.02*	18.30*	25.16*	4.57*
Unskilled	46.43*	18.81*	23.77*	3.85*
Living alone				

Table 1 (continued)

Variables	Weighted proportion			
	Tobacco (any) (SM or SLT)	Smoking (SM)	Smokeless Tobacco (SLT)	Tobacco (both) (SM + SLT)
No	33.63*	9.22*	19.77	1.50*
Yes	36.90*	14.10*	22.91	3.03*
Region				
North	31.76*	24.56*	5.77*	1.45*
Central	40.67*	15.55*	21.03*	4.07*
East	46.63*	11.88*	29.40*	5.35*
Northeast	54.29*	11.75*	36.65*	5.88*
West	36.76*	8.21*	26.66*	1.88*
South	24.02*	13.30*	9.85*	0.86*
Health related factors				
Physical activity				
Never	47.17*	18.29*	24.65*	4.08*
1–3 times /month	45.02*	16.39*	23.82*	4.96*
Once / week	42.10*	15.21*	21.31*	5.58*
More than once / week	42.04*	17.15*	22.09*	2.83*
Everyday	31.40*	12.07*	17.17*	2.15*
Self-rated health				
Excellent	32.92*	13.88*	16.45*	2.59*
Very good	34.84*	12.42*	19.59*	2.83*
Good	35.37*	12.81*	19.73*	2.82*
Fair	38.57*	14.99*	20.65*	2.93*
Poor	42.82*	17.67*	21.27*	3.88*
Comorbidity				
No	34.65*	13.44*	18.49*	2.72*
Yes	41.35*	14.96*	22.86*	3.52*
Multimorbidity				
No	31.88*	12.81*	16.69*	2.38*
Yes	39.64*	14.57*	21.74*	3.32*
Behavioural factors				
Alcohol consumption				
No	29.20*	10.07*	17.50*	1.62*
Yes	79.89*	35.80*	33.42*	10.69*
Media exposure				
No	40.81*	14.95	22.63*	3.22
Yes	34.29*	13.29	18.18*	2.82
Overall	**36.78***	**13.92***	**19.88***	**2.98***

*Chi-square p-value <0.05

The bold values indicate to document the overall value

Higher age group (≥ 60 years) was a significant determinant (1.13 times higher) of tobacco consumption (any). It is in line with research utilising GATS and Global Youth Tobacco Survey (GYTS) on a nationally representative sample, which found that tobacco consumption was highest among people over 45 years [27, 28]. Females had much lower odds (0.23 (0.22–0.24)) of tobacco consumption than males; which was even lower in SM (0.11 (0.10–0.12)) than SLT (0.80 (0.76–0.84)). These variations might be attributed to a confluence of behavioural patterns, cultural influences, and physiological reasons. According to neuroimaging research, smoking stimulates men's reward circuits more than women's, suggesting that males smoke for the psychological benefits of nicotine whereas women smoke to control their mood or in reaction to stimuli associated

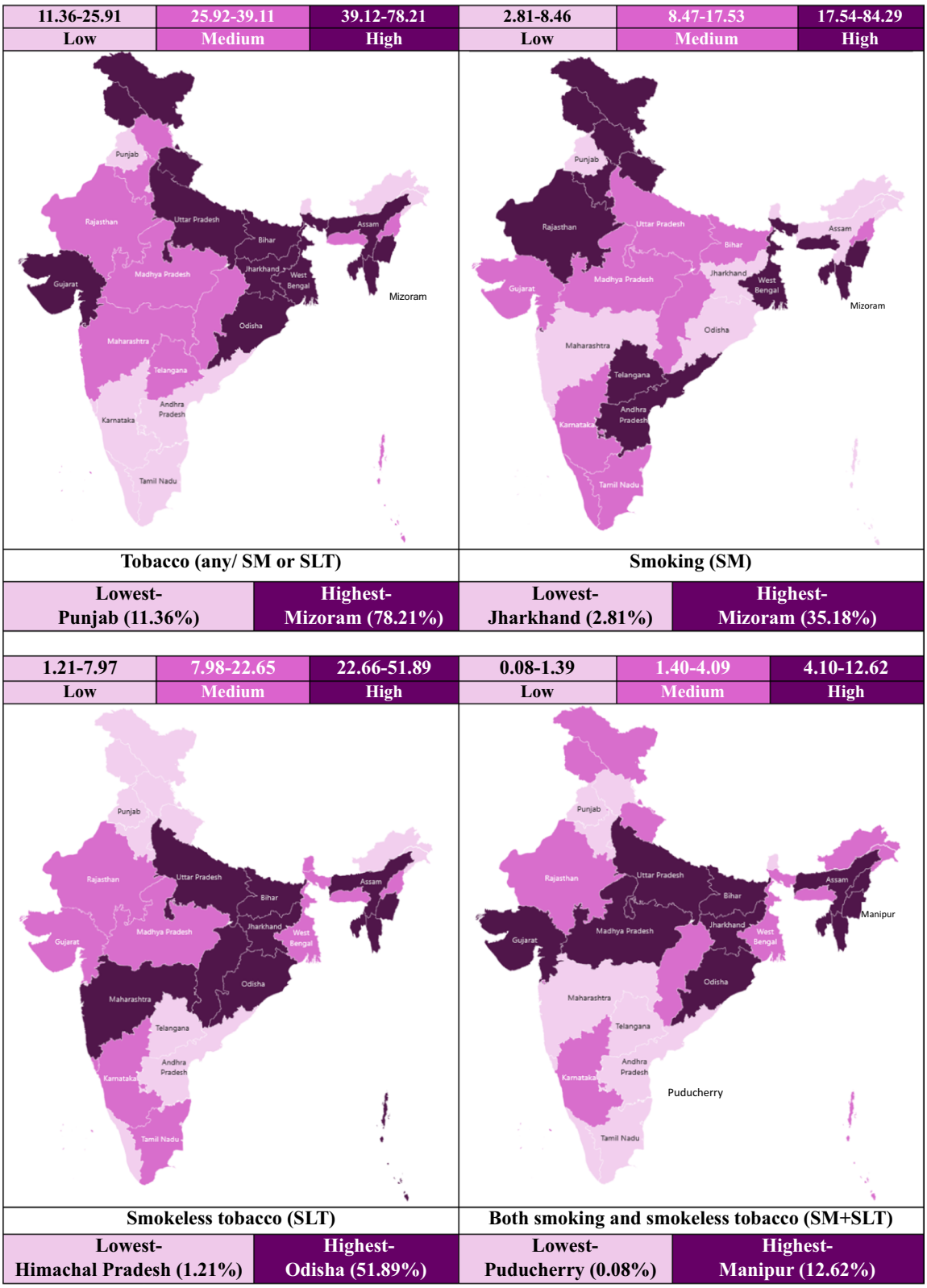

Fig. 1 State/Union Territory wise distribution of tobacco consumption (%)

Table 2 State/ union territory wise distribution of tobacco consumption among middle aged and elderly Indian adults (*Chi-square p-value < 0.05)

Variables	Weighted proportion			
	Tobacco (any) (SM or SLT)	Smoking (SM)	Smokeless Tobacco (SLT)	Tobacco (both) (SM + SLT)
North				
Chandigarh	21.41 (L)	15.71 (M)	4.22 (L)	1.49 (M)
Delhi	20.60 (L)	14.59 (M)	4.88 (L)	1.12 (L)
Haryana	36.94 (M)	34.60 (H)	2.00 (L)	0.44 (L)
Himachal Pradesh	33.39 (M)	31.56 (H)	1.21 (L)	0.66 (L)
Jammu & Kashmir	39.86 (H)	30.68 (H)	6.92 (L)	2.21 (M)
Punjab	11.36 (L)	6.04 (L)	3.92 (L)	1.38 (L)
Rajasthan	37.40 (M)	27.07 (H)	8.49 (M)	1.84 (M)
Uttarakhand	42.22 (H)	32.90 (H)	7.44 (L)	1.89 (M)
Central				
Chhattisgarh	36.05 (M)	10.57 (M)	24.07 (H)	1.41 (M)
Madhya Pradesh	36.90 (M)	15.99 (M)	16.22 (M)	4.70 (H)
Uttar Pradesh	43.56 (H)	16.12 (M)	23.27 (H)	4.15 (H)
East				
Bihar	41.77 (H)	9.64 (M)	27.29 (H)	4.83 (H)
Jharkhand	39.86 (H)	2.81 (L)	32.77 (H)	4.27 (H)
Odisha	65.16 (H)	3.02 (L)	51.89 (H)	10.26 (H)
West Bengal	44.28 (H)	20.39 (H)	20.05 (M)	3.84 (M)
North-East				
Arunachal Pradesh	18.16 (L)	8.44 (L)	6.27 (L)	3.45 (M)
Assam	56.54 (H)	7.51 (L)	43.82 (H)	5.21 (H)
Manipur	57.55 (H)	17.87 (H)	27.06(H)	12.62 (H)
Meghalaya	37.50 (M)	20.23 (H)	15.67 (M)	1.59 (M)
Mizoram	78.21 (H)	35.18 (H)	31.73 (H)	11.30 (H)
Nagaland	27.05 (M)	8.53 (M)	10.69 (M)	7.83 (H)
Sikkim	17.45 (L)	6.99 (L)	9.13 (M)	1.33 (L)
Tripura	71.22 (H)	28.52 (H)	35.54 (H)	7.16 (H)
West				
Dadra and Nagar Haveli	38.22 (M)	10.78 (M)	22.96 (H)	4.49 (H)
Daman and Diu	22.93 (L)	7.92 (L)	13.22 (M)	1.78 (M)
Goa	17.73 (L)	6.69 (L)	10.33 (M)	0.71 (L)
Gujarat	39.35 (H)	13.35 (M)	21.46 (M)	4.54 (H)
Maharashtra	35.78 (M)	5.86 (L)	29.24 (H)	0.66 (L)
South				
Andaman & NicobarIslands	34.91 (M)	6.82 (L)	24.68 (H)	3.42 (M)
Andhra Pradesh	25.74 (L)	18.28 (H)	6.77 (L)	0.69 (L)
Karnataka	25.42 (L)	9.00 (M)	14.93 (M)	1.49 (M)
Kerala	20.30 (L)	16.26 (M)	3.14 (L)	0.90 (L)
Lakshadweep	29.26 (M)	7.44 (L)	19.60 (M)	2.23 (M)
Puducherry	13.24 (L)	5.54 (L)	7.62 (L)	0.08 (L)
Tamil Nadu	21.51 (L)	13.04 (M)	8.10 (M)	0.37 (L)
Telangana	26.57 (M)	18.22 (H)	7.94 (L)	0.41 (L)
India	36.78	13.92	19.88	2.98

*Chi-square p-value < 0.05

Table 3 Nested multilevel regression of tobacco consumption (any) among middle aged and elderly Indian adults with various demographic, socioeconomic, health related and behavioural determinants (* p-value < 0.05)

Characteristics	Tobacco consumption			
	Model-1	Model-2	Model-3	Model-4
	Tobacco (any) (SM or SLT)	Smoking (SM)	Smokeless Tobacco (SLT)	Tobacco (both) (SM + SLT)
Age group (years)				
45–59	Reference	Reference	Reference	Reference
≥60	1.19 (1.15–1.23)*	1.19 (1.14–1.23)*	1.16 (1.12–1.21)*	1.23 (1.18–1.28)*
Gender				
Male	Reference	Reference	Reference	Reference
Female	0.20 (0.19–0.21)*	0.16 (0.15–0.16)*	0.15 (0.14–0.16)*	0.23 (0.22–0.24)*
Demographic and socioeconomic factors				
Religion				
Hindu		Reference	Reference	Reference
Muslim		1.31 (1.24–1.39)*	1.31 (1.24–1.39)*	1.76 (1.66–1.86)*
Christian		0.57 (0.54–0.63)*	0.58 (0.54–0.63)*	0.59 (0.55–0.64)*
Others		0.32 (0.30–0.36)*	0.33 (0.30–0.37)*	0.30 (0.27–0.33)*
Caste				
Schedule caste		Reference	Reference	Reference
Schedule tribe		0.91 (0.86–0.98)*	0.93 (0.87–0.99)*	0.78 (0.73–0.84)*
OBC		0.67 (0.64–0.72)*	0.68 (0.65–0.72)*	0.70 (0.66–0.74)*
Others		0.74 (0.69–0.78)*	0.74 (0.70–0.79)*	0.76 (0.72–0.81)*
Wealth index				
Richest		Reference	Reference	Reference
Richer		1.08 (1.03–1.16)*	1.09 (1.04–1.17)*	1.09 (1.04–1.18)*
Middle		1.09 (1.02–1.15)*	1.10 (1.03–1.16)*	1.10 (1.04–1.17)*
Poorer		1.11 (1.05–1.18)*	1.12 (1.05–1.19)*	1.12 (1.04–1.19)*
Poorest		1.03 (0.97–1.10)	1.04 (0.98–1.10)	1.01 (0.93–1.05)
Education				
Illiterate		Reference	Reference	Reference
Less than primary		0.89 (0.82–0.95)*	0.89 (0.82–0.96)*	0.91 (0.81–0.99)*
Primary completed		0.84 (0.79–0.89)*	0.84 (0.79–0.89)*	0.87 (0.82–0.92)*
Middle completed		0.76 (0.71–0.81)*	0.76 (0.71–0.81)*	0.78 (0.73–0.84)*
Secondary school		0.50 (0.47–0.54)*	0.50 (0.47–0.54)*	0.51 (0.48–56)*
Higher secondary		0.43 (0.39–0.47)*	0.43 (0.39–0.47)*	0.45 (0.41–0.49)*
Diploma/ Graduate		0.29 (0.27–0.33)*	029 (0.27–0.33)*	0.31 (0.28–0.35)*
Marital status				
Unmarried		Reference	Reference	Reference
Married/ in live -in		1.11 (0.94–1.31)	1.11 (0.94–1.31)	1.03 (0.86–1.22)
Widow/ separated/ divorced		1.46 (1.23–1.74)*	1.46 (1.23–1.74)*	1.34 (1.12–1.60)*
Residence				
Rural		Reference	Reference	Reference
Urban		0.70 (0.68–0.74)*	0.74 (0.71–0.77)*	0.72 (0.69–0.76)*
Health Insurance				
No		Reference	Reference	Reference
Yes		1.01 (0.89–1.13)	1.02 (0.90–1.15)	0.96 (0.85–1.10)
Occupation				
Unemployed		Reference	Reference	Reference
Professional and semi-professional		1.06 (0.93–1.20)	1.06 (0.93–1.20)	1.05 (0.92–1.20)
Clerical and skilled		1.39 (1.33–1.46)*	1.34 (1.27–1.41)*	1.32 (1.25–1.39)*
Unskilled		1.41 (1.34–1.48)*	1.36 (1.29–1.43)*	1.26 (1.20–1.33)*
Living alone				
No		Reference	Reference	Reference

Table 3 (continued)

Characteristics	Tobacco consumption			
	Model-1	**Model-2**	**Model-3**	**Model-4**
	Tobacco (any) (SM or SLT)	**Smoking (SM)**	**Smokeless Tobacco (SLT)**	**Tobacco (both) (SM + SLT)**
Yes		0.94 (0.85–1.05)	0.94 (0.84–1.04)	0.95 (0.86–1.07)
Region				
North		Reference	Reference	Reference
Central		1.27 (1.19–1.36)*	1.26 (1.17–1.35)*	1.36 (1.27–1.46)*
East		1.82 (1.71–1.94)*	1.78 (1.67–1.90)*	1.81 (1.70–1.93)*
Northeast		2.34 (2.17–1.94)*	2.42 (2.24–2.60)*	2.56 (2.37–2.76)*
West		1.11 (1.04–1.19)*	1.17 (1.09–1.25)*	1.13 (1.05–1.21)*
South		0.69 (0.65–0.73)*	0.70 (0.66–0.75)*	0.65 (0.61–0.69)*
Health related factors				
Physical activity				
Everyday			Reference	Reference
More than once / week			1.17 (1.11–1.22)*	1.11 (1.06–1.17)*
Once / week			1.19 (1.11–1.28)*	1.13 (1.05–1.22)*
1–3 times /month			1.25 (1.14–1.37)*	1.20 (1.09–1.33)*
Never			1.27 (1.17–1.38)*	1.22 (1.12–1.33)*
Self-rated health				
Excellent			Reference	Reference
Very good			1.01 (0.91–1.11)	0.97 (0.88–1.08)
Good			1.06 (0.96–1.17)	1.00 (0.91–1.11)
Fair			1.42 (1.27–1.56)*	1.34 (1.21–1.49)*
Poor			1.73 (1.55–1.94)*	1.61 (1.44–1.81)*
Comorbidity				
No			Reference	Reference
Yes			1.05 (0.99–1.11)	1.04 (0.98–1.10)
Multimorbidity				
No			Reference	Reference
Yes			1.10 (1.04–1.16)*	1.12 (1.05–1.19)*
Behavioural factors				
Alcohol consumption				
No				Reference
Yes				4.94 (4.69–5.21)*
Media Exposure				
No				Reference
Yes				0.89 (0.86–0.93)*
Pseudo R^2	0.1053	0.1769	0.1818	0.2272
LL	−38,455.3	−35,375.1	−35,165.9	−33,215.3
LR	9048.97	6160.39	418.44	3901.19
p-value	< 0.001	< 0.001	< 0.001	< 0.001
AIC	76,916.58	70,814.19	70,415.76	66,518.56
BIC	76,943.86	71,105.16	70,797.65	66,918.64

Model 1- Association tobacco consumption (outcome variable) with age group and gender

Model 2- 1 + Demographic and socioeconomic factors (religion, caste, wealth index, education, marital status, residence, health insurance, occupation, living alone and region)

Model 3- Model 2 + Health related factors (physical activity, self-rated health, comorbidity and multimorbidity)

Model 4- Model 3 + Behavioural factors (alcohol consumption, media exposure)

* p-value < 0.05 = significant

CI = Confidence Interval, LL = Log-likelihood, LR = Likelihood Ratio, AIC = Akaike Information Criterion and BIC = Bayesian Information Criterion

Classification accuracy = 75.48%

Table 4 Nested multilevel regression of tobacco consumption (any, smoking, smokeless tobacco and both) among middle aged and elderly Indian adults with various demographic, socioeconomic, health related and behavioural determinants (* p-value < 0.05)

	Characteristics	Tobacco consumption (Model-4)			
		Tobacco (any) (SM or SLT)	Smoking (SM)	Smokeless Tobacco (SLT)	Tobacco (both) (SM + SLT)
		Odds ratio (95% CI)	Odds ratio (95% CI))	Odds ratio (95% CI)	Odds ratio (95% CI)
Demographic and socio-economic factors	Age group (years)				
	45–59 (middle aged)	Reference	Reference	Reference	Reference
	≥60 (elderly)	1.23 (1.18–1.28)*	1.99 (1.14–1.27)*	1.08 (1.03–1.14)*	1.27 (1.14–1.40)*
	Gender				
	Male	Reference	Reference	Reference	Reference
	Female	0.23 (0.22–0.24)*	0.11 (0.10–0.12)*	0.80 (0.76–0.84)*	0.14 (0.12–0.16)*
	Religion				
	Hindu	Reference	Reference	Reference	Reference
	Muslim	1.76 (1.66–1.86)*	1.47 (1.36–1.59)*	1.44 (1.34–1.54)*	1.90 (1.62–2.22)*
	Christian	0.59 (0.55–0.64)*	1.18 (1.07–1.31)*	0.44 (0.40–0.49)*	1.17 (0.98–1.39)
	Others	0.30 (0.27–0.33)*	0.22 (0.19–0.25)*	0.65 (0.58–0.73)*	0.78 (0.61–0.98)*
	Caste				
	Schedule caste	Reference	Reference	Reference	Reference
	Schedule tribe	0.78 (0.73–0.84)*	0.76 (0.68–0.81)*	0.97 (0.90–1.04)	0.94 (0.80–1.11)
	OBC	0.70 (0.66–0.74)*	0.75 (0.72–0.83)*	0.82 (0.77–0.87)*	0.86 (0.75–0.99)*
	Others	0.76 (0.72–0.81)*	0.88 (0.82–0.95)*	0.82 (0.76–0.87)*	0.94 (0.81–1.10)
	Wealth index				
	Richest	Reference	Reference	Reference	Reference
	Richer	1.09 (1.04–1.18)*	1.14 (1.06–1.23)*	0.93 (0.87–0.99)*	0.91 (0.78–1.05)
	Middle	1.10 (1.04–1.17)*	1.19 (1.10–1.29)*	0.83 (0.7–0.89)*	1.18 (1.02–1.36)*
	Poorer	1.12 (1.04–1.19)*	1.21 (1.12–1.31)*	0.94 (0.88–1.01)	1.31 (1.13–1.51)*
	Poorest	1.01 (0.93–1.05)	1.15 (1.06–1.25)*	1.05 (0.98–1.12)	1.37 (1.17–1.60)*
	Education				
	Illiterate	Reference	Reference	Reference	Reference
	Less than primary	0.91 (0.81–0.99)*	0.93 (0.86–1.01)	1.04 (0.98–1.13)	1.03 (0.96–1.18)
	Primary completed	0.87 (0.82–0.92)*	0.72 (0.67–0.77)*	1.02 (0.99–1.12)	1.05 (0.92–1.20)
	Middle completed	0.78 (0.73–0.84)*	0.69 (0.64–0.75)*	0.98 (0.91–1.06)	0.95 (0.81–1.11)
	Secondary school	0.51 (0.48–56)*	0.47 (0.43–0.52)*	0.86 (0.79–0.94)*	0.69 (0.57–0.83)*
	Higher secondary	0.45 (0.41–0.49)*	0.44 (0.38–0.50)*	0.82 (0.73–0.93)*	0.51 (0.39–0.67)*
	Diploma/ Graduate	0.31 (0.28–0.35)*	0.33 (0.29–0.38)*	0.59 (0.52–0.67)*	0.49 (0.37–0.63)*
	Marital status				
	Unmarried	Reference	Reference	Reference	Reference
	Married/ in live -in	1.03 (0.86–1.22)	0.96 (0.77–1.20)	1.13 (0.92–1.39)	0.81 (0.56–1.19)*
	Widow/ separated/ divorced	1.34 (1.12–1.60)*	0.99 (0.79–1.24)	1.56 (1.27–1.92)*	0.97 (0.66–1.43)
	Residence				
	Rural	Reference	Reference	Reference	Reference
	Urban	0.72 (0.69–0.76)*	0.82 (0.78–0.87)*	0.77 (0.73–0.81)*	0.76 (0.68–0.86)*
	Health Insurance				
	No	Reference	Reference	Reference	Reference
	Yes	0.96 (0.85–1.10)	1.01 (0.87–1.18)	1.01 (0.86–1.18)	0.89 (0.66–1.21)
	Occupation				
	Unemployed	Reference	Reference	Reference	Reference
	Professional and semi-professional	1.05 (0.92–1.20)	0.93 (0.79–1.11)	1.12 (0.94–1.32)	1.18 (0.85–1.64)
	Clerical and skilled	1.32 (1.25–1.39)*	1.05 (0.99–1.13)	1.37 (1.29–1.45)*	1.22 (1.07–1.38)*
	Unskilled	1.26 (1.20–1.33)*	1.12 (1.04–1.09)*	1.24 (1.16–1.32)*	1.16 (1.02–1.33)*
	Living alone				
	No	Reference	Reference	Reference	Reference

Table 4 (continued)

	Characteristics	Tobacco consumption (Model-4)			
		Tobacco (any) (SM or SLT)	Smoking (SM)	Smokeless Tobacco (SLT)	Tobacco (both) (SM + SLT)
		Odds ratio (95% CI)	Odds ratio (95% CI))	Odds ratio (95% CI)	Odds ratio (95% CI)
	Yes	0.95 (0.86–1.07)	0.93 (0.79–1.09)	1.02 (0.91–1.15)	0.71 (0.51–1.02)
	Region				
	North	Reference	Reference	Reference	Reference
	Central	1.36 (1.27–1.46)*	0.40 (0.37–0.44)*	4.51 (4.09–5.00)*	2.60 (2.12–3.19)*
	East	1.81 (1.70–1.93)*	0.20 (0.19–0.22)*	7.53 (6.85–8.28)*	4.39 (3.66–5.26)*
	Northeast	2.56 (2.37–2.76)*	0.43 (0.39–0.48)*	7.56 (6.82–8.38)*	4.67 (3.84–5.66)*
	West	1.13 (1.05–1.21)*	0.25 (0.23–0.27)*	5.33 (4.82–5.89)*	1.59 (1.27–1.98)*
	South	0.65 (0.61–0.69)*	0.37 (0.34–0.40)*	2.16 (1.95–2.39)*	0.79 (0.64–0.99)*
Health related factors	Physical activity				
	Everyday	Reference	Reference	Reference	Reference
	More than once / week	1.11 (1.06–1.17)*	0.95 (0.84–1.10)	1.17 (1.12–1.25)*	1.01 (0.90–1.13)
	Once / week	1.13 (1.05–1.22)*	1.02 (0.93–1.11)	1.09 (1.01–1.19)*	1.08 (0.92–1.27)
	1–3 times /month	1.20 (1.09–1.33)*	0.98 (0.86–1.11)	1.17 (1.05–1.31)*	1.24 (1.01–1.54)*
	Never	1.22 (1.12–1.33)*	1.13 (1.02–1.26)*	1.18 (1.07–1.30)*	0.97 (0.78–1.19)
	Self-rated health				
	Excellent	Reference	Reference	Reference	Reference
	Very good	0.97 (0.88–1.08)	0.97 (0.84–1.10)	0.99 (0.88–1.12)	1.00 (0.76–1.32)
	Good	1.00 (0.91–1.11)	1.00 (0.88–1.14)	1.00 (0.89–1.12)	0.98 (0.75–1.27)
	Fair	1.34 (1.21–1.49)*	1.36 (1.20–1.56)*	1.13 (1.01–1.27)*	1.08 (0.82–1.41)
	Poor	1.61 (1.44–1.81)*	1.53 (1.33–1.77)*	1.22 (1.07–1.39)*	1.54 (1.15–2.05)*
	Comorbidity				
	No	Reference	Reference	Reference	Reference
	Yes	1.04 (0.98–1.10)	1.06 (0.99–1.14)	1.03 (0.97–1.10)	0.90 (0.79–1.03)
	Multimorbidity				
	No	Reference	Reference	Reference	Reference
	Yes	1.12 (1.05–1.19)*	1.05 (0.97–1.13)*	1.07 (1.01–1.15)*	1.15 (0.99–1.35)
Behavioural factors	Alcohol consumption				
	No	Reference	Reference	Reference	Reference
	Yes	4.94 (4.69–5.21)*	2.52 (2.38–2.68)*	1.85 (1.74–1.95)*	1.27 (1.15–1.41)*
	Media Exposure				
	No	Reference	Reference	Reference	Reference
	Yes	0.89 (0.86–0.93)*	0.92 (0.87–0.96)*	0.92 (0.87–0.96)*	0.94 (0.86–1.03)
	Pseudo R^2	0.2272	0.2202	0.1062	0.2095
	LL	−33,215.3	−21,443.4	−27,773.1	−7491.13
	LR	3901.19	1073.48	471.02	760.44
	p-value	< 0.001	< 0.001	< 0.001	< 0.001
	AIC	66,518.56	42,974.83	55,634.13	15,070.26
	BIC	66,918.64	43,374.91	56,034.21	15,470.34
	Classification accuracy	75.48%	86.09%	81.97%	96.72%

Model 1- Association tobacco consumption (outcome variable) with age group and gender

Model 2- 1 + Demographic and socioeconomic factors (religion, caste, wealth index, education, marital status, residence, health insurance, occupation, living alone and region)

Model 3- Model 2 + Health related factors (physical activity, self-rated health, comorbidity and multimorbidity)

Model 4- Model 3 + Behavioural factors (alcohol consumption, media exposure)

* p-value < 0.05 = significant

CI = Confidence Interval, LL = Log-likelihood, LR = Likelihood Ratio, AIC = Akaike Information Criterion and BIC = Bayesian Information Criterion

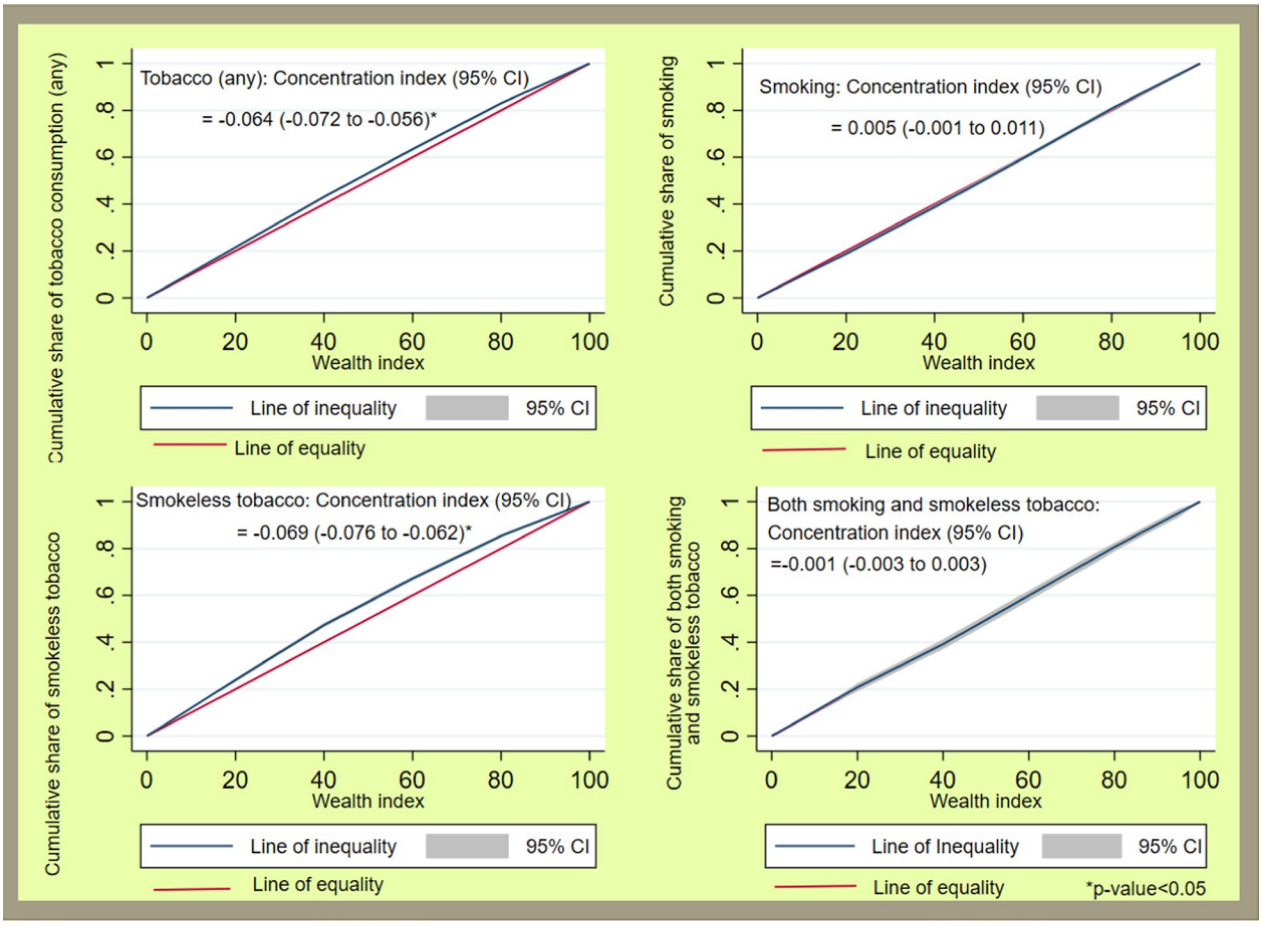

Fig. 2 Concentration curve showing socioeconomic inequalities of tobacco consumption among middle aged and elderly Indian adults

with cigarettes. Women may also have stronger cravings than males do in reaction to stress, which may make it harder for them to stop smoking. In smoking cessation attempts, it is important to address these gender-specific factors [29].

Under other demographic and socioeconomic factors, higher odds of tobacco consumption were associated with Muslims, decreasing wealth index, widow/ separated/ divorced, clerical and skilled occupation. This is probably due to economic constrains, higher stress and coping mechanism, sociocultural norms, accessibility and marketing, lower knowledge, attitude and public health awareness [30]. Lower odds of tobacco consumption was associated with higher education status, urban residence. People with higher levels of education can be thought to be more aware and thus, more conscious of the dangers smoking poses to one's health. Learning to think critically helps people make educated judgements regarding their health-related behaviours. Raising awareness, anti-smoking programmes frequently target educated groups. Healthcare, particularly programmes to help people quit smoking, is more easily accessible in urban locations. Reduced tobacco consumption may result from urban lifestyles that place a higher priority on health consciousness. Social norms in urban areas may have an impact on behaviour by discouraging smoking [31]. Multiple other studies documented similar inference in various throughout various age group [27, 28, 32].

Under health-related factors lower frequency of physical activity, poor self-rated health, comorbidity and multimorbidity was positively associated with tobacco consumption. Smoking is associated with a decrease in physical stamina. Tobacco smoke contains carbon monoxide, which replaces oxygen in the blood and impairs muscular performance and endurance.

Shortness of breath is a common symptom of smoking during strenuous activity. While smoking might lessen the desire for cigarettes, smokers often engage in less physical activity [33]. When compared to nonsmokers, smokers often rank their health poorer. SRH and smoking have different relationships depending on age and gender. Teenagers who start smoking at an early age tend

to assess their own health lower [34]. Comorbid chronic illnesses like diabetes, heart problems, hypertension, and chronic obstructive pulmonary disease (COPD) are made worse by tobacco use. Smokers are more prone to problems from various ailments, including mental disorders [35].

Under behavioural factors, Alcohol consumption was positively associated, where media exposure was negatively associated with tobacco consumption. When combined, nicotine and alcohol may have different effects on the same brain systems. They could be associated because of this mutual influence [36]. The results of studies on the connection between drinking and smoking have been conflicting. Heavy drinking seems to have a detrimental influence on lung function, despite other research suggesting that moderate alcohol use may improve lung function [37]. It is difficult to draw firm findings since smoking has a confounding effect and there is no standard method for quantifying alcohol intake. Research from population surveys and controlled field tests demonstrates that anti-tobacco mass media campaigns can influence young people's perceptions of tobacco use, prevent kids from starting to smoke, and support adult quitting [38].

Strengths and limitations

The strength of our study is it's higher generalisability due to inclusion of large nationally representative data. Coming to the limitations, due to self-reporting style of questionnaire there is high chance of recall bias, misclassification bias, social desirability bias; which might contribute to deviation from actual pragmatic scenario. We were unable to measure the lifetime consumption of tobacco due to unavailability of data. Being a cross-sectional study, temporality could not be established.

Overall, the socioeconomic inequalities in tobacco consumption among middle aged and elderly Indian adults were significantly distributed more among the poorest (any -0.064 (-0.072 to -0.056) and SLT -0.069 (-0.072 to -0.056)). Similar findings were documented by different studies.[39, 40]. Tobacco purchases divert funds from the impoverished towards essential needs including food, housing, healthcare, and education. Compared to wealthy households, tobacco is the primary expense for poorer households. Tobacco costs can occasionally surpass those for healthcare or education. Smokers have an increased chance of getting sick and passing away too soon from illnesses linked to tobacco use. Families may lose out on much-needed money as a result, and their medical expenses may rise. When the primary earner has a disease brought on by tobacco smoking, the family's capacity to afford necessities is jeopardised. Therefore, tobacco consumption poverty by taking money away from necessities and putting a strain on health-related expenses [41].

Policy and clinical implication

The Cigarettes and Other Tobacco Products Act was adopted by the Indian government in 2003 with the aim of regulating the production, distribution, sale, and supply of tobacco products. Following that, in 2007–8, the National Tobacco Control Programme (NTCP) was introduced. The NTCP has made district-level cessation facility establishment and improvement a top priority. The NTCP is implemented using a three tier structure. These three are located at the federal level: the State Tobacco Control Cell, the District Tobacco Control Cell, and the National Tobacco Control Cell. Furthermore, tobacco prevention programmes might be established at the district level with special focus to northeastern states [42].

Tobacco consumption has remained a significant issue though 1.5 decades have been passed, due to poor laws and policies being implemented and communicated. A number of policy proposals are also made in the report. First and foremost, a broader public awareness campaign is needed to highlight the harm that tobacco smoking causes. By combining tobacco cessation programmes with health and development initiatives, barriers to tobacco control may be addressed and the burden brought on by tobacco use can be decreased. Effective educational initiatives that raise public awareness of the health risks associated with tobacco use may be beneficial in the battle against tobacco use cessation [43, 44]. We recommend evidence-based community level pragmatic trials with multiple controlled follow ups to draw more scientific inference.

Recommendations

As a result, in order to create policies that effectively reduce tobacco use, it is imperative to take into account the variables that influence tobacco exposure. Tobacco use in India needs to be reduced, but policies that improve access to cessation counselling and increase knowledge of these interventions are still needed. Public health initiatives should be put into place to raise awareness of the detrimental effects of tobacco use on health at the local level in order to fully address this issue.

Conclusion

This study documented higher prevalence of tobacco consumption in any forms and in all the categories, was associated with higher age-group, male and residing in northeast region. This study emphasizes the imperative

to target elderly in rural areas who are widowed, separated, or unmarried, possess low socioeconomic and educational status, live alone, experience depression, engage in alcohol consumption, and exhibit poor overall health. Within this demographic, the ready accessibility of both smoke and smokeless tobacco products is a concerning factor. Initiatives aimed at preventing and ceasing tobacco smoking should prioritize these specific population groups, given their heightened susceptibility to tobacco use.

Abbreviations

LASI	Longitudinal aging study in India
SM	Smoking
SLT	Smokeless tobacco
LMICs	Low-and middle-income countries
GATS	Global Adult Tobacco Survey
OSMF	Oral submucous fibrosis
SC	Scheduled caste
ST	Scheduled tribe
OBC	Other backward castes
ICMR	Indian Council of Medical Research
CECHR	Central Ethics Committee on Human Research
SRH	Self rated health
COPD	Chronic obstructive pulmonary disease
NTCP	Tobacco Control Programme

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Author contributions
PH- Conceptualization, Methodology, Resources, Data Curation, Writing- Review and editing, Visualization, Supervision., AC- Conceptualization, Methodology, Resources, Data Curation, Writing- Review and editing, SR- Conceptualization, Methodology, Resources, Data Curation, Writing- Review and editing, SS- Conceptualization, Methodology, Resources, Data Curation, Writing- Review and editing.

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Availability of data and materials
The study utilizes nationally representative LASI survey data, which is publicly accessible and can be obtained by registering at https://iipsindia.ac.in/sites/default/files/LASI_DataRequestForm_0.pdf. The processed data can be provided by the corresponding author (Dr. Pritam Halder) upon request.

Declarations

Ethics approval and consent to participate
Being a secondary analysis of a dataset freely available in the public domain, ethical approval for the present study was not deemed necessary. However, the ethical approval to conduct LASI was given by the Indian Council of Medical Research's (ICMR) Central Ethics Committee on Human Research (CECHR).

Consent to Participate
Not applicable.

Competing interests
The authors declare no competing interests.

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