Review Article

Cardiovascular Disease in Bangladesh: A Review

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Abstract:

Like elsewhere, cardiovascular disease (CVD) is an increasingly important cause of morbidity and mortality in Bangladesh. Over the past few decades, because of epidemiological transition, the prevailing disease pattern in this country changed from predominantly communicable to predominantly non- communicable disease, CVD contributes to the latter a lot. Actually, CVD particularly coronary artery disease (CAD) is getting epidemic proportion day by day. Hypertension and heart failure are on the rise, whereas the prevalence of acute rheumatic fever is declining. However, despite some efforts, reliable data concerning various aspects of CVD is inadequate at present. The current prevalence of hypertension, CAD, rheumatic fever and rheumatic heart disease and stroke may be 20-25%, 4-6%, <1/1000, 0.3-1.0% respectively. Besides conventional risk factors for different CVD, genetic predisposition and some novel issues like high salt intake, arsenicosis, hypovitaminosis D and air pollution may play important role in the aetiopathogenesis of CVD in this population. Formulation of appropriate policy and more emphasis on preventive strategy may help combat CVD in Bangladesh.

Keywords: Coronary Artery Disease, Hypertension, Rheumatic Heart Diseases, Bangladesh.

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Introduction:

CVD is a major public health problem throughout the world. It is the number one cause of morbidity and mortality world-wide. The economic impact of different types of CVD is enormous. Traditionally, Bangladesh is a developing country burdened with communicable diseases. However, like many other low-income countries in the world, she has been experiencing epidemiological transition; the prevailing disease pattern is changing from communicable diseases to non-communicable diseases (NCD).[1,2] Small pox, once upon a time a regular epidemic, has been eradicated. Cholera is no longer a major threat to our health. The major causes of death in Bangladesh gradually shifted from acute infectious and parasitic diseases to NCDs.[3] In 1986, NCDs represented only 8% of total deaths compared to 52% of deaths due to communicable diseases[1], whereas in 2014, NCDs are estimated to account for 59% of total deaths; CVD is the single-most important contributor, and is responsible for 17% of total mortality[4]. Despite this paradigm shift, little is known regarding the epidemiological pattern and underlying pathophysiology of CVD in Bangladesh. Recognizing these limitations, the present review has been planned to compile the available data on this important public health issue. This review will make a basis for future research and would be a valuable source of information.

Methods:

Data was collected from the available articles searched via PubMed, Google Scholar and BanglaJOL supported by the International Network for the Availability of Scientific Publications up to December, 2016. Besides this, local journals which were not available online but recognized by the Bangladesh Medical and Dental Council were searched as well. Also, some information was collected from personal communication with responsible persons.

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Epidemiology of CVD

CVD is the number one killer worldwide.[5,6] According to the Heart Disease and Stroke Statistics — 2016 update by the American Heart Association, heart disease and stroke continue to be the top two killers worldwide. As of 2013, 31% of all deaths were from CVD, with 80% occurring in low- and middle-income countries; stroke accounted for 11.8% of all deaths. The burden of CVD, especially the CAD is increasing at a greater rate in South Asia than in any other region globally. The prevalence of CVD in India has been estimated to be nearly 3% in 2000, and upto10% in recent years, indicating rising prevalence.[7,8] Also, data from the Registrar-General of India shows that CVD is the top killer of Indians, accounting for 23% of all deaths in 2010-2013 as compared to 20% in 2004-2006.[9] Among the NCDs, CVD is probably the most important cause of mortality and morbidity in Bangladesh. In 2014, NCDs represented 59% of the total deaths; CVD was the single-most important contributor, being responsible for 17% of the country's deaths.[4] According to the Health Bulletin 2015[10], CVD and stroke together was the topmost cause of death in Upazila, District and Medical College Hospitals, and was responsible for 17.78%, 21.83% and 16.32% deaths respectively in 2014. Also, stroke and acute myocardial infarction together was the topmost cause of admission of the indoor patients in Medical College Hospitals across the country in the same year.[10]

The exact prevalence of CVD in Bangladesh is not known. Probably the first attempt to determine the prevalence of heart disease was made by Malik et al. in a survey amongst 7062 people of different age groups in Dacca City and in a village; the surgery revealed the prevalence of 2.92%.[11] Self-reported prevalence of heart disease among the 25 to 64-year-old respondents were 5.3% to 66.3% in males and 7.8% to 77.7% in females in another study in 2005.[12] The wide range of prevalence is presumably due to differences in study design and methodology.

The prevalence of CAD in Bangladesh has been reported to be 0.33% to 19.6% in different studies.[11, 13-6] (Table 1). Despite marked disparity in values, there seems to be a rising prevalence and mortality from CAD.[1,16] A recent study from rural Bangladesh demonstrated a dramatic increase in CVD, and the age-standardized CVD mortality increased by 30-fold (from 16 deaths per 100,000 to 483 deaths per 100,000) among males and 47-fold (from 7 deaths per 100,000 to 330 deaths per 100,000) in females.[1]

Like CAD, hypertension is an increasingly important medical and public health problem in Bangladesh. The reported prevalence varies widely from 1.21% to 32%.[11,16,18-35] (Table 2). According to the Bangladesh NCD Risk Factor Survey 2010[27], the prevalence of hypertension is 17.9% in general, 18.5% in men and 17.3% in women. On the other hand, overall, age-standardized prevalence of prehypertension and hypertension were 27.1 and 24.4%, respectively, in a recently published analysis based on the nationwide population-based 2011 Bangladesh Demographic and Health Survey (BDHS)[29]. Even higher prevalence of hypertension of 40% (95% confidence interval (CI) 38-42%) was found in a population-based study involving 3096 adults aged >30 years from rural Bangladesh.[33] A recently-published meta-analysis concerning risk factors for CVD in Bangladesh found the prevalence of hypertension to be 15.1%.[34]

Table-I

Prevalence of coronary artery disease in Bangladesh.

Reference	Year	Place	Age, year	Diagnostic criteria	No. screened	Prevalence (%)	Type of study
Malik A[11]	1976	Urban and rural	15-74	ECG, chest X-ray	7062	0.33	Cross sectional
Zaman, et al.[13]	2007	Rural	>20	Pathological Q wave or current medication	447	3.4;male 4.6, female 2.7	Cross sectional
Ahsan et al.[14]	2009	Urban; UGC Employee	Mean age 44.8	Not defined; ECG and echo were used	163	20.9	Cross sectional
Sayeed et al.[15]	2010	Rural	≥20	1) H/o angina plus ECG +ve; 2)post-MI with Q or non-Q MI; 3) diagnosis by a cardiologist.	768	1.85	Cross sectional
Parr et al.[16]	2011	Urban and rural	>25	Self-reported	8591	5.1; urban 6.0, rural 4.7	Cross sectional

UGC: University Grants Commission

Table-II

Prevalence of hypertension in Bangladesh.

Reference	Year	Place	Age, year	Diagnostic criteria (BP in mmHg)	No. screened	Prevalence (%)	Type of study
Malik A[11]	1976	Urban and rural	15-74	Not mentioned	7062	1.21	Cross sectional
Ullah W.[18]	1976	Rural	>20	Not mentioned	17569	2.6	Cross sectional
Islam et al.[19]	1983	Rural		dBP >90	5026	6.70	Cross sectional
Sayeed et al.[20]	1994	Rural	>15	sBP >140 and dBP ≥90	1005	sHTN 10.5; dHTN 9.0	Cross sectional
Sayeed et al.[21]	2002	Urban and rural	≥20	sBP ≥140 and dBP ≥90	2361	sHTN 14.4; dHTN 9.1	Cross sectional
Sayeed et al.[22]	2003	Rural	≥20	Not mentioned	4923	Male 15.7; female 22.5	Cross sectional
Zaman et al.[23]	2004	Rural	≥20	sBP≥140 ± dBP ≥90 ± medication	1271	17.8	Cross sectional
Chen et al.[24] HEALS study	2006	Rural	≥18	sBP≥140 or dBP ≥90 or, medication	11116	13.3	Cross sectional
Rahim et al.[25]	2007	Rural	≥20	sBP≥140 and dBP ≥90	1999: 4757; 2004: 3981	1999: sHTN 6.8, dHTN 6.6; 2004: sHTN 8.5, dHTN 6.9	Cross sectional
Van Minh et al.[12]	2008	Rural	25-64	Self-reported	7153	HSID: 14.6; WATCH: 17.1; Matlab: 10.6	Cross sectional
Bangladesh NCD Risk Factor Survey 2010[27]	2010	Urban and rural	≥ 25	BP≥140/90 or, medication	9,275	17.9	Cross sectional
Parr et al.[16]	2011	Urban and rural	>25	Self-reported	8591	13.60	
Cravedi et al.[28]	2012	Rural	>18	By clinical staff	1518	18.5	Cross sectional
BDHS 2011[29]	2013	Urban and rural	≥ 35	Pre-HTN: sBP 120-139 ± dBP 80-89; HTN: sBP≥140 ± dBP ≥90 or, medication	17,964	In male: Pre-HTN 27, HTN 19; In females: Pre-HTN 28, HTN 32	Cross sectional
Bhowmik et al.[30]	2013	Rural	≥ 20	sBP≥140 and dBP ≥90	4757	1999: 14.3; 2004: 18.4; 2009: 14.0	Cross sectional
Neupane et al.[31]	2014	Urban and rural		Pre-HTN: sBP 120-139 ± dBP 80-89; HTN: sBP≥140 ± dBP ≥90 or, medication		17.9	Meta-analysis
Khanam et al.[32]	2015	Rural	≥ 25	Pre-HTN: sBP 120-139 ± dBP 80-89; HTN: sBP≥140 ± dBP ≥90 or, medication	6,094	Pre-HTN 31.9; HTN 16.0	Cross sectional
Islam et al.[33]	2016	Rural	≥30	sBP≥140 and dBP ≥90 or, self-reported	3096	40	Cross sectional
Fatema et al.[34]	2016	Urban and rural	Different	Different		15.1	Meta-analysis

BP, blood pressure; sBP, systolic blood pressure; dBP, diastolic blood pressure; HTN, hypertension; sHTN, systolic hypertension; dHTN, diastolic hypertension; BDHS, Bangladesh Demographic and Health Survey; NCD, non-communicable diseases; HEALS, Health Effects of Arsenic Longitudinal Study; HSID, Health System and Infectious Disease; WATCH, Woman Abuse Tracking in Clinics and Hospitals

Rheumatic fever (RF) and rheumatic he art disease (RHD) are common CVD in Bangladesh. Data regarding the incidence and prevalence of these conditions vary widely.[36-42] (Table 3). However, over the past 3 decades, there is a declining trend of acute RF in the country. However, chronic RHD continues to be an important public health problem here. Current prevalence of RF and RHD may be <1/1000.[43] Recently, conventional and portable echocardiography is being used increasingly in studies concerning RF and RHD, as a result, more and more subclinical cases of RHD are being diagnosed. So, the prevalence of RF and RHD estimated so far may not be accurate, and the true prevalence of RHD may be much higher in Bangladesh as well.

Data regarding the incidence and prevalence of heart failure at the community level in Bangladesh are almost non-existing. In a hospital-based retrospective study at a tertiary cardiac hospital in Dhaka City[44], about one-seventh (1970 out of 14009) of the patients admitted between January 2005 and August 2006 had heart failure. Majority (35.79%) had CAD as the principal etiological factor, whereas hypertension was the primary risk factor for HF in 29.14% of cases. In another hospital-based study conducted in the National Institute of Cardiovascular Diseases (NICVD), Dhaka in 2009 involving 780 patients, 27.25% had heart failure.[45]

Little is known regarding the incidence and prevalence of congenital heart disease (CHD) in Bangladesh. A proportion of CHD in children may remain undetected unless specific efforts are made to diagnose them. In a prospective, hospital based study conducted over January 2006 to December 2008 in the Pediatric Cardiology unit of Combined Military Hospital (CMH) Dhaka, 142 babies out of 5668 live birth had CHD, giving an incidence of 25/1000 live births. Most common CHDs were atrial septal defect (ASD, 26%), ventricular septal defect (VSD, 16.9%), patent ductus arteriosus (PDA, 18%), tetralogy of Fallot (TOF, 14%), and pulmonary stenosis (PS, 7.75%).[46] Another study[47] conducted in Dhaka Shishu Hospital from January 2008 to December

Table-III
Prevalence of RF and RHD in Bangladesh.

Reference	Year	Place	Age, years	Echo used or not	No. screened	Prevalence (per 1000)	Type of study
Malik[10]	1976	Urban and rural	Different ages	No	7062	7.5, combined RF and RHD	Community project
Ahmed et al.[36]	1991	Rural	5-15	Yes, in selected cases	5923	RF 1.2; RHD 1.3	Community project
Haque et al.[37]	1992	Urban and rural	5-15	Yes, in selected cases	Urban 9875, rural 5923	3.6, combined RF and RHD	School and house to house survey
Banoo et al.[38]	1984-85	Urban	4-17	No	4349	RF 43.9; RHD 5.05	School survey
Mahmud et al.[39]	1989	Urban	5-18	Yes, in selected cases	5011	RF 0.85; RHD 2.8	School survey
Begum et al.[40]	1990-91	Urban	5-18	Yes, in selected cases	10538	RF 2.37; RHD 0.189	School survey
Majumder et al.[41]	2004	Rural	5-16	No	947	RF 4.22; RHD 0	School survey
Zaman et al.[42]	2005	Urban and rural	5-19	Yes	56827	RF 0.6; RHD 0.3	Cross-sectional survey

RF, rheumatic fever; RHD, rheumatic heart disease

2009 prospectively and from January 1998to December 1999 retrospectively, involved subjects aging from 1st day of life to 12 years of age. Majority were acyanotic congenital heart disease (75% and 78.5% in the past and present respectively); VSD was the commonest lesion (32.7% and 26.9% respectively), followed by ASD (25.6% and 21.2% respectively). TOF was the commonest cyanotic lesion both in the past and present.VSD (42.6%) was the commonest type of congenital heart disease reported in another prospective 1-year study among the admitted children (newborn to 12 years) in the Department of Paediatrics of Rajshahi Medical College & Hospital.[48] Other major types were TOF (18.3%), ASD (14.8%), and PDA (7.8%). A more recent retrospective study from 2010 to 2013 conducted in Sir Salimullah Medical College Hospital, Dhaka, demonstrated that out of 6520 cases of live births, 196 had CHD giving the incidence 30/1000 live births. Among the congenital heart lesions, the prevalence of ASD, VSD, PDA, TOF and transposition of great arteries (TGA) were 20.41%, 13.78%, 10.71%, 8.67% and 4.59% respectively.[49]

At present, there are probably no available data regarding arrhythmias, cardiomyopathies and peripheral arterial disease in Bangladesh.

Data regarding prevalence of stroke in Bangladesh is inadequate. The prevalence of stroke has been estimated from a community study involving 15,627 participants aged >40 years[50] with an overall prevalence of stroke of 0.30%. Stroke prevalences were reported as 0·20%, 0·30%, 0·20%, 1·00%, and 1·00% for the age groups of 40–49 years, 50–59 years, 60–69 years, 70–79 years, and 80 years and above, respectively. In a recently published study, the prevalence of stroke in rural population aged >30 years has been found to be 0.94% in general, 1.45% in male and 0.45% in female.[51]

Data regarding the prevalence of CVDs in Bangladesh are insufficient and not homogeneous. Well-designed epidemiological studies are needed to generate reliable and uptodate data which can be applied in formulation and implementation of healthcare policies at national level. , Realizing these limitations the estimated current prevalence of different CVDs in the country is shown in Table 4.

Risk factors of CVD in Bangladesh

Ethnicity and genetics

Ethnicity is an important determinant of prevalence of CVD specially CAD. When compared to other ethnicities, South Asians i.e. individuals originally from India, Pakistan, Nepal, Bangladesh and Sri Lanka, have a high prevalence of CAD and associated risk factors.[52-4] South Asians have a 3 to 5-fold increased risk of myocardial infarction.[55] South Asians also present with more severe disease and at an earlier age than Caucasians.[56] The London Life Sciences Population Study (LOLIPOP) and the Pakistan Risk of Myocardial Infarction Study (PROMIS) have given important insights into the genetics associated with the undue susceptibility of the South Asians to cardio-metabolic conditions including CAD.[57,58] Over 25 cosmopolitan loci for CAD[59,60] and type 2 diabetes[61-3] have already been discovered showing that there are genetic risk factors for cardio-metabolic conditions that apply to people of South Asian ancestry and to people of European ancestry. Bangladeshis appear to share with other South Asian populations the same susceptibility to CAD; however, the probability of existence of an even more prone 'Bangladeshi ethnicity' in not impossible.[17] In concert with this concept, the initial analyses of the ongoing Bangladesh Risk of Acute Vascular Events (BRAVE) study indicates that Bangladeshis are genetically distinct from major non-South Asian

Table-IV

Prevalence of cardiovascular diseases in Bangladesh.

Disease	Prevalence
Hypertension	20-25% in adults
Coronary artery disease	4-6% in adults
Rheumatic fever/Rheumatic heart disease	<1/1000 in children and young adults
Congenital heart disease	25-30/1000 live births
Stroke	0.3-1.0% in adults
Heart failure, arrhythmias, cardiomyopathies and peripheral arterial disease	No available data

ethnicities, as well as distinct from other South Asian ethnicities and were perhaps genetically closest to (though still distinct from) Sri Lankan Tamils.[64] There may also be genetic susceptibility to hypertension. The association between angiotensin converting enzyme (ACE) gene polymorphism and blood pressure has been studied inadequately in Bangladeshi population.[65,66] In 2002, Morshed et al. found positive association between ACE insertion/ deletion (I/D) polymorphism and hypertension in Bangladeshi population. Among the three ACE I/D variants, the DD genotype was associated with the highest value of both mean systolic and mean diastolic blood pressure (p = <0.05) in men. In the overall population, blood pressure was highest in DD, intermediate in ID, and the least in II subjects. Further research is needed to clarify this relationship.

Diabetes mellitus

Diabetes has become a national health concern in Bangladesh. The BDHS 2011 showed the overall, age-standardized prevalence of diabetes and pre-diabetes to be 9.7% and 22.4%, respectively; among urban residents, the age-adjusted prevalence of diabetes was 15.2% compared with 8.3% in rural residents.[67,68] The prevalence of diabetes mellitus was 7.4% (95% CI 7.2-7.7%) in a recently published review involving 51,252 participants, and also there was an increasing trend of diabetes prevalence among urban and rural population in Bangladesh.[69]

According to the International Diabetes Federation assumption in 2010, the explosion in diabetes prevalence will place Bangladesh among the top 7 countries in terms of the number of people living with diabetes in 2030.[70]

Smoking and smokeless tobacco use

Tobacco use is quite common in Bangladesh. Bangladesh is one of the top 10 countries that make up two-thirds of the world population of smokers.[71] According to the Bangladesh NCD risk factor survey 2010, the prevalence is 51.0% for any form of tobacco, 26.2% for smoking and 31.7% for smokeless tobacco (SLT).[27] Current tobacco use is 43.3% in Bangladesh; exclusively smoking is 16.1%, exclusively using SLT 20.3%, and dual use of smoking and SLT is 6.8% according to the Global Adult Tobacco Survey (GATS).[72] The prevalence of smoking among men in Bangladesh is higher than the world average of daily smoking among men (37% vs. 31.1%).[73] According to a proportional mortality study, smoking causes about 25% of all deaths in Bangladeshi men aged between 25 to 69 years and an average loss of 7 years of life per smoker.[74] However, currently published research does not provide conclusive evidence regarding the association between SLT use and CAD. In a recently published systematic review, 9 studies found no statistically significant positive association between SLT use and CAD, while 9 studies did find a positive association.[75]

Dyslipidaemia

The excess burden of CAD among South Asians appears to be primarily due to dyslipidemia that is characterized by high levels of apolipoprotein (apo) B, triglycerides (TG), and lipoprotein (Lp)(a); borderline high levels of low-density lipoprotein cholesterol (LDL-C); and low levels of high-density lipoprotein cholesterol (HDL-C) and apoA1.[76] Liberal use of saturated fats and trans fats, deep frying, reuse of cooking oil, and overcooking leading to destruction of folates may all contribute to dyslipidaemia in this population.[78] Studies exclusively related to dyslipidaemia are sparse in Bangladesh. A study[79] involving 51,353 predominantly urban population during 2005-2011 demonstrated significantly higher mean serum levels of total cholesterol (TC), LDL-C, TG, LDL to HDL cholesterol ratio and TC to HDL-C ratio among younger adults aged 30-39 years compared to other age groups, regardless of sex, which may lead to microvascular complications. Another study[80] involving 3201 individuals found rising trend of dyslipidaemia in sub-urban population; prevalence of dyslipidaemia was 16.6% in general and 22.2% in males and 15.9% in females. TC was high (>240 mg/dl) in 16.9%, LDL-C was high (>160 mg/dl) in 15.7%, HDL-C was low (<40 mg/dl) in 8.8%, and TG was high (>200 mg/dl) in 17.8% and very high (>350 mg/dl) in 2.0% population. Women had significantly higher TC and LDL-C in comparison to men above 40 years. Contrary to the popular belief, dyslipidaemia is common in rural people as well.[81] Studies are needed to determine the lipoprotein profile of the population for better understanding of the contribution of dyslipidaemia to the aetiopathogenesis of CVD.

Lifestyle related factors

As a result of socioeconomic transition, lifestyle, as well as, the dietary pattern is changing in Bangladesh. Increasing prevalence of obesity, tobacco use, high intake of processed foods and less physical activity accompany this transition.

Prevalence of overweight and obesity is increasing. In general, 21.5% adults (male 21%, female 22%) have

body-mass index (BMI) ≥25 kg/m^2; increased waist circumference is alarming especially in women (33.7%).[27] In a population-based, cross-sectional survey conducted in 2009 involving 2293 subjects aged ≥20 years from rural Bangladesh[82], the age standardized prevalence of overweight (BMI 23-24.9 kg/m^2) and obesity (BMI ≥25 kg/m^2) were 17.7% (95% confidence interval (CI): 16.1,-19.2%) and 26.2% (95% CI: 24.4-27.9%), respectively. The age standardized prevalence of central obesity based on waist circumference (male ≥90 & female ≥80 cm) and waist hip ratio (male ≥0.90 and female ≥0.80) were 39.8% (95% CI: 37.9, 41.7%) and 71.6% (95% CI: 69.8, 73.4%) respectively. The prevalence of central obesity was more in female than male. Both total obesity and abdominal adiposity were associated with development of CAD in Bangladeshi population.[83] Childhood obesity is a growing concern in this population as well. A recent review showed an increasing trend in childhood obesity over time in Bangladesh; prevalence ranged from less than 1% to 17.9% based on different reference standards, with higher percentage amongst urban children.[84] In a recent countrywide cross sectional study, from June to September 2009 among 10,135 students of 6 to 15-year age group from both the urban and rural schools[85], 3.5% were obese, 9.5% were overweight and 17.6% were underweight. The proportion of obese and overweight students were greater among the students from urban schools (5.6% and 10.6% respectively) compared to the students from rural schools (1.2% and 8.6% respectively) (Risk difference, RD = 4.3, 95% CI = 3.6, 5.0; RD = 2.0, 95% CI = 0.1, 3.1). A recent study[86] found a high prevalence of overall and central obesity in adolescent girls in Bangladeshi population; the prevalence of obesity and overweight were 23% and 14%, whereas the prevalence of central obesity was 26%. Around 14% of girls in the normal weight group were centrally obese.

The prevalence of metabolic syndrome is also high in Bangladesh. In a recent population-based cross-sectional study involving 2,293 randomly selected participants (aged ≥20 years) in a rural community in Bangladesh, the age-adjusted prevalence of metabolic syndrome was 30.7% (males 30.5%; females 30.5%) using the National Cholesterol Education Programme (NCEP) Adult Treatment Panel III (ATP III) definition, and 24.5% (males 19.2%, females 27.5%) using the International Diabetes Federation (IDF) definition.[87] In another study, the prevalence of metabolic syndrome was found to be 20.7%, 11.2% and 8.6% following ATP III, IDF and by the World Health Organization (WHO) definitions, respectively.[88] Metabolic syndrome is probably commoner in women.[88,89] The prevalence of metabolic syndrome was found to be 31.25% (NCEP ATP III modified) in 1485 rural women of Bangladesh aged ≥15 years.[90]

Sedentary life style may have an association with CAD. Bangladesh NCD Risk Factor Survey 2010[27] found low level of physical activity (<600 metabolic equivalent-minutes) per week. Future research is needed to determine the association of physical inactivity to the high incidence of CAD in Bangladesh.

Dietary pattern may play role in aetiopathogenesis of CVD. Like many other developing countries, socioeconomic transition is accompanied by a changing dietary pattern in Bangladesh. A prospective cohort analyses in 11,116 participants enrolled in the Health Effects of Arsenic Study in Araihazar, Bangladesh, with a follow-up of average 6.6 years, an animal protein-rich diet in rural Bangladesh was associated with increased risk of CVD mortality, especially among smokers.[91] Diets were classified in patterns: (i) a “balanced” pattern, comprised of steamed rice, red meat, fish, fruit and vegetables; (ii) an “animal protein” diet, which was more heavily weighted towards eggs, milk, red meat, poultry, bread, and vegetables; and (iii) a “gourd and root vegetable” diet that heavily relied on a variety of gourds, radishes, pumpkin, sweet potato, and spinach. ‘Western’ dietary pattern was associated with greater longitudinal increase in blood pressure in comparison to the ‘gourd vegetable’ dietary pattern and the ‘balanced’ dietary pattern.[92] Similar observations were found in a previous study.[93] In the participants (n-1149) randomly selected from the Health Effects of Arsenic Longitudinal Study, a gourd/root vegetable diet in this Bangladeshi population positively correlated with carotid intima-media thickness a validated surrogate marker of preclinical atherosclerosis, while a balanced diet was associated with decreased intima-media thickness.[94]

The average Bangladeshi eats a total of 126 g of fruit and vegetables daily[95], which is far below the minimum daily consumption of 400 g of vegetables and fruit recommended by Food and Agriculture Organization of the United Nations and the WHO.[96] Bangladesh NCD Risk Factor Survey 2010 revealed 95.7% people consume inadequate fruit and/or vegetables (<5 servings per day)[26]

High salt intake appears to be a significant problem with Bangladeshi population based on the data from salt production and sales, average daily intake has been calculated to be 15 g.[97] A more recent study using spot urine analysis found very high average sodium intake of

21 g/day.[98] Considering these data, salt intake in this country appears to be much higher than what is recommended by the WHO (sodium chloride <5 g/day, sodium <2 g/day)[99] or the 2015–2020 Dietary Guidelines for Americans (sodium <2.3 g/day in general and children ages >14 years, and <1.5 g/day for individuals with prehypertension and hypertension).[100] Extra salt intake along with age, BMI, physical inactivity, tobacco use and family history of stroke/CVD was found to have significant relationship with hypertension and pre-hypertension in a cross-sectional survey involving participants aged e" 25 years in an urban area in Dhaka between June to December 2012.[101] Also, more than 35 million people in coastal Bangladesh are vulnerable to increasing freshwater salinization; elevated salinity in drinking water has been found to be associated with higher BP in young coastal populations.[102] The overall risk perception regarding excessive salt consumption is low and there is widespread belief that the cooking process can render the salt harmless.[103] High salt intake presumably contributes to hypertension, which is an established risk factor for CAD.

Low-Birth Weight and Childhood Malnutrition

The developmental origin theory of CAD proposes that undernutrition in utero permanently changes body functions and metabolism leading to an increased risk of CAD in adult life.[104-6] However, a recently published study involving German youths aged 3-18 years did not find significant association between birth weight and traditional cardiovascular risk factors.[107] Low birth weight (<2,500 g) affects 36% of infants in Bangladesh, more than twice of 15% threshold that indicates a public health burden. Also, <1% of infants are born with very low birth weight (<1,500 g).[108] Research is needed to explore association, if any, between the two public health problems i.e. low birth weight and CAD in this community. Under-nutrition during childhood, adolescence, or young adulthood is related to CAD and stroke in adult life.[109,110] Despite the progress achieved, rates of malnutrition in Bangladesh are among the highest in the world; more than 54% of preschool-age children, equivalent to more than 9.5 million children, are stunted, 56% are underweight and more than 17% are wasted.[111] An analysis revealed that among the children under five years of age 16% were severely stunted, 25% moderately stunted, 3% severely wasted and 14% were moderately wasted; furthermore, 11% of the children were severely underweight and 28% were moderately underweight.[112] Such a high prevalence of low-birth weight childhood under-nutrition may facilitate development of CAD in adult in Bangladeshi population.

Hypovitaminosis D

Role of Vitamin D in cardiovascular health is of much interest at present. Experimental, as well as, some observational studies suggest that vitamin D and its metabolites are integrally related to blood pressure and the renin-angiotensin system. Vitamin D insufficiency affects almost 50% of the population worldwide. Few studies have been carried out to determine the prevalence of hypovitaminosis D in Bangladesh. In a recently published study involving husbands of pregnant women in Dhaka, vitamin D deficiency was prevalent in both men and women but men had substantially higher circulating 25-hydroxycholecalciferol (25(OH)D) concentrations and lower risk of vitamin D deficiency than their pregnant spouses; gender-related lifestyle factors, rather than ethnic or environmental factors likely explain the high risk of vitamin D deficiency among women of reproductive age in Bangladesh.[113] Vitamin D deficiency was found prevalent in young infants in rural Bangladesh.[114] High prevalence of suboptimal serum 25(OH)D level (<25 nmol/l) was described in lactating women of low socioeconomic status and those wearing Shari, a traditional ladies wear.[115] In another survey of women aged 18–60 years, serum 25(OH)D levels were <40 nmol/l in 78% of 36 university students and 83% of 30 veiled women.[116] Further research is needed to evaluate the association, if any, between vitamin D deficiency and CAD in Bangladesh.

Chronic arsenicosis

Arsenic contamination of groundwater in Bangladesh has been recognized as a massive public health hazard. Positive association has been found between chronic arsenic exposure and CVD[117-21], ECG abnormalities[121], hypertension[122], and stroke[123]. Chronic arsenic exposure may facilitate systemic inflammation and vascular endothelial dysfunction, which may, in turn, increase the risk of CVD. The Health Effects of Arsenic Longitudinal Study in Bangladesh (2007–2008) has reported positive association between arsenic exposure from drinking water and plasma levels of markers of systemic inflammation and endothelial dysfunction.[124] In the same population, positive association has been found between inorganic arsenic exposure from drinking water and risk of hypertension[125-6], and more recently, increased cardiovascular mortality. Further basic, as

well as, clinical research is needed to better define the role of arsenicosis in the aetiopathgenesis of CVD in Bangladeshi population.

Air Pollution

In the recent years, air pollution has been suggested to contribute to cardiovascular illness. The overall evidence is consistent with a causal relationship between exposure to particulate matter <2.5 μm in diameter ($PM_{2.5}$) and cardiovascular morbidity and mortality.[128] Air pollution is a significant problem specially in the urban areas of Bangladesh with marked temporal and directional variations in particulate matter concentrations.[129] A study to evaluate the emissions and air quality in megacities found Dhaka to have the poorest air quality in respect of total suspended particles (TSP), sulfur dioxide (SO_2), and nitrogen dioxide (NO_2) among the megacities, and the pollutant levels were far beyond the WHO standard.[130] One recent study involving Dhaka City found elevated concentrations of the number, surface and mass distributions of particulate matters; fine particles (0.5–1.0 μm) derived from vehicle emissions were dominating the aerosol particles number concentrations.[131] Investigation of sources of atmospheric aerosol at urban and semi-urban areas in Bangladesh revealed soil dust, road dust, cement, sea salt, motor vehicles and biomass burning to be the main sources of air pollution.[132-1] Vehicular emissions and emission from brick kiln are the major contributors to air pollution in Dhaka especially during dry seasons, while contribution from emissions from metal smelters increases during rainy seasons.[134] In rural areas, indoor air pollution from the combustion of traditional biomass fuels is a significant public health problem in many developing countries, including Bangladesh. One study found the major constituent of the particulate matter in rural air was carbonaceous matter.[135] Chronic exposure to the particulate matter in indoor air from combustion of traditional biomass fuels may be a contributor to the CAD in rural women who are specially concerned with cooking. In a retrospective cohort study in Matlab, Bangladesh, household solid-fuel use was associated with increased respiratory mortality and non-significantly increased risk of cardiovascular mortality.[136] Further research is needed to elucidate the role of air pollution to the aetiopathogenesis of CVD in Bangladeshi population.

Cardiovascular Care in the Past

Traditionally, cardiac diseases were treated by physicians specialized in medicine. In the Government sector, the cardiac patients were managed in the medicine outpatient and inpatient departments; the facilities were limited to the medical college hospitals, the formerly Institute of Postgraduate Medicine & Research (IPGMR), and the Combined Military Hospital (CMH).The first coronary care unit was established at IPGMR where electrocardiogram (ECG) and phono-cardiographs were available.

First integrated cardiovascular care started in this country with the establishment of the then Institute of Cardiovascular Diseases (ICVD), later named as the National Institute of Cardiovascular Diseases (NICVD) in 1978, and formally in 3rd April 1981. Generous technical and financial cooperation was provided by the Government of Japan in the advent of cardiovascular care in Bangladesh. Besides medical management, invasive diagnostic and therapeutic modalities were started there. First permanent pacemaker implantation was done in 1981. Since the introduction of angioplasty by Gruentzig in 1977, Bangladesh took more than a decade to make appropriate utilization of this technology. Percutaneous transluminal coronary angioplasty (PTCA) was introduced in ICVD by foreign experts in 1987; the first case was failed, while 1 case was successfully done in 1990. First PTCA was done by Bangladeshi team in 1995, first coronary stenting in 1997.[137-9] First pulmonary valvuloplasty was done in1987, while percutaneous transluminal mitral commissurotomy (PTMC) was introduced in1996. For the first time, few cases of closed mitral commissurotomy (CMC) were done in IPGMR in 1973 by Prof. Ali Ashraf, and then in National Institute of Diseases of Chest & Hospital (NIDCH) in 1979 by Prof. SR Khan. (Ahmed NU. Professor of Cardiac Surgery. Personal communication. 25 Dec 2013). First open heart surgery was done in NICVD in 1981, while coronary artery bypass grafting (CABG) was done in NICVD for the first time in 1985. CMC started in NICVD in 1980, and subsequently, a good number of cases were done at low cost with good results.[140-1] Under the patronization of Dr. Rafique Ahmed of USA, non-pharmacological management of cardiac arrhythmia started in Bangladesh; an electrophysiology (EP) lab was established in NICVD, and the first EP study was done in July 2004. Also under his supervision, automated implantable cardioverter-defibrillator (AICD) was implanted for the first time in NICVD in 2005. First device closure of PDA was done in 2006 in the same institute.

Present Status of Cardiovascular Care Facilities

After the 80s, cardiovascular care facilities in Bangladesh have increased steadily. At present, a good number of institutions are rendering cardiovascular care throughout the country; also, they are becoming decentralized. The cardiac care institutions in Bangladesh are public, private and autonomous. Some are dedicated cardiac institutions, while others are in fact multi-specialty institutions having cardiac care facilities. At present, cardiovascular intervention and surgical facilities are available approximately in 30 and 25 institutions respectively. There are 39 catheterization laboratories as in November, 2016. Almost all conventional noninvasive modalities including ECG, echocardiography,

exercise tolerance test are being more widely used for diagnosis of cardiac diseases. Side by side, invasive modalities are becoming more and more available; facilities for coronary angiogram and cardiac catheterization are rapidly expanding. More sophisticated diagnostic facilities including computed tomography (CT) coronary angiography, transesophageal and 3-dimensional echocardiography, electrophysiological study , fractional flow reserve , and optical coherence tomography are available in selected centres.

Besides diagnostic modalities and techniques, treatment facilities have also increased in numbers. Besides percutaneous coronary intervention (PCI), and PTMC, radiofrequency ablation for arrhythmias, AICD implantation, biventricular pacing, and device closure of shunt lesions are also available in practice. Different types of CABGs including OBCAB, minicab, midCAB, valve surgeries, surgery of congenital heart lesions, and importantly, vascular surgeries are in rapid evolution. Classically, severe cases of mitral stenosis with suitable valve morphology were managed by surgery i.e. CMC. However, open mitral commissurotomy (OMC) is being used for suitable, complicated cases, like before. On the other hand, for mitral valve replacement, some bioprostheses were used initially, which were later replaced by metallo-prostheses. Initial ball-and-case metallic valves are out of use now-a-days, majority of the prostheses used today are bileaflet valves. In the recent years, primary angioplasty is being performed in Government[14], as well as, in private[144] centers.

At present, no complete registry concerning CVD and cardiovascular care including interventions exist in Bangladesh. Hence, the available data are incomplete. Recently, a registry has been formulated and maintained by the Bangladesh Association of Cardiovascular and Thoracic Anaesthesiologists (BACTA); the purpose is to maintain data regarding the cardiovascular and thoracic operations done throughout the country. A registry involving

Table-V

Catheterization laboratory procedures performed in the NICVD in 2001-2016. (Rahman SW. Statistics Officer, NICVD. Personal communication. 28 February 2017)

Procedures	2001	2002	2003	2004	2005	2006	2007	2008	2009	2010	2011	2012	2013	2014	2015	2016
Coronary angiography	1043	1378	2827	3210	2780	3105	3266	3980	4437	4711	4426	4881	4239	4241	3452	5537
Cardiac Cath	250	206	308	225	227	229	295	380	340	334	251	256	240	183	99	163
Renal angiography	04	06	13	69	06	0	0	0	01	06	12	1	05	-	-	-
Renal angioplasty	0	0	0	0	0	0	0	0	09	07	17	6	04	-	-	-
Peripheral angiography	116	97	42	93	85	106	87	112	112	124	124	120	150	121	112	186
PCI	163	228	371	599	488	584	574	889	1149	1312	1254	1681	1828	1898	1413	2316
Peripheral angioplasty	0	0	0	0	04	7	43	23	03	18	12	22	13	-	2	40
PTMC	74	92	189	273	295	280	20	130	154	187	117	137	137	111	89	111
Device closure	0	0	0	0	0	01	0	0	0	0	0	-	-	-	69	165
EPS & RFA	0	0	0	0	0	161	204	113	177	66	72	56	57	35	130	255
PPM	244	344	320	333	368	321	359	414	487	402	418	461	439	525	552	568
TPM	525	634	646	715	708	675	850	741	950	647	905	1090	910	992	1077	1198
Others	04	11	12	13	07	04	0	18	40	56	34	97	93	123	93	191
Total	**2423**	**2996**	**4728**	**5530**	**4968**	**5473**	**5698**	**6800**	**7859**	**7870**	**7642**	**8808**	**8115**	**8229**	7088	10730

NICVD, National Institute of Cardiovascular Diseases; PCI, Percutaneous coronary intervention; PTMC, Percutaneous transvenous mitral commissurotomy; EPS, Electrophysiological study; RFA, Radiofrequency ablation; PPM, Permanent pacemaking; TPM, Temporary pacemaking.

Table-VI

Cardiovascular surgeries done in the NICVD in 2001-2016. (Rahman SW. Statistics Officer, NICVD. Personal communication. 28 February 2017)

Year	Open heart surgery					Closed heart surgery	Vascular surgery		
	CABG	Valve	Congenital	Other	Total		Routine	Emergency	Total
2001	60	134	133	03	330	157	100	193	293
2002	112	89	210	04	415	151	114	232	346
2003	170	142	162	22	496	140	69	153	222
2004	180	159	205	17	561	95	92	208	300
2005	267	102	237	20	626	93	90	206	296
2006	226	113	255	28	622	70	95	405	500
2007	188	165	256	46	655	58	121	447	568
2008	233	182	327	21	763	63	152	840	992
2009	218	264	364	11	854	71	219	1001	1220
2010	152	304	365	37	859	88	254	1036	1290
2011	101	207	342	67	717	98	183	1640	1823
2012	175	249	468	57	949	82	254	1274	1528
2013	147	293	450	26	916	41	265	1214	1479
2014	103	310	492	28	943	48	265	1258	1523
2015	147	239	393	149	928	31	301	1560	1861
2016	206	226	464	99	995		222	1602	1824

NICVD, National Institute of Cardiovascular Diseases; CABG, Coronary artery bypass graft

Table-VII

Cardiac surgeries done in Bangladesh in 2015.[145-6]

Type of surgery		2014	2015
Coronary	CABG	4809	5305
	CABG+Valve/ASD/VSD	77	83
Valvular	MVR	535	509
	AVR	248	251
	DVR	172	151
Congenital	ASD	789	779
	VSD	456	405
	TOF (Total correction)	358	390
	BT shunt	23	33
	PDA	165	207
Miscellaneous		378	1221
Total		8060	9094

CABG, Coronary artery bypass graft; Valve, Valvular surgery; ASD, Atrial septal defect; VSD, Ventricular septal defect; MVR, Mitral valve replacement; AVR, Aortic valve replacement; DVR, Double valve replacement; TOF, Tetralogy of Fallot; BT, Blalock–Taussig shunt; PDA, Patent ductus arteriosus.

the cardiac interventions done is under construction on behalf of the Bangladesh Cardiac Society.

Data available from NICVD and the registry maintained by BACTA are being presented here. (Table 5 to 8)

Besides curative services, there are some efforts to ensure preventive and promotive services.

In the current Health, Population and Nutrition Sector Development Program (HPNSDP) 2011-2016, control of NCDs, including CVDs is one of the topmost priority areas of healthcare in the country.[10] Government has formulated National NCD Strategy and plan of action. Different non-Government organizations, including WHO are playing important role in this regard as well.

The BRAVE [Bangladesh Risk of Acute Vascular Events] study

Despite the enormous magnitude of CVD in Bangladesh, the volume and quality of research related to this issue is limited. Also, many aspects of CVD in Bangladesh, including the undue prevalence of CAD in this population, are unknown. The Bangladesh Risk of Acute Vascular Events (BRAVE) study is an epidemiological bioresource established to examine environmental, genetic, lifestyle and biochemical determinants of CAD among the Bangladeshi population.[64] This study is a joint collaboration of Cambridge University of UK, International Centre for Diarrhoeal Disease Research, Bangladesh (ICDDRB) and the NICVD in Dhaka of Bangladesh. The study was established in 2011 by the Department of Public Health and Primary Care at the University of Cambridge (the study's international coordinating centre), in collaboration with the Chronic NCD Unit at ICDDRB and at NICVD in Bangladesh. By early 2015, the ongoing BRAVE study had recruited over 5000 confirmed first-ever myocardial infarction cases, and over 5000 controls "frequency-matched" by age and sex. Initial analyses indicate that Bangladeshis are genetically distinct from major non-South Asian ethnicities, as well as distinct from other South Asian ethnicities. Also, several environmental contaminants (e.g. arsenic in the blood) and nutritional elements (e.g. zinc deficiency) are emerging as important drivers for heart attacks in this population.

DNA genotyping data of 5755 subjects of the BRAVE study have been used in a recent study also involving the participants of the PROMIS study, and the participants belonging to the European ancestry.[147] The study demonstrates that carriers of loss-of-function mutations in ANGPTL4 gene had triglyceride levels that were lower than those among noncarriers; these mutations were also associated with protection from CAD.

Future Directions

Data related to different aspects of CVD in Bangladesh are inadequate. Large, preferably nationwide epidemiological and clinical studies should be carried out to gain reliable information on this important public health issue. CVD prevention should be integrated with primary health care. Cardiovascular health promotion should be part of the national media strategy and the health education curriculum. The public health approach should target population-wide lifestyle intervention, screening for high blood pressure, diabetes and dyslipidaemia. Healthy lifestyles including consumption of heart-healthy diets, avoidance to smoking and smokeless tobacco, moderation of salt intake and increased physical activity, should be promoted. Limitations can be placed on the concentrations of salt, sugar, trans-fats and saturated fats in manufactured food products. Food labeling should also be introduced to facilitate informed choice by consumers. Food adulteration should be dealt rigorously. Provision of safe, arsenic-free water and food should be ensured. Necessary legislative and administrative steps should be taken to reduce air pollution. Policy change should address urban planning, transport and preservation of environment. Special attention should be given to stop malnutrition and under nutrition in fetal and neonatal life through nutrition programmes. Public awareness should be created to avoid childhood obesity. If indicated by further research, vitamin D deficiency may be avoided by fortification of food. Further research, may be in collaboration with international organizations, should be undertaken to explore the still-unidentified risk factors of CVD unique to this nation.

Renovation of National Centre for Control of Rheumatic Fever and Heart Diseases (NCCRF&HD) may be done to boost up research in RF and chronic RHD and render point-of-care services involving medical, interventional, as well as, surgical modalities of treatment. Appropriate guidelines should be formulated in relation to RHD to bring about uniformity and rationality in existing practice.

Conclusion:

CVD is a major public health burden in Bangladesh. Besides the well-known risk factors, genetic factors and some emerging risk factors unique to this population may play an important role in CVD. At the advent of the new millennium, more and more information is becoming available; however, presumably much is still unknown.

We have no more time to lapse. Large-scale, preferably, nation-wide survey and clinical research should be conducted to determine the different aspects of CAD in Bangladesh. The information available hereby, would help to formulate national policy to combat the deadly epidemic more efficiently in future. This information would be used to formulate national cardiovascular guidelines for early detection and prevention of CVD with top importance.

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