Original Research

Escalating ischemic heart disease burden among women in India: Insights from GBD, NCDRisC and NFHS reports

Kiran Gaur[a], Indu Mohan[b], Manmeet Kaur[c], Shiva Ahuja[d], Shreya Gupta[b], Rajeev Gupta[b,e,*]

[a] Department of Statistics, Mathematics and Computer Science, Govt SKN Agriculture College, SKN Agriculture University, Jobner, Jaipur, India
[b] Department of Community Medicine, Mahatma Gandhi Medical College, Jaipur, India
[c] Department of Community Medicine, School of Public Health, Postgraduate Institute of Medical Education and Research, Chandigarh, India
[d] Department of Orthodontics, Jaipur Dental College and KDG Medical and Dental Centre, Jaipur, India
[e] Department of Preventive Cardiology and Internal Medicine, Eternal Heart Care Centre and Research Institute, Jaipur, India

ABSTRACT

Objective: To determine trends in ischemic heart disease (IHD) mortality and burden among women in India we performed a study.
Methods: Data were obtained from three publicly available resources. Cardiovascular disease (CVD) and IHD mortality were obtained from 2017 Global Burden of Diseases (GBD) Study. Metabolic risk factor data (body-mass index, blood pressure and diabetes) were obtained from Non-Communicable Disease Risk Factor Collaboration (NCDRiSC) and lifestyle factors were obtained from National Family Health Surveys (NFHS). Descriptive statistics are reported.
Results: GBD study reported that in year 2017 in India CVD caused 2.64 million deaths (women 1.18, men 1.45 million) and IHD 1.54 million (women 0.62, men 0.92 million). Burden of IHD related disability adjusted life years (DALYs) was 36.99 million (women 13.80, men 23.19 million). From 2000 to 2017 annual IHD mortality increased from 0.85 to 1.54 million (+81.1%) with greater increase in women 0.32 to 0.62 million (+93.7%) compared to men (0.53–0.92 million, +73.6%). Increase in age-adjusted IHD mortality rate/100,000 was also more in women (62.9–92.7, +47.4%) than men (97.5–129.5, +32.8%). Trends in cardiometabolic risk factors from 2000 to 2015 showed greater increase in body-mass index, diabetes, tobacco-use and periodontal infections among women than men.
Conclusion: IHD is increasing more rapidly among women than men in India and there is sex-associated convergence. This is associated with greater increase in overweight, diabetes, tobacco use and periodontal infections in women.

1. Introduction

Ischemic heart disease (IHD) is the most important cause of disease burden and mortality in women [1]. Pre-menopausal women are protected from IHD due to combination of hormonal and lifestyle influences but following this period, IHD occurs at same rate in women and men and the risk is greater among women at older age [2]. Cardiovascular diseases (CVD), especially IHD, are endemic in India [3]. Data from the Registrar General of India has shown that mortality from cardiovascular diseases, including IHD, has increased rapidly in the last 2 decades [4]. World Health Organization (WHO) and Global Burden of Disease (GBD) Studies have also reported increase in mortality and disability-adjusted life years (DALYs) from IHD in India in the last few decades. This is in contrast to most high- and middle-income countries where they are declining [5,6]. In India, epidemiological studies performed in 1960's to 1990's reported greater prevalence of IHD in women [7]. However, this higher prevalence of IHD in women could be due to inclusion of non-specific electrocardiographic (ECG) criteria such as non-specific T-wave changes [8, 9], based on earlier WHO guidelines that recommended ECG ST-T changes as suggestive of CHD [10]. However, when diagnosis was based on either a clinical diagnosis or presence of pathological Q-waves [10], IHD prevalence was observed to be greater in men as compared to women [9]. Million Death Study in India reported that in year 2015 age-standardized death rate from IHD in men was 173/100,000 and in women 96/100,000 but did not report secular trends [4,11,12]. On the other hand, GBD study has reported that IHD mortality rates have

declined in large countries including China, USA, Indonesia, Brazil, Russia and UK with identical rates of decline in women and men [13–20]. Secular-trends in sex-specific IHD mortality and disease burden at a national scale have not been previously reported from India. Therefore, to evaluate national burden of various CVDs, sex-specific trends in IHD mortality and DALYs and to determine macro-level association with risk factors, we performed the present study.

2. Methods

This study is based on secondary data analyses using three publicly available datasets: Global Burden of Disease (GBD) Study at http://ghdx.healthdata.org/gbd-results-tool [21]; Non-Communicable Disease Risk Factor Collaboration (NCDRiSC) at www.ncdrisc.org;22 and National Family Health Surveys (NFHS) (India) at http://rchiips.org/nfhs/ [23]. All the three studies have been approved by institutional review boards and ethics committees at the study sites. GBD study provides comprehensive and systematic assessments from 1980 to 2017 of age-specific and sex-specific mortality and years of life lost (YLLs) for 264 causes; and years lived with disability (YLDs) and DALY's for 328 diseases and injuries and 84 risk factors in 195 countries and territories [24]. Details of GBD study including cause-specific estimations for cardiovascular diseases and IHD have been previously published [25,26]. GBD 2017 data (latest available) used in the present study provides comprehensive and systematic assessments from 1980 to 2017 of age-specific and sex-specific mortality, prevalence and DALYs for cardiovascular diseases and IHD in India [6]. GBD 2019 data are not yet available. We extracted cardiovascular mortality and DALY data for the 5 most populous countries from the Global Health Data Exchange website, Institute of Health Metrics and Evaluation, University of Washington, Seattle, USA [21]. Sex-specific data on total CVDs, IHD and stroke were also obtained. For India, we extracted sex-specific data on IHD, ischemic stroke, hemorrhagic stroke and rheumatic heart disease (RHD) mortality, DALYs and age-adjusted rates/100,000. We extracted rates for these conditions from the year 2000 onwards because in earlier years the mortality data from India were non-representative as they were based on causes of death data from limited sources [27]. Data on urban versus rural CVD mortality or DALYs are not available at GBD website.

Data on cardiometabolic risk factors for India were obtained from the Global Burden of Metabolic Risk Factors study from Non-Communicable Disease Risk Factor Collaboration (NCDRiSC) website [22]. We obtained annual data on mean systolic blood pressure (BP), diastolic BP, body mass index (BMI) and total cholesterol levels in women and men in India from the years 2000–2015/6. Data on lifestyle risk factors (smoking, overweight or obesity, indoor air pollution, type of fuel used for cooking, cooking habits, etc.) were obtained from National Family Health Surveys (NFHS) [23]. The government of India periodically conducts these nationally representative surveys on health behaviors and anthropometric measures [28]. Data are available for 1992–93 (NFHS-1), 1998–99 (NFHS-2), 2005–06 (NFHS-3) and 2015–16 (NFHS-4). Data on prevalence of chronic periodontal infections were obtained from GBD website [21].

Statistical analyses: Descriptive statistics are reported. Secular trends in gender-specific IHD mortality, DALYs and rates have been plotted. Significance of trends has been determined using Pearson's correlation coefficients (r). Non-parametric tests such as Spearman's test for rank correlation (rho) and generalized estimating equations (GEE) were also evaluated but Pearson's test provided the most robust estimate and was retained. SPSS package was used for analyses (SPSS version 13.0; SPSS Inc. Chicago). Risk factor trends (R^2 values) in women and men have been plotted using polynomial regression function in Microsoft PowerPoint (Version 14.0.0) package. P values < 0.05 are considered significant.

3. Results

Data on cardiovascular and IHD mortality and DALYs (absolute numbers and age-adjusted rates) for the year 2017 in 5 most populous

countries are shown in Table 1. In 2017, in India there were 2,632,780 CVD related deaths of which 1,540,328 were due to IHD. Global comparison shows that CVD and IHD deaths are lower than in China, which has 4,377,972 CVD and 1,750,038 IHD deaths. IHD DALY's, which is measure of disease burden and includes premature disease, are the highest in India (36.99 million). There is a high absolute burden of IHD deaths (n = 623,042) as well as DALYs (n = 13,798,687) in Indian women. However, women have lower IHD mortality than men in terms of absolute number of deaths and DALYs as well as rates/100,000 (Table 1).

3.1. IHD mortality and disease burden trends

We plotted data on mortality trends from IHD in five most populous countries from the years 2000–2017 using GBD database (Fig. 1). China and India have the largest IHD related mortality and burden. China has overtaken India and currently has the highest number of IHD deaths while disease burden is the highest in India. Trends in IHD mortality and disease burden reveal that while the rates are decreasing in many high and middle income countries, e.g., USA, they are increasing in India. In India, from the years 2000–2017, total IHD mortality increased from 851,000 to 1,540,000 deaths (+81.1%), age-adjusted mortality rate increased from 80.2 to 111.1/100,000 (+38.5%) (Table 2). DALYs increased from 22,589,000 to 36,987,000 (+63.7%) and DALY rates increased from 2,124 to 2,663/100,000 (+25.4%) (Table 2). Trends show that total mortality has increased in both women and men and in year 2017, 623,042 deaths in women and 917,285 deaths in men were due to IHD. From the year 2000–2017, IHD mortality rate has increased in women from 62.9/100,000 to 92.7/100,000 and men from 97.5/100,000 to 129.5/100,000. The increase is significantly greater in women- +47.4% vs. +32.8% in men (p < 0.05) with evidence of convergence in IHD mortality rates (Fig. 2). GBD data also show that IHD DALYs are increasing rapidly in both women and men. From years 2000–2017, DALY rates increased in women from 1567.9 to 2052.4/100,000 (+30.9%) while in men from 2680.6 to 3274.1/100,000 (+22.1%) with evidence of convergence (Fig. 2).

3.2. Risk factor trends

We obtained data on secular changes in proximate cardiometabolic risk factors from Global Burden of Metabolic Risk Factors study from NCDRiSC [22]. Data on mean body mass index (BMI), mean systolic BP and diabetes (%) in India from years 2000–2015/6 in women and men are shown in Table 3. Women have greater BMI while other risk factors-systolic BP, hypertension and diabetes-are more in men. There is secular increase in all the risk factors from the year 2000 to 2015–2016. Risk factors such as BMI have increased more rapidly in women (R^2 = 0.99963) as compared to men (R^2 = 0.99953) while others have increased at the same rate. Chronic periodontal infection, which is a marker of chronic inflammatory state, also shows an increase, more in women (R^2 = 0.97764) than in men (R^2 = 0.97178). Trend graphs show that secular trends are greater in women than in men for BMI, diabetes and chronic dental infections. Increase in systolic BP is greater in men (Fig. 3).

We also determined trends in prevalence of various lifestyle risk factors in women using data from National Family Health Surveys- NFHS-1, NFHS-2, NFHS-3 and NFHS-4 [23]. Between NFHS-2 to NFHS-4 surveys (3 surveys, 20-year period) tobacco use among women increased from 3.0% to 10.8% and 6.8% while overweight or obesity (body-mass index ≥25 kg/m²) increased from 10.6% to 14.8% and 20.6% (Table 4). On the other hand, the use of biological and unclean fuels, markers of indoor air pollution [29], declined. We reviewed data on various social determinants of cardiovascular health among women from NFHS. The risk factors included low educational status, low socioeconomic status, low social capital, social isolation, depression, psychosocial stress, unemployment, nuclear family, number of children and awareness and control of risk factors. There is substantial prevalence of many of these

Table 1

Cardiovascular and IHD mortality (absolute numbers and age-adjusted rate/100,000) and disability adjusted life years (DALYs, absolute burden and rates/100,000) in women and men in 5 most populous countries in year 2017.

Country	Cardiovascular diseases						Ischemic heart disease					
	Absolute Number			Rates/100,000			Absolute Number			Rates/100,000		
Deaths												
	Total	Women	Men	Total	Women	Men	Total	Women	Men	Total	Women	Men
China	4,377,972	1,972,013	2,405,959	309.9	285.2	333.6	1,750,038	806,485	943,553	123.9	116.7	130.8
India	2,632,780	1,182,812	1,449,968	190.7	175.9	204.7	1,540,328	623,042	917,285	111.6	92.7	129.5
USA	902,271	446,731	455,540	277.8	270.9	284.9	533,166	248,199	284,967	164.1	150.5	178.2
Indonesia	597,995	278,854	319,141	231.7	217.9	245.2	234,755	95,739	139,016	90.9	74.8	106.8
Brazil	388,268	183,987	204,281	183.3	169.9	197.3	175,792	77,960	97,831	83.0	72.0	94.5
Disability adjusted life years												
China	85,040,846	34,837,814	50,203,032	6021	5039.5	6961.1	30,106,299	11,909,687	18,196,612	2131	1723	2523
India	65,117,830	27,804,195	37,313,635	4717	4135.6	5268.5	36,987,505	13,798,687	23,188,817	2679	2052	3274
USA	15,639,790	6,679,034	8,960,756	4815	4049.7	5603.6	8,025,817	3,020,202	5,005,614	2471	1831	3130
Indonesia	14,617,323	6,343,068	8,274,255	5663	4956.1	6357.5	5,717,632	2,087,089	3,630,544	2215	1631	2790
Brazil	8477,770	3,671,748	4,806,022	4003	3390.4	4642.9	3,678,316	1,406,476	2,271,840	1737	1299	2195

risk factors among women. Secular trends reveal that low educational status, high fertility rate and household pollution levels are declining among women in India (Table 4).

4. Discussion

Ischemic heart disease is increasing more rapidly among women as compared to men in India. The IHD mortality and disease burden ratio in women vs. men from the years 2000–2017 has increased from 0.64 to 0.72 for mortality and 0.58 to 0.63 for DALYs showing a narrowing of the gender gap. Cardiometabolic risk factors (body mass index, diabetes), tobacco use and periodontal infections, have increased more rapidly among women in India and appear to have catalyzed this convergence.

Studies from developed countries in North America and Europe have reported decline in IHD mortality and disease burden in the last 50 years [6]. Data from these countries reveal that the decline among women has been similar to men barring some age-group specific variations [30]. For example, in the US there has been a continuous decline in IHD mortality in the last two decades but a slower decline has been reported in younger women [31]. In Europe there has been variable decline in IHD mortality from the years 1980–2009 [32]. The largest decrease has been reported in the Netherlands (−73.8% males, −72.0% females) and United Kingdom (−67.3% males, −65.9% females) while modest reductions have been reported in eastern European countries. A sex-based convergence, similar to the present study, is observed in some of these countries. The different rates of decline of IHD mortality in women could be due to biological and sociocultural differences in IHD and its outcomes [33]. Women, especially younger women, suffer from a number of biases that lead to lower rates of diagnosis and inferior management [1,2]. Prospective Urban Rural Epidemiology (PURE) study has reported lower preventive management of CVD risk factors in women compared to men in multiple high-, middle- and low-income countries [34].

Reasons for the decline in IHD mortality in high-income countries have been well reported. The IMPACT model has reported that in both men and women, primary prevention has contributed to about 50–60% decline while better acute treatments and secondary prevention is responsible for the other 40% [35,36]. Risk factors contributing to declining mortality are reduction in tobacco use, sedentary lifestyle and unhealthy diets, and better treatment and control of hypertension and hypercholesterolemia. All these risk factors are declining in high-income and many upper middle income countries due to effective implementation of policies for primordial prevention and better clinic-based primary prevention [37]. On the other hand WHO has reported that these risk factors are increasing both in women and men in India and many other lower-middle income countries [5]. This is also observed in the present study that shows that in Indian women and men most of the proximate IHD risk factors are increasing. NFHS surveys have reported significant increase in tobacco use (although it has declined from NFHS-3 to NFHS-4 surveys) and overweight in women. These proximate and lifestyle risk factors have greater association with IHD mortality in women as compared to men. Especially important are tobacco use, second hand smoke, dietary risk factors, physical inactivity, particulate air pollution and chronic periodontitis. These risk factors need to be controlled using established strategies for primary prevention with greater emphasis among women [38]. However, the strategies for management of these risk factors among women may need to be different as women have lower control over resources.

Important IHD risk factors in women are same as in men and include established risk factors such as age, family history, hypertension, diabetes, hypercholesterolemia, hypertriglyceridemia, smoking, physical inactivity and low physical fitness [33]. These risk factors have also been implicated among South Asians in the Prospective Urban Rural Epidemiology (PURE) study [29]. Emerging risk factors are also important in women and include the metabolic syndrome, abdominal obesity, high sensitivity C-reactive protein (CRP), autoimmune disease, polycystic ovary syndrome, functional hypothalamic amenorrhea, eclampsia, pre-eclampsia, pregnancy-associated hypertension, gestational diabetes, breast cancer therapy, oral-contraceptive use and post-menopausal hormone therapy [1,33].

PURE study has also reported that socioeconomic factors are important for incident IHD in India and other low-income countries [39]. Low educational status is one of the most important risk factor for all-cause mortality, cardiovascular mortality and incident IHD events [29]. Literacy levels among women in India are lower than in men and this combined with other women-specific social factors could be important driver of more rapid increase of IHD in them. Stressors in women in India are macro-level societal factors- social isolation, neglect, low job prospects, inferior working conditions, limited promotional avenues and societal inequity [40]. Individual level factors are also important and are due to neglect from social stigmas and customs leading to psychosocial stress and depression. A low social capital, large number of children and nuclear families add to the burden of social constraints [41]. Content analysis of studies shows a mixture of low self-esteem, entrenched beliefs, pre-conceived notions, lack of true knowledge, and negative affect and emotions as important factors [42]. The lower educational status amongst women also results in general lack of awareness of risk factors for health, especially cardiovascular diseases, hypertension, diabetes, etc., and understanding the rationale for their control [43]. Low socio-economic status, unemployment and poverty also increase the burden of transportation costs, stress and difficulties accessing services and in following expensive and complex medication regimens [44]. Overwhelming communication problems with healthcare professionals in developing a trusting relationship hinders adequate information exchange [44]. The low risk factor burden and greater cardiovascular
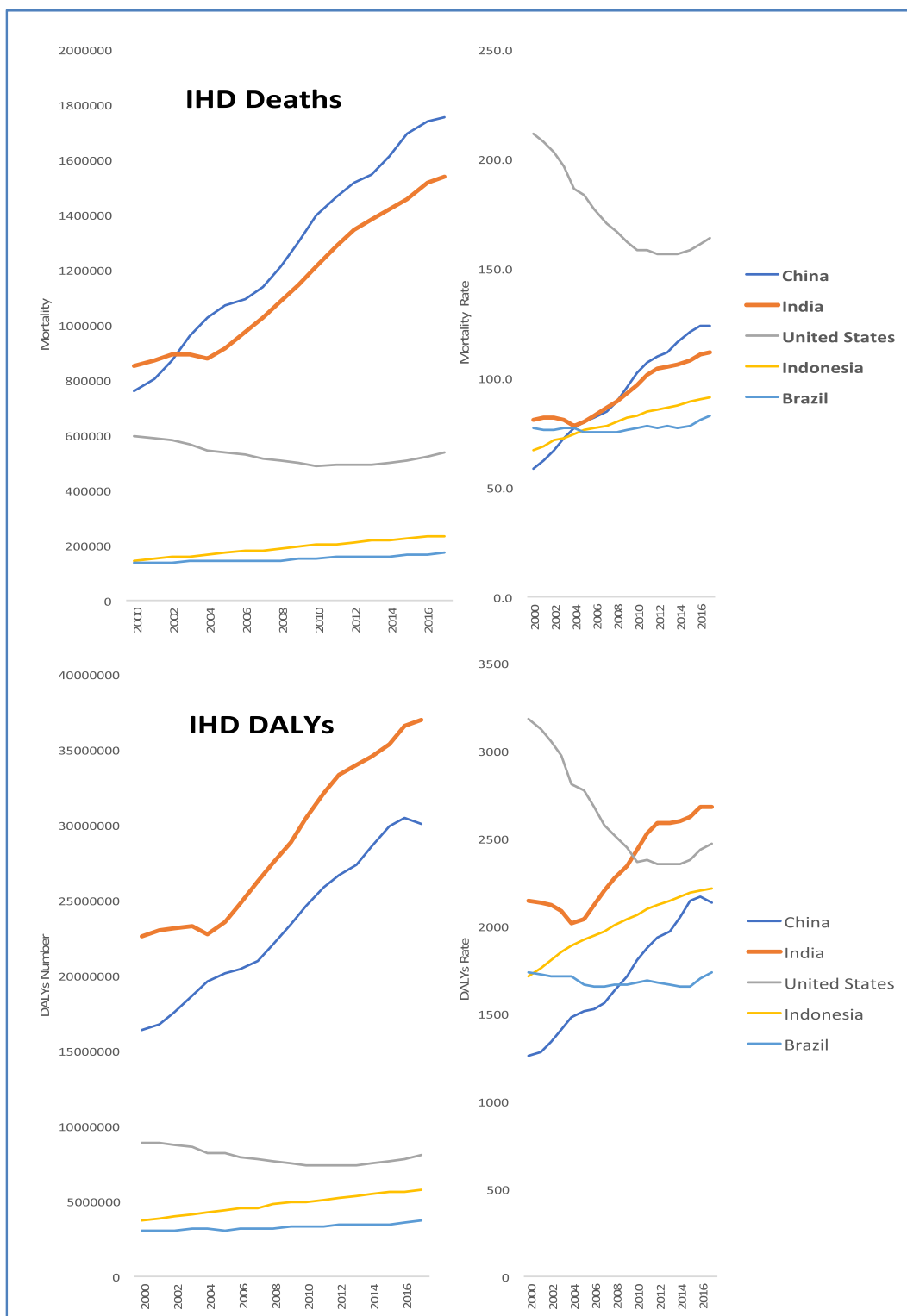
Fig. 1. Secular trends in IHD mortality (top panel) and DALYs (lower panel) in terms of absolute numbers and rate/100,000 in five most populous countries from the years 2000–2017: Global Burden of Diseases Study 2017.

mortality paradox in South Asian and Sub-Saharan African lower income countries as reported in the PURE study points to inferior quality of acute and chronic IHD management and poor risk factor control, especially in women [34,45].

The study has a few strengths and limitations. This is one of the first reports that highlight greater increase of IHD mortality among women in India using nationally representative data from GBD, NCDRiSC and NFHS. The IHD mortality data in the GBD study are similar to nationally representative Million Death Study, which has reported trends from the years 2003–2015. Although the verbal autopsy process used in this study has been validated, suboptimal availability of physician certified causes of deaths data in India is a study limitation [24]. Similarly the NCDRiSC study estimates for risk factors in India are based on modeling using regional studies and may not be nationally representative. Data regarding

Table 2
Secular trends in mortality and DALYs from IHD in women and men in India from 2000 to 2017.

Year	Women	Men	Women:Men ratio	Women	Men	Women:Men ratio
	IHD Absolute numbers			Mortality rate/100,000		
2000	318,417	532,654	0.60	62.9	97.5	0.64
2001	326,739	547,053	0.60	63.3	98.4	0.64
2002	334,833	554,270	0.60	63.6	97.9	0.65
2003	338,095	558,108	0.61	63.1	96.9	0.65
2004	330,145	550,188	0.60	60.5	94.0	0.64
2005	339,202	575,775	0.59	61.0	96.7	0.63
2006	361,422	609,468	0.59	63.9	100.7	0.63
2007	382,241	646,287	0.59	66.4	105.2	0.63
2008	398,775	686,736	0.58	68.0	110.0	0.62
2009	416,490	727,757	0.57	69.9	114.8	0.61
2010	444,604	766,796	0.58	73.4	119.2	0.62
2011	469,981	812,494	0.58	76.3	124.4	0.61
2012	490,569	853,213	0.57	78.3	128.7	0.61
2013	517,215	862,686	0.60	81.2	128.1	0.63
2014	553,356	862,409	0.64	85.5	126.3	0.68
2015	586,343	870,403	0.67	89.4	125.8	0.71
2016	612,629	899,733	0.68	92.2	128.5	0.72
2017	623,042	917,285	0.68	92.7	129.5	0.72
	DALY Absolute numbers			DALY Rate/100,000		
2000	7,942,114	14,647,864	0.54	1567.9	2680.6	0.58
2001	8,045,690	14,875,228	0.54	1558.2	2674.6	0.58
2002	8,146,528	15,027,050	0.54	1548.2	2655.4	0.58
2003	8,155,317	15,075,335	0.54	1521.2	2618.6	0.58
2004	7,940,951	14,823,746	0.54	1454.2	2531.8	0.57
2005	8,076,668	15,434,646	0.52	1452.5	2592.9	0.56
2006	8,489,950	16,285,002	0.52	1500.0	2692.0	0.56
2007	8,916,271	17,274,638	0.52	1548.0	2810.6	0.55
2008	9,271,798	18,245,512	0.51	1582.0	2922.6	0.54
2009	9,629,759	19,239,708	0.50	1615.5	3035.4	0.53
2010	10,241,192	20,189,451	0.51	1689.6	3137.9	0.54
2011	10,745,101	21,296,748	0.50	1743.5	3260.7	0.53
2012	11,109,469	22,206,466	0.50	1772.6	3348.5	0.53
2013	11,662,247	22,286,131	0.52	1830.1	3309.8	0.55
2014	12,448,911	22,122,175	0.56	1923.8	3239.2	0.59
2015	13,118,984	22,221,751	0.59	1999.7	3211.9	0.62
2016	13,630,185	22,880,130	0.60	2051.6	3267.4	0.63
2017	13,798,687	23,188,817	0.60	2052.4	3274.1	0.63

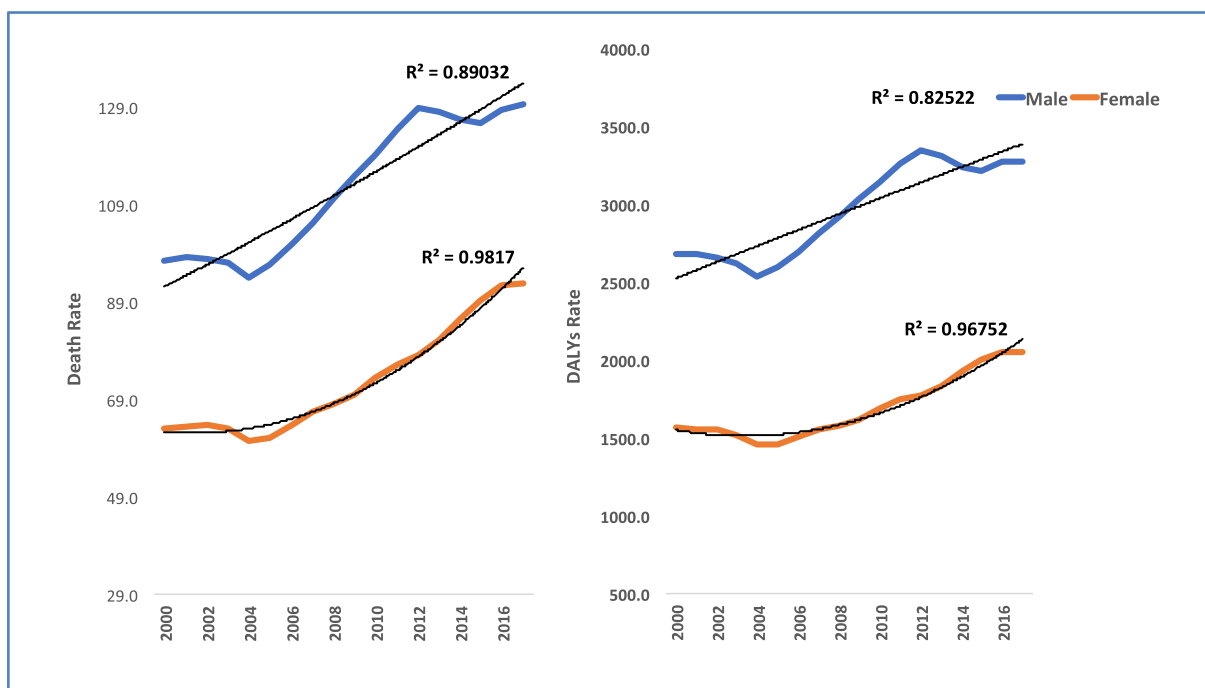IHD ischaemic heart disease; DALY disability adjusted life years.

Fig. 2. Trends in IHD mortality/100,000 and DALYs/100,000 among women and men in India from 2000 to 2017 (GBD Study). Polynomial regression in women vs. men shows greater escalation of IHD mortality ($R^2 = 0.98$ vs 0.89) as well as DALYs ($R^2 = 0.97$ vs 0.83).

Table 3
Trends in major cardiometabolic risk factors in India from 2000 to 2016 (NCDRiSC).

| Year	Mean body mass index (kg/m²)[a]		Mean systolic BP (mmHg)[a]		Diabetes (%)[b]		Chronic periodontal infection (%)[b]	
	Women	Men	Women	Men	Women	Men	Women	Men
2000	20.80	20.68	123.32	125.47	7.3	7.3	11.9	9.7
2001	20.86	20.75	123.49	125.66	7.4	7.5	12.0	9.8
2002	20.94	20.83	123.66	125.87	7.5	7.6	12.1	9.9
2003	21.03	20.90	123.84	126.08	7.6	7.8	12.3	10.0
2004	21.10	20.97	124.01	126.28	7.7	8.0	12.4	10.1
2005	21.18	21.04	124.16	126.47	7.8	8.1	12.5	10.2
2006	21.26	21.11	124.29	126.64	7.9	8.3	12.7	10.4
2007	21.33	21.17	124.40	126.80	7.9	8.4	12.8	10.5
2008	21.41	21.24	124.48	126.92	8.0	8.5	12.9	10.6
2009	21.48	21.30	124.52	127.02	8.1	8.6	13.0	10.7
2010	21.56	21.37	124.53	127.10	8.1	8.7	13.1	10.8
2011	21.63	21.44	124.51	127.14	8.2	8.8	13.3	10.9
2012	21.70	21.51	124.48	127.18	8.2	8.9	13.4	11.1
2013	21.78	21.58	124.43	127.21	8.3	8.9	13.6	11.3
2014	21.85	21.66	124.38	127.24	8.3	9.0	13.8	11.4
2015	21.93	21.73	124.32	127.26	–	–	14.1	11.7
2016	22.00	21.81	–	–	–	–	14.3	12.0

[a] Mean values.
[b] Percent.
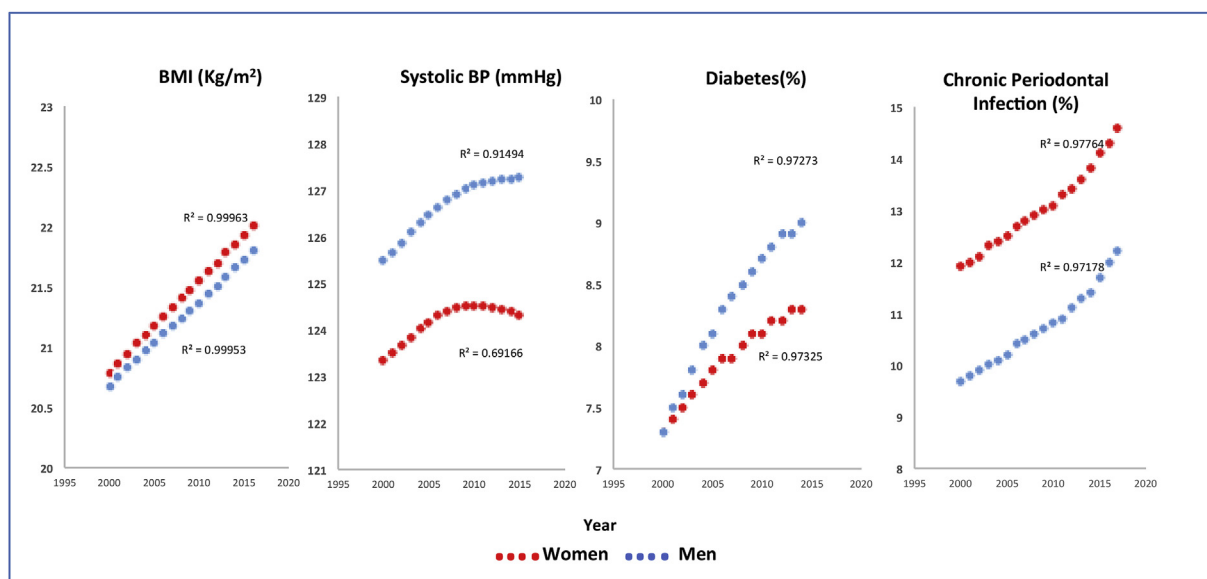
Fig. 3. Trends in IHD risk factors in women and men in India from 1990 to 2015 (NCDRiSC study). In women there is greater increase in body mass index, diabetes and chronic dental infections with greater R^2 values.

Table 4
Various lifestyle and other risk factors in women in India (%) from National Family Health Surveys (NFHS-1 to NFHS-4).

Survey	Smoking/Tobacco use (%)	Unclean fuels (%)[a]	Overweight/Obesity (%)	Literacy rate (%)	>10y education (%)	Total fertility rate (%)
NFHS-1 (1992–94)	–	85.2	–	43.3	–	3.4
NFHS-2 (1998–99)	3.0	81.3	10.6	51.4	–	2.9
NFHS-3 (2005–06)	10.8	74.5	14.8	55.1	22.3	2.7
NFHS-4 (2015–16)	6.8	56.2	20.6	68.4	35.7	2.2

[a] Data on unclean fuels is household percentage while for others is individual level prevalence.

trends in various macrolevel and microlevel social, economic, political and psychosocial factors, especially important in women are not available in India and this is also a study limitation.

In conclusion, our study shows that IHD is increasing more rapidly among women than men in India with sex-related convergence. This is associated with greater increase in overweight, diabetes, tobacco use and periodontal infections. The increase in IHD mortality in women calls for attention of researchers and policy makers. More research is required to

identify social determinants of IHD risk factors in women [38]. Focus on identification of individual level social stressors in women and determining differential physiological responses is needed. While quantitative studies can lead to identification of social determinants, qualitative studies can provide inputs for policy and program initiatives. It is also essential to develop strategies to empower women to reduce inequities and prevent IHD and to provide equitable prevention and treatment for IHD, the most important cause of death in women in India.

References

[1] Garcia M, Mulvagh SL, Bairey-Merz CN, Buring JE, Manson JE. Cardiovascular disease in women: clinical perspectives. Circ Res 2016;118(8):1273–93.

[2] Westerman S, Wenger NK. Women and heart disease, the under-recognized burden: sex differences, biases, and unmet clinical and research challenges. Clin Sci (Lond) 2016;130(8):551–63.

[3] Prabhakaran D, Jeemon P, Roy A. Cardiovascular diseases in India: current epidemiology and future directions. Circulation 2016;133(16):1605–20.

[4] Ke C, Gupta R, Xavier D, et al. Divergent trends in ischemic heart disease and stroke mortality in India from 2000 to 2015: a nationally representative mortality survey. Lancet Glob Health 2018;6(8):e914–23.

[5] World Health Organization. Global status report on non-communicable diseases 2014. Geneva: World Health Organization; 2014.

[6] GBD 2017 Causes of Death Collaborators. Global, regional, and national age-sex specific mortality for 282 causes of death, 1980-2017: a systematic analysis for the Global Burden of Disease Study 2017. Lancet 2018;392(10159):1736–88.

[7] Gupta R, Gupta VP. Meta-analysis of coronary heart disease prevalence in India. Indian Heart J 1996;48(3):241–5.

[8] Gupta R, Joshi PP, Mohan V, Reddy KS, Yusuf S. Epidemiology and causation of coronary heart disease and stroke in India. Heart 2008;94(1):16–26.

[9] Gupta R, Mohan I, Narula J. Trends in coronary heart disease epidemiology in India. Ann Global Health 2016;82(2):307–15.

[10] Luepkar RV, Evans A, McKeigue P, Reddy KS. Cardiovascular survey methods. third ed. Geneva: World Health Organization; 2002.

[11] Jha P, Gajalakshmi V, Gupta PC, , et alfor RGI-CGHR Prospecive Study Collaborators. Prospective study of one million deaths in India: rationale, design and validation results. PLoS Med 2006;3(2):e18.

[12] Ram U, Jha P, Gerland P, et al. Age-specific and sex-specific adult mortality risk in India in 2014: analysis of 0·27 million nationally surveyed deaths and demographic estimates from 597 districts. Lancet Glob Health 2015;3(12):e767–75.

[13] India State-Level Disease Burden Initiative Collaborators. Nations within a nation: variations in epidemiological transition across the states in India 1990-2016, in the Global Burden of Disease Study. Lancet 2017;390(10111):2437–60.

[14] India State-Level Disease Burden Initiative Collaborators. The changing patterns of cardiovascular diseases and their risk factors in the states of India: the Global Burden of Disease Study 1990-2016. Lancet Glob Health 2018;6(12):e1339–51.

[15] Liu S, Li Y, Zeng X, et al. Burden of cardiovascular diseases in China, 1990-2016: findings from the 2016 global burden of disease study. JAMA Cardiol 2019;4(4):342–52.

[16] Global Burden of Cardiovascular Diseases Collaboration, Roth GA, Johnson CO, Abate KH, et al. The burden of cardiovascular diseases among the US states 1990-2016. JAMA Cardiol 2018;3(5):375–89.

[17] Roth GA, Johnson C, Abajobir A, et al. Global, regional, and national cardiovascular disease prevalence, mortality, and disability-adjusted life-years for 10 causes of cardiovascular mortality, 1990 to 2015: a systematic analysis for the Global Burden of Disease Study. J Am Coll Cardiol 2017;70(1):1–25.

[18] Global Burden of Diseases 2016 Brazil Collaborators. Burden of disease in Brazil, 1990-2016: a systematic subnational analysis for the global burden of disease study 2016. Lancet 2018;392:760–75.

[19] GBD 2016 Russia Collaborators. The burden of disease in Russia from 1980-2016: a systematic analysis for the Global Burden of Disease Study. Lancet 2018; 392(10149):1138–46.

[20] Steel N, Ford JA, Newton JN, et al. Changes in health in the counties of the UK and 150 English Local Authority areas 1990-2016: a systematic analysis for the Global Burden of Disease study 2016. Lancet 2018;392(10149):1647–61.

[21] Global Health Data Exchange. Available at: http://ghdx.healthdata.org/gbd-results-tool. Accessed: 24 May 2019.

[22] Non-communicable disease risk factor collaboration. Available at: www.ncdrisc.org. Accessed: 24 May 2019.

[23] National Family Health Survey. Available at: http://rchiips.org/nfhs/. Accessed 25 May 2019.

[24] Vos T, Murray CJL. Measuring the health of populations: the Global Burden of Disease study methods. In: Detels R, Gulliford M, Abdool Karim Q, Tan CC, editors. Oxford textbook of global public health. Oxford: Oxford University Press; 2015. p. 634–44.

[25] Murray CJL, Ezzati M, Lopez AD, Rodgers A, Hoorn SV. Comparative quantification of health risks: consptual framework and methodological issues. In: Ezzati M, Lopez AD, Rodgers A, Murray CJL, editors. Comparative quantification of health risks: Global and regional burden of disease attributable to selected major risk factors: volume 1. Geneva: World Health Organization; 2004. p. 1–38.

[26] Flaxman AD, Vos T, Murray CJL. An integrative meta-regression framework for descriptive epidemiology. Seattle. University of Washington Press; 2015.

[27] Gupta R, Misra A, Pais P, Rastogi P, Gupta VP. Correlation of regional cardiovascular disease mortality in India with lifestyle and nutritional factors. Int J Cardiol 2006;108(3):291–300.

[28] Ram F, Paswan B, Singh SK, et al. National family health survey-4 (2015-16). Econ Polit Wkly 2017;52(16):66–70.

[29] Yusuf S, Joseph P, Rangarajan S, et al. Modifiable risk factors, cardiovascular disease, and mortality in 155,722 individuals from 21 high-income, middle-income, and low-income countries (PURE): a prospective cohort study. Lancet 2020; 395(10226):795–808.

[30] Benjamin EJ, Blaha MJ, Chiuve SE, et al. Heart disease and stroke statistics 2017 update: a report from the American Heart Association. Circulation 2017;135(10): e146–603.

[31] Wilmot KA, O'Flaherty M, Capewell S, et al. Coronary heart disease mortality declines in the United States from 1979 through 2011: evidence for stagnation in young adults, especially women. Circulation 2015;132(11):997–1002.

[32] Hartley A, Marshall DC, Salciccioli JD, Sikkel MB, Maruthappu M, Shahloub J. Trends in mortality from ischemic heart disease and cerebrovascular disease in Europe: 1980-2009. Circulation 2016;133(20):1916–26.

[33] Gulati M, Bairey-Merz CN. Cardiovascular disease in women. In: Zipes DP, Libby P, Bonow RO, Mann DL, Tomaselli GF, editors. Braunwald's heart disease: a textbook of cardiovascular medicine. eleventh ed. New York: Elsevier; 2019. p. 1767–79.

[34] Walli-Attei M, Joseph P, Rosengren A, et al. Variations between women and men in risk factors, treatments, cardiovascular disease incidence, and death in 27 high-income, middle-income and low-income countries (PURE): a prospective cohort study. Lancet 2020;396(10244):97–109. https://doi.org/10.1016/S0140-6736(20)30543-30552.

[35] Unal B, Critchley JA, Capewell S. Explaining the decline in coronary heart disease mortality in England and Wales between 1981 and 2000. Circulation 2004;109(9): 1101–7.

[36] Ford ES, Ajani UA, Croft JB, et al. Explaining the decrease in US deaths from coronary disease, 1980-2000. N Engl J Med 2007;356(23):2388–98.

[37] Weintraub WS, Daniels SR, Burde LE, et al. On behalf of American heart association advocacy coordinating committee and multiple councils. Value of primordial and primary prevention for cardiovascular disease: a policy statement from the American heart association. Circulation 2011;124(8):967–90.

[38] Gupta R, Wood DA. Primary prevention of ischemic heart disease: populations, individuals and health professionals. Lancet 2019;394(10199):585–96.

[39] Rosengren A, Smyth A, Rangarajan S, Ramasundarahettige C, Bangdiwala SI, AlHAbib KF, et al. Socioeconomic status and risk of cardiovascular disease in 20 low-income, middle-income and high income countries: the Prospective Urban Rural Epidemiology (PURE) study. Lancet Glob Health 2019;7(6):e748–60.

[40] O'Neil A, Scovelle AJ, Milner AJ, Kavanagh A. Gender/sex as a social determinant of cardiovascular risk. Circulation 2018;137(8):854–64.

[41] Havranek EP, Mujahid MS, Barr DA, et al. Social determinants of risk and outcomes for cardiovascular disease: a scientific statement from the American Heart Association. Circulation 2015;132(9):873–98.

[42] Mokta M. Empowerment of women in India: a critical analysis. Indian J Publ Adm 2014;60(3):473–88.

[43] Magnani JW, Mujahid MS, Aronow HD, et al. Health literacy and cardiovascular disease: fundamental relevance to primary and secondary prevention: a scientific statement from the American Heart Association. Circulation 2018;138(2):e48–74.

[44] Gupta S, Dhamija JP, Mohan I, Gupta R. Qualitative study of barriers to adherence for anti-hypertensive medications among rural women in India. Int J Hypertens 2019;2019:5749648.

[45] Yusuf S, Rangarajan S, Teo K, et al. Cardiovascular risk and events in 17 low-, middle- and high-income countries. N Engl J Med 2014;371(9):818–27.