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Original Article

Change in prevalence of Coronary Heart Disease and its risk between 1991-94 to 2010-12 among rural and urban population of National Capital Region, Delhi

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ABSTRACT

Objectives: We aimed to measure the change in prevalence of Coronary Heart Disease (CHD) and Cardiovascular Diseases (CVDs) risk among those aged 35–64 years in urban and rural areas of National Capital Region (NCR) of Delhi, between 1991-1994 (survey 1) and 2010–2012 (survey 2).

Methods: Both surveys used similar sampling methodology and mean ages of participants were similar. A total of 3048 and 2052 subjects were studied in urban Delhi and 2487 and 1917 participants recruited from rural Ballabgarh in survey 1 and in survey 2 respectively. CHD was diagnosed based on a Minnesota coded ECG and Rose angina questionnaire. Data on behavioural, physical, clinical and biochemical parameters were collected using standard methods. CVD Risk of participants was calculated using the gender specific Framingham risk equation.

Results: The age and sex standardised prevalence of CHD in urban Delhi increased from 10.3% (95% CI: 9.2–11.4) to 14.1% (95% CI: 12.6–15.6) between the two surveys as compared to an increase from 6.0% (95% CI: 5.0–6.9) to 7.4% (95% CI: 6.3–8.6) in rural Ballabgarh. The highest increase in the prevalence of CHD was reported among urban women (10.1% to 16.6%).The proportion of population with high 10-year CVD risk increased to 4.1% from 1.2% in rural areas as compared to 4.8% from 2.5% in urban areas.

Conclusions: The CHD and CVD risk has increased over 20 years period in and around Delhi and the increase was more in rural population and women, traditionally considered to be at low risk.

1. Introduction

Cardiovascular Diseases (CVDs) are a leading cause of death worldwide and account for 17.9 million deaths (31% of all deaths) each year. Nearly 80% of these deaths occurs in low income and middle income countries (LMICs).[1] A major portion of CVDs deaths (>85%) is attributed to Coronary Heart Disease and Stroke.[1] The world has witnessed epidemiological transition with the shift of leading of causes of death from communicable to non-communicable diseases which is driven by urbanization, industrialization, increase in life expectancy and changing life style.[2,3] Like other nations of the world, CVDs have also emerged as the leading cause of death in India[4–6] accounting for 28.1% of all deaths.[7] Majority of these CVD related deaths were caused by Coronary Heart Disease (CHD) (68.4%).[8] The Global Burden of Disease study has estimated that CHD has caused highest percentage of deaths 17.8% in India in 2016 and showed an escalating trend with 49.8% increase between 2007 to 2017.[7,9]

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The prevalence of CHD varies from 1.6 to 13.2% in different epidemiological studies conducted in various part of the country between 1968 to 2016.[3] The prevalence of CHD in Delhi was reported to be 9.7% in a study done in 1990. The key risk factors of CHD are well known and include physical inactivity, dietary risk, alcohol use, tobacco use, low fruit and vegetable intake, abdominal obesity, high total cholesterol, high systolic blood pressure, high plasma glucose, high body mass index etc.[3] The Global Burden of disease study describes an increasing prevalence of several major risk factors in India.[7] Modification of these studied risk factors can result in significant decline in the morbidity and mortality caused by Coronary Heart Disease.[10–12] There is a dearth of comprehensive and representative repeat surveys to study the trend in the prevalence of CHD and its associated risk factors in India.[5,13] Knowledge of trends will help advocate, with a sense of urgency, the need to accelerate national efforts to address cardio-vascular diseases.

We undertook community based survey on prevalence of CHD and its risk factor among the individuals ages 35–64 years of urban Delhi and Rural Ballabgarh in 2010–2012 and compared it with an earlier survey (1991–1994) in the same area to assess two decadal change in burden of CHD and its major risk factors.

2. Material and methods

2.1. Study population and design

The two separate representative community based cross-sectional surveys were conducted among adult population aged 35–64 years of urban and rural Delhi NCR during period of April 1991 to June 1994 (Survey 1) and August 2010 to January 2012 (Survey 2) respectively to assess the trends in prevalence of CHD and its risk factors using similar methodology and tools. Both the surveys were funded by Indian Council of Medical Research (ICMR) and received clearance from ethics committee of the All India Institute of Medical Sciences (AIIMS), New Delhi. The sample size calculation was based on the prevalence of Coronary Heart Disease (CHD) in the population. The multistage cluster sampling technique was used for sampling in urban Delhi and a random sampling technique was followed in rural Ballabgarh area (Delhi NCR). The details of the methodology including sample size calculation and sampling strategies have already been published.[14] Accordingly, samples of sizes 3048 and 2052 in urban area and 2487 and 1917 in rural area were recruited in survey 1 and survey 2 respectively.

2.2. Data collection and measurements

The details of data collection have been described elsewhere.[14] Briefly, in both the surveys, all sampled individuals were approached and explained about the survey and their consent obtained for participation. Information on sociodemographic profile, smoking habits, alcohol use, diabetes, hypertension were collected using standardised tools by trained interviewers. A Rose angina questionnaire was also administered to assess the prevalence of CHD.[15] The anthropometric measurements including height, weight, waist and hip circumference, blood pressure measurements were done using standardised tools during physician led camp in participant's localities. The Electrocardiogram (ECG) was done by a trained ECG technician followed by the reading and reporting by a cardiologist. It was coded using specific Minnesota codes to assess the prevalence of CHD. The Minnesota coding for CAD was done by an experienced cardiologist from the All India Institute of Medical Sciences, New Delhi.

Random zero sphygmomanometer and OMRON (HEM 7080) digital blood pressure apparatus were used to record blood pressure in survey 1 and survey 2 respectively. A strong correlation coefficient between random zero sphygmomanometer and automatic oscillometric BP monitor for Systolic Blood Pressure (0.84) and Diastolic Blood Pressure (0.67) has been reported.[16] Two blood pressure readings 5 minutes apart were recorded in sitting position. The third blood pressure reading was taken when the difference between two diastolic or two systolic blood pressure readings was >10 mm Hg. The mean of last two blood pressure readings were considered for analysis.

The venous blood of fasting participants were drawn for biochemical test by trained technician and centrifuged in the field itself. Fasting blood glucose was estimated using enzymatic glucose oxidase method in survey 1 whereas in survey 2 enzymatic glucose hexokinase method was employed for same day testing. Lipid profile was assessed from stored blood sample in batches using oxidase method. These investigations were carried out in laboratory of Department of Cardio-biochemistry, AIIMS, having external quality assurance facility from Randox Laboratory, Belfast, United Kingdom (Randox International Quality Assurance Scheme).

Coronary Heart Disease (CHD) was defined on the basis of findings of ECG and long version of Rose Angina Questionnaire.[15] The ECG positive (Minnesota scores: 1-1-1 to 1-1-7, 4-1-1, 4-1-2, 5–1, 5–2, 7-1-1)[17] and/or Rose angina questionnaire positive for CHD was considered as CHD disease in this study. CVD Risk Score was estimated based on a weighted sum of the participant's characteristics (age, BMI, diabetes, systolic blood pressure, smoker) using the Framingham risk score equation.[18] We have used the following gender specific Framingham risk score equation to calculate the score of each individuals:[19]

For male:

$$X_i = \text{Log}(Age) * 3.11296 + \text{Log}(BMI) * 0.79277 + \text{Log}(SBP) * 1.85508 + (smoker) * 0.70953 + (diabetes) * 0.53160$$

For female:

$$X_i = \text{Log}(Age) * 2.72107 + \text{Log}(BMI) * 0.51125 + \text{Log}(SBP) * 2.81291 + (smoker) * 0.61868 + (diabetes) * 0.77763$$

The actual risk was calculated from the individual score using below equation:

$$R_i = 1 - S_0^{\exp(X_i - X_o)}$$

where X_i = Score of patient, X_0 = Score of a reference individual (X_0= *23.9388 for male*, X_0 = *26.0145 for female*), S_0 = probability of not having CVD in 10 years (S_0= *0.88431 for male*, S_0= *0.94833 for female*), R_i = Actual Risk of CVD in next 10 years.

The calculated CVD risk score was categorized to be <10% low-risk, 10–30 moderate risk and >30 high risk of developing disease in 10 years.[20,21]

The Asia Pacific guideline cut-offs (BMI ≥25 kg/m^2) was used to define obese.[22] Diabetes was defined according to WHO criteria, as raised Fasting Blood Glucose (FBG) ≥126 mg/dl or on hypoglycaemic drug or on insulin.[23] Hypertension was defined as per European Society of hypertension (EHS) as having systolic blood pressure ≥140 mm Hg and/or diastolic blood pressure ≥90 mm Hg or currently on blood pressure lowering medication or, known to be hypertensive.[24] We defined current smoker as person who smoked any tobacco product at the time of survey.[25] Alcohol use was defined as use of any alcohol products in 12 months prior to the survey.[25]

2.3. Statistical analysis

The data were analysed using STATA version 15.0 (STATA Corporation, College Station, Texas, USA) statistical software. The age adjusted and sex standardised CHD prevalence of urban and rural population was calculated using the Census 2011 population for standardisation. The prevalence with confidence intervals of CHD and its risk factors is presented by area (urban/rural), gender and survey period. The proportion, confidence interval and percentage change were reported for CVD risk score categories. The percentage change was calculated as (Survey 2-Survey 1) *100/Survey 1. The differences in mean and proportion of participant characteristics between two surveys was determined by Student's *t*-test (normal continuous), Mann–Whitney *U* test (non-normal continuous) and Chi-square test (categorical). The individual and cumulative prevalence of risk factors (diabetes, hypertension, smoking, total cholesterol high density lipoprotein cholesterol ratio, obesity, waist hip ratio) were analysed to see the clustering of risk factors.

3. Results

A total of 3048 (52.3% women) and 2052 (54.2% women) participants in urban and 2487 (57.0% women) and 1917 (51.3% women) participants in rural areas were recruited in survey 1 and survey 2 respectively. The mean age of participants in urban areas (mean age survey 1 vs survey 2: 46.8 ± 9.0 years vs 46.5 ± 8.4 years; *p*-value = 0.13) and rural areas (mean age survey 1 vs survey 2: 46.6 ± 8.8 years vs 46.5 ± 8.5 years; *p*-value = 0.63) was found to almost similar in surveys 1 and 2. Baseline characteristics of the study participants are presented in Table 1.

The overall age and sex standardised prevalence of CHD increased significantly from 10.3% (95% CI: 9.2–11.4) to 14.1% (95% CI:12.6–15.6) in the urban subjects (*p*-value<0.0001). Similarly, the observed increase in CHD prevalence [from 6.0% (95% CI:5.0–6.9) to 7.4% (95% CI: 6.3–8.6)] in the rural population between 1991-94 to 2010–12 was statistically significant (*p*-value = 0.031) (Fig. 1). The steeper increase in the prevalence of CHD in urban area was largely driven by 1.6 times increase (from 10.1% to 16.6%) in prevalence among women. No major gender differences in increase in prevalence of CHD were noted in rural areas.

The overall CVD risk profile worsened among both rural and urban population over these 20 years (Table 2). The proportion of population with >30% risk over 10 years of CVD event doubled in urban area from: 2.5% (95% CI:1.9–3.0) to 4.8% (95% CI:3.7–5.9) and in rural area showed more than three-fold increase from 1.2% (95% CI:0.7–1.6) to 4.1% (95% CI:3.2–5.0); the increase in both cases were statistically significant (*p*-value<0.0001). Men had worse risk profile at both the time periods. Lower proportion of high CVD risk among rural men as compared to urban men at survey 1 (1.9% vs 4.0%) had almost disappeared at survey 2 (7.5% vs 7.9%). Among women, the rural urban differential was maintained. However, the rise in proportion of males and females with high CVD risk in both urban and rural areas over these two surveys were statistically significant (*p*-value <0.05). Largest change in CVD risk profile was seen among rural males (295%, *p*-value<0.0001). A comparison of gender and area specific risk distribution curves for the two time periods shows a definite blunting and rightward shift of the curves (Fig. 2).

There was significant decline in proportion of population with no risk factor, especially among women in rural area. Urban men showed an increase in the population with no risk factors during this period. Clustering of major risk factors (defined as three or more risk factors) showed an increase in both rural and urban population with higher relative percentage increase in rural areas and among women as compared to men (Fig. 3).

4. Discussion

In these community-based surveys repeated two decades apart in the NCR region, we found a rise in the prevalence of CHD.

Table 1
Baseline characteristics of study respondents in rural and urban samples of survey 1 and survey 2.

Characteristics	Rural survey 1		Rural survey 2		*p*-value	Urban survey 1		Urban survey 2		*p*-value
	N	n (%)/ mean ± SEM	N	n (%)/ mean ± SEM		N	n (%)/ mean ± SEM		n (%)/ mean ± SEM	
Age-group (years)	2487		1917			3048		2052		
35–39		652 (26.2)		522 (27.2)	0.571		779 (25.6)		497 (24.2)	<0.001
40–44		465 (18.7)		370 (19.3)			593 (19.5)		467 (22.8)	
45–49		416 (16.7)		325 (17.0)			467 (15.3)		379 (18.5)	
50–54		344 (13.8)		267 (13.9)			419 (13.7)		252 (12.3)	
55–59		281 (11.3)		216 (11.3)			346 (11.4)		222 (10.8)	
60–64		329 (13.2)		217 (11.3)			444 (14.6)		235 (11.5)	
Sex	2487		1917			3048		2052		
Female		1417 (57.0)		983 (51.3)	<0.0001		1593 (52.3)		1113 (54.2)	<0.0001
Male		1070 (43.0)		934 (48.7)			1455 (47.7)		939 (45.8)	
Education	1941		1915			2948		2050		
Illiterate		1257 (64.8)		689 (36.0)	<0.0001		487 (16.5)		216 (10.5)	<0.0001
Read/write		63 (3.2)		159 (8.3)			113 (3.8)		407 (19.9)	
Primary		171 (8.8)		42 (2.2)			293 (9.9)		8 (0.4)	
Middle school		184 (9.5)		245 (12.8)			320 (10.9)		123 (6.0)	
High school		218 (11.2)		569 (29.7)			813 (27.6)		500 (24.4)	
Secondary/graduate and above		48 (2.5)		211 (11.0)			922 (31.3)		796 (38.8)	
BMI (Kg/m^2)[a]	2435	20.2 ± 0.1	1910	23 ± 0.1	<0.001	3012	24.4 ± 0.1	1660	26.0 ± 0.2	<0.001
Waist to Hip ratio[a]	2338	0.89 ± 0.002	1908	0.92 ± 0.002	<0.001	3008	0.91 ± 0.001	2006	0.93 ± 0.002	1.0
Systolic Blood Pressure (mm Hg)[a]	2469	114.9 ± 0.4	1914	123.1 ± 0.3	<0.001	3041	121.2 ± 0.4	2026	129.8 ± 0.4	<0.001
Diastolic Blood Pressure (mm Hg)[a]	2470	73.1 ± 0.2	1914	82.3 ± 0.3	<0.001	3041	74.3 ± 0.2	2026	83.9 ± 0.3	<0.001
Fasting Blood Glucose (mg/dl)[a]	1275	83.9 ± 0.6	1245	103.2 ± 0.9	<0.001	2899	101.2 ± 0.7	1600	115.3 ± 1.1	<0.001
Total Cholesterol (mg/dl)[a]	1270	168.2 ± 1.1	1244	190.7 ± 1.2	<0.001	2897	192.4 ± 0.7	1604	184.9 ± 1.1	<0.001

Survey 1: 1991–1994; Survey 2: 2010–2012.
BMI, Body mass index; SEM, standard error of mean; p-value≤0.05 is considered statistically significant.
[a] Means were adjusted for age and sex (per Indian Census 2011).

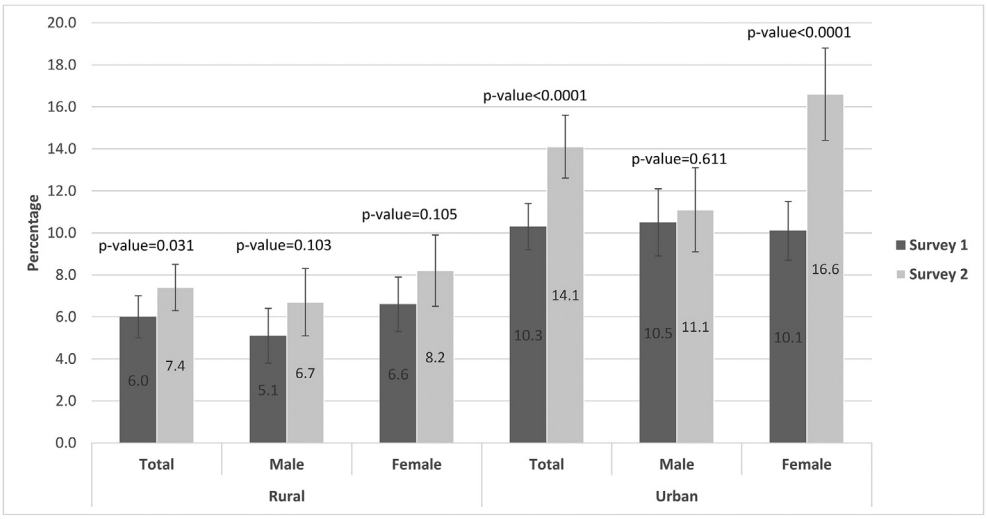

Fig. 1. Age and sex standardised CHD prevalence distribution in Survey 1 and Survey 2: Gender wise in rural and urban Delhi NCR. Age and sex standardization using Census 2011 data. p-value≤0.05 is considered statistically significant.

Table 2
Distribution of CVD risk score among non CHD participants in rural and urban Delhi NCR during survey 1 and survey 2.

CVD risk score		Total				Male				Female			
		Survey 1	Survey 2	% Change	*p*-value	Survey 1	Survey 2	% Change	*p*-value	Survey 1	Survey 2	% Change	*p*-value
		n = 2284 % (95% CI)	*n* = 1767 % (95% CI)			*n* = 991 % (95% CI)	*n* = 915 % (95% CI)			*n* = 1294 % (95% CI)	*n* = 852 % (95% CI)		
Rural	<10%	80.9 (79.6,82.3)	67.7 (65.8,69.6)	−16.3	<0.001	67 (64.8,69.2)	49.2 (46.8,51.6)	−26.6	<0.001	93.7 (92.3,95)	87.7 (85.7,89.6)	−6.4	<0.001
	10–30%	17.9 (16.5,19.3)	28.2 (26.2,30.1)	57.5	<0.001	31.1 (28.8,33.4)	43.3 (40.5,46)	39.2	<0.001	6.1 (4.8,7.4)	11.8 (9.8,13.7)	93.4	<0.001
	>30%	1.2 (0.7,1.6)	4.1 (3.2,5.0)	241.7	<0.001	1.9 (1.2,2.7)	7.5 (6.0,9.1)	294.7	<0.001	0.3 (0.0,0.6)	0.6 (0.1,1.1)	100.0	0.001
Urban		**n = 2693**	**n = 1391**			**n = 1286**	**n = 674**			**n = 1407**	**n = 717**		
	<10%	74.6 (73.2,76)	65.9 (63.7,68)	−11.7	<0.001	61.5 (59.5,63.5)	52 (49.2,54.8)	−15.4	<0.001	86.7 (85.2,88.2)	78.8 (76.2,81.4)	−9.1	<0.001
	10–30%	22.9 (21.5,24.3)	29.3 (27.2,31.5)	27.9	<0.001	34.5 (32.4,36.7)	40.1 (36.8,43.4)	16.2	0.029	12.2 (10.7,13.7)	18.8 (16.3,21.4)	54.1	<0.001
	>30%	2.5 (1.9,3.0)	4.8 (3.7,5.9)	92.0	<0.001	4.0 (3,4.9)	7.9 (5.9,9.9)	97.5	0.0002	1.1 (0.6,1.6)	2.3 (1.2,3.5)	109.1	0.032

% change calculated as (Survey 2 minus Survey 1)/Survey1*100.
Survey 1: 1991–1994; Survey 2: 2010–2012; CVD: Cardiovascular disease; p-value≤0.05 is considered statistically significant.

The increase in CHD prevalence in urban areas was driven by increase among urban women. CVD risk score distribution worsened over the two decades with men being worse off. Proportion of population with high CVD risk score increased more among rural than urban population with rural men showing the highest increase. Clustering of major risk factors also showed a higher increase in rural areas as compared to urban and among women as compared to men. These point to the fact that rural areas and women, traditionally considered as low-risk are fast catching up and are going to be major contributors of CVD disease burden in the future as majority of Indian population still lives in rural areas.

Earlier studies from India that reported prevalence of CHD ranging from 1.05% to 12.6% between 1960 and 2012 in urban areas of different part of the country[26–29] while it ranged from 2.7% to 7.6% between 1987 and 2012 in rural India.[27,29,30] A review by Gupta et al reported increasing trend of CHD prevalence from1.05% in 1960 to 9.67% in 1995 in urban areas and from 2.03% in 1974 to 3.7% in 1995 in rural India.[26] In another review Prabhakaran et al reported that the prevalence increased 7 times in urban areas from 2% in 1960 to ≈14% in 2013 and 4 folds from 1.7% in 1970 to 7.4% in 2013 in rural areas.[5] These findings support the results of the present study in urban and rural prevalence and its increase over 2 decades. The Vellore study using similar methodology reported significant rise in CHD prevalence among females and marginal increase among males in both urban and rural areas from 1994 to 2012 whereas the present study found a sharp increase among urban females and a steady increase among others.[29]

Many composite risk scores have been developed to predict the risk of a cardio-vascular event.These include Framingham, WHO/ISH among others.[11,18] In Indian population, Framingham CVD risk score prediction model is said to perform better than WHO, ASCVD, QRISK-2, JBS2.[31] The present study used Framingham equation for the prediction of CVD risk score and has found 4.8% people (who need therapeutic intervention to prevent the event) at high risk of developing CVDs in next 10 years. In comparision, a 2013 study by Parikh et al. reported a higher proportion i.e. 10.6% (20.0% males and 4.5% females) of people of Ahmedabad City were at high risk (> 20%) of developing CVD in next 10 years.[32] The present study also reported high proportion of men with high risk of CVDs as compared to females in both urban and rural areas in 1994 and 2012 respectively which is not correlated with the findings of high CHD prevalence and rapid increase among females. The possible

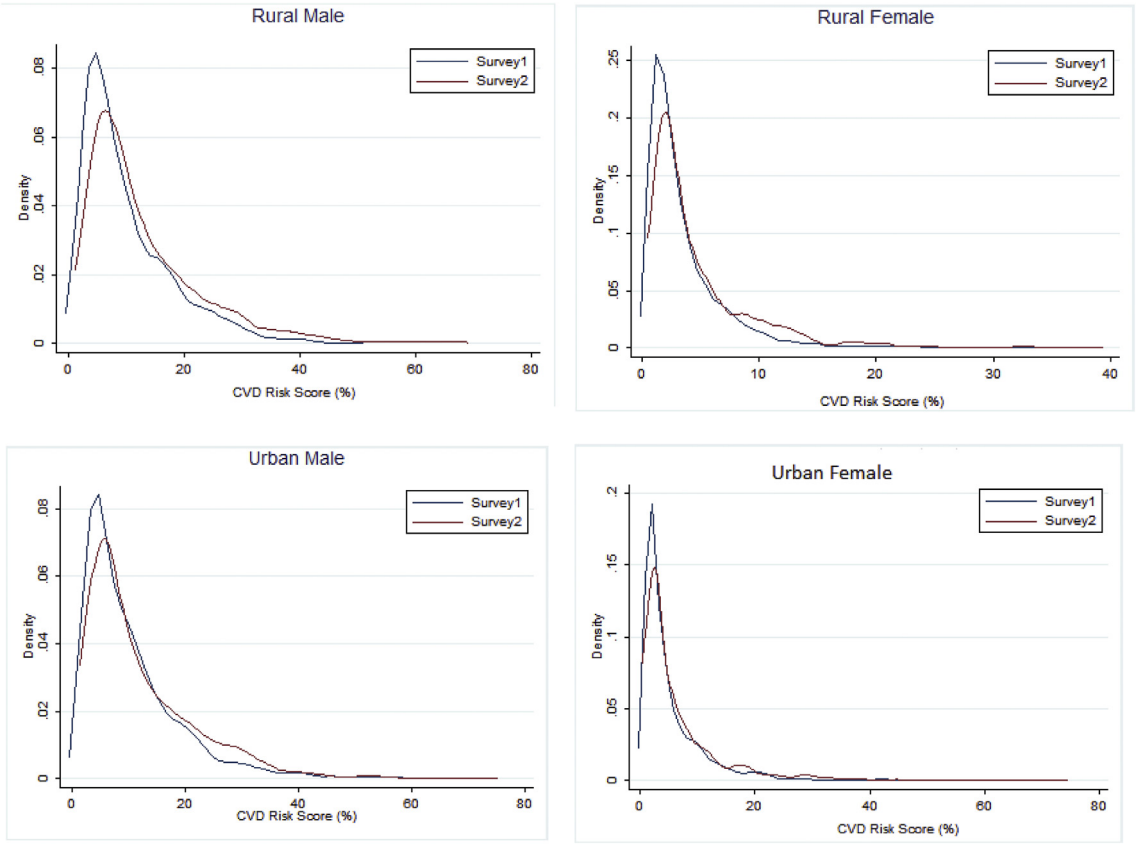

Fig. 2. Comparative density plots of CVD risk scores by gender and site (rural and urban areas) during Survey 1 and Survey 2.

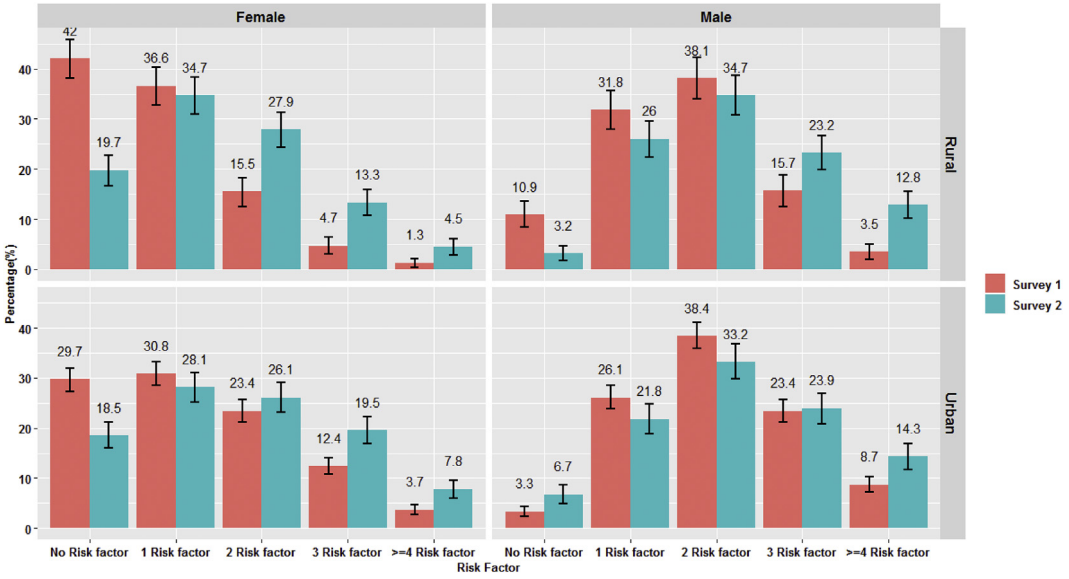

Fig. 3. Clustering of risk factors among rural and urban population over 2 decades. Risk factors: diabetes, hypertension, smoking, total cholesterol HDLc ratio, obesity, waist hip ratio. No Risk factor: no risk factor present; 1 Risk factor: any 1 risk factor; 2 Risk factor: any 2 risk factor; 3 Risk factor: any 3 risk factor; ≥4 Risk factor: any ≥4 risk factor.

explanation of the higher prevalence of CHD among women may be the differences in health perception, health seeking behaviour, high false positive CHD on angina symptom among women.[29,33,34] Like the present study the higher prevalence of angina on Rose angina questionnaire in females has been reported across 31 countries including India.[35]

The Global Burden of disease study also describes an increasing prevalence of several major CVD risk factors in India.[7] Further, the clustering of risk factors in individual are complicating the situation. The present study reported the accumulation of more risk factors in an individual in 2012 as compared to 1994. In a study of Sekhri et al conducted among 12,608 government employees aged

20–60 years in 2014, the clustering of 2 or more risk factors was reported in 78.6% of subjects[36] which is a little higher than our results of 61.7% in urban and 57.6% in rural people had 2 or more risk factors. Similarly 33% of Malaysian population[37] and 35.2% of Chinese population[38] had 2 or more risk factors which is lower than our results. Paradoxically, urban men showed an increase in the population with no risk factors during this period. This could be either due to difference in age and sex structure (as these were crude estimates) or could be early signs of reversal of CVD epidemic which would need to be confirmed.

The similar methodology and tools used in the two surveys by same study teams, robust sampling design, stringent sampling procedure, standard protocol for both surveys and representativeness of samples across sex and age are the strengths of the study. Data on physical activity and diet was not recorded in survey 1, thus has not been reported in this paper. Different instruments were used to measure blood pressure and weight in both surveys conducted 20 years apart, which represent the technological change over the time. One of the common limitations of community based study is the use of feasible tools and techniques in diagnosing the CHD (ECG/Rose Angina Questionnaire) as compared to facility based study where the range of specific tests are used (Treadmill Test, Coronary Computed Tomographic Angiography, Single Photon Emission Computed Tomography etc.).[39,40] In the facility-based study, the prevalence of CHD may not be generalised to the general population as the institutional diagnosis of CHD is very low in India. However, the limitation of using Rose angina questionnaire for diagnosis of CHD is the high false positive rate among females on angina symptoms and it may overestimate the CHD prevalence.[33]

5. Conclusion

CHD burden along with its precursors (CVD risk and clustering of risk factors) increased in Delhi NCR from 1990s to 2010s. This included rural areas and women who had much lower burden of CHD and its risk in the first survey. While India is strengthening its health system response to CVDs through the launch of the National Program for Prevention and Control of Cancer, Diabetes, Cardiovascular diseases and Stroke (NPCDCS), the increasing burden of CHD indicates the need to expedite it as well as expand its coverage. Also measures of prevention need to be strengthened. The launch of Health and Wellness centres as a part of comprehensive primary health care roll out with focus on health promotion is also a welcome step.

Financial disclosure statement

The authors have no financial disclosures to report.

Conflicts of interest

All authors have none to declare.

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Appendix A. Supplementary data

Supplementary data to this article can be found online at https://doi.org/10.1016/j.ihj.2020.08.008.

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