

RESEARCH

Open Access



# Changes in prevalence of alcohol and tobacco consumption across districts of India, 2016 and 2021

Sunil Rajpal<sup>1,2</sup>, Abhishek Kumar<sup>1,2</sup>, Shreya Ronanki<sup>2</sup>, Nehantha Sathesh<sup>2</sup>, Rockli Kim<sup>3,4\*</sup> and S. V. Subramanian<sup>4,5</sup>

## Abstract

**Background** India witnessed a rise in alcohol and tobacco consumption in the last few decades. However, the burden varies because of the huge population, diverse socioeconomic, cultural, and geographical characteristics, and different liquor policies across states. To understand the burden and progress, it is crucial to examine the consumption patterns at smaller geographical units. This study examines the trends and patterns in alcohol and tobacco consumption across 720 districts nested within 36 states (Union Territories) between 2016 and 2021.

**Methods** We used the fourth (2015–16) and fifth (2019–21) rounds of the National Family Health Survey of India. Both rounds provide the district-representative sample for the estimation. We used a 4-level (level 1-individuals; level 2-clusters; level 3-districts; level 4-states) random effects model to compute the predicted probabilities of alcohol and tobacco consumption (among males and females) for 720 districts in India. We used decile positions to map the consumption prevalence across districts.

**Results** Between 2016 and 2021, alcohol and tobacco consumption among men in India declined significantly, with national alcohol usage dropping from 29.2% to 17.5% and tobacco from 44.5% to 32.6%. The variation attributable to states for both alcohol (40.5% in 2016 and 56.6% in 2021) and tobacco (58% in 2016 and 68.3% in 2021) consumption among men was higher in 2021 as compared to 2016. The consumption of both tobacco and alcohol was notably high in the north-eastern states among both men and women. More than 80% of the districts reported a moderate to high reduction in alcohol consumption for men between the two rounds.

**Conclusions** The national decline in tobacco and alcohol consumption indicates progress. However, there remains a need for continuous and targeted interventions to target high-consumption pockets and address geographic disparities. The results of the present study indicate that interventions focusing on changing tobacco and alcohol consumption should consider the geographical variation at smaller administrative units. By implementing evidence-based policies and interventions suited to the needs of the local areas, public health authorities can continue to make significant strides in improving the health and well-being of the population and reducing the burden of alcohol and tobacco-related diseases.

**Keywords** Alcohol, Tobacco, India, District-level consumption, Risk factors

\*Correspondence:

Rockli Kim

rocklikim@korea.ac.kr

Full list of author information is available at the end of the article



© The Author(s) 2025. **Open Access** This article is licensed under a Creative Commons Attribution 4.0 International License, which permits use, sharing, adaptation, distribution and reproduction in any medium or format, as long as you give appropriate credit to the original author(s) and the source, provide a link to the Creative Commons licence, and indicate if changes were made. The images or other third party material in this article are included in the article's Creative Commons licence, unless indicated otherwise in a credit line to the material. If material is not included in the article's Creative Commons licence and your intended use is not permitted by statutory regulation or exceeds the permitted use, you will need to obtain permission directly from the copyright holder. To view a copy of this licence, visit <http://creativecommons.org/licenses/by/4.0/>.

## Background

Over four decades ago, the 32nd World Health Assembly took explicit cognizance of the problems related to excessive consumption of alcohol and tobacco and identified it as a major public health problem [1]. Findings from recent studies have observed that any amount of alcohol and tobacco consumption is significantly associated with an increased likelihood of chronic ailments (mainly cancer and heart diseases) [2, 3]. A large proportion of diseases and deaths in South Asia are associated with problematic patterns of alcohol and tobacco consumption (smoked and smokeless) [4]. The consumption patterns are complex to understand in developing countries like India due to its huge population base and diverse characteristics across population sub-groups based on geography, social environment (deprivation, social capital, and income inequality), and cultural factors [5, 6]. For example, alcohol consumption in India varies considerably across religions and social castes. India's alcohol and tobacco policies and administrative regulations have historically varied across states with limited national-level coordination [5, 7]. During 2016–2021, several states such as Tamil Nadu and Haryana introduced policies to restrict consumption but were forced to revoke them due to fiscal concerns and increased illicit alcohol use and distribution [7]. Further, geographical administrative units in India are categorized into three layers: states, districts, and villages. While policies and regulations are designed at the state level (based on the burden across states), they can mask the variations between districts within states. Studies have found significant inter-district and intra-district variations within the larger geographies for several outcomes like child undernutrition, child vaccination, and multidimensional poverty [8–10]. Examining the overtime trends and patterns in consumption for smaller administrative units (districts) can offer a better and more comprehensive understanding of the burden.

Interestingly, alcohol and tobacco use among females has increased in India, and future generations are anticipated to experience a relatively higher burden of non-communicable diseases (NCDs) among females [11–13]. The situation can be alarming, keeping in mind the risks pertaining to its effects on maternal and child health-related consequences [14]. Across geographies, regional variations have been observed in alcohol consumption in India, with the highest burden in the states of North-east, Chhattisgarh, Telangana, Himachal Pradesh, Punjab, and Jharkhand [15]. Further, demographic patterning shows that the age at initiation of alcohol and tobacco consumption is decreasing, with more and more younger groups being exposed to these risk factors [16]. Furthermore, younger age groups are found to be more likely to consume multiple substances (alcohol and tobacco),

and hence are more prone to increased risk of hypertension and other chronic ailments, including mental health issues, in India [17].

Evidence from previous studies points towards a limited success of alcohol control policies and programs, in terms of reducing the consumption burden and its associated impact in India [18]. While policy targeting (and administrative focus) in the case of alcohol and tobacco consumption is mostly state-oriented, it is critical to understand the intricacies at the district level. Examining the burden and overtime changes in consumption patterns can offer valuable insights to enhance the policy targeting strategies.

Further, it is imperative from the policy standpoint to assess the burden of multiple substance consumption (alcohol and tobacco) to prioritize the high-burden spots at smaller geographies. This paper utilized the two rounds of nationally representative cross-sectional surveys to analyze the district-level patterns in alcohol and tobacco consumption among men and women in India. Further, we also examined the change in consumption patterns across 720 districts between 2016 and 2021.

## Methods

### Overview

The study utilized the two rounds of the cross-sectional National Family Health Survey (NFHS) conducted in 2015–16 and 2019–21. Initiated in the early 1990s, the NFHS in India provides nationally representative information on key indicators such as fertility and mortality rates, contraceptive use, immunization coverage, and nutritional status of children, women, and men, making it a critical tool for assessing India's health and demographic trends.

### Data and survey design

The NFHS adopts a multistage, stratified cluster sampling design. Individual-level data from the fourth (2015–16) and fifth (2019–21) rounds of the surveys are the latest available and were used in this study. The NFHS collects the data for rural and urban areas separately using the latest census data as the sampling frame. According to the Demographic and Health Surveys (DHS), the clusters, which are villages (for rural areas) and Census Enumeration Blocks (CEBs) (for urban areas), serve as primary sampling units (PSUs). A representative sample of households was constructed for rural areas via stratified, probabilistic two-stage random sampling. In the first stage, the PSU (or cluster) corresponding to villages was classified on key variables including social group (percentage of population belonging to scheduled castes/scheduled tribes (SC/ST) and education (literacy rate of women aged 6+ years), and was selected by probability

proportional to cluster size. This was followed by household selections from the household list using systematic sampling with equal probability [19, 20]. A similar process was used for the urban areas, but because the urban clusters correspond to CEBs, a mix of a two-stage sampling approach was employed. It may be noted that PSUs with more than 300 households were divided into 100 to 150 household segments. Hence, one cluster can be a PSU or a segment of a PSU. The original sample size for NFHS-4 was 112,122 men aged 15 years or above, and 699,686 women aged 15–49 years. After excluding 8,597 men sample above 49 years, the final analytic sample was 103,525 men and 699,686 women aged 15–49 years for NFHS-4 (2015–16). For NFHS-5, the original sample was 990,474 men (15 years or above). After excluding the sample men above 49 years, the final sample was 700,561 men and 724,115 women aged 15–49 years (Supplementary File 1—Figure S1).

### Primary outcomes and geographies

The primary outcome variables were binary (Yes = 1/No = 0) coded responses for alcohol and tobacco consumption in any form among men and women separately in both survey rounds. It is worth mentioning here that we followed the NFHS report for deriving the variable for alcohol and tobacco consumption. The survey questions regarding alcohol and tobacco consumption were general (global/overall sense) without reference to the frequency, magnitude (quantity of alcohol), and time period of consumption. For alcohol, the survey question was “Do you drink alcohol?”. However, the binary variable for tobacco consumption was created based on four questions related to the consumption forms, i.e., (a) chew tobacco; (b) smokes/uses gutkha/pan masala with tobacco; (c) smokes/uses pan with tobacco; (d) does not use cigarettes and tobacco. The analyses included estimates for 720 districts nested within 36 states and Union Territories (UTs).

### Statistical analyses

To compute the variation across geographical units and estimate the district-level precision-weighted estimates for the prevalence of alcohol and tobacco consumption, we employed a four-level logistic regression with individual  $i$  (level-1); cluster  $j$  (level-2); district  $k$  (level-3); state  $l$  (level-4):  $Y_{ijkl} = \beta_0 + (u_{0jkl} + v_{0kl} + f_{0l})$ . In the model mentioned,  $u_{0jkl}$ ,  $v_{0kl}$ ,  $f_{0l}$  are model residuals specific to cluster, district, and state, respectively. These sets of residuals are assumed to have a normal distribution around the mean of 0 and the variance of  $u_{0jkl} \sim (0, \sigma_{u0}^2)$ ;  $v_{0kl} \sim (0, \sigma_{v0}^2)$ ;  $f_{0l} \sim (0, \sigma_{f0}^2)$ . Here, the term  $\sigma_{u0}^2$  denotes within-district, inter-cluster variation,  $\sigma_{v0}^2$

denotes within-state, inter-district variation, and  $\sigma_{f0}^2$  stands for interstate variation. Variance across individual men and women is not computed directly for binary outcomes and is instead assumed to follow a logistic distribution with a fixed variance of  $\pi^2/3$  or 3.29 [21]. We then computed the variance partitioning coefficient to assess the significance of each geographical unit ( $z$ ) in total variability as  $(\frac{\sigma_z^2}{\sigma_{u0}^2 + \sigma_{v0}^2 + \sigma_{f0}^2}) * 100$ .

Based on the multilevel logistic model estimates, we then generated precision-weighted cluster-level predicted probabilities of alcohol and tobacco consumption for both men and women. For more robust estimates, these probabilities were predicted by pooling information (and borrowing strength) from other clusters that share the same district membership. The probability of each  $Y$  for each cluster was calculated as  $\exp((\beta_0 + u_{0jkl} + v_{0kl} + f_{0l}) + (1/\exp(\beta_0 + u_{0jkl} + v_{0kl} + f_{0l})))$ . Finally, we estimated prevalence (%) for 720 districts by taking the mean of cluster-level predicted probabilities for the updated district boundaries. Multilevel modelling was performed using the STATA 15 and MLwiN 3.09 software program (using *runmlwin*) and the Markov Chain Monte Carlo (MCMC) method using the Gibbs sampler, keeping the default prior distribution of Iterated Generalized Least Squares (IGLS) as the starting value [22–24]. The logs of model output containing details about model specifications are presented as supplementary (Exhibit S1).

To infer the overtime district-level change in alcohol and tobacco consumption, we based the cut-off points – to classify the magnitude of change – on the distribution of the predicted estimates. This ensured a meaningful and interpretable threshold for classifying change. Given that NFHS-4 and NFHS-5 are large-scale, nationally representative surveys with substantial sample sizes, estimated differences were statistically significant. Therefore, we focused on substantive changes in prevalence over time. We considered a shift of less than 2.5 percentage points over the five years as “no change,” as such variations are expected and perhaps not meaningful. Any change exceeding 2.5 percentage points was classified as improvement or worsening and further categorized into three levels based on the distribution of the data. Specifically, we considered the following categories for positive as well as negative change: (a) No Change: Between 0 to 2.49 (increase) or 0 to –2.49 (decrease); (b) Small Change: Between 2.50 to 4.99 (increase) or –2.50 to –4.99 (decrease); (c) Moderate Change: Between 5.00 to 9.99 (increase) or –5.00 to –9.99 (decrease); (d) Substantial Change: 10.00 and above (increase) or –10.00 and below (decrease).

## Results

### Geographic variation in alcohol and tobacco consumption

Between 2016 and 2021, alcohol and tobacco consumption among men in India declined significantly, with alcohol usage dropping from 29.2% to 17.5% and tobacco from 44.5% to 32.6% (Table 1). Lakshadweep (0.5%), Gujarat (5%), and Jammu and Kashmir (7.5%) recorded the lowest alcohol prevalence, while Arunachal Pradesh (49.2%) and Telangana (39.2%) reported the highest alcohol prevalence in 2021. Prevalence of tobacco consumption was the highest in Mizoram (72.5%) and the lowest in Chandigarh (10.4%). States like Tamil Nadu and Tripura reported sharp declines in the prevalence of alcohol consumption, while Madhya Pradesh reported the highest reduction in tobacco consumption. Interestingly, a high correlation between the prevalence across the two survey rounds was observed (Figure S2). These patterns were consistent among women, i.e., the consumption of both alcohol and tobacco has declined among women as well.

### Variance decomposition across geographies

The variations in alcohol prevalence among men in 2016 attributable to different geographic levels were 40.5% to states, 16.9% to districts, and 42.6% to clusters (Fig. 1). The variations in tobacco prevalence attributable to different geographic levels were 58% to states, 8.2% to districts, and 33.8% to clusters. Interestingly, the variation attributable to states for both alcohol (40.5% in 2016 and 56.6% in 2021) and tobacco (58% in 2016 and 68.3% in 2021) was higher in 2021 as compared to 2016. The variations in prevalence of alcohol and tobacco have reduced at the cluster level. Similar geographic variations were observed with respect to the prevalence of consumption of tobacco and alcohol among women as well.

### District-level estimates of alcohol and tobacco consumption

A higher number of districts in Rajasthan and Uttar Pradesh reported low consumption of alcohol in both 2016 as well as 2021 (Fig. 2A and B). The maps elicit a notable concentration of high-consumption districts in the north-east and south-east parts of the country. Between 2016 and 2021, almost all districts showed a reduction in alcohol consumption among men (Fig. 2C). Prominent reductions were observed in the southern region districts from the states of Kerala, Tamil Nadu, Karnataka, and Andhra Pradesh. The (Fig. 3A and B) show a similar pattern of alcohol-consumption prevalence among women. Further, a high number of districts

in Telangana and Uttarakhand reported low consumption of tobacco prevalence in 2016 and 2021 (Fig. 4A and B, 5A and B). A large number of districts across north-eastern states such as Manipur, Meghalaya, Nagaland, and Mizoram reported a high burden of tobacco consumption. As of 2021, the prevalence of tobacco consumption was higher across all the districts in Arunachal Pradesh, Goa, Manipur, and Sikkim. It can be observed that districts from northern and central India have reported a substantial decrease in the tobacco consumption among men between 2016 and 2021 (Fig. 4C). The geographical clustering for tobacco consumption among women also showed a similar pattern (Fig. 5C).

### Distribution of the number of districts by absolute change (% points)

Figure 6 presents the distribution of the number of districts by absolute change (% points). The districts were distributed based on the following categories: Substantial Decrease ( $> 10.00\%$  points), Moderate Decrease (5.00–9.99% points), Small Decrease (2.50–4.99% points), No Change (–2.49 to 2.49% points), Small Increase (2.50–4.99% points), Moderate Increase (5.00–9.99% points), Substantial Increase ( $> 10.00\%$  points). More than 80% of the districts reported a moderate to substantial reduction in the prevalence of alcohol consumption among men between the two rounds (Fig. 6A and B). These patterns were similar for the consumption of alcohol and tobacco among women as well (Fig. 6C and D).

## Discussion

This study aimed to present the change in tobacco and alcohol prevalence based on two rounds of the nationally representative sample survey. The four salient findings from the study are as follows. First, alcohol and tobacco consumption among both men and women in India has declined between 2016 and 2021. Second, variance partitioning results reveal that the states and clusters accounted for the highest variation, followed by the lowest variation at the district level. Third, a large number of districts in north-eastern states such as Manipur, Meghalaya, Nagaland, and Mizoram reported a high prevalence of tobacco consumption. Fourth, the reduction in the prevalence of alcohol and tobacco was not uniform across the districts. We elaborate on each of these findings in the subsequent paragraphs.

First, alcohol and tobacco consumption among both men and women in India has declined between the two rounds of NFHS. States like Tamil Nadu and Tripura reported sharp declines in the prevalence of alcohol

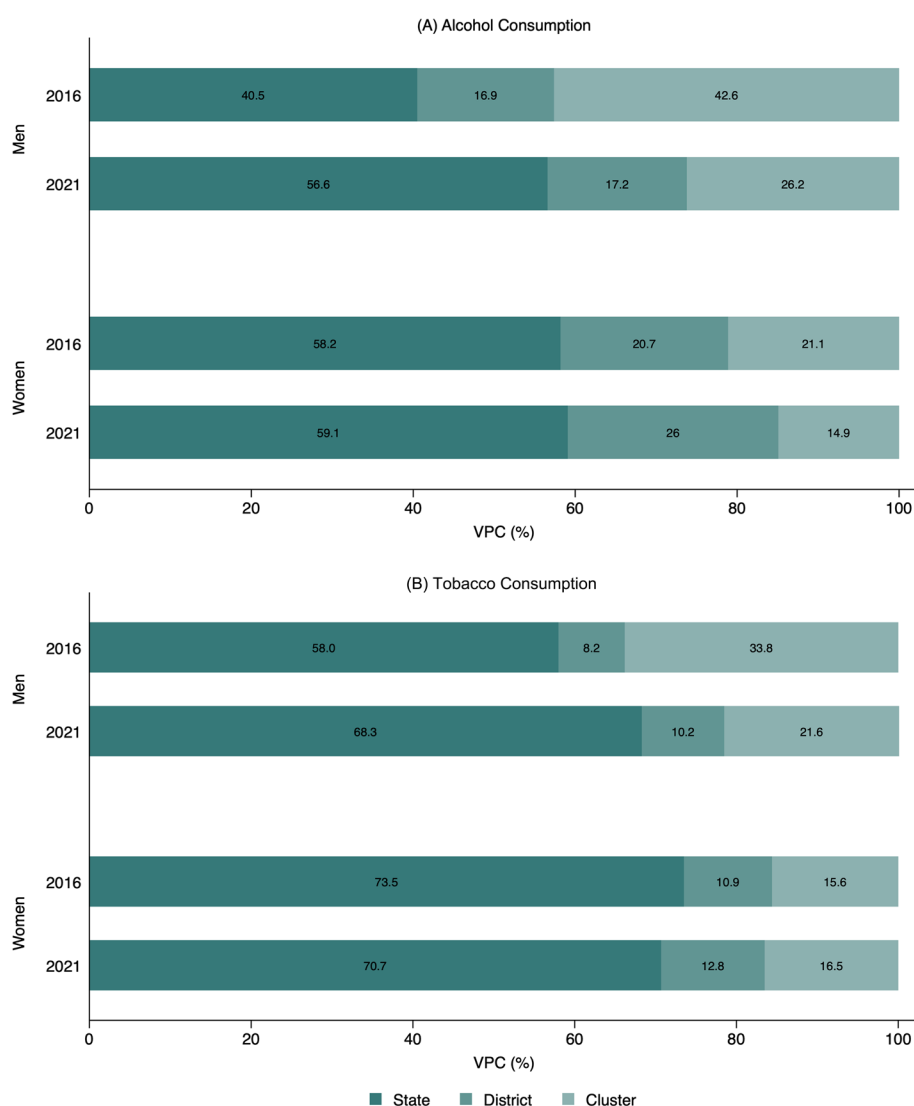
**Table 1** Prevalence of alcohol and tobacco consumption among adults (15–49 years) across States, India, NFHS, 2016–2021

States	Alcohol				Tobacco							
	Men		Women		Men				Women			
	2016 (%)	2021 (%)	Change (%) points)	2016 (%)	2021 (%)	Change (%) points)	2016 (%)	2021 (%)	Change (%) points)	2016 (%)	2021 (%)	Change (%) points)
Jammu & Kashmir	10.3	7.5	-2.8 <sup>c</sup>	0.1	0.2	0.1 <sup>b</sup>	38.2	32.2	-6.0 <sup>c</sup>	2.8	1.2	-1.6 <sup>c</sup>
Himachal Pradesh	39.8	25.9	-13.9 <sup>c</sup>	0.3	0.4	0.1	40.6	24.8	-15.8 <sup>c</sup>	0.5	0.2	-0.3 <sup>b</sup>
Punjab	34.1	20	-14.1 <sup>c</sup>	0.1	0.1	0	19.2	11.3	-7.9 <sup>c</sup>	0.1	0.1	0
Chandigarh	39.3	16.9	-22.4 <sup>c</sup>	0.5	0.1	-0.4	22.5	10.4	-12.1 <sup>c</sup>	0.4	0	-0.4 <sup>a</sup>
Uttarakhand	35.2	20.5	-14.7 <sup>c</sup>	0.3	0.1	-0.2 <sup>a</sup>	43.7	25.8	-17.9 <sup>c</sup>	2.9	0.8	-2.1 <sup>c</sup>
Haryana	24.5	14	-10.5 <sup>c</sup>	0.1	0.1	0	35.8	22.5	-13.3 <sup>c</sup>	1.6	0.4	-1.2 <sup>c</sup>
NCT of Delhi	24.5	19.8	-4.7 <sup>b</sup>	0.6	1.5	0.9 <sup>c</sup>	30.3	23	-7.3 <sup>c</sup>	1.6	1.6	0
Rajasthan	15.9	9.8	-6.1 <sup>c</sup>	0.1	0.1	0	46.9	35	-11.9 <sup>c</sup>	6.3	3.8	-2.5 <sup>c</sup>
Uttar Pradesh	22.1	13.8	-8.3 <sup>c</sup>	0.1	0.1	0 <sup>c</sup>	53	37.3	-15.7 <sup>c</sup>	7.6	3.3	-4.3 <sup>c</sup>
Bihar	28.9	15.9	-13.0 <sup>c</sup>	0.2	0.1	-0.1 <sup>c</sup>	50.1	40	-10.1 <sup>c</sup>	2.8	0.7	-2.1 <sup>c</sup>
Sikkim	51.2	37.9	-13.3 <sup>c</sup>	23	14.8	-8.2 <sup>c</sup>	40.3	40.3	0	7.3	8.7	1.4
Arunachal Pradesh	59.3	49.2	-10.1 <sup>c</sup>	26.3	17.8	-8.5 <sup>c</sup>	60.2	47	-13.2 <sup>c</sup>	18	10.7	-7.3 <sup>c</sup>
Nagaland	38.8	28.7	-10.1 <sup>c</sup>	3.3	1.4	-1.9 <sup>c</sup>	69.2	54.1	-15.1 <sup>c</sup>	27.4	14.1	-13.3 <sup>c</sup>
Manipur	52.6	38.5	-14.1 <sup>c</sup>	6.1	1.6	-4.5 <sup>c</sup>	70.6	57.2	-13.4 <sup>c</sup>	48.8	41.6	-7.2 <sup>c</sup>
Mizoram	49.5	28.2	-21.3 <sup>c</sup>	4.9	1	-3.9 <sup>c</sup>	80.5	72.5	-8.0 <sup>c</sup>	59.5	48.1	-11.4 <sup>c</sup>
Tripura	57.2	34.1	-23.1 <sup>c</sup>	4.8	4.4	-0.4	67.6	50.7	-16.9 <sup>c</sup>	42.2	39.3	-2.9 <sup>b</sup>
Meghalaya	44.6	31.3	-13.3 <sup>c</sup>	2.1	1.1	-1 <sup>c</sup>	72.2	54.9	-17.3 <sup>c</sup>	32.5	25.3	-7.2 <sup>c</sup>
Assam	35.4	24.7	-10.7 <sup>c</sup>	7	5.6	-1.4 <sup>c</sup>	63.8	48.1	-15.7 <sup>c</sup>	19.8	13.3	-6.5 <sup>c</sup>
West Bengal	28.7	18.9	-9.8 <sup>c</sup>	0.8	0.7	-0.1	58.8	43.9	-14.9 <sup>c</sup>	8.7	5.7	-3.0 <sup>c</sup>
Jharkhand	39.3	32.3	-7.0 <sup>c</sup>	4.1	2.6	-1.5 <sup>c</sup>	48.7	40.3	-8.4 <sup>c</sup>	5.8	2.4	-3.4 <sup>c</sup>
Odisha	39.3	29.6	-9.7 <sup>c</sup>	2.3	2.7	0.4 <sup>b</sup>	55.9	45.1	-10.8 <sup>c</sup>	17.3	12.6	-4.7 <sup>c</sup>
Chhattisgarh	52.7	31.9	-20.8 <sup>c</sup>	5	2.8	-2.2 <sup>c</sup>	55.2	37.8	-17.4 <sup>c</sup>	21.7	7.8	-13.9 <sup>c</sup>
Madhya Pradesh	29.6	16	-13.6 <sup>c</sup>	1.6	0.4	-1.2 <sup>c</sup>	59.5	40.8	-18.7 <sup>c</sup>	10.4	6.1	-4.3 <sup>c</sup>
Gujarat	11	5	-6 <sup>c</sup>	0.3	0.1	-0.2 <sup>b</sup>	51.5	38.1	-13.4 <sup>c</sup>	7.4	5.6	-1.8 <sup>c</sup>
DN & DD	34.7	27.1	-7.6 <sup>c</sup>	0.5	0.5	0	36.5	37.2	0.7	1.5	1.2	-0.3
Maharashtra	20.8	12.6	-8.2 <sup>c</sup>	0.2	0.1	-0.1	36.5	28.9	-7.6 <sup>c</sup>	5.8	4.4	-1.4 <sup>c</sup>
Karnataka	29.3	14.3	-15.0 <sup>c</sup>	1	0.3	-0.7 <sup>b</sup>	34.3	23	-11.3 <sup>c</sup>	4.2	2.7	-1.5 <sup>c</sup>
Goa	44.7	33.5	-11.2 <sup>c</sup>	4.2	4.8	0.6 <sup>c</sup>	20.8	16.1	-4.7 <sup>b</sup>	1.9	1	-0.9 <sup>b</sup>
Lakshadweep	5.4	0.5	-4.9 <sup>c</sup>	0	0.1	0.1	24.7	23.9	-0.8	16.4	4.4	-12.0 <sup>c</sup>
Kerala	37	16.5	-20.5 <sup>c</sup>	1.6	0.3	-1.3 <sup>c</sup>	25.7	12	-13.7 <sup>c</sup>	0.8	0.4	-0.4 <sup>c</sup>
Tamil Nadu	46.9	23.5	-23.4 <sup>c</sup>	0.4	0.1	-0.3 <sup>c</sup>	31.9	15.3	-16.6 <sup>c</sup>	2.2	1.1	-1.1 <sup>c</sup>

**Table 1** (continued)

States	Alcohol				Tobacco			
	Men		Women		Men		Women	
	2016 (%)	2021 (%)	Change (%) points)	2016 (%)	2021 (%)	Change (%) points)	2016 (%)	2021 (%)
Puducherry	41	24.7	-16.3 <sup>c</sup>	0.6	0.2	-0.4 <sup>a</sup>	14.4	11.9
Andaman & Nicobar Islands	51.7	38.4	-13.3 <sup>c</sup>	2.5	2.2	-0.3	61.6	53.6
Telangana	53.8	39.2	-14.6 <sup>c</sup>	8.7	5	-3.7 <sup>c</sup>	28.2	16.4
Andhra Pradesh	34.8	20.4	-14.4 <sup>c</sup>	0.4	0.2	-0.2 <sup>c</sup>	26.7	16
Ladakh	22.7	20.5	-2.2 <sup>c</sup>	2.8	3.6	0.8	23.6	31.5
All India	29.2	17.5	-11.7 <sup>c</sup>	1.2	0.8	-0.5 <sup>c</sup>	44.5	32.6

Estimates are <sup>a</sup>significant at 90%, <sup>b</sup> at 95%, <sup>c</sup> at 99.5%, DN & DD refers to Dadra Nagar Haveli and Daman & Diu

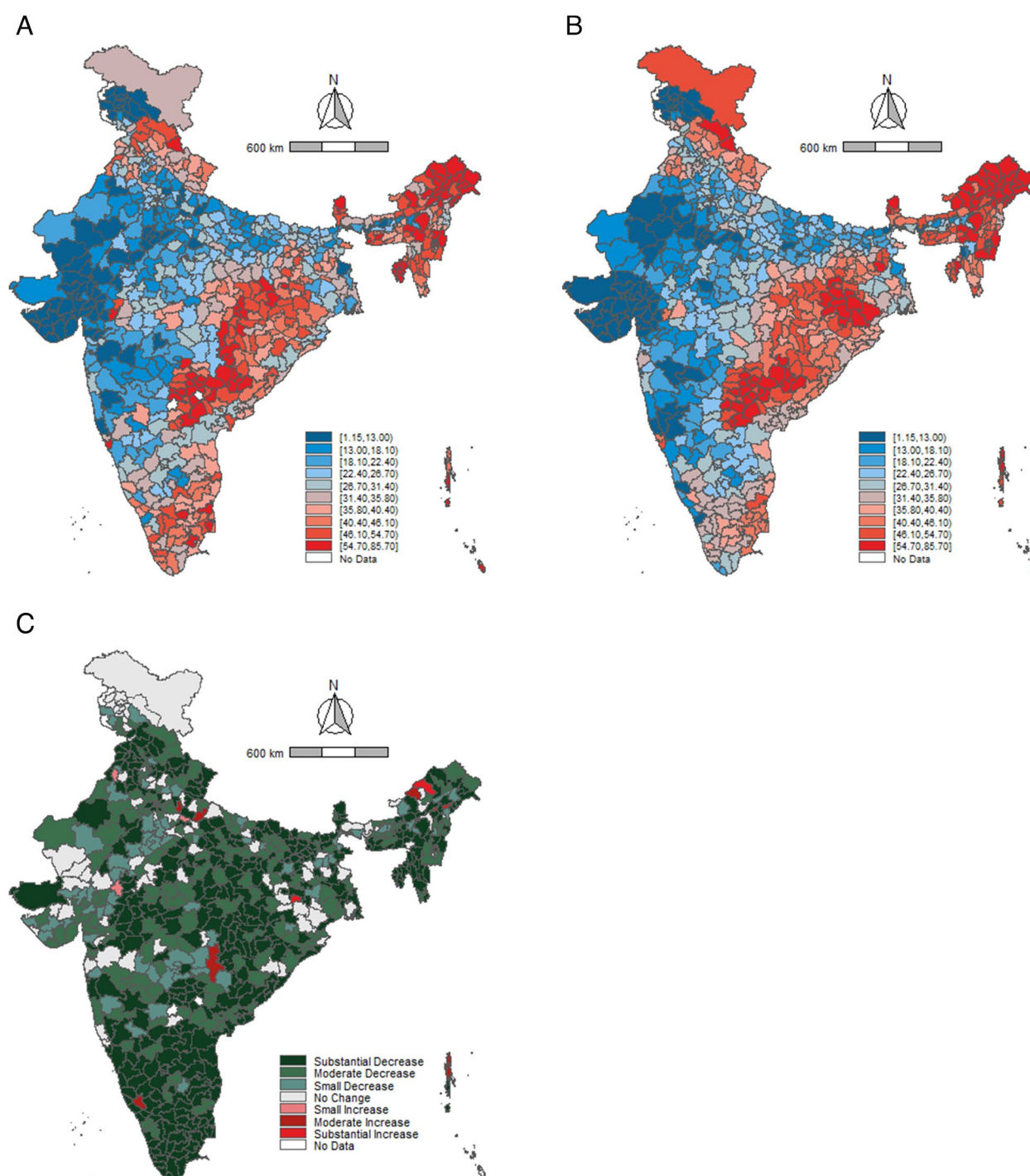


**Fig. 1** Geographic variance partitioning coefficient (VPC) (%) by clusters, districts, and states for alcohol and tobacco consumption among men and women, India, NFHS, 2016–2021

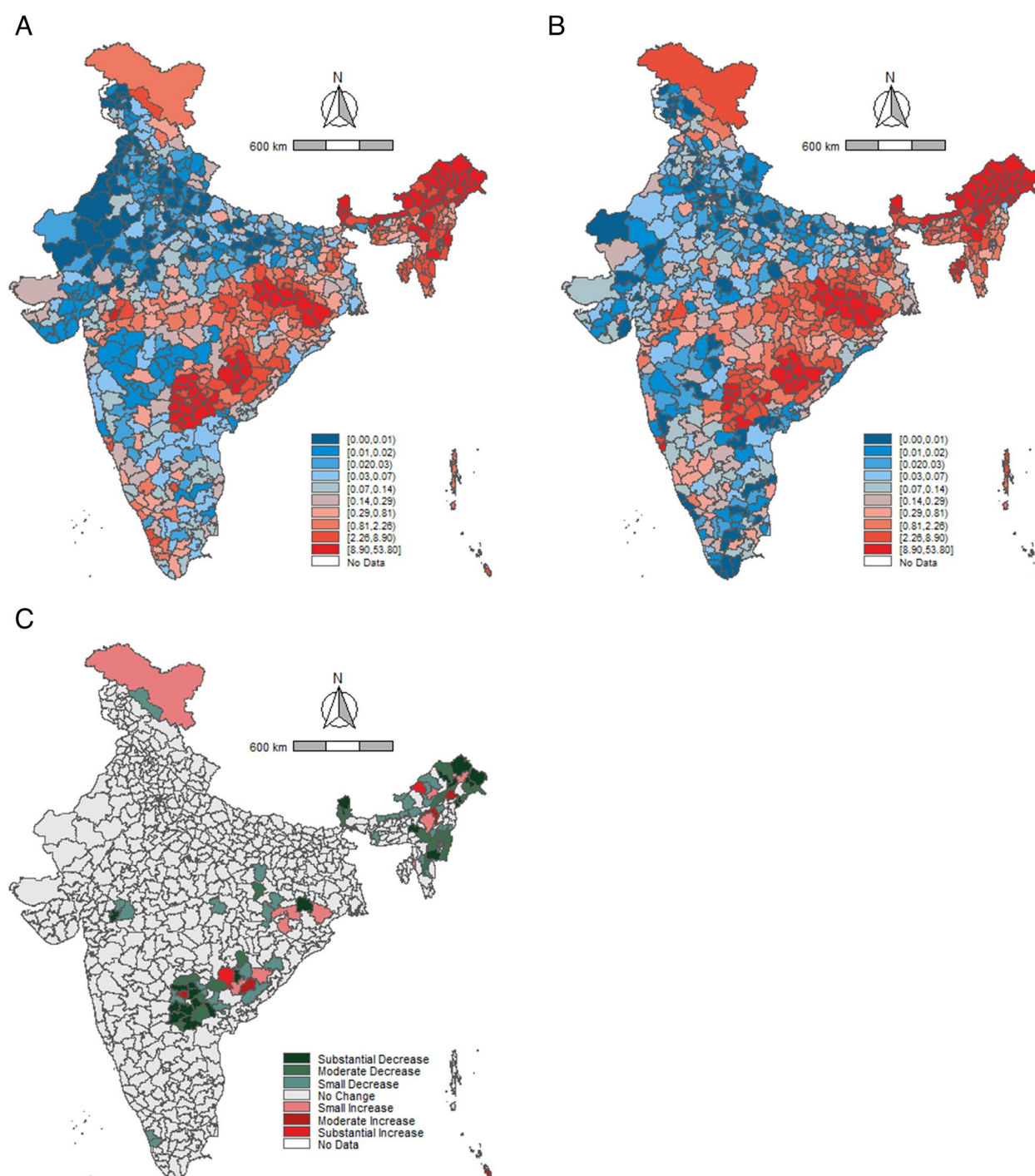
consumption, while Madhya Pradesh reported the highest reduction in tobacco consumption. The consumption of alcohol was the lowest in Gujarat. The consumption of both tobacco and alcohol was higher in the north-eastern region. Our findings are in line with similar studies based on previous rounds of NFHS as well as the Global Adult Tobacco Survey (GATS), asserting over time decline in the consumption of tobacco as well as alcohol in the country [25–27]. Previous studies have found that tobacco consumption in particular was high across the northeast region, which is corroborated by our findings as well [27–29]. In addition, a high correlation between the prevalence across the two survey rounds was observed. This suggests that both surveys

are likely capturing similar behaviours, validating the reliability of the findings that consumption remains high across states with high prevalence.

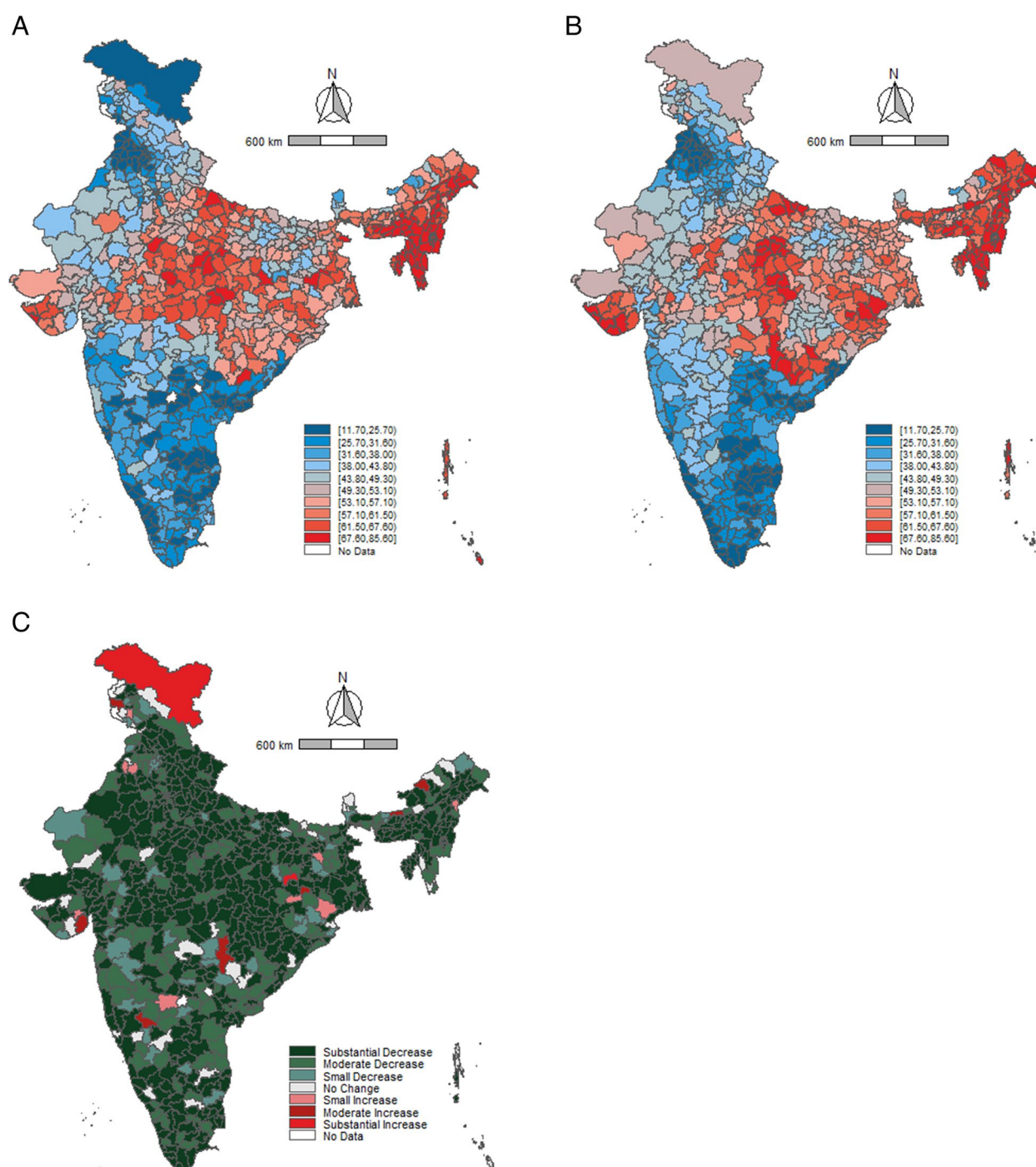
The reduction in tobacco consumption is likely due to increased taxes over time and the imposition of additional cess, which has increased the price of the product substantially [30]. However, there remains considerable potential to further increase taxes on tobacco products [31]. For example, the current tax structure imposes lower taxes on bidis and similar products compared to cigarettes, making bidis more affordable [31]. Additionally, significant price variations across states contribute to the uneven affordability of tobacco products [31]. Addressing these gaps could help reduce tobacco



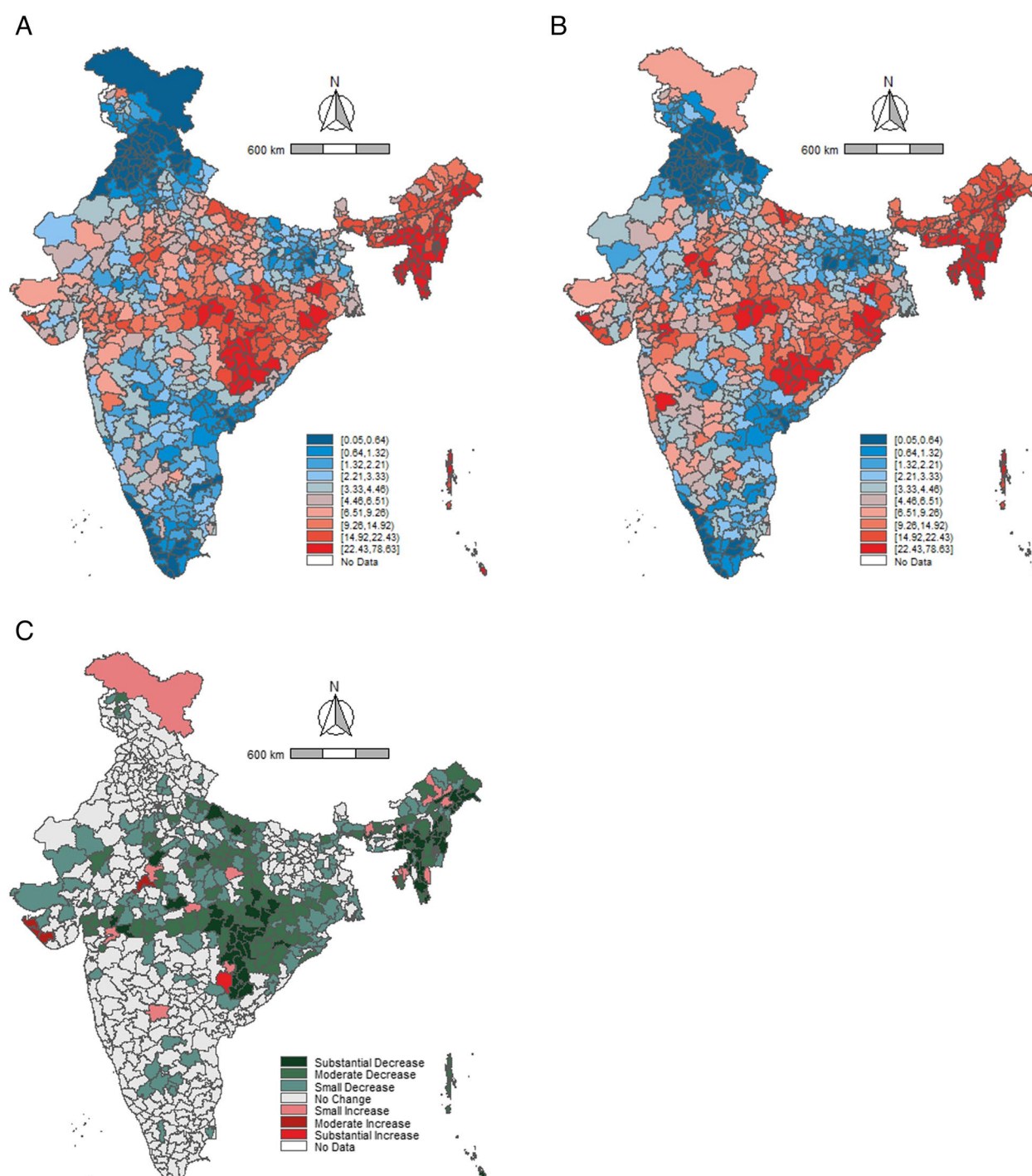
**Fig. 2** Prevalence (%) of alcohol consumption among men (15–49 years) across districts, India, NFHS, 2016–2021. Note: Prevalence cut points based on decile positions of 2016 consumption (Panels (A) and (B)). Cut-points for change (2021–2016) (Panel (C)): Substantial decrease ( $> 10.00\%$ , dark green), Moderate decrease ( $5.00\text{--}9.99\%$ , green), Small decrease ( $2.50\text{--}4.99\%$ , light green), No change ( $-2.49$  to  $2.49\%$ , gray), Small increase ( $2.50\text{--}4.99\%$ , light red), Moderate increase ( $5.00\text{--}9.99\%$ , red), Substantial increase ( $> 10.00\%$ , dark red)



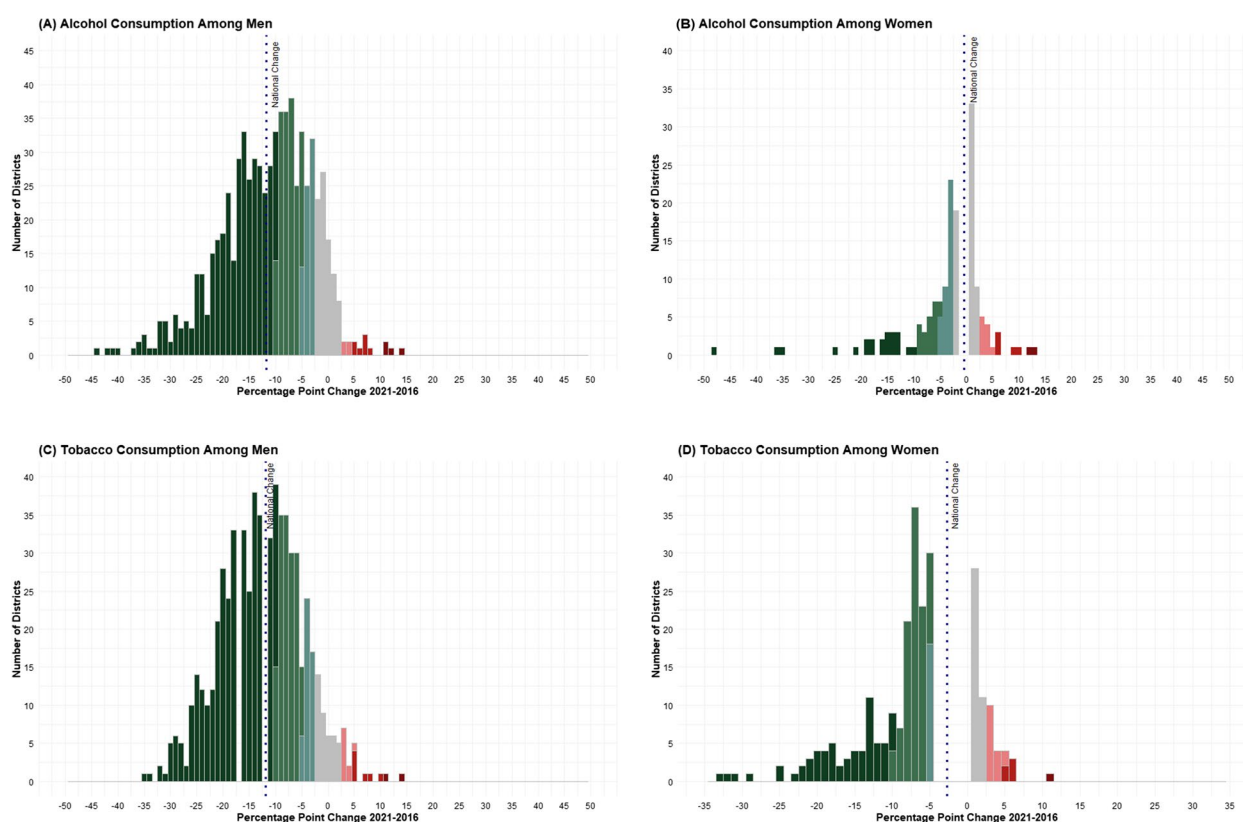
**Fig. 3** Prevalence (%) of alcohol consumption among women (15–49 years) across districts, India, NFHS, 2016–2021. Note: Prevalence cut points based on decile positions of 2016 consumption (Panels **(A)** and **(B)**). Cut-points for change (2021–2016) (Panel **(C)**): Substantial decrease ( $> 10.00\%$ , dark green), Moderate decrease (5.00–9.99%, green), Small decrease (2.50–4.99%, light green), No change ( $-2.49$  to  $2.49\%$ , gray), Small increase (2.50–4.99%, light red), Moderate increase (5.00–9.99%, red), Substantial increase ( $> 10.00\%$ , dark red)



**Fig. 4** Prevalence (%) tobacco consumption among men (15–49 years) across districts, India, NFHS, 2016–2021. Note: Prevalence cut points based on decile positions of 2016 consumption (Panels (A) and (B)). Cut-points for change (2021–2016) (Panel (C)): Substantial decrease ( $> 10.00\%$ , dark green), Moderate decrease (5.00–9.99%, green), Small decrease (2.50–4.99%, light green), No change ( $-2.49$  to  $2.49\%$ , gray), Small increase (2.50–4.99%, light red), Moderate increase (5.00–9.99%, red), Substantial increase ( $> 10.00\%$ , dark red)



**Fig. 5** Prevalence (%) of tobacco consumption among women (15–49 years) across districts, India, NFHS, 2016–2021. Note: Prevalence cut points based on decile positions of 2016 consumption (Panels (A) and (B)). Cut-points for change (2021–2016) (Panel (C)): Substantial decrease ( $> 10.00\%$ , dark green), Moderate decrease (5.00–9.99%, green), Small decrease (2.50–4.99%, light green), No change (–2.49 to 2.49%, gray), Small increase (2.50–4.99%, light red), Moderate increase (5.00–9.99%, red), Substantial increase ( $> 10.00\%$ , dark red)



**Fig. 6** Distribution of change (% points) in the prevalence of alcohol and tobacco consumption among adults (15–49 years) across districts, India, NFHS, 2016–2021. Note: Cut-points for change (2021–2016): Substantial decrease ( $> 10.00\%$ , dark green), Moderate decrease (5.00–9.99%, green), Small decrease (2.50–4.99%, light green), No change (–2.49 to 2.49%, gray), Small increase (2.50–4.99%, light red), Moderate increase (5.00–9.99%, red), Substantial increase ( $> 10.00\%$ , dark red)

consumption further. In addition, several studies have found that socio-economic factors, such as education, wealth, and age, as well as cultural norms, also play a significant role in determining the consumption of alcohol and tobacco, for which behaviour change interventions are warranted [29, 32, 33].

Second, the variance attributable to states is significantly higher than that at the district or cluster levels. This underscores the potential bias in relying solely on estimates derived from a single level of analysis. Previous studies on geospatial patterns of alcohol and tobacco use similarly found a high concentration in north-eastern states [28]. Our findings further indicate a much higher clustering of tobacco use at the cluster level than previously reported, highlighting the importance of local contexts and contextual determinants in India [34, 35]. Tobacco use remains disproportionately high among individuals from lower socioeconomic backgrounds, among scheduled caste groups and among uneducated adults. In lower-income neighbourhoods with limited

health awareness with a weaker tobacco-control policy environment, the likelihood of initiation and continued use is greater [29, 36, 37]. These variations are likely influenced by differences in the availability and enforcement of tobacco control policies, the social environment, as well as shared cultural and social norms regarding tobacco use [32, 33]. This finding assumes further attention, given that the prevalence of cancers is strongly correlated with high alcohol and tobacco consumption [38, 39]. A recent observational study has identified smoking and tobacco use as one of the main risk factors for NCDs among women [14]. This is distressing since the NCDs burden among women have serious implications for child health, emphasising the urgency of addressing these issues.

Third, a large number of districts in north-eastern states such as Manipur, Meghalaya, Nagaland, and Mizoram reported a high prevalence of tobacco consumption. As of 2021, alcohol consumption was notably higher in districts of Arunachal Pradesh, Goa, Manipur,

and Sikkim. The high prevalence of alcohol use in these regions is closely linked to social customs and ease of availability. Alcohol is a widely accepted norm at social events and, in many north-eastern states, traditional brewing is embedded in tribal customs, making alcohol consumption a culturally accepted practice [40–42]. This distribution may reflect differences in the implementation and effectiveness of tobacco control policies. For instance, in these states, the consumption of smokeless tobacco and bidis remains high, suggesting that existing policies have been less effective in targeting these products [31, 43]. In contrast, the low alcohol consumption levels in Gujarat highlight the success of the state's long-standing prohibition policy, first enacted under the Gujarat Prohibition Act, 1949, prohibiting the manufacture, sale, and consumption of alcohol. This act has been further amended multiple times in the past decades to include special courts and harsher penalties, creating a more stringent and comprehensive regulatory framework to restrict alcohol use [44]. These findings emphasise the need to revisit and redesign existing policies to address current gaps and improve their effectiveness.

Fourth, the reduction in the prevalence of alcohol and tobacco was not uniform across the districts. For instance, a higher number of the districts in Mizoram, Tamil Nadu, and Kerala have reported a high reduction in the prevalence of alcohol while a large number of districts in Uttarakhand and Meghalaya reported a high reduction in the consumption of tobacco. These findings could be again attributable to how the states differ in how strictly they enforce regulations on alcohol and tobacco, such as taxation, bans, and restrictions on advertising [32, 45–47]. For example, the Mizoram Liquor Prohibition Act, 2019, which instituted a state-wide ban on alcohol, and the implementation of the National Tobacco Control Programme (NTCP) in Meghalaya, which strengthened enforcement of smoke-free laws and advertising restrictions, highlight the potential influence of state-level policy interventions on district-level substance use outcomes [48, 49]. Additionally, the shift to a higher socioeconomic status may also explain the lower alcohol consumption observed, as highlighted in several small sample-based studies [50].

## Limitations

The following are the limitations of this study. Firstly, the data used in the study are cross-sectional. Therefore, it is not possible to do a comparative analysis over a longer period of time for the same households. Second, the sample size was very small for some of the States and Union Territories, so it was difficult to obtain reliable estimates. For this reason, we have presented the broad trends

and patterns and have not controlled for the socioeconomic characteristics. Third, NFHS has used the sampling frame of the 2011 Census for sampling. The data is available for 640 districts for 2016. However, in 2021, there were more than 700 districts. However, we believe that the same trends in multi-level variation will remain. Additionally, because of the nature of the data, the lowest geographic level we could observe was the PSU. Furthermore, tobacco and alcohol consumption are usually underreported in national surveys due to desirability bias and the presence of other people. Therefore, the results of this study might conceal the fact that the prevalence could be much higher.

## Conclusions

Overall, the decline in tobacco and alcohol prevalence indicates progress; however, there remains a need for continuous and targeted interventions such as taxation hikes and behavioural interventions. Introducing behaviour cessation programmes amongst adolescents and younger adults and in primary healthcare systems has demonstrated sustained effects on abstinence and use reduction [51, 52]. The results of the present study indicate that interventions focusing on changing tobacco and alcohol consumption must consider the geographical variation. By implementing evidence-based policies and interventions suited to the needs of the local areas, public health authorities can continue to make significant strides in improving the health and well-being of the population and reducing the burden of tobacco and alcohol-related diseases.

The authors declare that they have no competing interests.

## Abbreviations

UT	Union Territory
NFHS	National Family Health Survey
NCD	Non-communicable Disease
DHS	Demographic and Health Surveys
CEB	Census Enumeration Block
PSU	Primary Sampling Unit
SC	Scheduled Caste
ST	Scheduled Tribe
MCMC	Markov Chain Monte Carlo
IGLS	Iterated Generalized Least Squares
GATS	Global Adult Tobacco Survey
NTCP	National Tobacco Control Programme

## Supplementary Information

The online version contains supplementary material available at <https://doi.org/10.1186/s12889-025-23029-z>.

Supplementary Material 1.

## Acknowledgements

Not applicable.

### Authors' contributions

S Rajpal led data analysis and writing of the manuscript. AK, S Ronanki, and NS contributed to data analysis and interpretation of data and critical revision of the manuscript. RK and SVS conceptualized and designed the study, contributed to the interpretation of data, and provided critical revision of the manuscript. RK provided overall supervision. All authors read and approved the final manuscript.

### Funding

This research was funded by the Bill & Melinda Gates Foundation, INV-002992. The funder had no role in the design and conduct of the study; collection, management, analysis, and interpretation of the data; preparation, review, or approval of the manuscript; and decision to submit the manuscript for publication.

### Data availability

The study is based on publicly available data and can be accessed from <https://dhsprogram.com/data/available-datasets.cfm>.

### Declarations

#### Ethics approval and consent to participate

The current dataset does not meet the regulatory definition of human subject research. As such, an Institutional Review Board (IRB) review is not required. The Harvard Longwood Campus IRB allows researchers to self-determine when their research meets the requirements for IRB oversight via guidance online using an IRB Decision Tool. All authors had full access to all the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis.

#### Consent for publication

Not applicable.

#### Competing interests

The authors declare no competing interests.

#### Author details

<sup>1</sup>Department of Economics, FLAME University, Pune, India. <sup>2</sup>Centre for Research in Wellbeing and Happiness, FLAME University, Pune, India. <sup>3</sup>Division of Health Policy and Management, College of Health Science, Korea University, 145 Anam-Ro, Seongbuk-Gu, Seoul 02841, South Korea. <sup>4</sup>Harvard Center for Population and Development Studies, Cambridge, MA, US. <sup>5</sup>Department of Social and Behavioral Sciences, Harvard T.H. Chan School of Public Health, Boston, MA, US.

Received: 21 January 2025 Accepted: 2 May 2025

Published online: 27 May 2025

### References

- World Health Organization. Problems related to alcohol consumption. Geneva: World Health Organization. WHO technical report series. 1980;(7):650.
- Anderson BO, Berdazuli N, Ilbawi A, Kestel D, Kluge HP, Krech R, Mikelsen B, Neufeld M, Poznyak V, Rekve D, Slama S. Health and cancer risks associated with low levels of alcohol consumption. *The Lancet Public Health*. 2023;8(1):e6–7.
- Bryazka D, Reitsma MB, Abate YH, Abd Al Magied AH, Abdelkader A, Abdollahi A, Abdoun M, Abdulkader RS, Zuñiga RA, Abhilash ES, Abiodun OO. Forecasting the effects of smoking prevalence scenarios on years of life lost and life expectancy from 2022 to 2050: a systematic analysis for the Global Burden of Disease Study 2021. *Lancet Pub Health*. 2024;9(10):e729–44.
- Ezzati M, Riboli E. Behavioral and dietary risk factors for noncommunicable diseases. *N Engl J Med*. 2013;369(10):954–64.
- Eashwar VA, Umadevi R, Gopalakrishnan S. Alcohol consumption in India—An epidemiological review. *Journal of family medicine and primary care*. 2020;9(1):49–55.
- Singh A, Arora M, Bentley R, et al. Geographic variation in tobacco use in India: a population-based multilevel cross-sectional study. *BMJ Open*. 2020;10(6): e033178. <https://doi.org/10.1136/bmjopen-2019-033178>.
- Schess J, Bennett-Li L, Velleman R, et al. Alcohol policies in India: A scoping review. *PLoS ONE*. 2023;18(11): e0294392. <https://doi.org/10.1371/journal.pone.0294392>.
- Rajpal S, Kim J, Joe W, Kim R, Subramanian SV. Small area variation in child undernutrition across 640 districts and 543 parliamentary constituencies in India. *Sci Rep*. 2021;11(1):4558.
- Rajpal S, Kumar A, Johri M, Kim R, Subramanian SV. Patterns in the prevalence of unvaccinated children across 36 states and union territories in India, 1993–2021. *JAMA Network Open*. 2023;6(2):e2254919.
- Jain A, Rajpal S, Rana MJ, Kim R, Subramanian SV. Small area variations in four measures of poverty among Indian households: Econometric analysis of National Family Health Survey 2019–2021. *Humanities and Social Sciences Communications*. 2023;10(1):1–1.
- Bista B, Dhungana RR, Chalise B, Pandey AR. Prevalence and determinants of non-communicable diseases risk factors among reproductive aged women of Nepal: Results from Nepal Demographic Health Survey 2016. *PLoS ONE*. 2020;15(3):e0218840.
- Khuwaja AK, Kadir MM. Gender differences and clustering pattern of behavioural risk factors for chronic non-communicable diseases: community-based study from a developing country. *Chronic Illn*. 2010;6(3):163–70.
- Godfrey KM, Gluckman PD, Hanson MA. Developmental origins of metabolic disease: life course and intergenerational perspectives. *Trends Endocrinol Metab*. 2010;21(4):199–205.
- Mishra VK, Srivastava S, Muhammad T, Murthy PV. Relationship between tobacco use, alcohol consumption and non-communicable diseases among women in India: evidence from National Family Health Survey-2015-16. *BMC Public Health*. 2022;22(1):713.
- Rastogi A, Manthey J, Wiemker V, Probst C. Alcohol consumption in India: a systematic review and modelling study for sub-national estimates of drinking patterns. *Addiction*. 2022;117(7):1871–86.
- Prasad R. Alcohol use on the rise in India. *Lancet*. 2009;373(9657):17–8.
- Singh PK, Dubey R, Singh L, Singh N, Kumar C, Kashyap S, Subramanian SV, Singh S. Mixed effect of alcohol, smoking, and smokeless tobacco use on hypertension among adult population in India: a nationally representative cross-sectional study. *Int J Environ Res Public Health*. 2022;19(6):3239.
- Gururaj G, Gautham MS, Arvind BA. Alcohol consumption in India: A rising burden and a fractured response. *Drug Alcohol Rev*. 2021;40(3):368–84.
- International Institute for Population Sciences (IIPS) and ICF. National Family Health Survey (NFHS-4), 2015–16: IIPS, Mumbai, India: 2017.
- International Institute for Population Sciences (IIPS). National Family Health Survey (NFHS-4), 2019–21: India. Mumbai IIPS, 2021.
- Browne WJ, Subramanian SV, Jones K, Goldstein H. Variance partitioning in multilevel logistic models that exhibit overdispersion. *J R Stat Soc A Stat Soc*. 2005;168(3):599–613.
- Stata Corporation. Stata Release 16. College Station, Tx, 2019.
- Rasbash J, Charlton C, Browne WJ, Healy M, Cameron B. MLwiN Version 2.1. Centre for Multilevel Modelling, University of Bristol; 2009.
- Leckie G, Charlton C. runmlwin: a program to run the MLwiN multilevel modeling software from within Stata. *J Stat Software*. 2013;52(11):40.
- Mishra S, Joseph RA, Gupta PC, Pezzack B, Ram F, Sinha DN, Dikshit R, Patra J, Jha P. Trends in bidi and cigarette smoking in India from 1998 to 2015, by age, gender and education. *BMJ Glob Health*. 2016;1(1):e000005.
- Verma M, Bhatt G, Nath B, Kar SS, Goel S. Tobacco consumption trends and correlates of successful cessation in Indian females: findings of global adult tobacco surveys. *Indian Journal of Tuberculosis*. 2021;1(68):S29–38.
- Shaikh R, Janssen F, Vogt T. The progression of the tobacco epidemic in India on the national and regional level, 1998–2016. *BMC Public Health*. 2022;22(1):317.
- Balasubramani K, Paulson W, Chellappan S, Ramachandran R, Behera SK, Balabaskaran NP. Epidemiology, hot spots, and sociodemographic risk factors of alcohol consumption in Indian men and women: analysis of National Family Health Survey-4 (2015–16), a nationally representative cross-sectional study. *Front Public Health*. 2021;27(9):617311.

29. Karuppusamy B, Paulson W, Chellappan S, Behera SK, Nina PB. District-level epidemiology, hot spots and sociodemographic determinants of tobacco use in Indian men and women: analysis of national family health survey-4 (2015–16). *Public Health*. 2021;1(194):127–34.
30. Nazar GP, Sharma N, Chugh A, Abdullah SM, Lina S, Mdege ND, John RM, Huque R, Bauld L, Arora M. Impact of tobacco price and taxation on affordability and consumption of tobacco products in the South-East Asia Region: A systematic review. *Tobacco Induced Diseases*. 2021;19:97.
31. John RM, Dauchy E. Trends in affordability of tobacco products before and after the transition to GST in India. *Tob Control*. 2021;30(2):155–9.
32. Lahoti S, Dixit P. Declining trend of smoking and smokeless tobacco in India: A decomposition analysis. *PLoS ONE*. 2021;16(2):e0247226.
33. Chhabra A, Hussain S, Rashid S. Recent trends of tobacco use in India. *J Public Health*. 2021;29:27–36.
34. Tikhute V. Geospatial patterns of alcohol and tobacco use in India: A cluster analysis of NFHS 4.
35. Singh PK, Singh N, Jain P, Sinha P, Kumar C, Singh L, Singh A, Yadav A, Balhara YP, Kashyap S, Singh S. Mapping the triple burden of smoking, smokeless tobacco and alcohol consumption among adults in 28,521 communities across 640 districts of India: A sex-stratified multilevel cross-sectional study. *Health Place*. 2021;1(69):102565.
36. Shah S, Dave B, Shah R, Mehta TR, Dave R. Socioeconomic and cultural impact of tobacco in India. *J Family Med Prim Care*. 2018;7(6):1173–6. [https://doi.org/10.4103/jfmpc.jfmpc\\_36\\_18](https://doi.org/10.4103/jfmpc.jfmpc_36_18).
37. Singh SK, Kumar S, Kashyap GC, Ward K. Tobacco use and cessation among a nationally representative sample of men in India, 2019–2021. *J Smok Cessat*. 2023;2023: e7. <https://doi.org/10.1155/2023/4292647>.
38. Yoo JE, Han K, Shin DW, Kim D, Kim BS, Chun S, Jeon KH, Jung W, Park J, Park JH, Choi KS. Association between changes in alcohol consumption and cancer risk. *JAMA Netw Open*. 2022;5(8):2228544.
39. Hatta W, Koike T, Asano N, Hatayama Y, Ogata Y, Saito M, Jin X, Uno K, Imatani A, Masamune A. The Impact of Tobacco Smoking and Alcohol Consumption on the development of gastric cancers. *Int J Mol Sci*. 2024;25(14):7854.
40. Chaturvedi HK, Bajpai RC, Tiwari P. Association of religion and cultural tradition with alcohol use among some tribal communities of Arunachal Pradesh, India. *J Ethn Subst Abuse*. 2019;18(2):296–308. <https://doi.org/10.1080/15332640.2017.1355766>.
41. Verenkar YJ, Vaz FS. Prevalence and pattern of alcohol consumption using alcohol use disorder identification test among students at a medical college in Goa, India. *International Journal Of Community Medicine And Public Health*. 2018;5(7):2935–8. <https://doi.org/10.18203/2394-6040.ijcmph20182626>.
42. Konthoujam B, Kar S, Mehta VK, Dutta S. Prevalence and pattern of alcohol consumption among women of reproductive age group in urban settings of Sikkim: a cross sectional study. *International Journal Of Community Medicine And Public Health*. 2023;10(5):1897–904. <https://doi.org/10.18203/2394-6040.ijcmph20231293>.
43. Goodchild M, Sinha P, Gill Munish V, Tullu FT. Changes in the affordability of tobacco products in India during 2007/2008 to 2017/2018: a price-relative-to-income analysis. *WHO South East Asia J Public Health*. 2020;9(1):73–81. <https://doi.org/10.4103/2224-3151.283001>. PMID: 32341226.
44. Government of Gujarat, Legislative and Parliamentary Affairs Department, The Gujarat Prohibition Act, 1949 (Bombay Act No. XXV of 1949).
45. Grills NJ, Singh R, Singh R, Martin BC. Tobacco Usage In Uttarakhand: A Dangerous Combination Of High Prevalence, Widespread Ignorance, And Resistance To Quitting. *Biomed Res Int*. 2015;2015: 132120. <https://doi.org/10.1155/2015/132120>.
46. Gupta PC, Ray CS. Smokeless Tobacco And Health In India And South Asia. *Respirology*. 2003;8(4):419–31. <https://doi.org/10.1046/j.1440-1843.2003.00507.x>.
47. Quevedo IG de. Implementation Of The Uttarakhand Tobacco Free Initiative In Schools, India, 2016. *Prev Chronic Dis*. 2021;18. <https://doi.org/10.5888/pcd18.200650>.
48. Government of Meghalaya. Order Shillong: Office of the Deputy Commissioner, East Khasi Hills District. 2020.
49. Government of Mizoram, Law and Judicial Department, The Mizoram Liquor (Prohibition) Act. 2019.
50. Gowri SM, Belavendra A, Vasan SK, et al. Prevalence and long-term change in alcohol consumption: results from a population-based cohort in Southern India. *Int J Ment Health Syst*. 2024;18:30. <https://doi.org/10.1186/s13033-024-00650-w>.
51. Pahwa V, Pimple SA, Bhattacharjee A, Kuberkar D, Mishra GA, Chaturvedi P. Behavioural Interventions For Tobacco Cessation In India: A Systematic Review And Meta-Analysis. *J Family Med Prim Care*. 2023;12(11):2542–51. [https://doi.org/10.4103/jfmpc.jfmpc\\_1017\\_23](https://doi.org/10.4103/jfmpc.jfmpc_1017_23).
52. Hallihan H, Srimoragot M, Ma J, et al. Integrated Behavioral Interventions For Adults With Alcohol Use Disorder: A Systematic Review. *Drug Alcohol Depend*. 2024;263: 111406. <https://doi.org/10.1016/j.drugalcdep.2024.111406>.

## Publisher's Note

Springer Nature remains neutral with regard to jurisdictional claims in published maps and institutional affiliations.