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RESEARCH ARTICLE

Status and correlates of non-communicable diseases among children and adolescents in slum and non-slum areas of India's four metropolitan cities

Harihar Sahoo[1], Preeti Dhillon[2], Enu Anand[3], Anjula Srivastava[4], Mohd Usman[3], Praween K. Agrawal[5], Robert Johnston[5] and Sayeed Unisa[6]*

[1]Department of Family and Generations, International Institute for Population Sciences, (IIPS) Mumbai, India, [2]Department of Survey Research and Data Analytics, IIPS, Mumbai, India, [3]Doctoral Fellow, IIPS, Mumbai, India, [4]Independent Consultant, Technical Writer, [5]UNICEF, New Delhi, India and [6]Department of Biostatistics and Epidemiology, IIPS, Mumbai, India

*Corresponding author. Email: sunisa829@gmail.com

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Abstract

The emergence of non-communicable diseases (NCDs) in childhood poses a serious risk to a healthy adult life. The present study aimed to estimate the prevalence of NCDs among children and adolescents in slums and non-slums areas of four metropolitan cities of India, and in rural areas of the respective states The study further, investigated the effect of the place residence as slum vs. non-slum and other risk factors of the NCDs. Nationally representative data from the Comprehensive National Nutrition Survey (CNNS) was used.. Estimates were based on children (5-9 years) and adolescents (10-19 years) for whom biomarkers predicting diabetes, high total cholesterol, high triglycerides and hypertension were determined. Weight, height and age data were used to calculate *z*-scores of the body mass index. Overweight and obesity was higher in urban areas than in rural areas among children and adolescents. Regional differences in the prevalence of diseases were observed; children in Delhi and Chennai had a higher likelihood of being diabetic while children in Kolkata were at a greater risk of high total cholesterol and high triglycerides. The risk of hypertension was strikingly high among non-slum children in Delhi. Children from slums were at a higher risk of diabetes compared to the children from non-slums, while children and adolecents from non-slums were at a greater risk of high triglycerides and hypertension respectively than their counterparts from slums. Male children and adolecents had a higher risk of diabetes and high cholesterol. Screening of children for early detection of NCDs should be integrated with the already existing child and adolescent development schemes in schools and the community can help in prevention and control of NCDs in childhood.

Keywords: Non-communicable diseases; adolescents; slums; urban

Introduction

India has made significant progress in its fight against infectious diseases over the past few decades and focused initiatives have led to the decline in childhood mortality rates caused by these diseases (India State-Level Disease Burden Initiative Child Mortality Collaborators, 2020). Non-communicable diseases (NCDs), however, are the new emerging threat to child and adolescent health as NCDs and injuries together have overtaken infectious and childhood diseases in terms of disease burden in every state of India (India State-Level Disease Burden Initiative Collaborators, 2017). NCDs – defined as medical conditions or diseases which are long-term ailments, resulting from a combination of genetic, physiological, environmental and behavioural factors – contribute to a large share of mortality and morbidity not only in India, but globally. WHO states that NCDs increasingly affect people in low- and middle-income countries (LMICs) where more than three quarters of global NCD deaths occur (WHO, 2018a). In India, NCDs are estimated to cause 63% of all deaths that accounted for almost 6 million deaths in 2016 (WHO, 2018b).

One of the major reasons for the increasing shift in disease burden towards NCDs is urbanization and the changes in lifestyles and environments associated with it. As of 2007, more than half of the world's population lived in cities (United Nations, 2016) and 377 million lived in India (Census of India, 2011a). This constituted 31% of its total population in 2011 which is expected to rise to 39% by 2036 (National Commission on Population, 2019). The unprecedented rise of urban population has led to a massive growth of slums to an extent that the slums of Mumbai and New Delhi are home to as much as 50% of its total population. With the increasing share of the urban poor (~27%) in the total number of poor in India, more than 8.1 million children now live in slums (PwC-Save the Children, 2015). It is often observed that children residing in slums live on the margins of urban life and lack access to the advantages of city living resulting in poor health outcomes.

Not only are the adults affected by NCDs, but children are also not spared by the risk of NCDs. More than 2.1 billion children were affected by NCDs around the world in 2017 (Guariguata & Jeyaseelan, 2019). Recognizing the importance of preventing childhood NCDs is important as more than two thirds of the antecedents to NCDs emerge during childhood and adolescence (Guariguata & Jeyaseelan, 2019), though the symptoms may manifest much later in life. Moreover, going by the rights-based approach, one would agree that all children have the right to a healthy life; NCDs undermine children and adolescents' right to health, nutrition, education and play (WHO, 2019), more so among the young slum dwellers who are '*far from realizing the rights to "adequate shelter for all" and "sustainable human settlements development in an urbanizing world" enshrined in the Istanbul Declaration on Human Settlements, or Habitat Agenda, of 1996*' (UNICEF, 2012). India is home to about 41% of the population in the age group 0-19 years (Census of India 2011a) and experienced 143,000 deaths among children in the 5-14 years age group in 2018 (United Nations Inter-agency Group for Child Mortality Estimation UN IGME, 2019). Death rates from NCDs and injuries were generally higher for children aged 5-14 years in India than in China and Brazil as estimated by Fadel *et al.* (2019). Most of the NCDs can be prevented by modifiable behaviours such as healthy dietary practices, adequate physical activity, controlling tobacco use and harmful use of alcohol. The behavioural risk factors (such as unhealthy diet, physical inactivity, tobacco use and harmful use of alcohol) increase the likelihood of acquiring metabolic syndrome. The presence of this syndrome puts the individual at risk of developing one or more NCDs like obesity, hypertension, diabetes and dyslipidemia.

Global trends indicate that NCD-related behaviours are on the rise among young people. The prevalence of obesity is increasing and in 2016 an estimated 42 million children under the age of 19 years were overweight or obese (Guariguata & Jeyaseelan, 2019). In India, the prevalence of overweight and obesity among children 1-18 years of age had risen from 16 percent to 19 percent over the last decade (Ranjani *et al.*, 2016). Several empirical studies have established the prevalence of overweight and obesity among Indian children and adolescents at the regional level (Arora *et al.*, 2018; Dasgupta *et al.*, 2017; Patnaik *et al.*, 2015; Mishra *et al.*, 2015; Ranjani *et al.*, 2013; Kameswararao & Bachu, 2009). Panda *et al.* (2021) showed urban adolescents in India have a higher risk of being overweight or obese than their rural counterparts. Comprehensive National Nutrition Survey, CNNS (2016-18) has reaffirmed the existence of the condition (prevalence of childhood overweight and obesity) at the country and state level (MoHFW, GOI, UNICEF & Population Council, 2019). Studies have suggested that obesity is associated with all major NCDs (Banjare & Bhalerao, 2016). Childhood obesity raises the risk of developing diabetes and high blood pressure. The estimates of prevalence of hypertension among young children and adolescents vary widely ranging from 4.5% to 12.7% (MoHFW, GOI, UNICEF & Population Council 2019; Arora *et al.*, 2018; Maiti & Bandyopadhyay, 2017; Amritanshu *et al.*, 2015; Charan *et al.*, 2011).

Dyslipidemia, defined as an abnormal amount of lipids (e.g. triglycerides, cholesterol and/ or phospholipids) in the blood, is another NCD that affects children and adolescents. Half of the children with dyslipidemia have hyperlipidemia (abnormally high levels of bad cholesterol and triglycerides) during adulthood (Marateb, 2018). A study among school children aged 6-16 years in rural Jaipur estimated the prevalence of dyslipidemia to be 19% (Agarwal *et al.*, 2016).

In order to address the epidemic in India, it is crucial to understand the correlates of childhood and adolescent NCDs and the NCD risk factors. Currently, there are not many studies on the factors that increase the risk of NCDs among children, particularly in India. The few available studies indicate that socio-economic status is significantly correlated to the risk factors for NCDs among children and youth in India (Arora *et al.*, 2018; Mithra *et al.*, 2015). In a systematic review and meta-analysis, Wu *et al.* (2015) reported that family income, parental education level, parental employment status and living space were the main socioeconomic indicators associated with childhood overweight and obesity, although they did not find a consistent relationship in different studies. Likewise, other studies in India and the middle east (Mesawa *et al.*, 2020; Sashindran & Dudeja, 2020; Muthuri *et al.*, 2014) have found association between childhood obesity and different indicators of socio-economic status. The prevalence of NCDs is also affected by cultural factors like ethnicity and religion (Bhise *et al.*, 2018). Religion and caste are significant predictors of tobacco consumption (as is evident from several nationally representative surveys – NSSO, NFHS, GATS-1 & 2) as well as alcohol consumption (Barik *et al.*, 2016). Studies have concluded that members of the socially disadvantaged groups had a greater likelihood of consuming alcohol regularly, chewing tobacco and smoking. Literature suggests that demographic characteristics such as age, sex and place of residence are important correlates of NCDs. Patra & Bhise (2016) found a large gap in NCD prevalence between Indian men and women. In an analysis of middle-income countries, Oyebode *et al.* (2015) examined rural, urban and migrant differences in NCD risk factors. They concluded that migrants (rural to urban) and urban dwellers has similar risk-factor profiles and that these were not consistently worse than those seen in rural dwellers. A few other empirical studies conducted among adults in the Indian sub-continent have shown that the prevalence of risk factors of NCDs is high among the urban poor (Shanmugam *et al.*, 2018; Rawal *et al.*, 2017; Oli *et al.*, 2013). Sedentary lifestyle and highly processed foods resulting from over-use of mass media have also been found to increase the risk of NCDs (Ramadass *et al.*, 2017).

Rural-urban differences in child health have been examined by quite a few studies (e.g. Ameye & De Weerdt, 2020; Fagbamigbe *et al.*, 2020; Van de Poel *et al.*, 2007; Fotso, 2006); however, studies investigating differences between slum and non-slum areas are limited (Portner & Su, 2018; Mberu *et al.*, 2016; Gupta *et al.*, 2009). Several previous studies have compared the prevalence of NCDs by rural and urban areas and found urban residents at a higher risk of NCDs. However, estimates of NCDs in intra-urban areas are not available. Further, risk factors of NCDs including parental history of NCDs, consumption of unhealthy diets and sedentary behavior have not been examined for this age group at the national level in India. Therefore, the present study first aims to estimate the prevalence of specific NCDs among children and adolescents living in four megacities of India – Chennai, Delhi, Kolkata and Mumbai, disaggregated by slums and non-slums and compare them with their rural counterparts, that is, the estimates of rural areas of the states in which these cities are located, *viz.*, Tamil Nadu, Delhi, West Bengal and Maharashtra. Additionally, the research attempts to identify the effect of residence as slum vs. non slum and other correlates including socio-demographic factors, lifestyle factors and parental history on the selected NCDs.

Data and Methods

Data

The analyses were based on the data from Comprehensive National Nutrition Survey (CNNS) conducted in 2016-18 by the Ministry of Health and Family Welfare, Government of India, in collaboration with UNICEF. The survey employed multistage stratified sampling design and households from selected clusters or enumeration areas from the rural and urban areas across all states of India were included. The sample-size in four metropolitan cities (Chennai, Delhi, Kolkata and Mumbai) was inflated in order to facilitate separate estimations of the prevalence of non-communicable diseases in slum and non-slum settings. The CNNS adopted Census of India (2011) sampling frame and therefore, considered same definition of slums (notified, recognised and identified) in census. Slums, according to the Census of India (2011), are compact overcrowded residential areas with a population of at least 300 which are considered unfit for habitation due to lack of one or more of the basic infrastructure like drinking water, sanitation, electricity, sewerage and streets. The survey was designed to provide a nationally representative and comprehensive nutritional profiling of pre-school children aged 0-4 years, school children aged 5-9 years and adolescents aged 10-19 years. Anthropometric measurements of children were taken to understand nutritional imbalance among the population. Biological samples were collected from children 1-19 years of age for the estimation of nutritional deficiencies. Additionally, the biological samples of children aged 5-19 years were tested for non-communicable diseases. For adolescents aged 10-19 years, blood pressure was also recorded. The analytical sample for 5-9 years children for HbA1c (diabetes), high total cholesterol and high triglycerides is 571, 542 and 543 for slums, respectively. The analytical sample for 5-9 years children for HbA1C (diabetes), high total cholesterol and high triglycerides is 735, 689 and 688 for non-slum, respectively. The analytical sample for 10-19 years adolescents for HbA1c (diabetes), high total cholesterol and high triglycerides is 549, 519 and 519 for slums, respectively. The analytical sample for adolescents for HbA1c (diabetes), high total cholesterol and high triglycerides is 715, 678 and 680 for non-slum, respectively. The detailed analytical sample is provided in Table 1. Two thirds of children/adolescents aged 1–19 years whose individual interview was successfully completed were selected for biological sample collection using systematic random sampling. About the 5% sample were either homolysed or quantity not sufficient (QNS) for analysis but counted as non-response. Response rates for biological sample collection for India was 75% for 5-9 and 74% for 10-19 age group while in case of Maharashtra it was 74% and 70%, 84% and 85% for Delhi, 44% and 47% for Tamil Nadu, 77.2 and 77.1% for West Bengal for the age group 5-9 and 10-19 respectively. The detailed survey design and methods have been published elsewhere (MoHFW, UNICEF & Population Council, 2019). Although, the response rate of biological sample is not high as in usual household surveys, its distribution by background characteristics do not show any patten of biasness. For instance, around 46% of girls were observed in the analytical sample. According to Census of India, 2011 sex ratio in these cities is below 900 which equate to 47% of girls. Therefore, inspite of low response rates, the sample was sufficient and representative for these city level (slum vs non-sulm) estimates.

Methods

Dependent variables

Diabetes: Glycosylated haemoglobin (HbA1c) is a diagnostic test used to screen persons for diabetes. HbA1c reflects average plasma glucose levels over the previous 8 to 12 weeks. Children with glycosylated haemoglobin concentrations of $>5.6\%$ & $\leq 6.4\%$ were considered pre-diabetic and those having concentrations greater than 6.4% were considered diabetic. For the purposes of the present study, pre-diabetic and diabetic children were grouped as one category.

Lipid disorders: Children and adolescents were tested for lipid disorders. Participants with plasma lipid and lipoprotein concentrations of total cholesterol $\geq$200 mg/dl, low-density lipoprotein (LDL) $\geq$130 mg/dl, high-density lipoprotein (HDL) $<$40 mg/dl, and serum triglycerides $\geq$100 mg/dl (for 5–9 years) and $\geq$130 mg/dl (for 10–19 years) were considered as having high total cholesterol, high LDL, low HDL and high serum triglycerides, respectively.

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Table 1. Percent distribution of children and adolescents aged 5-19 years who were tested for NCDs in slum and non-slum areas of four metro cities# by selected background characteristics, India, CNNS 2016-2018

	HbA1c (Diabetes)		High total cholesterol		High triglycerides		HbA1c (Diabetes)		High total cholesterol		High Triglycerides		Hypertension	
	Children aged 5-9 years						Adolescents aged 10-19 years							
Background Characteristics/ Risk Factors	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Metro city														
Chennai	17.7	231	18.4	226	18.4	226	20.4	258	21.3	255	21.3	255	22.5	256
Delhi	39.4	515	41.3	508	41.3	508	37.6	475	39.2	469	39.1	469	27.7	316
Kolkata	20.9	273	20.9	257	20.9	257	20.2	255	20.2	242	20.4	244	22.7	259
Mumbai	22.0	287	19.5	240	19.5	240	21.8	276	19.3	231	19.3	231	27.1	309
Place of residence														
Slum	43.7	571	44.0	542	44.1	543	43.4	549	43.4	519	43.3	519	47.7	544
Non-Slum	56.3	735	56.0	689	55.9	688	56.6	715	56.6	678	56.7	680	52.3	596
Age														
5-7 years I 10-14 years	58.2	760	57.9	713	57.9	713	53.1	671	53.0	634	53.0	636	53.0	604
8-9 years I 15-19 years	41.8	546	42.1	518	42.1	518	46.9	593	47.0	563	47.0	563	47.0	536
Sex of child														
Male	53.9	704	54.5	671	54.5	671	55.0	695	54.2	649	54.1	649	54.0	616
Female	46.1	602	45.5	560	45.5	560	45.0	569	45.8	548	45.9	550	46.0	524
Caste/Tribe														
Scheduled Castes/ Scheduled Tribes	26.8	350	25.4	312	25.4	312	29.0	366	28.7	344	28.7	344	28.5	325
OBC	31.9	417	32.3	398	32.3	397	31.5	398	31.6	378	31.6	379	32.9	375
Others	41.3	539	42.3	521	42.4	522	39.6	500	39.7	475	39.7	476	38.6	440
Religion														
Hindu	74.8	977	75.0	923	75.0	923	76.7	970	76.7	918	76.7	919	75.4	860
Non-Hindu	25.2	329	25.0	308	25.0	308	23.3	294	23.3	279	23.4	280	24.6	280

(*Continued*)

Table 1. (*Continued*)

	HbA1c (Diabetes)		High total cholesterol		High triglycerides		HbA1c (Diabetes)		High total cholesterol		High Triglycerides		Hypertension	
	Children aged 5-9 years						Adolescents aged 10-19 years							
Background Characteristics/ Risk Factors	%	N	%	N	%	N	%	N	%	N	%	N	%	N
Mother's schooling														
No schooling	14.3	222	13.6	215	19.3	215	18.5	294	21.5	278	18.0	278	20.0	255
1-7 years	18.7	292	12.1	266	20.1	266	14.6	293	24.6	271	29.7	272	22.2	265
8+ years	67.0	790	74.2	748	60.6	748	67.0	677	53.9	648	52.3	649	57.8	620
Wealth status														
Poor/Middle	36.3	559	21.2	523	39.7	523	38.8	530	33.9	498	23.4	281	42.2	455
Rich	63.7	747	78.8	708	60.3	708	61.2	734	66.2	701	58.5	701	57.8	685
Consumption of unhealthy food														
No	67.0	924	68.2	862	69.5	863	61.2	761	58.5	714	61.0	715	55.6	667
Fried/Junk food	7.7	141	13.6	135	12.1	135	15.5	201	10.8	188	15.9	189	20.0	195
Sweets/Aerated drinks	25.3	241	18.2	234	18.5	233	23.3	302	30.7	295	23.1	295	24.4	278
Either parent diabetic														
No	94.5	1259	95.5	1187	96.8	1187	87.4	1,139	83.1	1,071	85.1	1,073	95.6	1,029
Yes	5.5	47	4.6	44	3.2	44	12.6	125	16.9	126	14.9	126	4.4	111
Either parent hypertensive														
No	–	–	–	–	–	–	86.4	1,126	89.2	1,060	89.7	1,062	88.9	1,014
Yes	–	–	–	–	–	–	13.6	138	10.8	137	10.3	137	11.1	126
Watching TV														
<7 hours/week	–	–	–	–	–	–	39.8	524	47.7	497	42.6	497	46.7	487
>=7 hours/week	–	–	–	–	–	–	60.2	739	52.3	699	57.4	701	53.3	653
Total	100.0	1,306	100.0	1,231	100.0	1,231	100.0	1,264	100.0	1,197	100.0	1,199	100.0	1,140

Note: #Chennai, Delhi, Kolkata, Mumbai; '-': Not Available

Hypertension: Adolescents 10-19 years' old were categorized as hypertensive if they had a systolic blood pressure level ≥140mmHg, or a diastolic blood pressure level ≥90mmHg.

The threshold for all NCD indicators considered in the study has been adopted from the CNNS wherein the cut-offs have been determined based on national and international guidelines.

Independent variables

The following socio-demographic background characteristics were considered as predictor variables in the analysis: sex of the child (male, female); age of the child; residing in slum or non-slum settings (slum/non-slum); metro city (Chennai, Delhi, Kolkata, Mumbai); religion of the child recoded as Hindu, Non-Hindu; social groups according to caste/tribe recoded as scheduled castes (SCs)/scheduled tribes (STs), other backward classes (OBCs), others; mother's educational years recoded as no schooling, 1-7 years of schooling, 8 or more years of schooling and wealth status recoded as poor/middle and rich where poor includes poorest, poorer and middle while rich includes richer and richest. To assess the relationship between body mass index and prevalence of NCDs, body mass index of children was constructed into three categories underweight (<-2SD), Normal (-2 to +1 SD) and overweight/obese (>+1 SD). The role of unhealthy food consumption in NCD prevalence was assessed by the variable 'consumption of unhealthy food' categorized as no or <3 times per week, consumption of fried/junk food (> = 3 times per week) and consumption of sweets/aerated drinks (> = 3 times per week). Family history of diabetes and blood pressure was considered a predictor if either parent was diabetic or hypertensive. The number of hours a child watches television on a weekly basis 7>) hours, > = 7 hours) and her/ his physical/leisure activity hours were also included in the analyses to assess the effect of sedentary lifestyle. Information on watching television and hours of any physical or leisure activity were available only for adolescents (aged 10-19 years).

Statistical analyses

The analytical study sample is limited to slum/non-slum areas in four metropolitan cities (Delhi, Mumbai, Chennai and Kolkata). Equal sample size allocation strategy adopted in the survey, along with reasonable representation gives an opportunity to provide comparative estimates for both slum and non-slum areas in the four cities. All analyses were done on the unweighted sample because sampling weights in data were given only to generate combined estimates for urban areas. Univariate analyses were performed to present the sample size distribution of selected independent variables in the slums and non-slums. Bivariate analyses were used to assess the prevalence of selected NCDs in slum and non-slum areas and rural areas. Proportion t-test was adopted to see the differentials in the prevalence of different NCDs. The prevalence of different types of NCDs was estimated for the age groups 5-9 years (hereafter referred to as 'children' and 10-19 years (hereafter referred to as 'adolescents'). Association between non-communicable diseases and different socio-demographic variables, genetic factors, dietary pattern and lifestyle indicators was tested; unadjusted odds ratios (UOR) and adjusted odds ratios (AOR) were estimated using logistic regression analyses at 95% confidence intervals (CI). Stata version 14.0 was used for all the analyses.

Ethical Considerations

Ethical approvals were obtained from the ethics committee of the Postgraduate Institute for Medical Education and Research in Chandigarh, India, and the Institutional Review Board of the Population Council, New York. Informed consent in written was obtained from caregivers of children aged 0–10 years. For adolescents aged 11–17 years, written informed consent was

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obtained from their caregivers and informed assent obtained from the adolescents. Adolescents aged 18–19 years provided their own consent. Biological samples and blood pressure measurements were taken only after verbal (child) and written (caregiver/adolescent) consent was obtained and the household interview was completed. Interviews were conducted in the respondents' preferred state language or in English. This study used data which did not contain any personally identifiable information and hence did not require ethical clearance.

Results

Prevalence of NCDs among children and adolescents

The prevalence of overweight and obesity among children was higher in urban areas compared to rural areas, both for slums and non-slums (Table 2). The prevalence of overweight was 13% in slum and non-slum areas, more than double the rate in rural areas (5.3%). Similarly, the prevalence of obesity was estimated at 5.3 percent in slum areas and 5.5 percent in non-slum areas, and was estimated at only two percent in rural areas. The percentage of children with high total cholesterol was higher among rural children (9.2%), followed by non-slum children (6%) and was lowest among slum children (4.6%). The prevalence of high triglycerides among children was highest in rural areas (38.5%) and was significantly ($p<0.05$) higher in non-slum areas (35.5%) compared to slum areas (29.8%).

The prevalence of overweight and obesity was lowest among rural adolecents (7.2%), and prevalence of obesity was significantly higher in non-slums than slums adolecents. There was no significant difference in the prevalence of diabetes/prediabetes among adolecents by place of residence. The lipid profile parameters revealed that a higher proportion of rural adolecents had values beyond the cut-off mark for lipid disorders. The lipid profile of adolecents do not differ significantly by slum and non slum. Further, the prevalence of hypertension was highest among non-slum adolescents (5.7%), which was significantly ($p<0.01$) higher than their slum counterparts (2%) and adolescents residing in rural areas (2.8%).

Table 3 presents the prevalence of diabetes (HbA1c), high total cholesterol, high serum triglycerides and hypertension in children aged 5-9 years and 10-19 years in four metropolitan cities of India stratified by slum, non-slum and rural areas of their respective states. Overall, the prevalence of all three parameters among children aged 5-9 years was higher in rural areas of the states compared to city slum and non-slum areas. Compared to slum areas, non-slum had lower prevalence of diabetes and higher prevalence of high total cholesterol and serum triglycerides. The prevalence of prediabetes/diabetes (HbA1c) among children aged 5-9 years was highest in Delhi and the lowest in Kolkata. Except for Chennai, all other cities showed higher prevalence of diabetes in rural children, followed by slum children although these differences were not statistically significant between slum and non-slum areas Furthermore, Kolkata had the highest prevalence of high total cholesterol and high serum triglycerides compared to other cities. The prevalence of high serum triglycerides was exceedingly high in rural Tamil Nadu (26.3%) compared to Chennai slum and non-slum area (14.4% and 20.4%). Children from the slum areas consistently showed low prevalence of high serum triglycerides than non-slum children irrespective of cities.

For adolescents 10-19 years of age, no consistent pattern in diabetes prevalence was observed among slum, non-slum and rural children in various cities. Further, lipid profile of adolecents did not vary by place of residence. However, like children, adolecents too showed very high prevalence of high total cholesterol and high serum triglycerides in Kolkata city. Overall, the prevalence of hypertension was higher in non-slum areas compared to slum areas except in Kolkata. Delhi and Mumbai showed significantly higher prevalence of hypertension among adolecents in non-slum areas than in slum area. The prevalence of hypertension in non-slum areas was the highest in Delhi (11.1%), followed by Chennai (6.2%).

Table 2. Prevalence of NCDs among children and adolescents 5-19 years of age in four metro cities# in slum, non-slum and rural areas of respective states## of India, CNNS 2016-18

NCD Indicators	Slum		Non-Slum		p-value###	Rural	
	%	N	%	N		%	N
					Children aged 5-9 years		
BMI for age z score							
Overweight (>+1SD to +2SD)	12.9	1,596	12.9	2,002	0.979	5.3	1,894
Obese (>+2SD)	5.3	1,596	5.5	2,002	0.774	2.0	1,894
NCDs							
Diabetes							
Elevated glycosylated haemoglobin concentration (HbA1c) (Pre-diabetic/Diabetic > 5.6%)	8.1	571	6.1	735	0.173	8.1	904
Lipid Profile							
% High total cholesterol (≥ 200 mg/dl)	4.6	542	6.0	689	0.301	9.2	860
% Low HDL (< 40 mg/dl)	19.5	543	21.6	685	0.217	17.7	857
% High LDL (≥ 130 mg/dl)	4.2	542	5.8	689	0.370	6.1	859
% High triglycerides (≥ 100 mg/dl for 5-9 years)	29.8	543	35.5	688	0.038	38.5	859
					Adolescents aged 10-19 years		
BMI for age z score							
Overweight (>+1SD to +2SD)	15.5	1,387	17.2	1,736	0.212	7.2	1,673
Obese (>+2SD)	3.2	1,387	4.6	1,736	0.041	2.0	1,673
NCDs							
Diabetes							
Elevated glycosylated haemoglobin concentration (HbA1c) (Pre-diabetic/Diabetic > 5.6%)	8.2	549	8.1	715	0.956	8.8	869
Lipid Profile							
% High total cholesterol (≥ 200 mg/dl)	6.0	519	5.0	678	0.468	8.0	823
% Low HDL (< 40 mg/dl)	28.2	517	30.2	678	0.196	23.5	817
% High LDL (≥ 130 mg/dl)	5.4	519	3.8	679	0.453	6.4	825
% High triglycerides (≥ 130 mg/dl for 10-19 years)	15.8	519	16.6	680	0.800	20.0	825
Hypertension (systolic >139 mmHg, or diastolic > 89 mmHg)	2.0	544	5.7	596	0.007	2.8	780

Note: #Chennai, Delhi, Kolkata, Mumbai; ##Tamil Nadu, Delhi, West Bengal, Maharashtra; HDL = high-density lipoprotein; LDL = low-density lipoprotein; ### p value from t- test applied for difference in indicators by slum and non-slum areas.

Determinants of NCDs among children and adolescents

Table 4 presents the unadjusted and adjusted odds ratios of prevalence of various NCDs including prediabetes/diabetes, high total cholesterol, high triglycerides among children in four metro cities of India during 2016-18. The children residing in Delhi, Chennai and Mumbai were at a higher risk of diabetes (HbA1c) compared to children from Kolkata. The children from Delhi were at 5.07 (2.18-11.77) times higher risk of HbA1c (prediabetes/diabetes) compared to children from Kolkata.Children from slums were at higher risk of diabetes as compared to their counterparts

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Table 3. Prevalence of NCDs among children and adolescents 5-19 years of age in slum and non-slum areas by four metro cities# and rural areas of respective states## of India, CNNS 2016-18

City/State	HbA1c (Diabetes) %	HbA1c (Diabetes) N	High total cholesterol %	High total cholesterol N	High serum triglycerides %	High serum triglycerides N	Hypertension %	Hypertension N
				Children aged 5-9 years				
Chennai		(0.440)		(0.724)		(0.236)		
Chennai slum	9.1	121	2.5	118	14.4	118	–	–
Chennai non-slum	6.4	110	1.9	108	20.4	108	–	–
Tamil Nadu rural	6.2	177	4.2	168	26.3	167	–	–
Delhi		(0.324)		(0.983)		(0.149)		
Delhi slum	10.7	168	3.0	168	29.1	168	–	–
Delhi non-slum	8.1	347	2.9	340	35.6	340	–	–
Delhi rural	13.5	163	<1	167	22.2	167	–	–
Kolkata		(0.154)		(0.756)		(0.187)		
Kolkata slum	4.4	137	13.3	128	50.4	129	–	–
Kolkata non-slum	1.5	136	21.7	129	58.6	128	–	–
West-Bengal rural	5.8	326	21.8	316	67.7	316	–	–
Mumbai		(0.506)		0.284)		(0.855)	–	–
Mumbai slum	7.6	145	<1	128	24.2	128	–	–
Mumbai non-slum	5.6	142	<1	112	23.2	112	–	–
Maharashtra rural	8.8	238	1.4	209	17.2	209	–	–
Total		(0.173)		(0.301)		(0.037)		
Urban slum	8.1	571	4.6	542	29.8	543	–	–
Urban non-slum	6.1	735	6.0	689	35.5	688	–	–
Rural	8.1	904	9.2	860	38.5	859	–	–
				Adolescents aged 10-19 years				
Chennai		(0.198)		(0.658)		(0.362)		(0.989)
Chennai slum	7.0	129	1.6	127	10.2	127	4.7	127
Chennai non-slum	11.6	129	2.3	128	7.0	128	6.2	129
Tamil Nadu rural	8.5	176	6.6	167	12.5	167	4.7	171
Delhi		(0.558)		(0.803)		(.987)		(0.001)
Delhi slum	8.8	159	1.9	158	16.5	158	1.5	135
Delhi non-slum	7.3	316	2.3	311	16.4	311	11.1	181
Delhi rural	11.9	168	1.8	167	9.0	167	3.6	110
Kolkata		(0.731)		(0.773)		(0.411)		(0.286)
Kolkata slum	6.4	125	20.2	119	30.2	119	2.4	127
Kolkata non-slum	5.4	130	18.7	123	35.2	125	<1.0	132
West Bengal rural	8.0	286	18.3	274	42.7	276	1.0	288

(*Continued*)

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Table 3. (*Continued*)

City/State	HbA1c (Diabetes) %	HbA1c (Diabetes) N	High total cholesterol %	High total cholesterol N	High serum triglycerides %	High serum triglycerides N	Hypertension %	Hypertension N
Mumbai		(0.778)		(0.556)		(0.617)		(0.043)
Mumbai slum	10.3	136	1.7	115	6.0	115	<1.0	155
Mumbai non-slum	9.3	140	<1.0	116	7.8	116	3.3	154
Maharashtra rural	7.5	239	<1.0	215	5.1	215	3.3	211
Total		(0.956)		(0.468)		(0.704)		(0.001)
Urban slum	8.1	549	6.0	519	15.8	519	2.0	544
Urban non-slum	8.2	715	5.0	678	16.6	680	5.7	596
Rural	8.8	869	8.0	823	20.0	825	2.8	780

Note: #Chennai, Delhi, Kolkata, Mumbai; ##Tamil Nadu, Delhi, West Bengal, Maharashtra; '-': Not Available; level of significance for difference in indicator by slum and non-slum is given in the parenthis

from the non-slums. Further findings suggests that female children had a lower risk (AOR: 0.57, 0.36-0.90) of prediabetes/diabetes than their male counterparts.

Children from the SC/ST population had significantly lower risk (AOR: 0.49, 0.26-0.95) of diabetes than children from other castes. Compared to children from poorer wealth status, the children from the richer households were at a higher risk of prediabetes/diabetes, though this association was not statistically significant. The hereditary linkage between parents and children for prevalence of diabetes was not observed in the study settings. In general, age, religion, BMI, mother's educational status, and consumption of unhealthy food were not significantly associated with prediabetes/diabetes after adjusting for other characteristics.

With regard to the correlates of the prevalence of high cholesterol levels, the findings reveal that the odds ratios of high cholesterol among children was lower in Delhi, Chennai and Mumbai compared to Kolkata (AOR = 0.11, 0.11, 0.02 respectively). The unadjusted odds ratio for high total cholesterol levels among children from SCs/STs (0.44, 0.23-0.86) and OBCs (0.32, 0.16-0.62) was lower compared to children from the other castes; however, the difference turned insignificant after adjustment for other covariates. Compared to children with normal BMI for age Z-score, the overweight children were at a higher risk for high cholesterol level.

Similar to high level of cholesterol, the odds ratio for high triglycerides levels among children from Delhi, Chennai and Mumbai were low compared to Kolkata. For example, children from Delhi were at 63% lower risk (AOR:37, 0.26-0.54) of high low risk of triglycerides compared to children from Kolkata. Similarly, the risk of high triglycerides in children from Mumbai was 76% lower (AOR:0.28, 0.16-0.38) compared to Kolkata. Compared to children with normal BMI, the overweight children were 2.26 (1.48-3.44) times at a higher risk of elevated levels of triglycerides.

Table 5a presents the adjusted and unadjusted odds ratios of prevalence of prediabetes/diabetes and high total cholesterol among adolescents in four cities of India. The results of test of association for diabetes indicated that adolescents living in Mumbai were 2.63 times (1.11-6.24) more likely to be prediabetics/diabetic as compared to adolescents in Kolkata. Unlike children, slum or non-slum residence did not make any significant difference in the prevalence of diabetes among adolecents. Females were significantly at a lower risk of pre-diabetes/diabetes (0.61, 0.38-0.99). Further covariates including overweight, consumption of unhealthy food, watching TV extensively, parental diabetes and hypertension status were not significantly associated with adolecent diabetes..

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Table 4. Adjusted and unadjusted odds ratios of NCDs children aged 5-9 years in slum and non-slum areas of four metro cities# by selected background characteristics, India, CNNS 2016-18

Background Characteristics	HbA1C		High total cholesterol		High triglycerides	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Metro City						
Kolkata (ref)						
Chennai	2.63**(1.11 - 6.21)	2.88**(1.07 - 7.73)	0.11***(0.04 - 0.27)	0.11***(0.04 - 0.31)	0.17***(0.11 - 0.27)	0.15***(0.09 - 0.24)
Delhi	3.25***(1.51 - 6.99)	5.07***(2.18 - 11.77)	0.14***(0.08 - 0.26)	0.11***(0.06 - 0.23)	0.42***(0.31 - 0.57)	0.37***(0.26 - 0.54)
Mumbai	2.35(1.01 - 5.46)	3.27**(1.28 - 8.31)	0.02***(0.00 - 0.14)	0.02***(0.00 - 0.13)	0.26***(0.18 - 0.38)	0.24***(0.16 - 0.38)
Place of residence						
Non-slum (ref)						
Slum	1.38(0.90 -2.11)	1.59**(1.01 - 2.51)	0.76(0.46 - 1.27)	0.76(0.44 - 1.33)	0.77**(0.61 - 0.98)	0.78(0.60 - 1.02)
Age of the child						
5-7 years (ref)						
8-9 years	0.81(0.52 -1.27)	0.80(0.51 - 1.27)	1.18(0.72 - 1.94)	1.09(0.63 - 1.88)	1.18(0.93 - 1.50)	1.11(0.86 - 1.44)
Sex						
Male (ref)						
Female	0.63**(0.40 - 0.98)	0.57**(0.36 - 0.90)	1.06(0.65 - 1.75)	1.00(0.58 - 1.71)	1.07(0.84 - 1.35)	1.04(0.81 - 1.34)
Religion						
Hindu (ref)						
Non-Hindu	1.09(0.67 - 1.76)	0.89(0.53 - 1.50)	1.32(0.77 - 2.28)	1.71(0.92 - 3.17)	0.83(0.62 - 1.09)	0.81(0.60 - 1.10)
Caste						
Others (ref)						
SC/ST	0.60(0.33 - 1.08)	0.49**(0.26 - 0.95)	0.44**(0.23 - 0.86)	0.81(0.39 - 1.68)	0.63***(0.47 - 0.86)	0.91(0.65 - 1.27)
OBC	1.11(0.69 - 1.78)	0.98(0.56 - 1.70)	0.32***(0.16 - 0.62)	0.58(0.26 - 1.26)	0.68**(0.52 - 0.90)	1.23(0.89 - 1.71)

(*Continued*)

Table 4. (*Continued*)

Background Characteristics	HbA1C		High total cholesterol		High triglycerides	
	Unadjusted	Adjusted	Unadjusted	Adjusted	Unadjusted	Adjusted
Household wealth status						
Poor/Middle (ref)						
Rich	1.32(0.85 - 2.05)	1.62(0.96 - 2.74)	2.88***(1.58 - 5.26)	0.86(0.41 - 1.81)	1.19(0.93 - 1.53)	0.83(0.61 - 1.13)
Mother's education						
No education (ref)						
1-7 years of schooling	1.00(0.48 - 2.11)	1.13(0.52 - 2.47)	0.72(0.27 - 1.89)	0.71(0.25 - 1.99)	0.75(0.51 - 1.10)	0.77(0.51 - 1.15)
8 or more years of schooling	1.33(0.72 - 2.48)	1.16(0.57 - 2.37)	1.62(0.78 - 3.35)	1.79(0.78 - 4.10)	0.83(0.61 - 1.14)	0.94(0.66 - 1.35)
BMI						
Normal (ref)						
Undernourished	0.77(0.41 - 1.42)	0.76(0.40 - 1.43)	0.99(0.49 - 2.03)	1.19(0.55 - 2.57)	1.05(0.76 - 1.46)	1.11(0.79 - 1.56)
Overweight/obese	1.13(0.58 - 2.20)	0.95(0.46 - 1.93)	2.38**(1.23 - 4.60)	1.87(0.88 - 3.97)	2.13***(1.45 - 3.11)	2.26***(1.48 - 3.44)
Weekly consumption of unhealthy food						
Not at all (ref)						
Fried/Junk food	0.96(0.54 - 1.71)	1.07(0.58 - 1.96)	1.16(0.62 - 2.17)	0.74(0.37 - 1.49)	1.19(0.88 - 1.62)	1.06(0.76 - 1.49)
Sweets/Aerated drinks	1.57(0.96 - 2.58)	1.68(0.99 - 2.87)	0.94(0.50 - 1.79)	0.65(0.32 - 1.32)	0.96(0.71 - 1.30)	0.86(0.62 - 1.21)
Either parent has diabetes						
No/Don't know (ref)						
Yes	1.66(0.64 - 4.30)	1.45(0.53 - 4.00)	1.30(0.39 - 4.31)	1.02(0.27 - 3.82)	0.85(0.44 - 1.64)	0.76(0.37 - 1.55)
Either parent has hypertension						
No/Don't know (ref)						
Yes	1.12(0.50 - 2.49)	1.08(0.47 - 2.51)	1.84(0.85 - 3.98)	1.26(0.53 - 2.96)	1.54(0.99 - 2.38)	1.32(0.82 - 2.13)

Note: #Chennai, Delhi, Kolkata, Mumbai; ®Reference category; *** P<0.001, **P<0.05, *P<0.1; NA = Not Applicable; '-'Cases not available
@The Indian Constitution has provisions for people who have historically been disadvantaged and vulnerable. They have been classified as scheduled castes (SCs), scheduled tribes (STs) and other backward classes (OBCs). Scheduled Castes have suffered extreme social, educational and economic deprivation because of their caste. Adivasis or the indigenous people belonging to the Scheduled Tribes have no land holdings, and often earn a living as landless labourers or through casual work. Other Backward Classes (OBCs) refer to other socially and educationally disadvantaged groups who belong to neither the SCs nor the STs.

Table 5a. Adjusted and unadjusted odds ratios of HbA1c (Diabetes) and high total cholesterol for 10-19 years' old adolescents in slum and non-slum areas of four metro cities# by selected background characteristics, India, CNNS 2016-18

	HbA1C		High total cholesterol	
Background Characteristics	Unadjusted	Adjusted	Unadjusted	Adjusted
Metro City				
Kolkata (ref)				
Chennai	1.60(0.80 - 3.21)	1.60(0.63 - 4.10)	0.08***(0.03 - 0.21)	0.05***(0.02 - 0.17)
Delhi	1.45(0.77 - 2.74)	1.88(0.82 - 4.31)	0.09***(0.04 - 0.18)	0.05***(0.02 - 0.12)
Mumbai	1.87(0.96 - 3.65)	2.63**(1.11 - 6.24)	0.05***(0.02 - 0.18)	0.05***(0.01 - 0.16)
Place of residence				
Non-slum (ref)				
Slum	0.98(0.65 - 1.48)	0.95(0.60 - 1.51)	1.20(0.73 - 1.99)	1.11(0.59 - 2.12)
Age of the child				
10-14 years (ref)				
15-19 years	0.81(0.53 - 1.22)	0.83(0.52 - 1.31)	0.90(0.55 - 1.49)	0.74(0.39 - 1.40)
Sex				
Male (ref)				
Female	0.64**(0.41 - 0.97)	0.61**(0.38 - 0.99)	0.89(0.54 - 1.48)	0.48**(0.25 - 0.92)
Religion				
Hindu (ref)				
Non-Hindu	1.11(0.69 - 1.78)	1.30(0.78 - 2.16)	1.08(0.60 - 1.93)	1.3(0.60 - 2.81)
Caste				
Others (ref)				
SC/ST	0.85(0.50 - 1.45)	1.16(0.63 - 2.11)	0.56(0.31 - 1.02)	0.89(0.41 - 1.96)
OBC	1.28(0.80 - 2.05)	1.38(0.77 - 2.48)	0.34***(0.17 - 0.68)	1.29(0.50 - 3.29)
Household wealth status				
Poor/Middle (ref)				
Rich	0.88(0.47 - 1.66)	0.70(0.32 - 1.52)	0.63(0.31 - 1.27)	1.06(0.41 - 2.73)
Mother's education				
No education (ref)				
1-7 years of schooling	0.78(0.39 - 1.57)	0.61(0.28 - 1.33)	1.18(0.57 - 2.47)	0.99(0.38 - 2.54)
8 or more years of schooling	1.56(0.92 - 2.66)	1.38(0.75 - 2.53)	1.08(0.57 - 2.03)	1.10(0.46 - 2.63)
BMI				
Normal (ref)				
Undernourished	1.05(0.61 - 1.81)	0.90(0.51 - 1.59)	0.73(0.35 - 1.55)	0.71(0.31 - 1.62)
Overweight/obese	1.83**(1.05 - 3.16)	1.73(0.98 - 3.07)	1.24(0.60 - 2.56)	0.80(0.34 - 1.89)
Weekly consumption of unhealthy food				
Not at all (ref)				
Fried/Junk food	0.98(0.62 - 1.54)	1.02(0.61 - 1.73)	1.04(0.60 - 1.81)	0.81(0.40 - 1.65)
Sweets/Aerated drinks	1.01(0.62 - 1.62)	0.99(0.57 - 1.71)	1.39(0.80 - 2.39)	1.34(0.65 - 2.74)

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Table 5a. (*Continued*)

Background Characteristics	HbA1C Unadjusted	HbA1C Adjusted	High total cholesterol Unadjusted	High total cholesterol Adjusted
Watching TV (hours/week)				
< 7 hours/week (ref)				
>=7 hours/week	1.12(0.74 - 1.70)	1.18(0.74 - 1.88)	0.77(0.47 - 1.27)	1.13(0.61 - 2.10)
Either parent has diabetes				
No/Don't know (ref)				
Yes	1.15(0.60 - 2.21)	1.12(0.54 - 2.32)	1.79(0.91 - 3.53)	2.40(0.99 - 5.83)
Either parent has hypertension				
No/Don't know (ref)				
Yes	1.25(0.68 - 2.31)	1.58(0.82 - 3.07)	0.93(0.41 - 2.07)	0.59(0.22 - 1.57)

Note: #Chennai, Delhi, Kolkata, Mumbai; ®Reference category; *** P<0.001, **P<0.05, *P<0.1; NA = Not Applicable; '-'Cases not available; confidence interval in parenthesis ()

The risk of high total cholesterol level was significantly less likely among adolescents across three metro cities i.e. Delhi, Chennai, and Mumbai as compared to Kolkata. Female adolecents were at a lower risk (AOR: 0.48, 0.25-0.92) of high level of total cholesterol than their male counterparts. Further, high total cholesterol level was significantly lower among adolescents from OBC caste group (UOR = 0.34), however, in the adjusted model this association was not significant. Other covariates considered in the model were not significantly associated with the high total cholesterol among adolecentes.

Table 5b presents the adjusted and unadjusted odds ratio of prevalence of high triglycerides and hypertension among adolescents in four cities. High triglycerides were significantly less likely among adolescents across three metro cities i.e. Delhi, Chennai, and Mumbai as compared to Kolkata. Place of residence (slum vs non-slum) did not influence the high level of triglycerides in adolecents. Further, high triglycerides were significantly lower among adolescents from SCs/STs and OBCs but this association disappeared in the adjusted model. The risk of high triglycerides was significantly higher among adolescents with mothers educated upto upper primary (1-7 years) as compared to mothers with no schooling. Triglycerides were significantly higher among overweight/obese adolescents (AOR:1.74, 1.09-2.78). The risk of high triglycerides level was significantly higher (AOR:1.78, 1.04-3.06) among adolescents whose either parent was diabetic.

The adjusted and unadjusted odds ratio of individuals diagnosed with hypertension showed that adolescents from cities of Delhi and Chennai were significantly more likely to be hypertensive as compared to those residing in Kolkata. Adolecents from slums had significantly lower risk (UOR:0.34, 0.16-0.72) of being hypertensive than adolecents from non-slums. Being overweight/obese is an important predictor of hypertension among adolescents. Overweight/obese adolescent were 3 times (3.29, 1.47-7.35) more likely to be hypertensive than adolescents with a normal BMI.

Discussion and Conclusions

The present study provides estimates of the prevalence of non-communicable diseases (NCDs) among adolescents (10-19 years' old) in addition to children (5-9 years' old), in the four largest cities of India (Chennai, Delhi, Kolkata and Mumbai), which account for 38% of the total slum population of the million plus cities (Census of India, 2011b). Utilizing data from the

Table 5b. Adjusted and unadjusted odds ratios of high triglycerides and hypertension for 10-19 years' old adolescents in slum and non-slum areas of four metro cities# by selected background characteristics, India, CNNS 2016-18

	High triglycerides		Hypertension	
Background Characteristics	Unadjusted	Adjusted	Unadjusted	Adjusted
Metro City				
Kolkata (ref)				
Chennai	0.19***(0.12 - 0.32)	0.17***(0.09 - 0.32)	3.69**(1.20 - 11.36)	6.55**(1.27 - 33.76)
Delhi	0.40***(0.28 - 0.58)	0.41***(0.26 - 0.63)	4.77**(1.62 - 14.03)	10.16***(2.23 - 46.39)
Mumbai	0.15***(0.09 - 0.27)	0.14***(0.07 - 0.26)	1.05(0.28 - 3.95)	1.88(0.35 - 10.21)
Place of residence				
Non-slum (ref)				
Slum	0.94(0.69 - 1.28)	1.13(0.78 - 1.63)	0.34***(0.17 - 0.68)	0.34***(0.16 - 0.72)
Age of the child				
10-14 years (ref)				
15-19 years	0.87(0.64 - 1.19)	0.81(0.57 - 1.17)	1.30(0.72 - 2.37)	1.35(0.70 - 2.61)
Sex				
Male (ref)				
Female	1.17(0.86 - 1.60)	1.13(0.78 - 1.63)	1.24(0.68 - 2.25)	1.77(0.89 - 3.51)
Religion				
Hindu (ref)				
Non-Hindu	1.28(0.90 - 1.81)	1.23(0.80 - 1.88)	1.57(0.83 - 2.96)	1.37(0.64 - 2.91)
Caste				
Others (ref)				
SC/ST	0.60***(0.41 - 0.87)	0.87(0.55 - 1.37)	1.28(0.61 - 2.68)	1.26(0.51 - 3.10)
OBC	0.55***(0.37 - 0.79)	0.98(0.60 - 1.59)	1.26(0.62 - 2.59)	0.93(0.37 - 2.29)
Household wealth status				
Poor/Middle (ref)				
Rich	1.10(0.66 - 1.85)	1.24(0.67 - 2.30)	1.97(0.60 - 6.44)	1.75(0.38 - 8.05)
Mother's education				
No education (ref)				
1-7 years of schooling	1.88**(1.19 - 2.97)	1.90**(1.13 - 3.19)	1.07(0.43 - 2.68)	1.50(0.52 - 4.37)
8 or more years of schooling	1.29(0.86 - 1.96)	1.07(0.66 - 1.76)	1.20(0.55 - 2.59)	1.48(0.57 - 3.83)
BMI				
Normal (ref)				
Undernourished	0.89(0.58 - 1.37)	0.92(0.58 - 1.46)	1.56(0.71 - 3.42)	1.59(0.70 - 3.61)
Overweight/obese	1.65**(1.07 - 2.53)	1.74**(1.09 - 2.78)	3.12***(1.49 - 6.52)	3.29***(1.47 - 7.35)
Weekly consumption of unhealthy food				
Not at all (ref)				
Fried/Junk food	0.99(0.70 - 1.39)	0.99(0.65 - 1.50)	1.16(0.62 - 2.19)	1.29(0.61 - 2.72)

(*Continued*)

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Table 5b. (*Continued*)

Background Characteristics	High triglycerides Unadjusted	High triglycerides Adjusted	Hypertension Unadjusted	Hypertension Adjusted
Sweets/Aerated drinks	0.90(0.63 - 1.30)	0.94(0.60 - 1.46)	1.00(0.50 - 2.01)	1.13(0.50 - 2.53)
Watching TV hours/week				
< 7 hours/week (ref)				
>=7 hours/week	0.95(0.70 - 1.30)	1.08(0.75 - 1.55)	0.85(0.47 - 1.54)	0.77(0.40 - 1.50)
Either parent has diabetes				
No/Don't know (ref)				
Yes	1.64**(1.05 - 2.56)	1.78**(1.04 - 3.06)	0.42(0.10 - 1.76)	0.35(0.08 - 1.51)
Either parent has hypertension				
No/Don't know (ref)				
Yes	0.87(0.53 - 1.43)	0.49**(0.26 - 0.91)	1.00(0.39 - 2.59)	1.05(0.38 - 2.92)

Note: #Chennai, Delhi, Kolkata, Mumbai; ®Reference category; *** P<0.001, **P<0.05, *P<0.1; NA = Not Applicable; '-'Cases not available; ^: Merged with no schooling because of less number of cases; confidence interval in parenthesis ().

Comprehensive National Nutrition Survey (CNNS), a first of its kind survey in India, the research delves into within-urban and rural-urban disparities in the prevalence of childhood NCDs.

The prevalence of overweight and obesity among children was more or less the same in slum as well as the non-slum areas and was double that of rural areas. The large difference in the prevalence of overweight between rural and urban counterparts can be explained with the comparative wealth and mother's education of these three groups (appendix). This reveals that both slum and non-slum characteristics appears to be similar with each other but differ from rural areas. Among adolescents, a significantly lower proportion of slum-dwellers were obese as compared to the non-slum residents. The estimate of overweight for slum being close to the non-slum may be attributed to the rapid epidemiological transition. Other studies also documented an increasing proportion of the overweight and obese population coming from lower socioeconomic backgrounds (Luhar *et al.*, 2018; Ranjani *et al.*, 2016), particularly in large metropolitan cities and peri-urban areas. Difference in the levels of physical activity, whether it be engaging in outdoor games or involvement in household activities, is associated with the lower risk of being overweight or obese and this partly explains the advantageous position of rural children and adolescents as against their urban counterparts. Unhealthy dietary habits (Cockx *et al.*, 2018; Gupta *et al.*, 2018; Laxmaiah *et al.*, 2007), television viewing/ computer use and motorized transportation for commute to school (Gupta *et al.*, 2018), especially with income changes may, however, put children/adolescents at risk of overweight and obesity, not only in towns and cities but even in the villages.

A higher prevalence of diabetes, as measured by HbA1c, among slum children is an indication of the negative influences of urbanization on the urban poor which probably gets aggravated by their poor living conditions. Childhood infections in poor environment are potential risk factors of type-1 diabetes which usually occur in childhood and adolescence (Rewers & Ludvigsson, 2016). Another interesting finding of the study is that the female children and adolecents were at a lower risk of diabetes which is consistent with the findings from previous studies on prevalence of diabetes in adult age in India (Akhtar & Dhillon, 2017). This finding suggests that the male sex is at a disadvantage in diabetes irrespective of their age. An inter-city comparison showed that children in Delhi, Chennai and Mumbai were at a relatively greater risk of diabetes as compared to the children in Kolkata. There is no earlier evidence on diabetes among young people by covering all of these cities or districts in India. Few evidences suggest that districts from south and

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eastern coast of India have higher prevalence of diabetes among adults (Ghosh *et al.* 2019; Singh *et al.*, 2020). The prevalence of high triglycerides among children was the highest in rural areas and was significantly higher in non-slum areas compared to slum areas. A higher proportion of rural adolecents parameters of lipid profile outose the cut-off values. This is in contrast to the findings from a systematic reviewed study by de Groot *et al.*, (2019) who found that urban residents are at a greater risk of disorders of low density lipoprotein (LDL), cholesterol and triglycerides as compared to their rural counterparts. The lipid profile of adolecents did not differ significantly by slum and non slum. Affordability of high-fat food items due to better socioeconomic background may adversely affect the total cholesterol levels among the non-slum population. An analysis by cities revealed that Kolkata residents were at a greater risk of high total cholesterol and high serum triglycerides. This may be explained by their dietary pattern characterized by high intakes of butter, hydrogenated oil, ghee, vegetable oil, mustard oil, condiments, sweets, fish, high-fat dairy and refined grain as argued by Ganguli *et al.*, (2011). A study on diets of students (aged 14–16 years) attending private schools in Kolkata reported that 70% of adolecents had eaten three or more servings of energy-dense snacks, on the previous day (Rathi *et al.*, 2017). CNNS data on food consumption is limited to recording the frequency of intake of specified food items during a given time period and does not assess the portion consumed, type of oil used and other aspects of the frying process that may be associated with the risk of high total cholesterol and other NCDs (Guallar-Castillón *et al.,* 2012). On the other hand, people with a lower educational background might not be conscious enough in making healthy food habits (Ganguli *et al.*, 2011) putting the slum children and adolescents at an increased risk of high total cholesterol.

Most studies have found that urban residents have higher abnormalities of lipid parameters (de Groot *et al.*, 2019; Gupta *et al.*, 2017; Joshi *et al.*, 2014) when compared to their rural counterparts as expected but this is not true for our present study. One of the probable reasons could be the proximity of non-remote villages to towns and cities with improved connectivity which gives villagers an opportunity to 'enjoy a good exposure to the modern day living and are affected by all its vices like sedentary jobs, decreased physical activity, stress and high energy junk foods' (Singh *et al.* 2016).

The likelihood of being hypertensive was high among adolescents residing in non-slum areas. Delhi adolescents from the non-slum areas exhibited a strikingly high rate of hypertension as was also concluded by another study among school-going adolescent boys in Delhi (Singh & Verma, 2020). Adolecents from the metro-cities particularly from the upper strata who live in non slum areas may be living in a competitive environment and under pressure for getting into higher education. They are also more likely to live sedentary life and be overweight (Regis *et al.*, 2016). The present study also finds overweight/obese adolecents at a higher risk of hypertension.

One of the salient findings that emerged from our analyses of correlates is the regional differences in the prevalence of NCDs and its risk factors. The plausible explanation could be the varying dietary preferences and holding on to traditional beliefs pertaining to the body image of children or choosing to adopt 'modern' eating habits instead which is considered to be a status symbol. There is a significant positive association of most NCDs with household wealth status both among children and the adolescents. Overnutrition among adolescents poses a risk for high triglycerides levels and hypertension.

This study on NCDs among children and adolescents are based on slums and non-slums in four metropolitan cities of India. Given India's considerable heterogeneity, the findings are not generalizable to the whole of urban India. Although alcohol abuse and use of tobacco have been identified as significant behavioural risk factors, these could not be included in our analysis due to very small numbers reporting indulging in these habits. Despite these limitations, estimations of NCDs based on biomarkers at a city level is the greatest strength of the study. Separate analyses for age-groups 5-9 years and 10-19 years allowed comparisons of prevalence of NCDs by areas and its correlates for children and adolescents. Stratified analyses by cities located in different regions of the country provide insight into how to best tailor interventions geographically to be most

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effective. Although some results particularly related to high triglycerides in Kolkata need further investigation for potential factors as well as quality of biomarkers data in this setting, this was beyond the scope of the present study. Disaggregation of the urban population into slum and non-slum reiterates the need for specific programmes for the urban poor on one hand, and on the other prompts that the non-poor cannot be neglected.

In conclusion, children and adolescents, among the poor and the non-poor, are all exposed to the risk of being affected by non-communicable diseases which seems to be on the rise under the effects of globalization and urbanization. Affluence, instead of being an unfavorable correlate, should be turned to act in favour of positive nutritional outcomes so as to prevent the spread of non-communicable diseases. Educating caretakers and the children themselves could be an effective and sustainable means to control non-communicable diseases among children and adolescents. In order to tackle the increasing prevalence of NCDs in childhood and adolescence, early detection by screening should be integrated with the already existing child and adolescent development schemes in schools and the community.

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Appendix: Household wealth status and mother's schooling among children and adolescents in slum, non-slum and rural areas

Characteristics	Slum	Non-Slum	Rural
Children aged 5-9 years			
Wealth Status			
Poor/middle	38.3	35.1	65.1
Rich	61.7	64.9	34.9
Mother's Schooling			
No Schooling	13.1	11.8	18.0
1-7 years	20.9	18.8	27.4
8 or more years	66.0	69.4	54.6
Adolescents aged 10-19 years			
Wealth Status			
Poor/Middle	40.9	33.8	72.2
Rich	59.1	66.2	27.8
Mother's Schooling			
No Schooling	23.4	21.3	29.2
1-7 years	25.5	22.5	30.1
8 or more years	51.1	56.3	40.7

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