

Spatial Patterns and Socio-Demographic Correlates of Tobacco and Alcohol Consumption among Men and Women in Maharashtra: A District-Level Analysis

Rupesh Madhukar Dhundale

Research scholar

Department of Geography

K. C. E. Society's Moolji Jaitha College (Autonomous), Jalgaon.

Email: dhundalerupesh@gmail.com

Abstract:

Tobacco and alcohol use are significant behavioural risk factors with large public health and socio-spatial implications. The current study aims to analyze the spatial distribution, gender disparities and socio-demographic association of tobacco and alcohol consumption in the 36 districts of Maharashtra, India. The analysis was done separately for male and female using district level estimates from the National Family Health Survey-5 (NFHS-5) 2019-21. Thematic and bivariate choropleth mapping, Global Moran's I, Pearson's correlation, Spearman's rank correlation and multivariable regression were used in the study. Four main indicators were explored: tobacco use by women and men aged 15 years and older, and alcohol use by women and men aged 15 years and older. The results show significant differences in consumption patterns across space and between men and women. There was significant positive spatial autocorrelation for women's tobacco consumption (Moran's I = 0.0803, $p = 0.0020$), men's tobacco consumption ($I = 0.1690$, $p = 0.0001$) and men's alcohol consumption ($I = 0.1327$, $p = 0.0001$), but not for women's alcohol consumption. Pearson's correlation showed positive correlation between tobacco and alcohol consumption among women ($r = 0.5631$, $p = 0.0004$) and men ($r = 0.6572$, $p < 0.001$). Spearman's correlation was significant among men ($\rho = 0.4867$, $p = 0.0026$) but not women ($\rho = 0.3143$, $p = 0.0619$). Overall, regression models with selected socio-demographic and household indicators were not statistically significant. The results indicate the need for spatial and gender perspectives to understand behavioural health risks in Maharashtra.

Keywords: Tobacco consumption, Alcohol consumption, Global Moran's I, Spatial autocorrelation, Bivariate mapping.

Introduction

The use of tobacco and alcohol is a public health concern as these are associated with several non-communicable diseases, injuries, premature death and negative social and economic impacts, and they are among the leading preventable risk factors for cardiovascular diseases, respiratory diseases, cancers and

other chronic diseases [1]. Excessive alcohol use is also associated with liver disease, cardiovascular disease, cancer, injuries, mental and behavioural disorders and social problems. Tobacco and alcohol use often co-occur and may increase the risk of health problems and may contribute to disparities in population health. Geographically, there is significant variation in the consumption patterns which can be due to socio-economic, educational, employment, urbanization, cultural, household, accessibility and awareness of health risks [2]. Given the regional and socio-demographic diversity of the state, with highly urbanized metropolitan regions, rural, agricultural and tribal regions, and with significant variations between the districts in terms of population, urbanization, literacy, economic development, household conditions, and health and social infrastructure, it offers a suitable geographical context for this type of analysis [3]. Spatial analysis is a useful tool to explore the spatial aspects of health-related behaviours, and given the regional and socio-demographic diversity of Maharashtra, with highly urbanized metropolitan regions, rural, agricultural and tribal regions, and with significant variations between the districts in terms of population, urbanization, literacy, economic development, household conditions, and health and social infrastructure, it is a relevant geography for this type of analysis.

There are considerable differences in the spatial distribution of tobacco and alcohol consumption in the districts of Maharashtra, which is affected by various socio-demographic factors. Research has shown that tobacco and alcohol consumption is localized in certain areas, such as northeastern states and certain districts in Maharashtra [4,5]. Gender, age, socioeconomic status and occupation are the most important socio-demographic factors associated with these differences. Men are much more likely to use tobacco and alcohol than women, nationally 4-5 times more likely to use tobacco and 15-25 times more likely to use alcohol than women [6]. Further, tobacco consumption is higher in rural areas than in urban areas, with rural people being 1.6 times more likely to consume tobacco [7]. Socioeconomic status is also a significant factor as lower socioeconomic status and education levels are linked to higher tobacco consumption [8]. Occupation is another factor and manual labourers and agricultural labourers have higher consumption rates [6]. Tobacco and alcohol retail outlets are more concentrated in disadvantaged areas, and are associated with higher consumption rates in those areas [9]. Moreover, cultural and historical factors also help to sustain tobacco use, especially in areas where there is a strong traditional association with tobacco use [10]. Tobacco and alcohol consumption have a synergistic effect, greatly increasing health risks, especially cancer, a major concern in areas where consumption is high [6]. These findings highlight the importance of designing public health interventions that take these socio-demographic factors into account to effectively tackle consumption patterns and reduce health risks in Maharashtra and other parts of the world [5,11].

The present study uses estimates at the district level (36 districts) in Maharashtra for males and females to study the tobacco and alcohol consumption and uses thematic and bivariate spatial mapping to find out the districts with relatively low, moderate and high tobacco and alcohol consumption and to explore the spatial co-occurrence of the districts. Pearson's correlation coefficient and Spearman's rank correlation coefficient are used to measure the association between tobacco and alcohol consumption at district level (36 districts). The former measures the linear association, whereas the latter measures the monotonic association, which are two ways of measuring the association to avoid overusing one statistical measure. The study also includes selected socio-demographic and household characteristics as potential correlates of tobacco and alcohol use, because we know that not one, but many interacting geographical and social

determinants of health shape health-related behaviours. This district-level view can provide insight into spatial variation in behavioural health risks and provide a spatial basis for prioritizing areas where greater focus may be needed in health planning, health awareness and health prevention efforts.

The present study is conducted in the State of Maharashtra, India. Maharashtra is located in the western and central part of India between the latitudes of 15°37' N and 22°00' N and longitudes of 72°36' E and 80°54' E. It is one of the largest states in India in terms of geographical area (307,713 km²). In the present district level analysis, Maharashtra is treated as a spatial unit with 36 districts. These districts vary significantly in geography, population, socio-economic and cultural factors, with highly urbanised areas (Mumbai, Thane, Pune, and Nagpur) and predominantly rural and tribal areas (Nandurbar, Gadchiroli, Palghar, and Dhule). The current study focuses on the geographical variation in tobacco and alcohol use among males and females at the district level, and gender differentials and association between tobacco and alcohol consumption, based on district-level prevalence estimates from the NFHS-5 (2019-21). The 36 districts are therefore treated as the most appropriate spatial unit for statistical analysis and thematic mapping. The study is a combination of health geography, spatial analysis, statistical correlation and thematic cartography to explore the geographical aspects of tobacco and alcohol consumption in Maharashtra. The study aims to offer a holistic picture of the distribution of these two key behavioural risk factors, gender differences and their interrelationships at the district level using both statistical evidence and spatial visualization.

Aim:

To analyze the spatial distribution, gender differentials, and socio-demographic correlates of tobacco and alcohol consumption across the districts of Maharashtra.

Objectives:

- To map the spatial distribution of tobacco and alcohol consumption.
- To examine gender-wise variations in consumption patterns.
- To measure the correlation between tobacco and alcohol consumption using Pearson's and Spearman's methods.
- To identify spatial co-occurrence patterns through bivariate mapping.
- To assess the association of selected socio-demographic characteristics with consumption patterns.

Database and Methodology

The study is secondary data based on the National Family Health Survey-5 (NFHS-5) conducted by the Ministry of Health and Family Welfare, Government of India in 2019-21. The analysis includes all 36 districts in Maharashtra and the tobacco and alcohol consumption is analysed separately for men and women and for selected socio-demographic and household indicators. The NFHS-5 attributes were combined with the district boundary data to create a spatial database using GIS.

Descriptive statistics, thematic mapping, bivariate choropleth mapping, Global Moran's I, Pearson's correlation and Spearman's rank correlation are used in the study. The prevalence of tobacco and alcohol consumption was categorized by district-level terciles and the spatial distribution of the prevalence of both was illustrated using bivariate maps. Linear association between tobacco and alcohol consumption was measured using Pearson's correlation and monotonic association was measured using Spearman's

correlation [12]. Two-tailed p-values were used to determine statistical significance at 5% level ($p < 0.05$). To visualize the spatial variation and to identify geographical patterns across the 36 districts, GIS techniques were used.

Four key district-level behavioural health measures from NFHS-5 (2019-21) are analyzed. Tobacco consumption among women is the percentage of women aged 15 years and over who use any type of tobacco, and tobacco consumption among men is the percentage of men aged 15 years and over who use any type of tobacco. Alcohol consumption among women is the percentage of women aged 15 years and older who drink alcohol, and alcohol consumption among men is the percentage of men aged 15 years and older who drink alcohol. Spatial variation and gender differences were analyzed using these four indicators in all the 36 districts of Maharashtra. Pearson's and Spearman's correlation coefficients were used to analyze the tobacco–alcohol relationships separately for women and men.

Other socio-demographic and household indicators were: female educational attainment, household electricity availability, improved drinking-water facilities, clean cooking fuel and percentage of women aged 15-49 years with 10 or more years of education. These indicators were explored as potential district level correlates of tobacco and alcohol use.

Results

Spatial Pattern of Tobacco and Alcohol Consumption

The district level analysis shows that there is significant spatial variation in tobacco and alcohol consumption in Maharashtra. The bivariate maps (Figures 1-3) indicate that the prevalence of tobacco and alcohol use is significantly different across the 36 districts, and that the spatial pattern is different for men and women. The map for men indicates significant clusters of high tobacco–high alcohol districts, especially in the eastern region of Maharashtra and certain northern districts. Otherwise, some of the western and central districts are in low or intermediate combinations. The map for women also shows significant spatial variation, with high tobacco–high alcohol combinations being found in certain northern, eastern and southern districts, and a number of western and central districts having lower or mixed combinations [13]. These patterns show that tobacco and alcohol use is not evenly distributed throughout the state, but rather is geographically differentiated.

The comparative consumption map also shows that there are significant gender disparities in the prevalence of tobacco and alcohol consumption at the district level [14]. Overall, the tobacco and alcohol consumption of males is greater than that of females in most districts. Gender disparities in behavioural risk patterns are more evident in a few districts in the east and north (Figure 1).

Figure 1 Spatial Distribution of Tobacco and Alcohol Consumption among Men and Women across the Districts of Maharashtra, India.

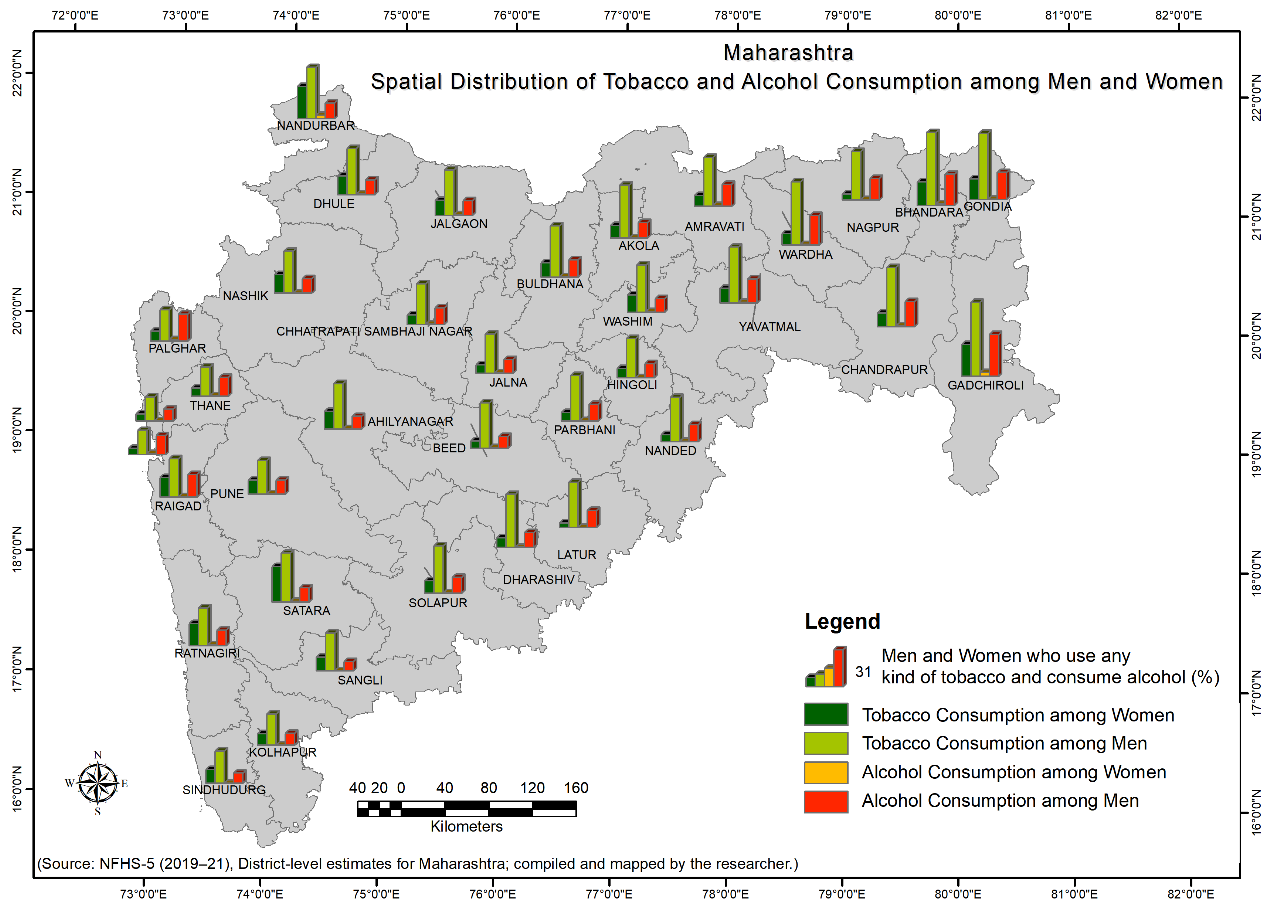


Figure 2 District-Level Bivariate Spatial Distribution of Tobacco and Alcohol Consumption among Men in Maharashtra, India.

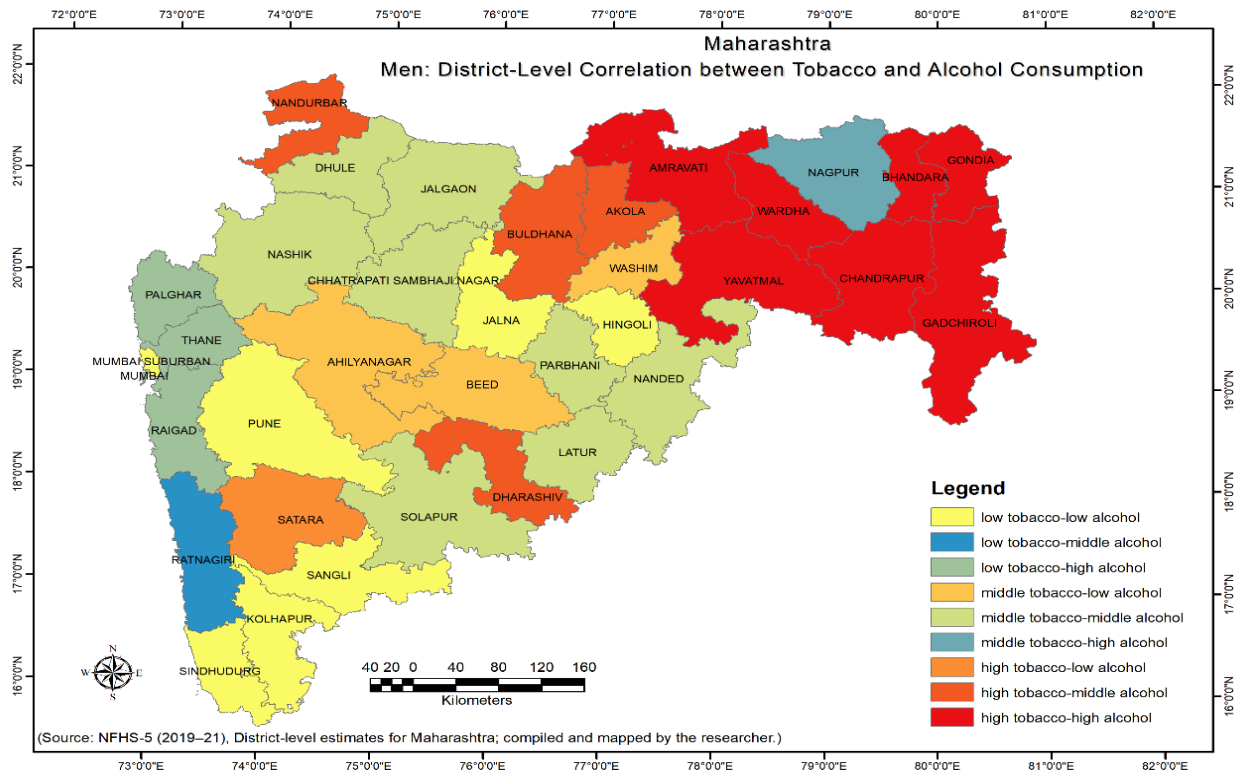
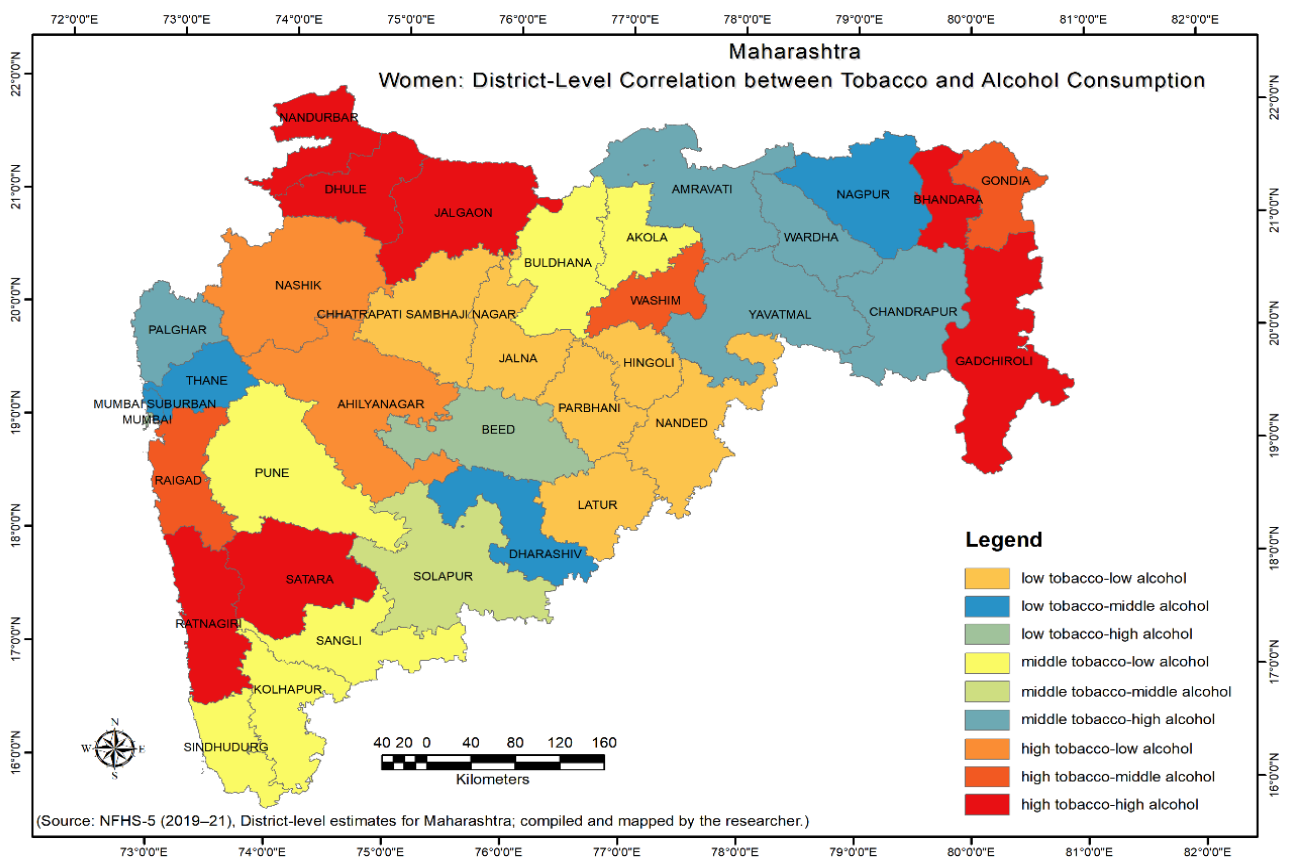


Figure 3 District-Level Bivariate Spatial Distribution of Tobacco and Alcohol Consumption among Women in Maharashtra, India.



Global Spatial Autocorrelation

Table 1 Global spatial autocorrelation of tobacco and alcohol consumption in Maharashtra

Consumption indicator	Global Moran's I	Expected I	Permutation SD	p-value	Spatial autocorrelation
Tobacco – Women (15+)	0.0803	-0.0066	0.0254	0.0020	Significant positive
Tobacco – Men (15+)	0.1690	-0.0063	0.0260	0.0001	Significant positive
Alcohol – Women (15+)	0.0210	-0.0064	0.0232	0.3901	Not significant
Alcohol – Men (15+)	0.1327	-0.0064	0.0249	0.0001	Significant positive

(Source: Author's computation using district-level NFHS 5 data and Queen contiguity spatial weights.)

The results of the Global Moran's I analysis show that three of the four indicators are highly positively spatially autocorrelated (Table 1). The Moran's I for women's tobacco consumption was 0.0803 ($p = 0.0020$), which showed that there was significant positive spatial autocorrelation. Spatial autocorrelation was also present and significant in men's tobacco consumption with a Moran's I of 0.1690 ($p = 0.0001$). This means that districts with similar tobacco consumption are more likely to be located next to each other than randomly.

Women's prevalence for alcohol consumption resulted in a Moran's I of 0.0210 ($p = 0.3901$) and no statistically significant global spatial autocorrelation. Alcohol consumption by males, on the other hand, had a Moran's I of 0.1327 ($p = 0.0001$), indicating strong positive spatial autocorrelation. Thus, there is a spatial structure of alcohol consumption that varies by gender, and it is possible to see a geographical structure for men, but not for women [15].

In general, the Moran's I results indicate that tobacco use among both males and females, and alcohol use among males are statistically significantly positively spatially clustered, while alcohol use among females is not statistically significantly globally clustered [16].

Socio-Demographic Regression Results

Table 2 Multivariable regression model summary for tobacco and alcohol consumption

Dependent variable	R ²	Adjusted R ²	F-statistic	Model p-value	AIC	BIC
Tobacco – Women (15+)	0.1249	-0.0210	0.6371	0.6730	240.072	249.573
Tobacco – Men (15+)	0.1923	0.0576	0.9981	0.4357	270.821	280.322
Alcohol – Women (15+)	0.3118	0.1971	0.8818	0.5053	70.757	80.258
Alcohol – Men (15+)	0.1234	-0.0227	0.9248	0.4787	232.883	242.384

(Source: Author's computation from the 36-district NFHS 5 dataset.)

Table 3 Socio-demographic predictors included in regression models

Predictor	Indicator definition
Education	Female population aged 6 years and above who have ever attended school (%)
Electricity	Population living in households with electricity (%)
Improved drinking water	Population living in households with improved drinking water (%)
Clean cooking fuel	Households using clean cooking fuel (%)
Women's schooling	Women aged 15–49 years with 10 or more years of schooling (%)

(Source: NFHS 5 District-level socio-demographic dataset.)

Table 4 Summary of spatial and regression findings

Outcome	Moran's I	Spatial significance	Regression R ²	Regression model p-value
Female tobacco	0.0803	Significant	0.1249	0.6730
Male tobacco	0.1690	Significant	0.1923	0.4357
Female alcohol	0.0210	Not significant	0.3118	0.5053
Male alcohol	0.1327	Significant	0.1234	0.4787

Multivariable regression analysis was used to explore the relationship between socio-demographic and household factors and tobacco and alcohol use (Tables 2 and 3). Female education, availability of electricity in the household, improved access to drinking water, clean cooking fuel and women's schooling were the explanatory variables.

Overall, none of the four regression models were statistically significant. The model for women's tobacco consumption had an R² of 0.1249 and an overall p-value of 0.6730, and the model for men's tobacco consumption had an R² of 0.1923 and p = 0.4357. The women's model was the most explanatory of the four models with an R² of 0.3118 and an adjusted R² of 0.1971, but the model was not statistically significant (p = 0.5053) for alcohol consumption. The men's alcohol model produced an R² of 0.1234 and p = 0.4787.

Therefore, while the socio-demographic and household indicators selected explain some of the variation in the prevalence at the district level, especially in the women's alcohol model, the overall regression results do not show a statistically significant combined effect of the selected socio-demographic and household indicators on the respective consumption outcomes at the 5% level [17].

Correlation between Tobacco and Alcohol Consumption

Correlation analysis shows that there is positive correlation between tobacco and alcohol consumption for both women and men in 36 districts (Table 5). For females, Pearson's correlation coefficient was r = 0.5631 (p = 0.0004), which was statistically significant and showed a positive linear association. The corresponding Spearman's rank correlation was however, statistically not significant at 5% level with p = 0.3143 (p = 0.0619).

The association was stronger among men. Pearson's correlation produced r = 0.6572 (p < 0.001), while Spearman's correlation produced p = 0.4867 (p = 0.0026). Both the coefficients were significant at 5%.

This suggests that districts with higher prevalence of male tobacco use tend to have higher prevalence of male alcohol use.

Table 5 Pearson's and Spearman's Correlation between Tobacco and Alcohol Consumption among Women and Men across 36 Districts of Maharashtra

Group	No. of Districts	Indicator X	Indicator Y	Pearson r	Pearson p two sided	Spearman rho	Spearman p two sided
Women	36	Women's tobacco consumption (%)	Women's alcohol consumption (%)	0.5631	0.0004	0.3143	0.0619
Men	36	Men's tobacco consumption (%)	Men's alcohol consumption (%)	0.6572	0.0000	0.4867	0.0026

(Source: Computed by the researcher based on district-level NFHS-5 (2019–21) data.)

The Pearson and Spearman results for women are interesting. The Pearson result shows that there is a significant linear association, while the rank-based Spearman test does not reach the 5% significance level. Both methods show a statistically significant positive association for men, with more consistent evidence of association at the district level.

The spatial and statistical analyses, combined, show three main patterns. First, there is significant geographical variation in tobacco and alcohol use in Maharashtra, with varying patterns of low, medium and high prevalence evident in the bivariate maps [18]. Second, there is positive spatial autocorrelation in women's and men's tobacco consumption and in men's alcohol consumption, but not in women's alcohol consumption. Third, the tobacco–alcohol association is positive for both genders, but is statistically consistent across the two correlation methods only among males.

The results thus show that there are spatial and gender-specific dimensions of tobacco and alcohol consumption in Maharashtra. However, none of the overall associations between the selected socio-demographic and household predictors and the regression models are statistically significant. The analysis is conducted at the district level and these results should be interpreted as ecological relationships and not as indicative of behaviour or causality at the individual level.

Discussion

The results show significant district and gender differences in tobacco and alcohol use in the 36 districts of Maharashtra. The bivariate maps show that there are significant differences across districts in the prevalence of tobacco and alcohol. The distribution of high–high, low–low and mixed combinations across the state indicate that these behavioural risk factors are not evenly distributed, but rather have a geographical pattern.

The Global Moran's I values indicate that there is significant spatial structure for three of the four indicators. There is significant positive spatial autocorrelation in tobacco consumption among women (I

= 0.0803, $p = 0.0020$) and men ($I = 0.1690$, $p = 0.0001$), meaning that districts with similar tobacco-consumption levels tend to be spatially clustered. This suggests that the spatial association is comparatively higher among males, as their Moran's I is higher. There is no significant spatial autocorrelation for women's alcohol consumption ($I = 0.0210$, $p = 0.3901$), but there is significant positive spatial autocorrelation for men's alcohol consumption ($I = 0.1327$, $p = 0.0001$). This gender gap indicates that the spatial organisation of alcohol consumption is more evident for men.

The correlation analysis also shows positive correlation between tobacco and alcohol consumption. For women, Pearson's correlation is $r = 0.5631$ ($p = 0.0004$), which is significant at the 5% level, and shows a strong positive linear association, while Spearman's correlation is $\rho = 0.3143$ ($p = 0.0619$) and is not significant at the 5% level. Among men, both Pearson's ($r = 0.6572$, $p < 0.001$) and Spearman's ($\rho = 0.4867$, $p = 0.0026$) correlations are positive and statistically significant. So, the association between tobacco and alcohol use is more consistently observed among males at the district level. These statistical results are complemented by bivariate maps that show where relatively high prevalence of tobacco and alcohol use overlap. The spatial co-occurrence depicted on the maps should not, however, be interpreted as evidence of causation. It shows geographical association between the two indicators at district level.

The regression analysis offers another point of view. Although the selected socio-demographic and household variables explain some variation in the outcomes, none of the four regression models is statistically significant overall. Women's alcohol consumption ($R^2 = 0.3118$) has the highest explanatory power, followed by men's tobacco consumption ($R^2 = 0.1923$). However, their model p -values are still above the 5% significance level. This indicates that the variation in tobacco and alcohol use at the district level is not fully explained by the indicators selected [14].

In summary, the results emphasize the need to consider spatial context and gender differences in understanding tobacco and alcohol consumption in Maharashtra. There is strong spatial clustering for tobacco use for both sexes and for alcohol use for males, and strong spatial clustering for the tobacco–alcohol association for males. The results also illustrate the value of combining GIS mapping, Global Moran's I , correlation analysis, and regression analysis for the analysis of geographical patterns of behavioural health risks. The analysis is conducted at the district level and the results are ecological associations and are not to be interpreted as individual-level relationships or causal effects.

Conclusion and Suggestions

Conclusion

The study shows significant district and gender differences in tobacco and alcohol use in the 36 districts of Maharashtra. The thematic and bivariate maps show that there are unique geographical patterns of tobacco and alcohol prevalence, and that these behavioural risk factors are not evenly distributed throughout the state. There is strong positive spatial autocorrelation in tobacco use for both women and men and strong spatial clustering for alcohol use among men but not among women.

Correlation analysis shows a positive correlation between tobacco and alcohol use. Pearson's correlation indicates a significant positive association among women, but not at the 5% level for Spearman's correlation. Pearson and Spearman correlations are both positive and statistically significant for men, suggesting a more uniform district-level relationship between tobacco and alcohol use. The regression analysis, however, shows that the selected socio-demographic and household indicators do not significantly explain the overall variation in any of the four consumption outcomes.

Overall, the results highlight the need to consider spatial context and gender differences in the analysis of behavioural health risks. The use of GIS mapping, Global Moran's I, correlation analysis and regression give a multidimensional understanding of tobacco and alcohol consumption in Maharashtra. Because the analysis is conducted at the district level, the results are ecological associations and are not causal relationships at the individual level.

Suggestions

1. District-specific interventions: Geographical variation identified in the study should be taken into account in the development of health awareness and prevention programmes, and a uniform approach should not be used for all districts.
2. Gender-sensitive strategies: The spatial distribution of tobacco and alcohol consumption varies by gender, so tobacco and alcohol control programmes should include gender-specific strategies.
3. Integrated prevention programmes: Due to the positive association between tobacco and alcohol consumption, especially among men, prevention programmes might want to consider addressing both behaviours together, rather than treating them as completely distinct risks.
4. Prioritise areas with spatial clustering: Districts with spatial clustering of higher prevalence can be given more attention in awareness, screening, counselling and cessation programmes.
5. Improve socio-demographic interventions: While the regression models were not statistically significant overall, socio-demographic factors such as education, household conditions and access to basic facilities are important contextual factors to be considered in addition to behavioural and health interventions.
6. Local-level data: Future studies should include individual-level survey data and other factors including occupation, income, urban–rural differences, cultural practices, availability of substances, and accessibility to health services.
7. Additional spatial analysis: Additional spatial analysis can be done using Local Moran's I (LISA) or other local spatial statistics to identify statistically significant local clusters and spatial outliers, in addition to the Global Moran's I results.
8. Longitudinal analysis: Successive NFHS rounds can be compared to determine if there are changes in the geographical distribution of tobacco and alcohol use over time.
9. Community based interventions: District level findings can be supplemented by community and field level studies to gain insights into the social and cultural determinants of observed geographical patterns.
10. Evidence-based health planning: The spatial database and maps created in the study can be used as a geographical reference for researchers, public-health planners, and local authorities to develop targeted behavioural health programmes.

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