ORIGINAL ARTICLE

Urbanization, Human Development and Literacy and Syndemics of Obesity, Hypertension and Hyperglycemia in Rajasthan: National Family Health Survey-4

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Abstract

Objective: Non-communicable diseases (NCDs) are the new epidemic in India. District-specific prevalence of various NCD risk factors and their macrolevel determinants is unknown. We used National Family Health Survey-4 (NFHS-4) data to map the syndemics of obesity, hypertension and hyperglycemia in Rajasthan, the largest state of the country, and correlated their prevalence with selected social determinants of health- urbanization, human development index (HDI) and literacy.

Methods: Data on location-adjusted prevalence of various NCD risk factors among women (15-49y) and men (15-54y) were obtained from NFHS-4 data sheets. Heat maps were created to determine geographic distribution of obesity (body mass index, BMI ≥25 kg/m^2), hypertension (known and/or BP ≥140/≥90 mmHg) and hyperglycemia (random glucose >140 mg/dl) in all the districts (n=33). We determined correlation of various social determinants with NCD risk factors.

Results: Significant geographic variation was observed in prevalence of obesity, hypertension and hyperglycemia in women and men. High prevalence of obesity and hypertension was observed in central and northwestern districts of the state. In women and men respectively, there was a significant positive correlation of obesity with urbanization (r=0.68, 0.51), HDI (r=0.70, 0.66) and female literacy (r=0.46, 0.34). Prevalence of hypertension also showed significant correlation with urbanization (r=0.18, 0.33), HDI (r=0.38, 0.52) and literacy (r=0.32, 0.21) while no correlation was observed with hyperglycemia.

Conclusion: There is significant geographic variation in prevalence of obesity, hypertension and hyperglycemia in Rajasthan. Significant correlation of obesity and hypertension with urbanization, human development and female literacy is observed.

Introduction

Urbanization is one of the most important social changes of the twentieth century. In western countries massive urbanization of rural population occurred in the last five hundred years but the most rapid change occurred in the 19th century.[1] On the other hand, this change began in low and lower-middle countries in the 20th century and is more rapid.[1] This has led to multiple changes in political, social and family structures. The outcomes of these changes are complex but lead to significant social changes.[2] These changes also impact health and are collectively known as social determinants of health. World Health Organization (WHO) defines social determinants of health as "the conditions in which people are born, grow, work, live, and age, and the wider set of forces and systems shaping the conditions of daily life. These forces and systems include economic policies and systems, development agendas, social norms, social policies and political systems".[3] Wilkinson and Marmot proposed the following social determinants as important for health: social gradient, stress, early life factors, social exclusion, work, unemployment, social support, addiction, food, and transport.[4] In low and lower middle income countries other important factors are urbanization, human development and education.[5-7] All these social determinants of health are associated with the epidemic of cardiovascular disease (CVD) and associated risk factors of smoking, obesity, hypertension and diabetes and are "causes of causes" of syndemics of CVD.[8]

Syndemics are defined as clustering of two or more diseases within a population that contributes to and results from persistent social and economic inequalities.[8] It was initially reported as clustering of substance abuse, violence and AIDS.[8] Presently focus has shifted from disease-specific and multimorbidity-based models to evaluate how social and economic conditions foster and exacerbate the diseases.[9] In India there is dual burden of communicable and non-communicable diseases (NCDs).[10] Sociocultural factors responsible for these associations have not been well examined. Macrolevel epidemiological studies could provide an impetus to study these associations. We examined data from the Fourth National Family Health Survey (NFHS-4)[11] using state-level and district-level data from published fact-sheets.[12] Hypertension and diabetes share common pathogenetic factors and overweight and obesity are important in pathogenesis of both the conditions especially in India.[13] Socioeconomic factors are important in all of these.[7] To evaluate presence of NCD risk factors in Rajasthan we mapped district level

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prevalence of overweight/obesity (body mass index ≥25 kg/m^2), hypertension, and hyperglycemia (random glucose >140 mg/dl) from NFHS-4 fact-sheets.[11] We also performed correlation of these conditions with district level data on urbanization, human development index (HDI) and female-literacy levels to determine the importance of these social determinants on obesity, hypertension and hyperglycemia to determine syndemicity in the largest Indian state.

Methods

We used the district level data for Rajasthan obtained during the district level health survey and published by NFHS-4.[11] This is secondary analysis of the existing data and hence ethics clearance was not obtained. National Family Health Surveys are a series of nationally representative surveys that are periodically commissioned by government of India and performed under the guidance of International Institute of Population Sciences (IIPS), Mumbai, India; ORC Macro, Calverton, MD, USA and East-West Center, Honolulu, Hawai, USA. The studies are approved by the ministry of health of government of India and the research review board at IIPS, Mumbai. So far three surveys have been performed- NFHS-1 from 1992-1993, NFHS-2 from 1998-1999 and NFHS-3 from 2004-2005 [14]. NFHS-1 collected extensive information on population, health, and nutrition, with an emphasis on women and young children. Eighteen Population Research Centres located in universities and institutes of national repute assisted IIPS in all stages of conducting NFHS-1.[15] The NFHS-2 was conducted in all the 26 states of India with additional data on quality of health and family planning services, domestic violence, reproductive health, anemia, nutrition of women and status of women. NFHS-3 used 18 research organizations including 5 population research centers who carried out surveys in 29 states of India. NFHS-4 was performed in 2015-16 and is focus of present article.[15]

Detailed manuals for the conduct of NFHS-4 are available.[16-18] Specific goals of NFHS-4 were: (a) to provide essential data on health and family welfare needed by the Ministry of Health and Family Welfare and other agencies for policy and program purposes, and (b) to provide information on important emerging health and family welfare issues. Specific objectives were to provide estimates of the levels of fertility, infant and child mortality, and other family welfare and health indicators by background characteristics at the national and state levels; and measure trends in family welfare and health indicators over time at the national and state levels. Besides the usual details of perinatal mortality, adolescent reproductive health, high-risk sexual behavior, safe injections, tuberculosis, and malaria and family welfare and health conditions among slum dwellers, this study for the first time was designed to obtain data on common non-communicable diseases such as hypertension and hyperglycemia (diabetes).[19]

Sampling

The survey was implemented in both urban and rural areas.[15] A uniform sample design was adopted in all the districts. IIPS, Mumbai selected primary sampling units for rural (villages) and urban (Census Enumeration Blocks, CEBs) areas following the NFHS sampling design. The field agencies were given a list of selected sampling units for each state or union territories that were selected for the fieldwork. When any regional linked primary sampling unit was selected, then mapping and household listing was undertaken for all the linked villages and urban blocks as a single unit. Prior to interviewing, all households located in the selected unit were listed as per the procedure by mapping and household listing teams. The list of households in each unit was used in selecting the final sample of households to be included in the NFHS-4 survey.

NFHS-4 was designed to provide information on various demographic parameters and other family welfare and health indicators by background characteristics at the national and state level and, for the first time, at the district level also. Because of need to report health indicators at the district level, the NFHS-4 sample size was increased to approximately 571,660 households, as compared with 109,041 households in NFHS-3.[19] The survey used 4 schedules (Household, Woman's, Man's and Biomarker), and information was collected from all women aged 15-49 years and, in a sub-sample of households, men aged 15-54 years. This was expected to yield a total sample of 628,826 women and 94,324 men eligible for the interview. In these selected households, information on approximately 267,272 children below age 5 years was also obtained. In addition to the 29 states, NFHS-4 also included all six union territories and has provided estimates of most indicators at the district level for all 640 districts in the country as per the 2011 Census.[19] The data were collected using Computer Assisted Personal Interviewing on mini-laptops. The domain of clinical, anthropometric and biochemical testing was expanded in NFHS-4 to include random blood glucose and blood pressure (BP) measurements with estimates to be reported at the district level for women age 15-49 and men age 15-54. All these components in the field were evaluated using portable equipment. A recently developed, improved model of the HemoCue instrument was used for anemia testing. A battery-operated portable glucometer was used for blood glucose testing. An automatic and battery operated BP instrument was used. Lancets and all blood contaminated materials were disposed in a biohazard bag according to an established protocol. Only medical or other personnel with specific training on the procedures and on universal precautions regarding blood-borne pathogens were involved in conducting the anemia and blood glucose testing. NFHS-4 was conducted in two phases, and each phase covered almost an equal number of states/groups of states and union territories.[19] The two phases helped in managing the whole operation of implementation more efficiently. Identical strategy was used for Rajasthan state which was part of the second phase.

Interview and assessments

The detailed interviewer manual is available at NFHS-4 website.[17] In the first step a Household Questionnaire permits the interviewer to identify women and men who are eligible for interview with the relevant Individual Questionnaire. Women age 15-49 years and men age 15-54 years who are members of the household were interviewed. The Household Questionnaire also permits the interviewer to identify women, men, and children who are eligible for anthropometric measurement, anemia

Table 1: Prevalence (%) of various social determinants and non-communicable disease risk factors in different districts of Rajasthan in women (15-49 y) and men (15-54 y)

District (alphabetic)	Sample size	Urbanization Index	Human Development Index	Literacy Rate		Overweight (BMI ≥5 Kg/m²)		Hypertension (known or BP ≥140/90 mmHg)		Hyperglycemia (glucose >140 mg/dl)		Hyperglycemia (glucose >160 mg/dl)	
				Women	Men	Women	Men	Women	Men	Women	Men	Women	Men
Ajmer	2659	40.1	0.677	65.1	83.8	16.8	18.5	6.5	14.3	5.7	7.1	1.8	1.7
Alwar	1252	17.8	0.744	59.1	90.4	10.9	18.1	8.0	15.7	2.4	8.4	0.9	1.5
Banswara	1253	7.1	0.425	44.1	78.7	9.0	8.7	3.5	4.9	4.5	7.1	2.0	4.4
Baran	1319	20.8	0.653	52.9	85.6	9.7	7.6	5.4	7.2	3.9	9.2	1.4	4.7
Barmer	1077	7.0	0.578	37.8	71.3	11.7	15.0	7.1	10.9	3.0	3.7	0.7	2.8
Bharatpur	1253	19.4	0.604	52.5	87.7	14.4	12.5	10.1	13.2	3.1	4.7	1.4	2.4
Bhilwara	1033	21.3	0.633	48.5	91.5	14.1	10.2	3.8	5.5	3.0	6.7	0.9	3.5
Bikaner	2794	33.9	0.779	59.8	78.5	15.4	13.2	6.1	11.8	3.9	5.3	0.9	1.5
Bundi	1149	20.1	0.649	51.8	80.2	10.9	10.5	5.1	12.6	4.3	7.0	1.7	3.8
Chittaurgarh	1017	18.5	0.558	48.6	77.7	17.6	12.8	9.0	11.3	3.9	5.5	2.2	3.5
Churu	1304	28.3	0.606	58.1	79.3	13.5	9.3	7.6	10.7	2.6	2.5	1.2	0.7
Dausa	1243	12.4	0.576	57.3	92.3	10.2	9.6	7.3	12.5	2.5	7.2	0.5	2.3
Dhaulpur	1310	20.5	0.497	57.1	87.1	10.3	9.5	4.2	7.0	2.5	5.7	0.9	2.4
Dungarpur	1226	6.4	0.409	53.9	79.8	6.2	5.7	5.2	11.0	4.6	5.0	1.2	2.1
Ganganagar	1423	27.2	0.809	69.0	85.8	20.5	24.4	8.0	14.5	5.3	4.4	1.9	3.1
Hanumangarh	1315	19.8	0.761	62.6	82.1	14.8	12.1	9.5	22.4	3.7	7.8	1.5	2.7
Jaipur	2660	52.4	0.778	68.6	92.6	17.4	14.6	9.7	19.1	3.0	6.2	1.0	1.9
Jaisalmer	1161	13.3	0.673	37.0	69.6	12.8	9.7	4.6	10.5	1.9	3.1	1.3	0.8
Jalor	1299	8.3	0.527	41.7	79.2	9.3	9.6	6.2	8.6	3.8	6.1	1.0	3.6
Jhalawar	1195	16.3	0.614	49.9	78.8	8.6	9.0	5.2	9.9	4.3	10.1	1.7	3.2
Jhunjhunun	1395	22.9	0.711	68.7	94.5	17.3	17.1	8.1	14.3	2.4	2.4	0.8	0.7
Jodhpur	2555	34.3	0.686	55.7	89	18.3	18.1	6.0	13.6	3.2	8.9	1.2	4.3
Karauli	1267	15.0	0.566	49.3	86.6	10.2	7.5	7.7	13.2	3.1	4.5	1.3	1.0
Kota	2507	60.3	0.787	70.6	89.6	20.6	16.3	5.7	11.3	4.6	7.7	2.1	3.7
Nagaur	1335	20.0	0.61	53.2	84.3	14.1	11.6	8.6	14.7	3	1.8	0.8	1.3
Pali	1184	19.3	0.547	57.8	91.2	14.5	13.3	5.9	10.4	3.7	2.1	1.8	0.0
Pratapgarh	1211	22.6	--	45.7	72.1	7.8	9.5	6	5.5	3.6	5.1	1.2	2.5
Rajsamand	1198	8.3	0.578	59	83.8	12.5	6.7	6.1	8.9	4.4	3.5	1.5	0.7
Sawaimadhopur	1270	15.9	0.561	44.9	84.1	11.2	13.5	7.3	11.6	3.4	4.4	0.9	2.6
Sikar	1419	23.7	0.698	66.5	88.3	18.4	13.6	7.9	12.4	3.9	3.8	1.3	0.0
Sirohi	1144	20.1	0.645	43.5	84.3	10.1	9.6	4.7	9.3	3.0	4.6	1.4	0.7
Tonk	1220	22.4	0.571	52.1	88.9	10.5	9.7	3.8	18.4	2.6	9.9	1.1	3.8
Udaipur	1120	19.8	0.595	50.5	84.3	10.4	12.7	6.2	9.1	2.3	6.8	1.0	3.9

testing, HIV testing, random glucose testing and BP measurement.

The Woman's Questionnaire obtained information from each woman enrolled for participation on background characteristics including age, marital status, education, employment status, occupation, religion, and duration of residence. Detailed of reproductive behavior, knowledge and use of contraception, availability of family planning, children's health, feeding practices for children, women's health, AIDS and sexually transmitted infections, knowledge and attitudes concerning tuberculosis, sexual life, interpersonal household relations and violence. The Man's Questionnaire obtained information on most of the same topics. Details of smoking and tobacco use and alcohol use were also obtained from both men and women. History of presence of diabetes, asthma, heart disease, thyroid swelling and cancer were inquired. However, these details are not available on the fact sheets.[11]

Biomarkers included measurement of height, weight, hemoglobin levels, random blood glucose using standardized glucometers and BP measurement using electronic instruments.[18] For weighing children and adults the survey used SECA-874-U digital scale. This scale has a maximum capacity of 200 kg and weighs in 0.01 kg increments. 6 type AA 1.5 V batteries power the scale. SECA-213 stadiometer was used for measuring the height of adults. For blood glucose estimation NFHS-4 used Free Style Optium H Glucometer. The readings were considered equivalent to blood glucose levels in laboratory estimations using the glucose oxidase method for glucose levels in the range of 10-600 mg/dl. BP of eligible respondents was measured using an Omron BP Monitor to determine the prevalence of hypertension. BP of each respondent was taken on three separate occasions and the readings recorded in the biomarker questionnaire with interval of 5 minutes between readings. The first result was discarded and the average of the last two measurements has been calculated. Informed consent was obtained from each individual for clinical evaluation, anthropometry and blood tests. Computer assisted personal interview technique was used for a majority of participants. However, when this was not possible due to logistic reasons the data were filled on paper case-report forms.

Statistical analyses

NFHS-4 data were manually obtained from the website. Descriptive statistics are reported. Body mass index (BMI) was calculated by dividing weight in kilograms by squared height

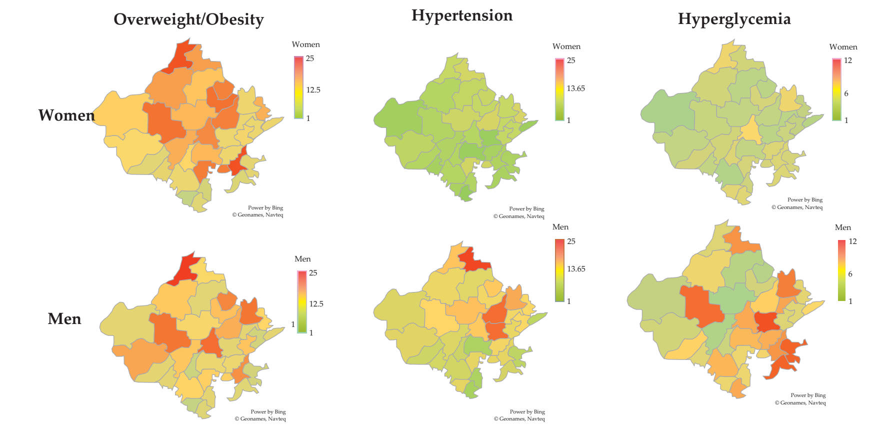

Fig. 1: Heat maps depicting prevalence of overweight/obesity (BMI ≥25 kg/m^2), hypertension, and hyperglycemia (random blood glucose ≥140 mg/dl) in various districts of Rajasthan in women and men.

in meters [BMI= weight in kg/(height in $m)^2$. Underweight was diagnosed when BMI was <18 kg/m^2 and overweight and obesity was considered when BMI was ≥25 kg/m^2.[20] Hypertension was diagnosed when either the participant was a known hypertensive on medical treatment or systolic BP was ≥140 mm Hg and/or diastolic BP ≥90 mmHg according to standard definitions.[20] Non-fasting blood glucose estimation was performed in the NFHS-4 survey. Two criteria for diagnosis of hyperglycemia were adopted, high and very high glucose with random values >140 mg/dl and >160 mg/dl respectively. The urban-rural prevalence of risk factors and other conditions has been adjusted to the population proportions at each district to provide district-level estimates. Data of women and men are reported separately.

We developed heat-maps of each of the risk factors in each district of Rajasthan state using Microsoft Excel program in MS Office Version 14.0. Prevalence of various risk factors is reported from green (low prevalence) to red (high prevalence) according to percent prevalence of risk factors separately in men and women in each district of Rajasthan. Urbanization index was derived as proportion of urban to total population of each district available from the NFHS data sheets. Human Development Index of various districts was obtained from Government of Rajasthan report.[21] Female and male literacy levels were obtained from NFHS-4 fact sheets. Pearson's correlation coefficient (r) as well as Spearman's correlation coefficient (rho) were calculated to determine significance of associations of these risk factors. Logarithmic correlation of district level prevalence of obesity BMI ≥25 kg/m^2, hypertension and hyperglycemia (random blood glucose >140 mg/dl) was performed using graphics program in MS Excel. P values less than 0.05 were considered significant.

Results

NFHS-4 adopted a two-stage sampling design in rural and urban areas of each district of India. Survey interviewed 601,509 households, 699,686 women and 103,525 men from 28,583 primary sampling units composed of villages in rural areas and census enumeration blocks in urban areas in 640 districts of the country.[19] In Rajasthan data are available from all the 33 districts (Table 1). In Rajasthan 34915 households were evaluated with sample size of 41965 women aged 15-49 years and 5892 men aged 15-54 years.

Data regarding various risk factors- overweight or obesity (BMI ≥25 kg/m^2), hypertension and hyperglycemia (random capillary glucose >140 mg/dl) in women and men are shown in Table 1. There is a wide variation in prevalence of these risk factors in women as well as men. Prevalence of obesity in women and men is significantly greater in central and northwestern districts (Figure 1). In women and men, respectively, low prevalence of obesity (<5%) is in 6 and 14 districts, moderate prevalence 5-15% in 18 and 13 districts and high prevalence (>15%) in 9 and 6 districts (Table 1).

Prevalence of hypertension also shows significant regional differences. Among women its prevalence is significantly greater in eastern districts while in men is more in central and northwestern districts of the state (Figure 1). Prevalence of hypertension is more in men than in women. Hypertension prevalence among women is low in most of the districts of the state while in men almost a third of districts have high prevalence (Table 1). Regional variation is also observed in prevalence of hyperglycemia (Figure 1). Among women prevalence of hyperglycemia is significantly greater in eastern regions of the state while in men is more in southeastern and central districts. There is a low prevalence of hyperglycemia among women in most of the state while in men more than half of the districts have moderate or high prevalence.

We performed correlation analysis of prevalence of obesity with hypertension and hyperglycemia in women and men. Obesity prevalence shows a significant positive correlation with hypertension in both women (r= 0.45, rho= 0.48) and men (r= 0.43, rho= 0.57) ($p<0.001$). Prevalence of obesity shows a significant positive correlation with hyperglycemia in women (r= 0.20, rho= 0.11) but not in men. Analysis of association with hypertension and hyperglycemia prevalence showed a weak positive correlation in men (r= 0.11, rho= 0.07) and an insignificant negative correlation in women (r= -0.07, rho= -0.10). Correlation of hypertension prevalence with severe hyperglycemia (blood glucose >160 mg/dl) also shows insignificant results (r value, women -0.07, men 0.11; rho value, women -0.10, men 0.07).

Correlation (parametric and non-parametric) of obesity hypertension and hyperglycemia with macrolevel social risk factors- urbanization, HDI and female literacy is reported in Table 2. Urbanization significantly correlated with obesity and hypertension in both women and men (Figure 2). District-level HDI also positively correlated with obesity and hypertension (Figures 3) and so did female literacy (Figure 4). There is insignificant correlation of hyperglycemia with all the social determinants studied.

Discussion

This study shows that there are significant regional differences in prevalence of major non-communicable

Table 2: Correlation of urbanization, human development and educational status with obesity, hypertension and hyperglycemia

		Obesity		Hypertension		Hyperglycemia	
		Pearson r	Spearman rho	Pearson r	Spearman rho	Pearson r	Spearman rho
Urbanization index	Women	0.678***	0.591***	0.181	0.105	0.174	0.045
	Men	0.509**	0.484**	0.328*	0.306*	0.189	0.139
Human development index	Women	0.701***	0.625***	0.381*	0.294	0.053	0.052
	Men	0.656***	0.592***	0.524**	0.494**	0.110	0.144
Educational status	Women	0.458**	0.401**	0.318*	0.338*	0.186	0.076
	Men	0.336*	0.336*	0.208	0.267	0.165	0.147

*p<0.05, **p<0.01, ***p<0.001

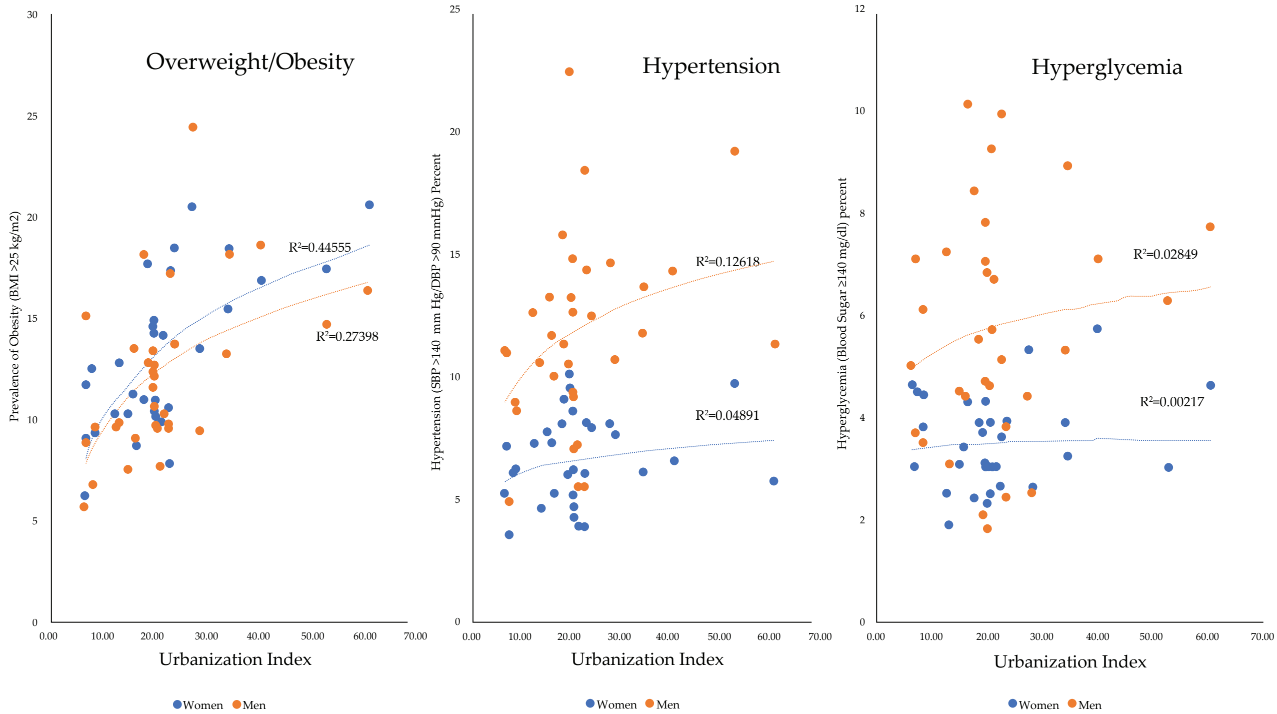

Fig. 2: Logarithmic correlation of district-level urbanization with prevalence of overweight/obesity, underweight, hypertension and hyperglycemia in women and men

diseases risk factors- obesity, hypertension and hyperglycemia- in Rajasthan, the largest state of the country. There is a significant positive correlation of obesity and hypertension with macrolevel social determinants of health- urbanization, human development index and female educational status.

Previous studies from India have reported regional differences in prevalence of cardiovascular diseases and their risk factors.[22] Registrar General of India reported greater age-adjusted cardiovascular mortality in southern and eastern states of the country.[23] Coronary heart disease (CHD) mortality was greater in south India while stroke was more common in the eastern Indian states. Epidemiological studies have reported that CHD prevalence is greater in South Indian states as compared to others.[22] Geographic variation in cardiovascular risk factors has been reported in previous reviews.[22] To determine regional variation in cardiovascular risk factors, India Heart Watch study was performed in 11 cities in the country and reported that compared with national average, prevalence of most risk factors was significantly lower in cities of eastern region with lower prevalence of overweight, hypertension, hypercholesterolemia, diabetes and metabolic syndrome.[24] It was also observed that cities with low social and human development index had lowest prevalence of these risk factors similar to the present study. The first phase of ICMR-INDIAB study was performed in 4 states (Tamilnadu, Maharashtra, Jharkhand and Chandigarh) and reported inter-state variations in cardiovascular risk factors.[25] However, there are no epidemiological studies that compared within-state differences in prevalence of risk factors and our results cannot be compared to previous data from India. Multiple studies from UK, USA and other developed countries have reported large regional differences in prevalence of various cardiometabolic risk factors.[26-30] Our data shows that similar differences exist in Rajasthan.

Previous NFHS reports have highlighted regional differences in multiple social determinants of health including literacy, access to health care, family violence and smoking.[19] The present study, derived from the NFHS-4 data, for the first time has reported that there are significant within state differences in various non-communicable disease risk factors. Important omissions in NFHS-4 are lack of data on important lifestyle determinants of various cardiovascular risk factors. We have no district specific data on smoking, alcohol intake, healthy diet (high fruits and vegetables,

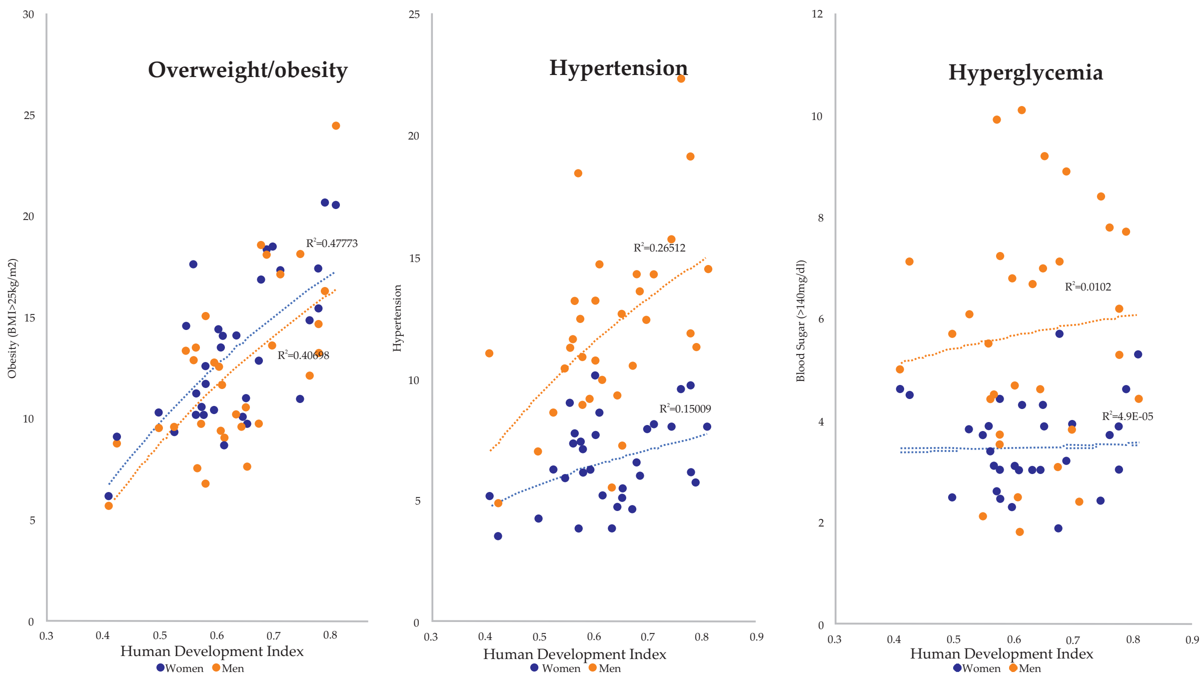

Fig. 3: Logarithmic correlation of district-level human development index with prevalence of overweight/obesity, underweight, hypertension and hyperglycemia in women and men

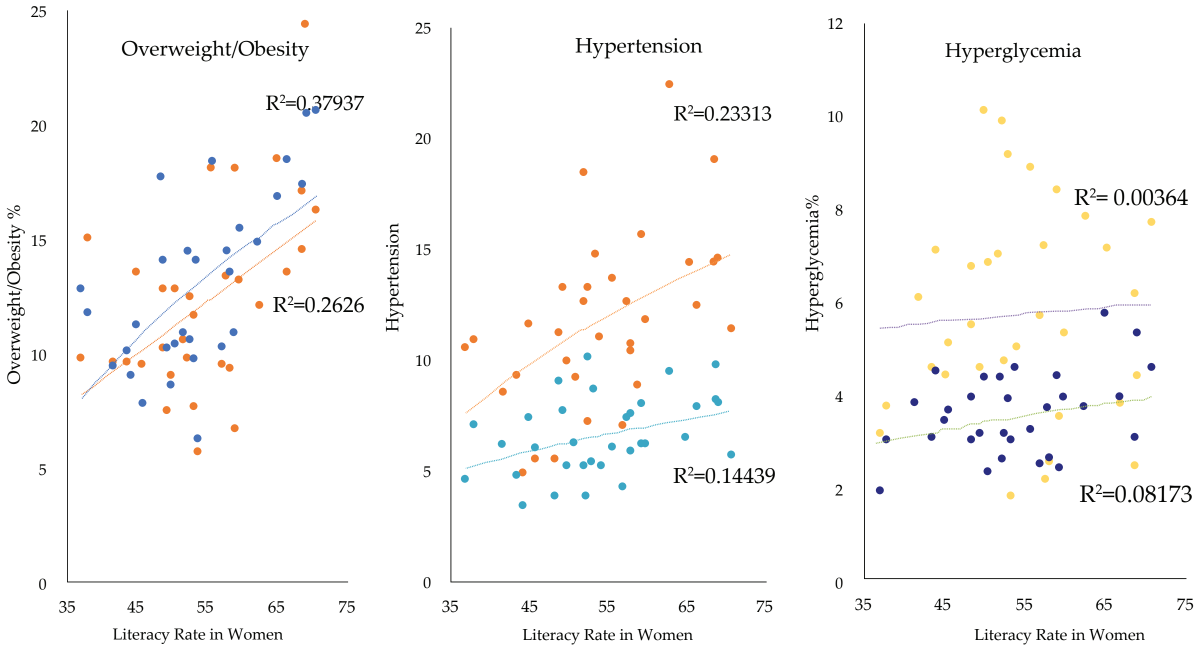

Fig. 4: Logarithmic correlation of district-level female literacy levels with prevalence of overweight/obesity, underweight, hypertension and hyperglycemia in women and men

low saturated and trans fats) and physical activity. This is a major study limitation. It is hoped that the next rounds of NFHS shall focus on these important determinants or "causes of causes" of cardiovascular and other non-communicable diseases.

Our study shows that there is a significant positive correlation of important CVD risk factors (obesity and hypertension) with macrolevel social determinants- urbanization, HDI and educational status (Table 2). This is in contrast to developed countries where CVD risk factors are greater in more deprived populations and low socioeconomic locations.[29] Our data suggest that in India (and other lower-middle income countries) the cardiovascular disease epidemic is still not fully mature. It has been reported that in earlier phase of epidemiological transition the prevalence of CVD and its risk factors is greater in more literate people living in affluent regions.[30,31] Once the transition matures, there is inversion of the disease pattern with greater CVD and risk factors among the deprived.[31] Eckert and Kohler performed a systematic review of urbanization and health in developing countries.[32] Accordingly, the urbanization was associated with a lower risk of undernutrition and a higher prevalence of overweight and risk factors for chronic diseases, similar to the present study.

This study has a few strengths and multiple limitations. Strengths include population wide sampling and vast geographic representation. The foremost limitation is inclusion of only young adults (women 15-49y, men 15-54y) for assessment of various NCD risk factors- obesity, hypertension and hyperglycemia. This has resulted in a significantly lower prevalence in the NFHS as compared to earlier population based studies in different regions of India.[22] Secondly, although the criteria for measurement and diagnosis of hypertension are according to international guidelines,[20] the diagnosis of hyperglycemia is based on ill-defined criteria. WHO has recommended measurement of either a fasting glucose alone or fasting and 2-hour post-glucose estimation for diagnosis of diabetes.[20] In the present study the random capillary blood glucose of >140 mg/dl has been taken as hyperglycemia and >160 mg/dl as severe hyperglycemia. Both these criteria are not according to any national or international guidelines. This may have resulted in a falsely skewed distribution of hyperglycemia. This is apparent when we correlate prevalence of obesity and hypertension with hyperglycemia.[12] No significant correlation emerges. Thirdly, we have performed only a macrolevel analysis using the NFHS-4 fact-sheets available at the website. It is likely that when individual level data are similarly analyzed different results may emerge. Fourthly, we have not reported on other major lifestyle CVD risk factors including smoking, tobacco use, alcohol abuse, unhealthy diet and sedentary lifestyle as these data are not available. We have also not evaluated associations of the prevalence of hypertension and hyperglycemia with available health systems and availability of appropriate health care. And finally, we have not identified regional differences in causes of deaths in the present study, nor gleaned data from Registrar General of India database on district level mortality. Other limitations are sampling bias, small urban representation in smaller districts and failure to adjust for regression-dilution bias especially in hypertension.

In conclusion, the present study shows that there are significant regional differences in prevalence of various non-communicable disease risk factors (obesity, hypertension and hyperglycemia) in Rajasthan. Positive association of multilevel social determinants (urbanization, human development index and literacy) with obesity and hypertension shows that these factors are important. The WHO Commission on Social Determinants of Health suggests focus on multiple factors to ameliorate socioeconomic disparities in risk factors. These include focus on better daily living, creating mechanisms to avoid and manage inequitable distribution of power, money and resources and implementation of policies to improve health.[33] The present study shows that the syndemics of obesity and hypertension are associated with urbanization and greater human development in India. This shows that urbanization and human development has not led to better health outcomes in contrast to high-income countries.[30] Focus on improved quality of urban living which has been suggested by Lancet Commission on Urban Health is important.[2] This commission has reported that cities are complex systems and urban health outcomes are dependent on many interactions. Inequalities in health outcomes should be recognized at the urban scale and creating good health needs dialogue between stakeholders to improve decision making and practices.[2] Improving human development to decrease non-communicable disease outcomes is difficult but can be achieved through implementation of policies for risk factor control and individual empowerment.

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