20-Year Trend of CVD Risk Factors

Urban and Rural National Capital Region of India

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ABSTRACT

Background: The World Health Organization and the Government of India have set targets to reduce burden of noncommunicable diseases. Information on population level trend of risk factors would provide insights regarding the possibility of achieving them.

Objective: This study aimed to determine the population trends of cardiovascular disease risk factors in the National Capital Region of Delhi over 2 decades.

Methods: Two representative cross-sectional surveys were conducted among men and women ages 35 to 64 years, residing in the urban and rural areas (survey 1 [1991 to 1994] and survey 2 [2010 to 2012]) using similar methodology. The urban sample was collected from the Municipal Corporation of Delhi, and the rural sample was from the Ballabgarh block of the adjoining state of Haryana. A total of 3,048 and 2,052 subjects of urban areas and 2,487 and 1,917 subjects of rural areas were surveyed in surveys 1 and 2, respectively. Behavioral (smoking and alcohol use), physical (overweight, abdominal obesity, and raised blood pressure), and biochemical risk factors (raised fasting blood glucose and raised total cholesterol) were measured using standard tools.

Results: Urban and rural prevalence of overweight, alcohol use, raised blood pressure, and blood glucose increased with increases in age-standardized mean body mass index (urban: 24.4 to 26.0 kg/m^2; rural: 20.2 to 23.0 kg/m^2), systolic blood pressure (urban: 121.2 to 129.8 mm Hg; rural: 114.9 to 123.1 mm Hg), diastolic blood pressure (urban: 74.3 to 83.9 mm Hg; rural: 73.1 to 82.3 mm Hg), and fasting glucose (urban: 101.2 to 115.3 mg/dl; rural: 83.9 to 103.2 mg/dl). The smoking prevalence increased in the rural male population. Raised total cholesterol declined in urban and increased significantly in rural populations.

Conclusions: The study indicates an overall worsening of population levels of all cardiovascular disease risk factors in National Capital Region over past 20 years, though some signs of stabilization and reversal are seen in urban Delhi.

The meeting of the U.N. General Assembly on noncommunicable diseases (NCD) [1] and the subsequent goals and targets set by the World Health Organization (WHO) has opened an enormous window of opportunity to reduce the burden of chronic diseases worldwide. These targets set by WHO include those on major risk factors such as tobacco and alcohol use, inappropriate diet, physical inactivity, raised blood pressure, overweight/obesity, and raised blood glucose and cholesterol levels [2]. India has taken the agenda further and developed its own national targets for reducing NCD burden [3]. However, achieving and monitoring these targets requires a robust surveillance system and benchmarks against which the targeted reductions can be measured. Among NCD, cardiovascular diseases (CVD) are the major causes of morbidity and mortality in India [4]. Epidemiological studies (largely cross-sectional surveys) conducted at different points in time and from different locations of India suggest a consistent increase in the prevalence of CVD risk factors over the past 50 years [5,6]. Recent mortality surveillance from rural north India showed that there has been a significant increase in deaths due to CVD [7]. However, in the absence of a comprehensive surveillance system and well-designed repeat population surveys in a representative sample, an accurate trend of CVD risk factors in the Indian population cannot be ascertained.

We conducted surveys on prevalence of CVD risk factors between April 14, 1991 and June 30, 1994 (survey 1) in National Capital Region (NCR) of India (urban Delhi and adjoining rural Haryana). To estimate the changes in CVD risk factors, we repeated a survey between August 10, 2010 and January 15, 2012 among another set of randomly selected individuals from the same population using

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TABLE 1. Comparison of methods and measurement of CVD risk factors of surveys 1 and 2

Parameters	Survey 1	Survey 2
Height	Measured in centimeters using a scale with movable rule attached	Measured in centimeters using a portable stadiometer
Weight	Measured in kilograms using a beam balance	Measured in kilograms using a portable platform scale weighing machine
Waist circumference	Measured in millimeters using a fiberglass tape after applying a tension of 600 g. The measurement was done at the midpoint between the subcostal margin and highest point of the iliac crest	Measured in millimeters using a nonstretchable tape. The measurement was done at the midpoint between the subcostal margin and highest point of the iliac crest
Hip circumference	Measured in millimeters using fiberglass tape after applying a tension of 600 g. The measurement was done at the level of the greater trochanters	Measured in millimeters using a nonstretchable tape. The measurement was done at the level of the greater trochanters
Blood pressure	Random 0 sphygmomanometer	OMRON (HEM-7080) digital blood pressure apparatus*
Blood glucose	Enzymatic glucose oxidase method	Enzymatic method using hexokinase
Total cholesterol	Enzymatic cholesterol oxidase method	Enzymatic cholesterol oxidase method

*Omron Healthcare (Kyoto, Japan).

similar sampling techniques (survey 2). Here we report the changes in CVD risk factors between the 2 surveys.

METHODS

The cross-sectional surveys were carried out in adults ages 35 to 64 years using a multistage cluster random sampling method in the urban area and a simple random sampling method in the rural area. Both the surveys received ethical clearance by the Ethics Committee of All India Institute of Medical Sciences, New Delhi, and were funded by Indian Council of Medical Research. Table 1 describes the methodological similarities and differences between the 2 surveys.

Sample size

The sample size estimations of both the surveys were based on the prevalence of coronary artery disease. A design effect of 1.5 was used to adjust for the cluster sampling in the urban population. The sample size was further increased to adjust for the nonresponse rate (15%). The final sample was sufficient to detect an estimated absolute increase in coronary artery disease prevalence between the surveys (1.5% to 2.0% in rural area and 3.0% to 3.5% urban area) with a power of 80%. Because the prevalence of risk factors is higher than that of coronary artery disease, the final sample size was sufficiently powered to detect an increased prevalence of all risk factors. The sample size for the survey 2 was for 30+ year age group. As the first survey was restricted to the 35 to 64 year age group, we have only reported for that age group in this paper.

Sampling

The rural sample was collected from villages that are part of the Ballabgarh Health and Demographic Surveillance System (HDSS) [8]. The same villages participated in the 2 surveys and are located in Ballabgarh block of Faridabad district in the state of Haryana, India. Being an HDSS site, it had population level sampling frame and a simple random sampling was used to select households and all eligible individuals in that household were included. The urban sample was collected from areas within the jurisdiction of the Municipal Corporation of Delhi. Urban villages, unauthorized colonies, government colonies including New Delhi Municipal Corporation and Delhi Cantonment areas and Diplomatic Enclave were excluded from the sampling frame. Of the 143 Municipal Corporations of Delhi wards, 12 were randomly selected. Three census enumeration blocks (CEB) were selected randomly from each of these wards (36 total CEB). Finally, 70 randomly selected households from each CEB were enrolled for the study.

In both surveys, all eligible individuals from the primary sampling unit (household) were approached for their consent to participate in the survey. A detailed questionnaire was administrated by trained interviewers to capture data on sociodemographic characteristics, presence of CVD risk factors, and treatment status. Physician-led medical camps were conducted at respective CEB (urban)/villages (rural) to collect data on anthropometric and biochemical risk factors of CVD. Data collected included height and weight measurements to calculate body mass index (BMI), measurement of hip and waist circumference, and blood pressure measurements. Two blood pressure readings were recorded in sitting position, 5 min apart. If the difference between the 2 readings was >10 mm Hg, a third measurement was taken. The mean of the last 2 measurements were taken for final analysis. Standard instruments and equipment (Table 1) were used to record anthropometric measurements. Regular calibration and periodic checking of stadiometers and weighing machines were as per manufactures' guidelines to ensure the validity and reliability of data collected. The blood pressure measurement was done

TABLE 2. Comparison of study respondents in urban and rural samples of surveys 1 and 2

	Urban Survey 1	Urban Survey 2		Rural Survey 1	Rural Survey 2	
	n (%)	n (%)	p Value*	n (%)	n (%)	p Value†
Age-group, yrs			<0.001			0.571
35–39	779 (25.6)	497 (24.2)		652 (26.2)	522 (27.2)	
40–44	593 (19.5)	467 (22.8)		465 (18.7)	370 (19.3)	
45–49	467 (15.3)	379 (18.5)		416 (16.7)	325 (17.0)	
50–54	419 (13.7)	252 (12.3)		344 (13.8)	267 (13.9)	
55–59	346 (11.4)	222 (10.8)		281 (11.3)	216 (11.3)	
60–64	444 (14.6)	235 (11.5)		329 (13.2)	217 (11.3)	
Total	3,048	2,052		2,487	1,917	
Sex			<0.0001			<0.0001
Female	1,593 (52.3)	1,113 (54.2)		1,417 (57.0)	983 (51.3)	
Male	1,455 (47.7)	939 (45.8)		1,070 (43.0)	934 (48.7)	
Total	3,048	2,052		2,487	1,917	
Education			<0.0001			<0.0001
Illiterate	487 (16.5)	216 (10.5)		1,257 (64.8)	689 (36.0)	
Read/write	113 (3.8)	407 (19.9)		63 (3.2)	159 (8.3)	
Primary	293 (9.9)	8 (0.4)		171 (8.8)	42 (2.2)	
Middle school	320 (10.9)	123 (6.0)		184 (9.5)	245 (12.8)	
High school	813 (27.6)	500 (24.4)		218 (11.2)	569 (29.7)	
Secondary/graduate and above	922 (31.3)	796 (38.8)		48 (2.5)	211 (11.0)	
Total	2,948	2,050		1,941	1,915	

*For urban surveys 1 and 2.
†For rural surveys 1 and 2.

using automated blood pressure machines that were within the valid period of calibration. Trained technicians collected fasting venous blood samples for estimating the levels of fasting blood glucose (FBG) and lipids. The samples were centrifuged without much delay in the field itself. The samples were analyzed for FBG on the same day. Remaining plasma and serum were aliquoted and stored in -70^{o}C. Lipid estimations were done in batches in serum samples. All biochemical analyses were done using standard methods (Table 1), and the laboratory that analyzed the samples underwent an external quality assurance program (Randox International Quality Assurance Scheme; Randox Laboratories, Belfast, UK).

Definitions

Subjects were labeled to have raised FBG according to WHO criteria (FBG values ≥126 mg/dl or on oral hypoglycemic agents/insulin) [9]. Raised blood pressure was defined using the Seventh Joint National Committee VII criteria (systolic blood pressure [SBP] ≥140 mm Hg and/or diastolic blood pressure [DBP] ≥90 mm Hg or on blood pressure–lowering medication) [10]. We considered total cholesterol (TC) ≥200 mg/dl to denote raised TC [11]. NCEP-ATP (National Cholesterol Education Program Adult Treatment Panel) III cutoffs were used to define overweight (BMI ≥25 kg/m^2) [11]. Central obesity was defined as waist to hip ratio >0.90 for men and >0.85 for women [12]. Smoking was defined as use of any smoked tobacco product such as a cigarette, bidi, hookah, chillum, or cigar in the past 6 months. Alcohol use was defined as any use in the last 12 months of any alcohol product.

Statistical analysis

We present age-sex standardized values for urban and rural population and time trend comparison. To adjust for change in age and sex structure of the population, the age-standardized estimates for all CVD risks factors were estimated using Indian census data for 2011 as standard population to compare the prevalence of risk factors [13]. The mean and point estimates of prevalence of the CVD risk factors are presented along with their standard errors and the mean difference (survey2 − survey1) and percentage change [(survey2 − survey1/survey1)100] of these risk factors between survey 1 and survey 2. To compare continuous variables, Student *t* tests were used, whereas chi-square tests were used to test differences in proportions. We considered $p < 0.05$ statistically significant. STATA version 12.1 (STATA Corporation, College Station, TX, USA) was used for the statistical analysis.

RESULTS

The urban sample sizes for surveys 1 and 2 were 3,048 and 2,052, respectively. In the rural area, sample sizes were 2,487 for survey 1 and 1,917 for survey 2. Among those surveyed in the households, 95% and 78% in survey 1 and

TABLE 3. Adjusted CVD risk factors: surveys 1 and 2 (urban)

	Survey 1		Survey 2			
Parameters	N	Mean ± SEM	N	Mean ± SEM	MD	p Value
BMI (kg/m^2)						
Total	3,012	24.4 ± 0.1	1,660	26.0 ± 0.2	1.6	<0.001
Men	1,444	23.6 ± 0.1	773	25.1 ± 0.2	1.5	<0.001
Women	1,568	25.2 ± 0.1	887	27.1 ± 0.2	1.9	<0.001
Waist-Hip Ratio						
Total	3,008	0.91 ± 0.001	2,006	0.93 ± 0.002	0.02	1.0
Men	1,445	0.99 ± 0.002	915	0.97 ± 0.003	−0.02	1.0
Women	1,563	0.83 ± 0.002	1,091	0.89 ± 0.003	0.06	<0.001
Systolic Blood Pressure (mm Hg)						
Total	3,041	121.2 ± 0.4	2,026	129.8 ± 0.4	8.6	<0.001
Men	1,451	121.0 ± 0.5	924	131.7 ± 0.6	10.7	<0.001
Women	1,590	121.5 ± 0.5	1,102	127.8 ± 0.6	6.3	<0.001
Diastolic Blood Pressure (mm Hg)						
Total	3,041	74.3 ± 0.2	2,026	83.9 ± 0.3	9.6	<0.001
Men	1,451	75.6 ± 0.3	924	82.7 ± 0.4	7.1	<0.001
Women	1,590	73.0 ± 0.3	1,102	85.1 ± 0.4	12.1	<0.001
Fasting Blood Glucose (mg/dl)						
Total	2,899	101.2 ± 0.7	1,600	115.3 ± 1.1	14.1	<0.001
Men	1,405	101.8 ± 0.9	739	113.9 ± 1.4	12.1	<0.001
Women	1,494	100.6 ± 0.9	861	116.7 ± 1.8	16.1	<0.001
Total Cholesterol (mg/dl)						
Total	2,897	192.4 ± 0.7	1,604	184.9 ± 1.1	−7.5	<0.001
Men	1,403	191.6 ± 1.1	740	187.1 ± 1.4	−4.5	0.01
Women	1,494	193.2 ± 0.9	864	182.8 ± 1.7	−10.4	<0.001

	Survey 1			Survey 2				
Parameters	N	%	SEP	N	%	SEP	% Change	p Value
Overweight								
Total	3,012	42.2	0.9	1,660	56.0	1.2	32.7	<0.001
Men	1,444	35.9	1.3	773	47.3	1.8	31.8	<0.001
Women	1,568	48.7	1.3	887	65.0	1.6	33.5	<0.001
Central Obesity								
Total	3,008	65.9	0.7	3,041	75.0	0.9	13.8	<0.001
Men	1,445	90.8	0.8	915	82.9	1.2	−8.7	<0.001
Women	1,563	40.1	1.2	1,091	66.8	1.4	66.6	<0.001
Raised Blood Pressure								
Total	3,041	23.0	0.7	2,026	42.2	1.1	83.5	<0.001
Men	1,451	22.3	1.1	924	43.3	1.6	1.9	<0.001
Women	1,590	23.8	1.0	1,102	41.1	1.4	72.7	<0.001
Raised Fasting Blood Glucose								
Total	2,899	12.7	0.6	1,600	20.2	1.0	59.1	<0.001
Men	1,405	13.2	0.9	739	22.5	1.5	70.5	<0.001
Women	1,494	12.2	0.8	861	17.9	1.3	46.7	<0.001
Raised Total Cholesterol								
Total	2,897	38.1	0.9	1,604	32.9	1.2	−13.6	0.001
Men	1,403	36.8	1.3	740	30.5	1.7	−17.1	0.001
Women	1,494	39.4	1.2	864	35.3	1.6	−10.4	0.05
Smoking								
Total	3,048	16.1	0.6	2,052	17.4	0.8	8.1	0.34
Men	1,455	29.2	1.2	939	30.5	1.5	4.5	0.60
Women	1,593	2.6	0.4	1,113	3.8	0.6	46.2	0.16
Alcohol Use								
Total	2,947	16.1	0.6	2,051	25.6	0.8	59.0	<0.001
Men	1,400	30.9	1.2	939	50.3	1.6	62.8	<0.001
Women	1,547	0.9	0.2	1,113	0.2	0.1	−77.8	0.001

Total mean/proportions were adjusted for age and sex, whereas sex-stratified results were adjusted for age (per India Census 2011) [13].
BMI, body mass index; CVD, cardiovascular disease; MD, mean difference (survey2 − survey1); SEP, standard error of proportion.

TABLE 4. Adjusted CVD risk factors: surveys 1 and 2 (rural)

Parameters	Survey 1		Survey 2		MD	p Value
	N	Mean ± SEM	N	Mean ± SEM		
BMI (kg/m^2)						
Total	2,435	20.2 ± 0.1	1,910	23.0 ± 0.1	2.8	<0.001
Men	1,051	20.0 ± 0.1	979	22.6 ± 0.1	2.6	<0.001
Women	1,384	20.3 ± 0.1	931	23.4 ± 0.2	3.1	<0.001
Waist-Hip Ratio						
Total	2,338	0.89 ± 0.002	1,908	0.92 ± 0.002	0.03	<0.001
Men	1,044	0.95 ± 0.002	980	0.96 ± 0.002	0.01	<0.001
Women	1,294	0.83 ± 0.002	928	0.88 ± 0.003	0.05	<0.001
Systolic Blood Pressure (mm Hg)						
Total	2,469	114.9 ± 0.4	1,914	123.1 ± 0.3	8.2	<0.001
Men	1,065	115.7 ± 0.5	981	126.6 ± 0.6	10.9	<0.001
Women	1,404	114.2 ± 0.5	933	119.5 ± 0.6	5.3	<0.001
Diastolic Blood Pressure (mm Hg)						
Total	2,470	73.1 ± 0.2	1,914	82.3 ± 0.3	9.2	<0.001
Men	1,066	74.1 ± 0.3	981	84.0 ± 0.4	9.9	<0.001
Women	1,404	72.0 ± 0.3	933	80.6 ± 0.4	8.6	<0.001
Fasting Blood Glucose (mg/dl)						
Total	1,275	83.9 ± 0.6	1,245	103.2 ± 0.9	19.3	<0.001
Men	577	84.0 ± 0.8	589	106.3 ± 1.4	22.3	<0.001
Women	698	83.8 ± 1.0	656	100.1 ± 1.0	16.2	<0.001
Total Cholesterol						
Total	1,270	168.2 ± 1.1	1,244	190.7 ± 1.2	22.5	<0.001
Men	576	170.1 ± 1.6	592	189.9 ± 1.8	19.8	<0.001
Women	694	166.2 ± 1.4	652	191.6 ± 1.6	25.4	<0.001

Parameters	Survey 1			Survey 2			% Change	p Value
	N	%	SEP	N	%	SEP		
Overweight								
Total	2,435	9.7	0.6	1,910	30.3	1.1	212.4	<0.001
Men	1,051	8.1	0.9	979	28.4	1.5	250.6	<0.001
Women	1,384	11.5	0.9	931	32.3	1.5	180.9	<0.001
Central Obesity								
Total	2,338	56.3	1.0	1,908	72.1	1.0	28.1	<0.001
Men	1,070	75.4	1.4	983	79.3	1.3	5.2	0.04
Women	1,294	36.7	1.3	928	64.7	1.5	76.3	<0.001
Raised Blood Pressure								
Total	2,469	11.2	0.6	1,914	28.9	1.0	158.0	<0.001
Men	1,065	12.2	1.0	981	32.6	1.5	2.7	<0.001
Women	1,404	10.2	0.8	933	25.2	1.4	147.1	<0.001
Raised Fasting Blood Glucose								
Total	1,275	3.0	0.5	1,245	9.6	0.8	220.0	<0.001
Men	577	2.9	0.7	589	12.0	1.3	313.8	<0.001
Women	698	3.0	0.7	656	7.1	1.0	136.7	0.001
Raised Total Cholesterol								
Total	1,270	17.0	1.1	1,244	37.7	1.4	121.8	<0.001
Men	576	17.1	1.6	592	37.7	2.0	120.5	<0.001
Women	694	16.9	1.4	652	37.8	1.9	123.7	<0.001
Smoking								
Total	2,487	40.5	1.0	1,916	46.6	1.0	15.1	0.001
Men	1,070	54.9	1.6	983	67.4	1.5	22.8	<0.001
Women	1,417	25.6	1.2	933	25.2	1.4	−1.6	0.82
Alcohol Use								
Total	1939	8.0	0.7	1,915	33.2	0.8	315.0	<0.001
Men	836	15.2	1.3	982	65.0	1.5	327.6	<0.001
Women	1,103	0.4	0.2	933	0.5	0.2	25.0	0.73

Total mean/proportions were adjusted for age and sex, whereas sex-stratified results were adjusted for age (per India Census 2011) [13].
Abbreviations as in Table 3.

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survey 2, respectively, of the urban sample and 51.0% and 64.9% in survey 1 and survey 2, respectively, of the rural sample agreed to provide a fasting blood sample for biochemical analysis.

The age structure of populations in surveys 1 and 2 in urban areas differed significantly with survey 2 having a younger sample. However, in rural areas, the age distribution in both surveys was similar, indicating a slower demographic transition. In the urban area, the proportion of female subjects in survey 2 was higher than in survey 1, whereas in the rural area, the proportion of male subjects were higher in survey 2 than in survey 1. The proportion of respondents who were highly skilled decreased from 33% to 13%, and those who were semiskilled increased from 8.1% to 28.4% between the 2 surveys in the urban sample. In rural sample and among women, there was little change in the occupation. Education status of the population in both urban and rural areas also improved significantly over the years (Table 2).

Change in the prevalence of CVD risk factors

Urban Delhi. The age and sex standardized levels of risk factors were as in Table 3 [13]. All the conventional risk factors of CVD except smoking and lipids worsened significantly in urban Delhi (Table 3). The prevalence of alcohol use increased significantly from 16.1% to 25.6%, mainly driven by increase in alcohol use among men. The prevalence of smoking did not show much change between the surveys in either of the sexes. Mean BMI increased from 24.4 kg/m^2 to 26.0 kg/m^2 and was associated with rise in prevalence of overweight, with similar increase in both the sexes. The overall prevalence of central obesity increased significantly from 65.9% to 75.0% in the population, despite a significant fall in prevalence among men (90.8% to 82.9%), due to marked increase in prevalence among women (40.1% to 66.8%). Mean SBP and DBP increased among both men and women. This resulted in an overall increase of prevalence of raised blood pressure from 23.0% to 42.2%. Mean FBG increased leading to an increase in prevalence of raised blood glucose from 12.7% to 20.2%. This increase was observed in both men and women. However the mean TC showed a significant decline. The prevalence of dyslipidaemia also decreased significantly between the 2 surveys. The self-reported use of cholesterol-lowering drugs was 2.4% in the population.

Rural Haryana. The adjusted levels of risk factors were as in Table 4 [13]. Unlike urban Delhi, smoking prevalence increased (40.5% to 46.6%) in the rural population. The rise of smoking was due to increase in smoking among men, but it remained similar in women. Alcohol consumption in the rural area showed a more than 4× increase from 8.0% to 33.2%, again due to the increased use among men. The increase in mean BMI (20.2 to 23.0 kg/m^2) resulted in >3-fold increase in the prevalence of overweight in both the sexes. Central obesity increased significantly overall and was proportionately more among women than men. Mean SBP and DBP increased both among men and women. This resulted in an overall increase of prevalence of raised blood pressure from 11.2% to 28.9%. Mean FBG increased in both men and women leading to an increase in prevalence of raised blood glucose from 3.0% to 9.6%. Unlike urban areas, the mean TC increased (168.2 mg/dl to 190.7 mg/dl) in both men and women with >2× increase in the proportion of individuals with raised TC in both sexes. The self-reported use of cholesterol-lowering drugs was 0.2%.

The population distribution of BMI, SBP and DBP, FBG, and TC are as in Figure 1. All the measurements, except TC, in the urban population showed a rightward shift with a leftward shift in urban TC.

DISCUSSION

This repeat community prevalence study of CVD risk factors in a representative population of the same region for the first time in India demonstrates a marked rise in burden of most conventional CVD risk factors over the last 2 decades. The community prevalence of alcohol use, obesity, high blood pressure, and high blood sugar increased over the last 2 decades in both urban and rural areas of NCR of Delhi. The smoking prevalence increased in rural male subjects and raised TC increased in both rural male and female subjects, whereas prevalence of raised TC declined in the urban population. These results are in keeping with the rising burden of CVD risk factors such as obesity, hypertension, and diabetes observed from other studies conducted at different locations of the country and at different time periods [14—18]. A 20-year trend reported from another North Indian city of Jaipur reported an increase in the prevalence of obesity and diabetes while high cholesterol and hypertension remained stable and smoking declined [19]. However, this study was limited to urban middle-class citizens and was not representative of the entire city and had no rural representation.

The rise in burden of CVD risk factors is indirectly supported in this population by an increase in share of mortality due to CVD. Although representative data on mortality from Delhi is not available, a study from resettlement colony of Delhi reported an increasing share of mortality due to NCD from 1994 to 2004 [20]. In Ballabgarh HDSS, the proportions of mortality due to cardiovascular diseases increased from 12.6% to 18.8% between 2002 and 2011 [21].

These trends of increase in most CVD risk factors are in conformity with the trends of these factors seen during 1950 to 1960 among high-income countries and during the 1970s to the 1990s in middle-income countries and were the harbinger of the CVD epidemic [22]. From the 1970s onward, there has been a continuing decline in prevalence of these risk factors leading to decline in CVD

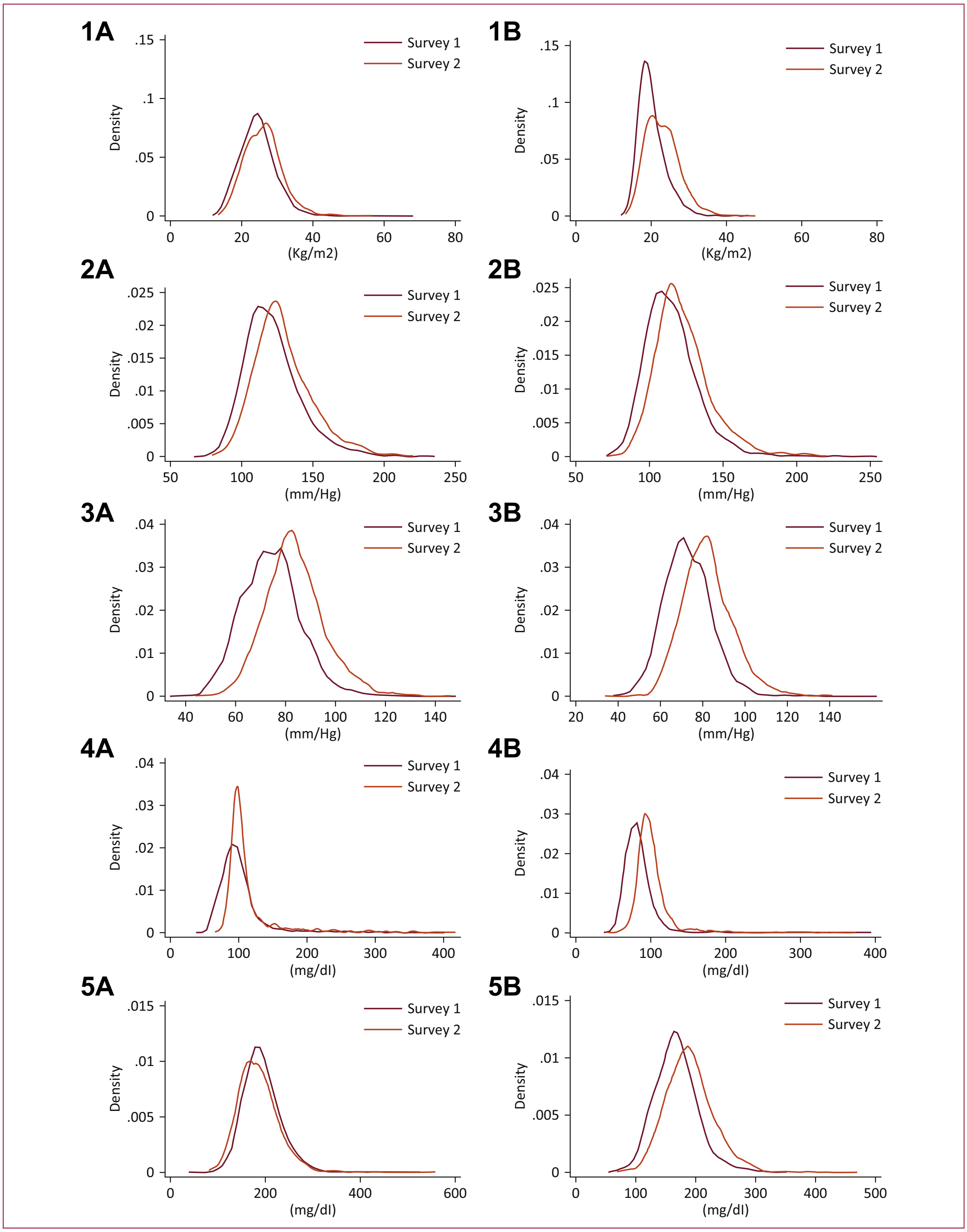

FIGURE 1. Comparative density plots of urban BMI (1A), rural BMI (1B), urban SBP (2A), rural SBP (2B), urban DBP (3A), rural DBP (3B), urban FBG (4A), rural FBG (4B), urban TC (5A), and rural TC (5B) between the 2 surveys. BMI, body mass index; DBP, diastolic blood pressure; FBG, fasting plasma glucose; SBP, systolic blood pressure; TC, total cholesterol.

morbidity and mortality in those countries [22–24]. Such population-based studies describing CVD risk factor trends from the low-income countries are absent.

Although this study documents the rise in cardiovascular risk factors between the 2 periods, it is very difficult to fully explain these changes. We suggest some hypotheses, fully aware that these are complex pathways and it is very difficult to ascribe causality. We think the differences seen are a combined result of 3 factors—changing lifestyles, measurement issues including response rates and differences in tools used, and varied levels of interventions—that are government or market led. A rapid economic transition was ushered in the year 1991 (survey 1 period) that marked the beginning of liberal economic policies and globalization in India. The post-liberalized era between these 2 surveys witnessed a rapid urbanization, rural to urban migration, and changes in the diet and lifestyle of the Indian population [25]. Among important changes in measurement tools, the current method of automated blood pressure monitors is known to underestimate blood pressure levels [26]. However, this would only underestimate the increase in blood pressure levels observed in survey 2. The response rates were lower in the first survey and rural areas. Those who did not participate for blood collection were more likely to be female, lesser educated, smokers, and with low BMI. There were no planned government-led public health interventions against NCD risk factors except against tobacco with varied implementation of tobacco control laws in the country. No specific evaluation of effectiveness of tobacco control has been carried out in Delhi. The changes in fat consumption have been largely due to industry-driven marketing toward use of polyunsaturated and refined oils. Increase in the diagnoses of hypertension and CVD and the resultant use of statins could also be possible explanations for the change in cholesterol, though we do not have evidence to support this.

Perhaps the best explanation we have is for the drastic difference in alcohol use in the rural male subjects. There was a women-led antialcohol movement including picketing of alcohol vendors in rural Haryana in early 1990s that led to the state experimenting with prohibition between 1996 and 1999 [27]. It is possible that the low alcohol consumption during survey 1 was partly due to lower consumption due to decrease in alcohol availability as well as lower reporting of alcohol use by men, who were afraid of repercussions.

The rate of increase in CVD risk factors such as alcohol use, central obesity, high blood pressure, high blood sugar, and high TC was higher in rural areas than in urban areas. There was a significantly higher prevalence of smoking and alcohol use in rural areas. The rural burden of CVD risk factors seems to be much higher than previous studies from rural India [28,29]. The epidemiologic transition thus seems to be much faster in rural areas in comparison to their urban counterparts in the last 2 decades, though both populations have revealed increases in CVD risk factor burden. This has long-lasting implications in terms of the burden of the disease and the health system capacity to address this epidemic, keeping in mind that more than two-thirds of the population lives in rural areas in India, which currently have limited or no capacity to handle CVD and other NCD. Whereas India has launched its NPCDCS (National Program for Prevention and Control of Cardio-vascular diseases, Diabetes, Cancer and Stroke), it has yet to attain national coverage and has not been implemented effectively. Additionally, it does not focus adequately on risk factor reduction.

Women had a steep rise in prevalence of obesity, raised blood pressure, and raised blood glucose; increase in prevalence of central obesity was only seen in women, whereas it marginally declined in urban men and remained unchanged in rural men. The prevalence of smoking and alcohol use remained unchanged in women and increased in men. Women in India are known to have poor access to health care including that for CVD. The burden of smoking was much higher in rural women than in urban women, whereas alcohol use was low among women in urban and rural areas. This trend is also reported in the WHO report on trends of NCD and its risk factor report [30].

Strengths and limitations of the study

A major strength of the study is the simultaneous urban-rural comparison using a robust sampling design. The study had representativeness across age and sex strata. Additionally, the methods that were used were standard and comparable for most variables measured. Certain tools for measuring risk factors have undergone a change during these 20 years such as that of automation of blood pressure measurement and digitalization of weighing machines. However we do not think these methodological differences have contributed significantly to the observed changes in risk factors. Response to blood collection was lower in rural areas than in urban areas. Behavioral CVD risk factors such as diet and physical activity were not well assessed during the first survey and therefore not reported, and it is not possible to make comparison between the 2 surveys. Being restricted to urban and rural NCR of Delhi, generalizing results across India should be done with caution even though supported by similar high risk factor burden observed from other cross-sectional studies from different parts of India.

CONCLUSIONS

Our study indicates that there has been a significant rise in the prevalence of all CVD risk factors in urban and rural areas of NCR over the past 20 years except TC levels in urban NCR. This study shows that the risk reduction targets set by WHO and India to reduce the CVD burden are ambitious and call for a stronger response by all the stakeholders with a combination of population and high risk approach to reduce population risk burden. The study also highlights the need for establishing a surveillance system in India to monitor risk factor trends on a more frequent, regular, and sustainable basis.

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