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Original Article

Socioeconomic Inequalities in Clustering of Health-Compromising Behaviours among Indian Adolescents

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Abstract

Background: The simultaneous occurrence of health-compromising behaviors can accentuate the risk of noncommunicable diseases (NCDs). This study aimed to examine the existence and patterns of clustering of four NCD risk behaviors among adolescents and its association with social position. In addition, socioeconomic inequalities in the occurrence of clustering of NCD risk behaviors were also assessed. **Methods:** A cross-sectional study was undertaken among 1218 adolescents (14–19 years old) in the city of New Delhi, India. An interviewer-administered questionnaire was used to assess health-compromising behaviors (tobacco and alcohol use, fruit/vegetable intake, and physical inactivity). Clustering was assessed using pairwise correlations, counts of clustering of health-compromising behaviors, comparison of observed/expected ratios, and hierarchical agglomerative cluster analysis. Multivariable logistic regressions were used to test the associations of clustering with social position (education and wealth). The relative and slope indices of inequalities in the presence of clustering of behaviors according to education and wealth were estimated. **Results:** Three major clusters of health behaviors emerged: (a) physical inactivity + lower fruit and vegetable intake, (b) tobacco + alcohol use, and (c) lower fruit and vegetable intake + tobacco + alcohol use. Pronounced clustering of health-compromising behaviors was observed with lower educational attainment and wealth. **Conclusion:** The presence of clustering of health-compromising behaviors was considerably higher among adolescents with lower educational attainment and wealth. The area of residence has an important influence on socioeconomic inequalities in clustering of NCD risk factors.

Keywords: Clustering, health behavior, noncommunicable disease, relative index of inequality, slope index of inequality

Introduction

Many lower-middle-income countries (LMICs) suffer a dual burden of infectious and noncommunicable diseases (NCDs).[1] The toll of NCDs is also largely suffered by LMICs, as three-quarters of total NCD-related deaths (28 million) occur within LMICs.[2] In addition to their effects on death and disability, NCDs further impact on the already resource-constrained health systems in LMICs, further suppressing economic development.[3] These risk factors are common for a wide range of NCDs rather than being specific to a condition.[4] Several studies have indicated that these risk factors tend to co-occur simultaneously within the same individuals and population groups,[5,6] a phenomenon known as "clustering of health behaviors."[7] Investigating the clustering of health-compromising behaviors is vital as it may signal the vulnerability of individuals to both increased occurrence and severity of NCDs.[8,9]

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Studies have investigated different features of clustering of risk factors such as its degree (number of clustering behaviors), pattern (type of clustering behaviors), and nature (health compromising or health protective).[10] The public health burden of NCDs is often shared disproportionally according to levels of disadvantage both between and within societies.[11]

Few studies have examined associations between clustering of behaviors and social position.[7,12] Most of these studies have tested associations through individual-level social position

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measures and through area-level deprivation. Consistent positive associations between disadvantage and clustering of risk factors were reported in all studies.[7,13]

Most studies were conducted among adults[7,13] and in high-income countries.[7,13] Evidence from LMICs is limited to Brazil,[14] and there is only one study on clustering of behaviors in adolescents, despite the fact that most health-compromising behaviors are often established during adolescence and continued in adulthood.[12]

Although studies in India have looked at the associations between independent health-compromising behaviors and social position,[15-17] to our knowledge no study has investigated the clustering of health-compromising behaviors and its association with social position.

In order to address this gap, the current study had the following objectives: (a) to assess if the presence, degrees, and patterns of clustering exist between four major behavioral risk factors (low fruit and vegetable intake, physical inactivity, and tobacco and alcohol use); (b) to assess and describe the degrees and patterns of clustering to individual's sociodemographic characteristics and social position; (c) to test the associations between presence of the behavioral clustering and individual social position; and (d) to examine socioeconomic inequalities in the presence of behavioral clustering among adolescents aged 15–19 years living in the National Capital Territory of Delhi.

Methods

A cross-sectional survey was undertaken among adolescents (15–19 years of age) from four different neighborhoods of Delhi and belonging to different socioeconomic groups. The sampling frame included four strata based on the area of residence, namely urban, rural, urban slums (a compact area of at least 300 population or about 60–70 households of poorly built congested tenements with inadequate infrastructure), and resettlement colonies (legalized settlement by the government with a slightly better off infrastructure than slums).[18]

Study sample

A multistage random sampling technique was used to obtain the required sample from each of the four strata – urban, rural, slums, and resettlement colonies. The urban areas were divided into municipal wards. Two wards were randomly selected from the listed wards. From the rural areas, two "village panchayats" which are the local administrative units were randomly picked. The enlisted slums and resettlement colonies by the Government of Delhi were used to identify two slums and resettlement colonies. Census was conducted in each of the selected areas to list households with eligible adolescents. The eligible adolescents were then randomly picked from the list by simple random sampling through system-generated random numbers in STATA (version 13.0 StataCorp, 4905 Lakeway Drive, College Station, Texas 77845 USA). Informed, signed, and witnessed consent was taken from adolescents as well as one of their parents/local guardians. The study was approved by the Public Health Foundation of India Institutional Ethics Committee.

The sample size was calculated based on estimates of behavioral clustering from the pilot study on 200 individuals with an 80% power and a 5% significance level. The mean expected clustering count was 2.3 for the low social position and 2.0 for the high social position group, based on the relevant estimates from a previous study.[10] We used "sampsi" package for sample size calculation in STATA (version 13.0). After the inclusion of 20% nonresponse, the final estimated sample size was 1218 adolescents.

Study tools

An interviewer-administered questionnaire was used to gather relevant data. The questions pertaining to tobacco use, alcohol consumption, and diet were based up prevalidated questions derived from the WHO Health Behavior in School Children Questionnaire.[19] Nationally validated questionnaires were used to assess standard of living, education level, peer relationships, family support, and satisfaction with life of adolescents.[20,21] Information regarding history of tobacco use was recorded by asking respondents "Have you ever smoked tobacco or used smokeless tobacco?" Alcohol consumption was assessed through the question "Have you ever consumed a drink that contains alcohol?" The participants were asked separately, "How many servings of fruits do you eat on a typical day?" and "How many servings of vegetables do you eat on a typical day?" to measure their fruit and vegetable consumption. A binary variable was created in order to categorize participants who had a daily intake of <5 servings of either fruits or vegetables or combined. Based on the recommended values of physical activity by the World Health Organization's Global Physical Activity Questionnaire,[22] an aggregate binary variable based on responses to the three questions regarding moderate and vigorous physical activity was created to identify participants with <1.25 h of vigorous physical activity and 2.5 h of moderate physical activity during a typical week. The main explanatory variable was social position, measured using two different measures, educational attainment and a composite index of wealth.

Educational attainment was recorded by asking the respondents "What is the highest level of education that you have completed?" Those with secondary school and higher were combined together as "higher educational attainment" and those with less than primary education were combined together as "lower educational attainment."

Wealth of adolescents was assessed by asking them questions about various material assets (television, car, electricity at home, bicycle, built-in kitchen sink, hot running water, washing machine, dishwasher, refrigerator, domestic help, mobile/cellular phone, bullock cart, computer, stereo system, livestock, internet access, motorbike, and a second home) they possess. Principal component analysis using these household assets was used to create a wealth index.[17,23] The wealth index was further divided into

tertiles. Age, sex, and area of residence were included as covariates in the analysis.

Statistical analysis

Descriptive statistics were calculated to describe the sociodemographic profile of the study participants. Statistical significance for the bivariate associations was determined by Wald's test. Clustering and its different features were assessed using four methods: count of health-compromising behaviors, correlations between the four health-compromising behaviors, observed-to-expected (O/E) ratios, and Hierarchical Agglomerative Cluster Analysis (HACA).[7,12,13] The presence of any cluster was confirmed by generating a binary variable to identify those with the presence of two or more health-compromising behaviors. With four health-compromising behaviors, a total of 16 combinations ranging from no health-compromising behavior to the presence of all health-compromising behaviors were identified. Six distinct patterns of two health-compromising behaviors, four patterns of three health-compromising behaviors, and one pattern of all four behaviors were possible.

In order to assess the associations between presence of clustering and socioeconomic variables (wealth and education), multivariable logistic regression models with sequential adjustment of confounders were constructed. The regression-based relative index of inequality (RII) and the slope index of inequality (SII) in the outcome of any clustering were estimated using RIIGEN command.[24]

Unadjusted estimates of absolute and relative inequalities according to education and wealth were sequentially adjusted for age and sex and area of residence. All statistical analyses were conducted using STATA (version 13.0).

Results

Overall, 1218 adolescents participated in the study, a response rate of 90.4%. The sociodemographic characteristics of the participants are described in Table 1. Among the health-compromising behaviors, physical inactivity was the most prevalent followed by low fruit/vegetable intake, tobacco use, and alcohol use.

Tobacco use and alcohol use were most prevalent among males, older adolescents, and in individuals living in slums and resettlement areas in comparison to rural or other urban areas. Physical inactivity was more prevalent in females. The prevalence of physical inactivity and low fruit and vegetable intake was also much higher among adolescents who were 18–19 years old. The simultaneous occurrence of two or more health-compromising behaviors was identified in 19% of the adolescents.

This co-occurrence was significantly higher among males, older adolescents, those living in resettlement areas and slums, those with less than primary education, and from lower socioeconomic positions [Table 1].

The only significant correlations were between tobacco use and alcohol use (phi coefficient: 0.59, $P < 0.05$) and between tobacco and fruit/vegetable intake (phi coefficient: 0.09, $P < 0.05$). Looking at the 16 possible combinations of behaviors, the O/E ratio for clustering ranged from 2.2 to 1220.6 [Table 2]. Overall, 14% of the sample reported clustering of two behaviors, 3.7% of three behaviors, and 1% of four health-compromising behaviors.

Among all clustering patterns, the most prevalent clusters were: (a) physical inactivity + lower fruit and vegetable intake, (b) tobacco + alcohol use, and (c) lower fruit and vegetable intake + tobacco + alcohol use. Physical inactivity (21%) and lower fruit and vegetable intake (15%)

Table 1: Descriptive characteristics of the sample with distribution of behavioral outcomes (*n*=1218)

Variable	Category	*n* (%)	Wealth index: Mean (SD)	Smoking (12.1%)	Alcohol (10.4%)	Physical inactivity (31.2%)	Lower fruit and vegetable intake (27.6%)	Any cluster (18.9%)
Sex	Male	730 (59.9)	0.1 (2.45)	18.1*	15.3*	26.3*	28.8	22.5*
	Female	488 (40.1)	−0.1 (2.6)	3.1*	3.1*	39.5*	25.8	12.9*
Age	14-15	471 (38.7)	−0.8 (2.6)	5.3*	5.5*	27.1*	18.3*	9.1*
	16-17	496 (40.7)	0.1 (2.3)	12.7*	9.7*	33.7*	26.8*	17.5*
	18-19	251 (20.6)	1.4 (1.9)	23.5*	21.1*	35.7*	46.6*	38.8*
Area	Urban	304 (25)	−3.1 (0.8)	2.0*	5.6*	25.3*	0.0*	1.7*
	Rural	298 (24.5)	−1.3 (1.4)	7.7*	5.4*	42.3*	5.4*	8.1*
	Resettlement areas	307 (25.2)	1.7 (1.2)	16.6*	14.0*	34.6*	48.9*	31.6*
	Slums	309 (25.4)	2.4 (0.9)	21.7*	16.5*	24.6*	55.0*	32.3*
Education	Secondary or above	1070 (90.5)	−0.1 (2.4)	10.1*	9.3*	32.2*	27.5	17.4*
	Primary or less	112 (9.5)	−0.03 (2.9)	28.6*	21.4*	20.0*	27.7	27.7*
Wealth	Rich	484 (39.7)	−3.0 (0.7)	4.6*	6.1*	28.0*	1.8*	3.8*
	Middle	244 (20.0)	0.3 (1.1)	11.7*	9.6*	37.2*	31.4*	20.5*
	Poor	490 (40.2)	2.7 (0.5)	20.3*	15.4*	28.1*	51.2*	32.1*

*P<0.05 (obtained from Wald's test). SD: Standard deviation

occurred mostly independently within adolescents, while tobacco use and alcohol use were present mostly in clusters [Table 2].

Adolescents between 18 and 19 years had high levels of clustering of health-compromising behaviors. Except for adolescents with lower educational attainment, clustering of two behaviors was significantly higher compared to clustering of three and four behaviors among all subgroups [Table 3].

Unadjusted estimates from multivariable regression models showed poorest adolescents, and those belonging to middle socioeconomic position group had 12 times (95% confidence interval [CI]: 6.9, 21.0) and 6.6 times (3.7, 11.6), relatively higher odds for the presence of clustering when compared to their richer counterparts (Model 1). These odds attenuated considerably after the adjustments for covariates including age, sex, area of residence, and educational attainment in the subsequent models.

However, these odds did not change considerably after the introduction of covariates in the subsequent models. After adjustment for all covariates, less-educated adolescents had 1.8 times higher odds of clustering of behaviors, when compared to more educated adolescents [Table 4].

Associations in multivariable logistic regression models were tested for three patterns of clustering (physical inactivity + lower fruit and vegetable intake, tobacco + alcohol use, and tobacco + alcohol + lower fruit and vegetable intake) with social position. The crude and age–sex-adjusted associations of the physical inactivity + lower fruit and vegetable intake clustering pattern with wealth and educational attainment were significant [Table 5, Models 1 and 2] but were explained by additional adjustment for area of residence [Table 5, Model 3]. The same was also the case for the associations of wealth with two other clustering patterns (tobacco + alcohol use and tobacco + alcohol use + lower fruit and vegetable intake).

In contrast, after adjustment for age, sex, wealth, and area of residence, adolescents not educated beyond primary school had 4.1 (95% CI: 1.3, 12.8) times higher odds of reporting clustering between tobacco use and alcohol use and 7.4 (95% CI: 2.4, 22.8) times higher odds for clustering between tobacco

Table 2: Different patterns of clustering and the corresponding observed-to-expected ratio (*n*=1218)

	n	Observed (%)	Expected (%)	O/E
No health-compromising behavior	523	43.0	65.7	0.7
Independent occurrence of behaviors (total observed=38.4%)				
Physical inactivity (A)	246	20.2	16.6	1.2
Low fruit and vegetable intake (B)	181	14.9	11.5	1.3
Alcohol (C)	19	1.6	1.0	1.5
Tobacco Use (D)	21	1.7	1.2	1.5
Clustering of two behaviors (total observed=14.0%)				
A + B	82	6.7	2.9	2.3
A + C	7	0.6	0.3	2.2
A + D	8	0.7	0.3	2.3
B + C	12	1.0	0.2	5.4
B + D	18	1.5	0.2	7.3
C + D	44	3.5	0.0	192.6
Clustering of three behaviors (total observed=3.7%)				
A + B + C	4	0.3	0.0	7.2
A + C + D	10	0.8	0.1	16.0
A + B + D	8	0.7	0.0	142.1
B + C + D	23	1.9	0.0	590.2
Clustering of four behaviors (total observed=1%)				
A + B + C+D	12	1.0	0.0	1220.6
Total	1218	100	100	

O/E: Observed to expected

Table 3: Bivariate associations between degree of clustering and sociodemographic and socioeconomic characteristics (row percentages)

Variable	Category	No health-compromising behavior (%)	Only one behavior (%)	Cluster of two behaviors (%)	Cluster of three behaviors (%)	All behaviors (%)
Sex*	Male	42.7	34.8	15.5	5.3	1.6
	Female	43.3	43.7	11.8	1.2	0
Age*	14-15	55.8	35	6.8	1.9	0.4
	16-17	40.3	42.1	13.1	3.6	0.8
	18-19	24	37.2	29.2	7.2	2.4
Area*	Urban	69.6	28.7	1.3	0.3	0
	Rural	50.3	41.6	6	2	0
	Resettlement areas	24.4	44	25.7	4.9	1
	Slums	28.2	39.2	22.3	7.4	2.9
Education*	Secondary or Above	42.8	39.9	14	2.7	0.7
	Primary or less	50	22.3	11.6	12.5	3.6
Wealth*	Richer	65.2	31.1	2.5	1.3	0
	Middle	36	43.5	16.7	2.5	1.3
	Poorer	27.3	40.6	23.4	7.5	1.3

*All associations significant $P<0.05$ (obtained from Wald's test)

Table 4: Multivariable logistic regression for the association between clustering of health behaviors and socioeconomic position (*n*=1218)

	Model 1	95% CI	Model 2	95% CI	Model 3	95% CI	Model 4	95% CI
Clustering versus no clustering								
Richer	1		1		1		1	
Middle	6.6	3.7-11.6	4.6	2.6-8.2	2.2	1.1-4.3	2.2	1.1-4.3
Poorer	12	6.9-21.0	8.8	5.0-15.6	2.8	1.3-6.1	2.7	1.2-5.9
Clustering versus no clustering								
Secondary or above	1		1		1		1	
Primary or less than primary	1.8	1.2-2.8	2.2	1.4-3.7	2.0	1.1-3.3	1.8	1.0-3.1

Model 1: Crude, Model 2: Adjusted for age and sex, Model 3: Model 2 + area of residence, Model 4: Model 3 + education/wealth vice versa, CI: Confidence interval

Table 5: Multivariable logistic regression for the association between clustering patterns with at least 20 cases and socioeconomic position (*n*=1218; Reference: No health-compromising behavior/independently occurring two behaviors)

Clustering patterns	Socioeconomic position/ education	Model 1	95% CI	Model 2	95% CI	Model 3	95% CI
Physical inactivity and low fruit and vegetable intake							
Wealth	Richer	1		1		1	
	Middle	18.9	4.5-79.6	13.7	3.2-58.5	1.6	0.3-8.0
	Poorer	34.1	8.2-141.8	25.1	6.0-105.6	1.7	0.3-8.9
Education	Secondary or above	1		1		1	
	Primary or less than primary	0.1	0.02-1.1	0.2	0.02-1.3	0.2	0.0-1.5
Tobacco and alcohol							
Wealth	Richer	1		1		1	
	Middle	4.9	1.9-12.9	2.6	0.9-7.1	0.6	0.1-2.3
	Poorer	8	3.2-20.4	4.2	1.5-11.6	0.7	0.1-3.4
Education	Secondary or above	1		1		1	
	Primary or less than primary	1.7	0.7-3.9	3.1	1.1-8.6	4.1	1.3-12.8
Tobacco and alcohol and low fruit and vegetable intake							
Wealth	Richer	1		1		1	
	Middle	5.1	0.6-46.1	2.9	0.3-29.7	0.1	0.0-0.9
	Poorer	22.4	3.0-169.1	14.6	1.8-117.0	0.2	0.1-2.2
Education	Secondary or above	1		1		1	
	Primary or less than primary	5.3	2.1-13.1	6.2	2.2-17.8	7.4	2.4-22.8

Model 1: Crude, Model 2: Adjusted for age, sex, and education/wealth vice versa, Model 3: Model 2 and area of residence, Reference: No health-compromising behavior/independently occurring two behaviors, CI: Confidence interval

use, alcohol use, and lower fruit and vegetable intake compared to those with secondary and above education [Table 5].

Unadjusted estimates of relative and SII showed significant socioeconomic inequalities in clustering of behaviors for both wealth and education [Model 1, Table 6]. However, the magnitude for RII according to educational attainment increased [Model 2, Table 6]. Adjustment for area of residence explained both relative and slope indices of inequalities in the presence of clustering according to education and wealth [Model 3, Table 6].

Discussion

This study showed significant social gradients according to wealth and significant differences according to educational attainment in the clustering of health-compromising behaviors among Indian adolescents. The most common clustering patterns were (a) physical inactivity + lower fruit and vegetable intake, (b) tobacco + alcohol use, and (c) lower fruit and vegetable intake + tobacco + alcohol use. Among these, tobacco + alcohol use and lower fruit and vegetable intake + tobacco + alcohol use were more likely to occur among less-educated adolescents.

This study is the first assessment from the Indian subcontinent on how various health-compromising behaviors cluster together and the socioeconomic inequalities associated with clustering of behaviors. The study was undertaken on a large representative sample of adolescents with a very good response rate, used validated measures to assess behaviors, and sociodemographic characteristics, and clustering was evaluated through four different methodologies (count of clustering, correlations, O/E ratio, and HACA).

Table 6: Socioeconomic inequalities in the presence of clustering (n=1218)

	Model 1	95% CI	Model 2	95% CI	Model 3	95% CI
Relative index of inequality						
Wealth	25.93	12.5-53.6	18.7	8.7-40.2	1.8	0.6-5.4
Education	3.1	1.2-8.3	4.4	1.6-12.5	2.9	0.9-9.0
Slope index of inequality						
Wealth	0.3	0.1-0.5	0.3	0.1-0.4	0.1	−0.1-0.3
Education	0.3	0.01-0.5	0.3	0.1-0.5	0.2	−0.01-0.4

Model 1: Unadjusted, Model 2: Adjusted for age and sex, Model 3: Adjusted for age, sex, and area of residence

In terms of limitations, the cross-sectional design of the study limits any causal interpretation. Tobacco and alcohol may be underreported due to recall bias and lack of social desirability associated with these behaviors. Another limitation of the current study was that the variables analyzed on alcohol and tobacco use assessed experimentation, while those on lack of fruit and vegetable intake and physical inactivity examined behavior. However, behaviors of alcohol and tobacco use are different to fruit and vegetable intake and physical inactivity.

Conclusion

Clustering of health-compromising behaviors was present among adolescents in Delhi. The presence of clustering was considerably higher among adolescents with lower educational attainment and wealth. Social inequalities in clustering of health behaviors re-emphasize the need to direct policies to address the underlying social determinants in order to reduce inequalities in health.

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Conflicts of interest

There are no conflicts of interest.

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