Geospatial Patterns of Alcohol and Tobacco Use in India: A Cluster Analysis of NFHS 4

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Abstract - Cluster analysis explains statistical procedures to explore segmentation within complex data sets. Alcohol and tobacco use are the major public health issues in India. Knowing the geographic distribution of alcohol and tobacco use is crucial in identifying high-priority healthcare intervention areas. Thus, the study aims to arrange Indian states as per alcohol and tobacco use. NFHS-4 data for 28 Indian states were used for analysis. The input parameters included – alcohol and tobacco use among men and women in 28 Indian states. Ward linkage algorithm along with hierarchical cluster analysis method was used. Minimum 10% cut off was set for clustering. States with similar consumption patterns were grouped and presented on a dendrogram. Results suggest that the geospatial patterns of alcohol and tobacco use were primarily concentrated in north-eastern India. Targeted interventions discouraging addictive behaviours and promoting a healthy lifestyle are recommended for these geographical hotspots of alcohol and tobacco use in India.

Keywords - tobacco, alcohol, addictive behaviours, cluster analysis, India, statistics

I. INTRODUCTION

Alongside alcohol, Tobacco use is a serious public health problem in many countries including India (Goswami et al., 2005). Smoking causes a vast spectrum of diseases, which ultimately result in death (Gupta and Sinha 2004). There are over 50 diseases that are caused, increased or exacerbated by smoking (Gupta and Sinha 2004). Globally, approximately, 47 per cent of men and 12 per cent of women smoke (WHO 2018). Available data suggest that in developing countries, 48 per cent of men smoke compared with seven per cent of women (WHO 2018). Further, various studies have shown that there is a moderately strong association between use of alcohol and tobacco (Goswami et al., 2005; Istvan, J., & Matarazzo, 1984). Smoking is linked to higher risk of nearly all forms of cardiovascular diseases, including myocardial infarction, ischemic stroke and bleeding into the brain (i.e., haemorrhagic stroke), congestive heart failure and narrowing of the arteries in the extremities (i.e., peripheral arterial disease) (Burns, 2003; Mukamal, 2006). In a similar way, alcohol use induces the risk of morbidity and mortality due to hypertension – an important cardiovascular risk factor (Klatsky et al., 2005; Mukamal, 2006). Further, Myocardial damage from heavy alcohol intake can cause heart failure (HF) syndrome (Mukamal, 2006). The consistent combined use of alcohol and tobacco results in hazardous health effects (Mukamal, 2006). Particularly, if the use is for a prolonged period, it results in fatal complications such as stroke and cardiovascular diseases (Mukamal, 2006).

The recent National Family Health Survey (NFHS) – fourth-round reports 6.8 per cent of Indian women use any kind of tobacco, 44.5 per cent of men use any kind of tobacco, 1.2 per cent of women consume alcohol and 29.2 per cent of men consume alcohol (IIPS and ICF 2017). The states wise prevalence also differed. Therefore, to form state-specific policies and strategies to reduce alcohol and tobacco consumption, it is necessary to group states

according to their pattern of alcohol and tobacco consumption.

II. METHODS AND DATA

The present study aims to group states according to alcohol and tobacco use patterns with respect to their geographical location. The secondary data from the National Family Health Survey (NFHS) 2015 – 16, 4th round, were extracted and used for analysis. All 28 Indian states were included in the study. The state-wise individual consumption of alcohol and tobacco was the unit of analysis. Data on alcohol and tobacco consumption among men and women of age between 15-49 years from each state were derived from the respective state fact sheet.

2.1. Description of Data Set

The 2015-16 National Family Health Survey (NFHS-4), the fourth in the NFHS series, provides information on population, health, and nutrition for India and each state and union territory (IIPS 2017). NFHS – 4 dataset was available on the IIPS website; data on tobacco consumption for each state were derived from the respective state fact sheet. The *Input parameters/variables are:*

- Tobacco use women (age 15-49 years)
- Tobacco use men (age 15-49 years)
- Alcohol use women (age 15-49 years)
- Alcohol use men (age 15-49 years)
- Total 28 Indian states.

2.2. Statistical Analysis

SPSS v 23 was used for the cluster analysis. Ward's minimum-variance hierarchical clustering method was performed using an agglomerative (bottom-up) approach and Ward's linkage (Ward, 1983).

2.2.1 Cluster Analysis

Cluster analysis used to describe a set of statistical procedures specifically designed to discover classifications within complex data sets (Gore, 2000). The objective of cluster analysis is to group objects into clusters such that objects within one cluster share more in common with one another than they do with the objects of other clusters (Gore, 2000). The current study uses this approach to group 28 Indian states based on alcohol and tobacco use into homogenous clusters.

Using Ward linkage algorithm, clusters were formulated using the following steps:

A. Data extraction: data derived from NFHS-4 states facts were re-entered into SPSS. For the analysis purpose proportion of alcohol and tobacco use (in %) among males and females of age 15 – 49 years from all 28 states were used as input parameters.

B. Hierarchical cluster analysis –where two or more variables with high correlation were removed from the model. Measures for similarity were determined using Euclidean distance. Further, to determine the cluster size with an adequate sample in each cluster a cut off of minimum 10% of total sample size (i.e. 28) was set and accordingly three clusters were formulated.

C. Clustering: a) Clusters numbers were set to two to four (considering small sample size). b) Initial cluster results were tested for minimum 10% cluster size; those clusters with < 10% size were removed.

D. Non- Hierarchical cluster analysis and test for homogeneity of clusters.

A. Extraction of NFHS – 4 Data

Data on input variables were derived from NFHS-4 states facts sheets for all 28 states. The data was obtained through online permission and was downloaded from IIPS website. The detailed parameters with data for the respective state presented in Table 1.

Table 1. Adult (15-49 Years) alcohol and tobacco use

State	Women who use any kind of tobacco (%)	Men who use any kind of tobacco (%)	Women who consume alcohol (%)	Men who consume alcohol (%)
Andhra Pradesh	1	19.7	0.1	29.6
Arunachal	15.3	56.6	22.3	55.2
Assam	16.6	63.5	2.9	29.7
Bihar	1.5	43.1	0.2	26.2
Chhattisgarh	13.1	52.2	1.4	52.1
Gujrat	5.2	46	0.1	10.6
Haryana	1.7	30.6	0.2	24.9
Himachal Pradesh	0.9	35.1	0.5	36.8
Jammu & Kashmir	1.6	34.8	0.2	9.2
Jharkhand	3.3	44.5	0.6	33.2
Karnataka	3.1	34.2	1.6	30.1
Kerala	0.1	23.6	2.4	32.8
Madhya Pradesh	6.5	53.1	0.6	28.3
Maharashtra	4.2	33.9	0.2	22.8
Manipur	46	66.1	6.2	52.9
Meghalaya	28.6	65.9	3.1	40.7
Mizoram	59.2	82	6.7	52.3
Nagaland	33.1	70.8	4.7	41.5
Odisha	10	45.3	1.3	32.2
Punjab	0.1	17.1	0.1	29.7
Rajasthan	6.4	43.8	0.1	19.4
Sikkim	8.2	39.6	22.7	48.9
Tamil Nadu	1.5	32.2	0.5	46
Telangana	1.1	25	2.7	46
Tripura	37.9	57.5	0.4	54.7
Uttar Pradesh	5.9	48.2	0.1	21.6
Uttarakhand	2.9	39.4	0.5	33.7
West Bengal	7.4	59.9	0.7	35.7

Source: Derived from NFHS-4 states facts sheets.

B. Hierarchical Cluster Analysis

At each generation of clusters, samples were merged into larger clusters to minimize the within-cluster sum of squares or to maximize the between-cluster sum of squares. Further, to compare differences between clusters, analysis of variance was used. The following agglomeration schedule provides the stage and distance between two observations in the respective cluster.

Table 2. Agglomeration schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	1	20	3.790	0	0	7
2	7	14	14.565	0	0	15
3	21	26	26.790	0	0	11
4	10	27	40.005	0	0	9
5	16	18	63.735	0	0	20
6	8	11	89.610	0	0	13
7	1	12	117.913	1	0	21
8	23	24	146.333	0	0	21
9	4	10	184.045	0	4	13
10	13	19	228.440	0	0	16
11	6	21	294.382	0	3	18
12	3	28	363.602	0	0	16
13	4	8	442.292	9	6	22
14	15	25	530.517	0	0	20
15	7	9	679.149	2	0	18
16	3	13	856.186	12	10	24
17	2	22	1045.816	0	0	19
18	6	7	1316.795	11	15	22
19	2	5	1626.025	17	0	26
20	15	16	1953.787	14	5	23
21	1	23	2322.334	7	8	25
22	4	6	2860.630	13	18	24
23	15	17	3532.173	20	0	27
24	3	4	4570.573	16	22	25
25	1	3	6585.350	21	24	26
26	1	2	9023.587	25	19	27
27	1	15	18738.271	26	23	0

C. Clustering

Using Wald's minimum-variance hierarchical clustering method and an agglomerative (bottom-up) approach, all input parameters were clustered. With successive clustering, 2-4 groups became obvious. Table 3 presents the cluster membership for two-four clusters. Further, criteria for the composition of each cluster was set to a minimum of 10%. Clusters with less than 10% cases were not considered.

If considered as minimum 10% of total 28 states to be in each group, cluster membership provides following options:

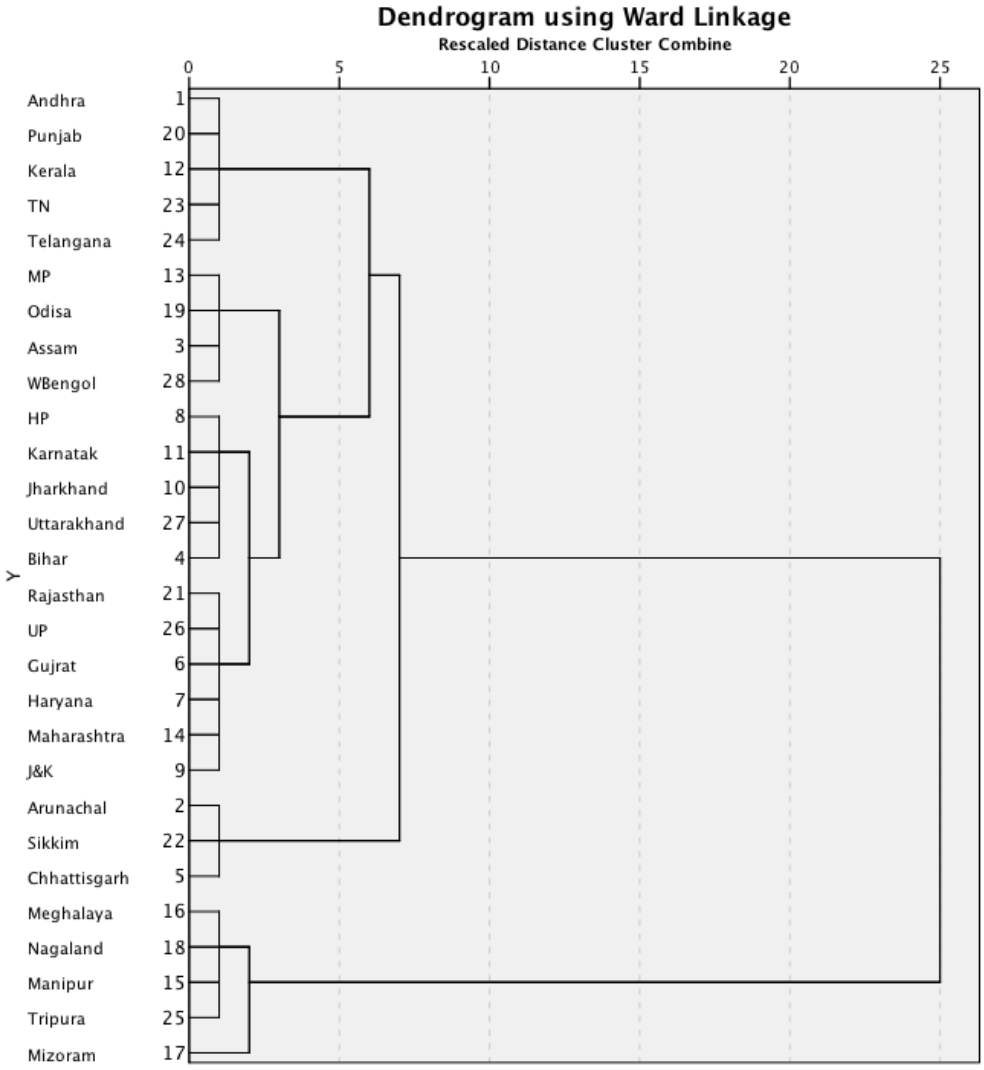
- *Option -1:* If two clusters have to be formed, we would have had: five (which is minimum i.e. 18 %) and 23 (82 %) observations.
- *Option -2:* If three clusters have to be formed, we would have had: 19 (67 %), six (22 %) and three (which is minimum i.e. 11 %) observations.
- *Option -4:* If four clusters have to be formed, we would have had: 15 (54 %), five (18), five (18) and three (which is minimum i.e. 10 %) observations.

Table 3. Cluster membership

Case	4 Clusters	3 Clusters	2 Clusters
1: Andhra	1	1	1
2: Arunachal	2	2	1
3: Assam	3	1	1
4: Bihar	3	1	1
5: Chhattisgarh	2	2	1
6: Gujrat	3	1	1
7: Haryana	3	1	1
8: Himachal Pradesh	3	1	1
9: Jammu & Kashmir	3	1	1
10: Jharkhand	3	1	1
11: Karnataka	3	1	1
12: Kerala	1	1	1
13: Madhya Pradesh	3	1	1
14: Maharashtra	3	1	1
15: Manipur	4	3	2
16: Meghalaya	4	3	2
17: Mizoram	4	3	2
18: Nagaland	4	3	2
19: Odisha	3	1	1
20: Punjab	1	1	1
21: Rajasthan	3	1	1
22: Sikkim	2	2	1
23: Tamil Nadu	1	1	1
24: Telangana	1	1	1
25: Tripura	4	3	2
26: Uttar Pradesh	3	1	1
27: Uttarakhand	3	1	1
28: West Bengal	3	1	1

Therefore, to achieve the criteria of minimum 10 % sample size, the second option – two i.e. to have three clusters becomes obvious. Therefore, a total of three clusters were formulated and presented in the dendrogram (Figure 1). The dendrogram shows the states of similar consumption pattern are grouped, i.e. they are homogeneous. It also shows each cluster of states is dissimilar with each other, they are heterogeneous with others. Here we have three clusters with 19, six and three states in the respective cluster.

Fig. 1 Dendrogram



D. Non-Hierarchical Cluster Analysis

K-means cluster- was done to finalize the clusters calculated in step three above. The following initial cluster centre table gives the mean value of each parameter in the respective cluster. Table 4 presents the initial cluster centre. While Table 5 gives iteration history with cluster wise cluster centre value for one member (state) i.e. centroid, for the rest states in the respective cluster we will calculate values in cluster membership.

Table 4. Initial Cluster Centres

Parameter	Cluster		
	1	2	3
Women who use any kind of tobacco (%)	0.1	15.3	59.2
Men who use any kind of tobacco (%)	17.1	56.6	82.0
Women who consume alcohol (%)	0.1	22.3	6.7
Men who consume alcohol (%)	29.7	55.2	52.3

Table 5. Iteration History

Iteration	Change in Cluster Centers		
	1	2	3
1	18.263	19.713	16.293
2	1.020	2.844	4.809
3	.000	.000	.000

Table 6 presents the ANOVA for the homogeneity of each cluster. ANOVA table shows that none of the variables has *p*-value >=0.005 hence, all the input parameters have similarity among set clusters, none of them needs to be removed.

Table 7 provides the agglomeration schedule for clusters at different stages. The following agglomeration schedule provides the stage and distance between two observations in the respective cluster.

Table 6. Test for Homogeneity of Clusters (ANOVA)

Parameter	Cluster		Error		F	*p*-value
	Mean Square	df	Mean Square	df		
Women who use any kind of tobacco (%)	2778.005	2	32.411	25	85.713	.000
Men who use any kind of tobacco (%)	2257.987	2	101.577	25	22.229	.000
Women who consume alcohol (%)	156.153	2	23.947	25	6.521	.005
Men who consume alcohol (%)	1078.603	2	89.936	25	11.993	.000

Table 7. Agglomeration schedule

Stage	Cluster Combined		Coefficients	Stage Cluster First Appears		Next Stage
	Cluster 1	Cluster 2		Cluster 1	Cluster 2	
1	1	20	3.790	0	0	7
2	7	14	14.565	0	0	15
3	21	26	26.790	0	0	11
4	10	27	40.005	0	0	9
5	16	18	63.735	0	0	20
6	8	11	89.610	0	0	13
7	1	12	117.913	1	0	21
8	23	24	146.333	0	0	21
9	4	10	184.045	0	4	13
10	13	19	228.440	0	0	16
11	6	21	294.382	0	3	18
12	3	28	363.602	0	0	16
13	4	8	442.292	9	6	22
14	15	25	530.517	0	0	20
15	7	9	679.149	2	0	18
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23	15	17	3532.173	20	0	27
24	3	4	4570.573	16	22	25
25	1	3	6585.350	21	24	26
26	1	2	9023.587	25	19	27
27	1	15	18738.271	26	23	0

Table 9 gives the distance of respective member from centroid in their respective cluster. Using this cluster membership, the following numbers of cases (states) in each cluster were finalised and were presented in Table 10.

Assuming minimum 10% of total 28 in each cluster, three clusters can be formed, with 18 (64 %), six (21 %) and four (which is minimum i.e. 15 %) states in each. These clusters can be presented in the dendrogram in Fig 1.

Table 9. Determining the final cluster size and cluster process

Cluster	State	Distance
Cluster 1	Andhra	16.577
	Bihar	7.581
	Gujrat	20.574
	Haryana	6.745
	Himachal Pradesh	8.657
	Jammu & Kashmir	19.417
	Jharkhand	9.634
	Karnataka	2.643
	Kerala	13.668
	Madhya Pradesh	17.336
	Maharashtra	6.215
	Odisha	12.066
	Punjab	19.28
	Rajasthan	12.375
	Tamil Nadu	18
	Telangana	20.915
	Uttar Pradesh	14.218
	Uttarakhand	6.168
Cluster 2	Arunachal	17.693
	Assam	16.94
	Chhattisgarh	12.066
	Meghalaya	17.979
	Sikkim	23.269
	W. Bengal	14.125
Cluster 3	Manipur	4.711
	Mizoram	20.114
	Nagaland	14.183
	Tripura	14.426
Total	**28**	

Table 10. Number of cases (states) in each cluster

Cluster	*n*
1	18
2	6
3	4
Total	**28**

III. RESULTS

Cluster 1 (n=18) has mean values for the first parameter (i.e. women who use any kind of tobacco) of 3.2 per cent and for men, it is 36 per cent. For alcohol-related parameters, the mean value is 0.7 per cent and 28.5 per cent for women and men respectively. If compared with other clusters, it shows the lowest consumption of alcohol and tobacco among men and women. Hence, this cluster can be labelled as *'Cluster-1: States with low consumption'*.

For cluster 2 (n=6) the mean values for the first parameter (i.e. women who use any kind of tobacco) are 15 per cent for women and 56 per cent for men. For alcohol-related parameters, the mean value is nine per cent and 44 per cent for women and men respectively. If compared with other clusters, it shows moderate (higher than cluster 1 and lower than cluster 3) consumption of alcohol and tobacco among men and women. Hence, this cluster can be labelled as *'Cluster-2: States with moderate consumption'*.

For cluster 3 (n=4) mean values for the first parameter (i.e. women who use any kind of tobacco) are 44 per cent for women and 69 per cent for men. For alcohol-related parameters, the mean value is five per cent and 50 per cent for women and men respectively. If compared with other clusters, it shows the highest consumption of alcohol and tobacco among men and women. Hence, this cluster can be labelled as *'Cluster-3: States with high consumption'*.

Table 11. Final cluster centres

Cluster	Women who use tobacco (%)	Men who use tobacco (%)	Women who consume alcohol (%)	Men who consume alcohol (%)
1	3.2	36.1	0.7	28.5
2	14.9	56.3	8.9	43.7
3	44.1	69.1	4.5	50.3

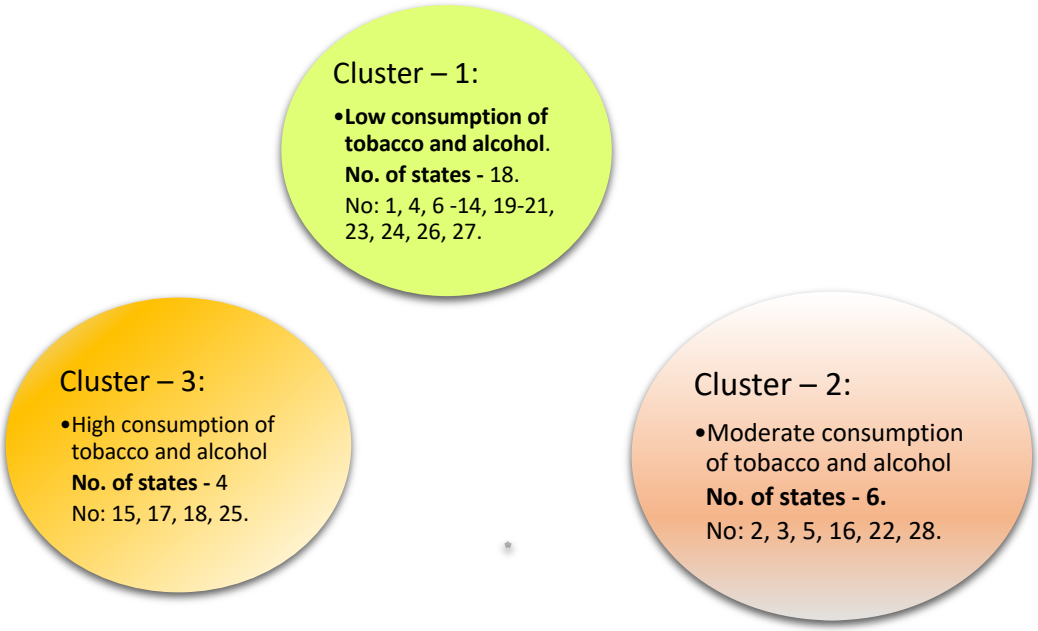
From the above tables and respective interpretations, these three clusters can be formed and are presented in Fig. 2.

Cluster – 1: Low consumption of alcohol and tobacco together by men and women.

Cluster – 2: Moderate consumption of alcohol and tobacco together by men and women.

Cluster – 3: High consumption of alcohol and tobacco together by men and women.

Fig. 2. Clusters for alcohol and tobacco use



Accordingly, all 28 states can be grouped into three clusters. Cluster 3 has four states- Manipur, Mizoram, Nagaland and Tripura which are situated in the north – eastern region. These states have shown higher consumption of alcohol and tobacco among men and women of age 15 to 49 years. This was followed by Cluster 2 with moderate consumption of alcohol and tobacco. Cluster 2 has a total of six states – Arunachal, Assam, Chhattisgarh, Meghalaya, Sikkim and West Bengal. With the exception of West Bengal and Chhattisgarh, all the states in this cluster belong to the north – eastern region of India.

The rest of the 18 states form cluster 1 and have shown low consumption of alcohol and tobacco. Cluster 1 has diverse spatial distribution. It has some states from the northern and most of the states from the central and southern part of the country.

Table 12. Final clusters

Cluster – 1	Cluster – 2	Cluster – 3
1: Andhra	2: Arunachal	15: Manipur
4: Bihar	3: Assam	17: Mizoram
6: Gujrat	5: Chhattisgarh	18: Nagaland
7: Haryana	16: Meghalaya	25: Tripura
8: Himachal Pradesh	22: Sikkim	
9: Jammu & Kashmir	28: W. Bengal	
10: Jharkhand		
11: Karnataka		
12: Kerala		
13: Madhya Pradesh		
14: Maharashtra		
19: Odisha		
20: Punjab		
21: Rajasthan		
23: Tamil Nadu		
24: Telangana		
26: Uttar Pradesh		
27: Uttarakhand		
Total: 18	**Total: 6**	**Total: 4**

IV. DISCUSSION AND CONCLUSION

At a global, national, and regional level, alcohol and tobacco use are the major public health issues that equally affect human development particularly in low- and middle-income countries (LMICs) like India. The geographical distribution plays a major role in the addictive behaviours of the population. Therefore, the present study used cluster analysis for the spatial distribution of alcohol and tobacco use as it offers a statistically sound means of delineating natural groupings within the data (Hillhouse & Adler, 1997). The findings from the cluster analysis reveal that the states in the north-eastern region of India had higher to moderate consumption of alcohol and tobacco among adults. Comparatively, the states in the central and southern regions of the country had low consumption of alcohol and tobacco. With ANOVA, the consumption pattern in the respective regions has shown homogeneity and dissimilarity with a group of states in other regions. Further comparative analysis is needed to assess the geographical characteristics, such as the rampant cultivation of tobacco and the illegal production of alcoholic beverages in certain regions.

Predominantly, rampant urbanization and unregulated industrialization have failed to provide quality of life to the overall human population (Tikhute, 2023). Resultant stress and uncertainty might have contributed to the inclination of the youth and adult population towards addictive behaviours. Therefore, further exploratory assessment is needed to identify associated factors concerning political, social, and geographical dimensions in regions with higher consumption of alcohol and tobacco.

The increase in the use of substances like alcohol and tobacco is a major public health issue. Particularly youth (15 to 24 years) and adults (15 to 49 years) have become addicted to these substances. Strict implementations of laws restricting the use of alcohol and tobacco by people below the age of 25 are required, particularly in regions with higher use of these substances.

With results deduced from the secondary source of data, the study has its scope and limitations. It is simply an attempt to recommend policy solutions and community-based interventions to reduce the use of alcohol and tobacco among the adult population. The study recommends that a comprehensive national-level study to explore the underlying factors along with geographical variations should be designed. Accordingly, state-specific community-based interventions can be implemented, particularly in states from the north-east region with higher consumption of tobacco and alcohol.

Although it is not mentioned, the higher use of tobacco among adults represents a higher proportion of second-hand smoke among their family members, particularly pregnant women and children. Further, the use of tobacco among pregnant women may result in teratogenic effects in the foetus and multiple health issues

among neonates later on (Winklbaur, et. al. 2008). The healthcare system needs to devise strategies to detect and provide additional counselling to pregnant women who smoke tobacco. For the same, Gynaecologist and nurses can provide counselling to pregnant women and their spouses during antenatal check-up visits to the healthcare facility. In this regard, capacity building for health providers plays a crucial role. Health care providers at community or primary healthcare centres must be trained to 'ask, record, teach, and report' all such mothers or their partners who smoke. Through 'asking', pregnant women exposed to smoke at the workplace or residence can be identified and provided with additional care and support through counselling serviced during the ANC period. Further, ground-level healthcare link providers such as ASHA's should be trained to detect and report all such cases where pregnant women are exposed to smoke (either through personal use or through second-hand smoke).

The study concludes that states in the north-east region had higher users of tobacco and alcohol. State-specific policies are required to curb the production, use, sale, and marketing of alcohol and tobacco products. In order to curb addictive behaviours, the development and implementation of programmes to increase awareness among adults regarding the harmful use of alcohol and tobacco must be developed and implemented with the help of local non-governmental organisations (NGOs). Further, community-based interventions to reduce second-hand smoking and the overall use of tobacco and alcohol must be designed and implemented through the channels of local healthcare facilities.

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