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Research Article

Cardio-metabolic risk and morbidity of a cohort in a rural community of Bangladesh

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Abstract

Background and objectives: Of the ever-increasing non-communicable diseases (NCDs), cardiometabolic morbidity and mortality constitute the major health burden world-wide. Several cross-sectional studies revealed the increasing prevalenceof NCDs irrespective of cast, culture, ethnicity, socio-economic growth and geopolitical environment. Recent cross-sectional studies revealed South Asians are the most susceptible to cardiovascular diseases (CVD). Few cohort studies addressed cardiometabolic morbidity and related risks, particularly in the rural population. This study was carried out to find out the prevalence of metabolic syndrome (MetSyn) and its changes overtime in a rural cohort of Bangladesh.

Methods: The study used baseline data of a study conducted in 2011- 2013 on prevalence of coronary artery disease among a cohort living in 16 villages. During 2021-2023, the baseline data collected in 2011-2013 were retrieved and the participants were searched and categorized into a) physically present, b) died and c) missing. Those who were present were requested to volunteer for re-investigations. Briefly the investigations included interviewing on social, family, personal and clinical history, anthropometry, blood pressure measurement, blood biochemistry and electrocardiography (ECG).

Results: A total of 3928 people participated in baseline study of 2011- 2013. Of them, 1075 could be tracked by village and household. Of them, 953 were found alive. Of the 953 available participants, 651 (254 men and 397 women) volunteered to participate in 2021-2023 study. Compared to 2011-2013 baseline, the prevalence of MetSyn and type2 diabetes mellitus (T2DM) increased to 31.6% and 5.2% from 7.5% and 0.8% respectively in 2021-2023. Similarly, compared to baseline, the prevalence of obesity and hypertension also showed significant increase overtime. Estimated incidence of MetSyn was 260.8 per 1000 population, which was more profound in women than men (W: M= 300.3:200.8).

Conclusions: The study revealed a significant increase of obesity, hypertension, diabetes and metabolic syndrome within a decade indicating an emerging health burden among the rural people of Bangladesh.

Introduction

Globally non-communicable diseases (NCDs) are now considered as the most common causes of increasing morbidity and mortality in humans [1]. The significant burden of NCDs is related to global increase of metabolic diseases or syndrome [2].

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Metabolic diseases include hypertension (HTN), type 2 diabetes mellitus (T2DM), dyslipidemia, obesity and non-alcoholic fatty liver disease [2,3]. Metabolic diseases have been increasing in the Southeast Asian Region (SEAR) [4-6] and the trend is also observed in Bangladesh [7-10]. However, there is paucity of studies on trends of metabolic diseases in rural population of Bangladesh. Therefore, the present study was undertaken to assess the trends in the prevalenceof metabolic diseases in a rural cohort of Bangladesh.

Materials and methods

The present study was designed based on a cross-sectional study that assessed the prevalence of coronary artery disease in a rural population of 16 villages located about 100 km north-east of capital Dhaka. The baseline investigations of the cohort were done in the year 2011 through 2013. Data collection and analyses were completed in 2013 and the findings published in 2017 [9]. The baseline data of this cross-sectional study were retrieved. The participants' lists with house number in 16 villages were used for searching and tracking the baseline participants. The participants of the baseline study (2011-2013) still living and present in the villages were approached and enrolled in the present study of 2021-2023. The detailed procedure is shown in Figure-1.

The investigations for the present study (2021-2023) were the same as the baseline one [9]. Briefly the investigations included interviewing on social, family, personal and clinical history, anthropometry (height, weight, waist- and hip-circumference), blood pressure measurement, biochemistry (FBG, Lipids, creatinine, SGPT) and electrocardiography (ECG). Metabolic syndrome was defined when 3 or more of the following 5 components were present: 1) waist circumference (≥88 cm for women and ≥102 cm for men), 2) triglycerides (≥150 mg/dL), 3) HDL cholesterol (<40 mg/dL for men and <50 mg/dL for women), 4) blood pressure (systolic ≥130 mm Hg, or diastolic

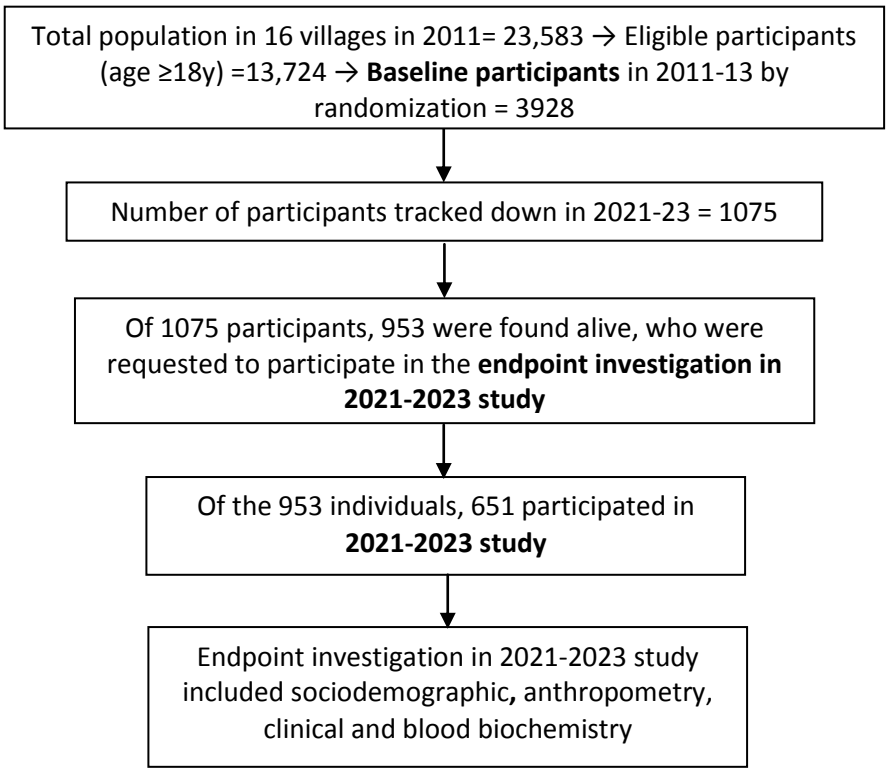

Figure-1: *Flow chart showing study procedure*

≥85 mm Hg, or both) and 5) fasting blood sugar (>5.6 mmol/l) [11].

Statistical analysis: The prevalence of biophysical characteristics is shown in percentages and 95% confidence interval. All biophysical values are presented as mean with (±SD). Correlations among variables were measured to determine whether their associations changed significantly at endpoint from the starting point. The trend of the prevalence rates was estimated by chi-sq trend, according to age quartiles, both at baseline and at endpoints. Paired t-test was used to find any significant differences between the two for each variable.

Results

As mentioned, the study population of the present study was based on a population who took part in a cross-sectional study conducted in 2011-13 to estimate the prevalence of coronary artery disease. A total of 3928 participated at baseline [Figure-1]. At the endpoint 2021 -2023), 953 (24.3%) of 3928 were found alive, and were requested to participate. Of the 953 presently available baseline participants, 651 (men/women= 254/397) volunteered to participate in the endpoint investigation in 2021-2023. Thus, 651 individuals constituted the present study cohort.

Table-1 illustrated the biophysical characteristics of this cohort at baseline (2011-13) and at endpoint (2021-23). Compared to baseline, a significant increase of general (BMI) or central (WHR/ WHtR) obesity was observed at endpoint. Height, as expected, reduced significantly ($p<0.01$). Biochemical variables (FBG, TG, and HDL) were also found increased significantly ($p<0.001$) at endpoint compared to baseline. In contrast, total cholesterol concentration showed no significant change.

Table-2 shows the comparisons of different parameters of men and women participants at the endpoint assessment. Data revealed that mean BMI, WHR & WHtR were significantly higher among women in comparison to men.

Table-1: *The biophysical characteristics of the study cohort (n = 651) at baseline and endpoint*

	Baseline (2011–2013, n=651)		End-point (2021–2023, n=651)		*p*
	Mean ± SD	**95% CI**	**Mean ± SD**	**95% CI**	
Age (Y)	33.6 ± 12.2	32.6, 34.5	43.6 ± 12.2	42.6, 44.5	<0.001
Height (cm)	156.5 ± 8.8	155.8, 157.2	155.3 ± 7.8	154.7, 155.9	<0.01
Weight (kg)	48.3 ± 9.6	47.6, 49.1	51.4 ± 10.2	50.6, 52.2	<0.001
BMI (kg/m^2)	19.7 ± 3.4	19.4,20.0	21.3 ± 3.8	21.0,21.6	<0.001
WHR	0.85 ± 0.08	0.84, 0.86	0.95 ± 0.06	0.95,0.96	<0.001
WHtR	0.46 ± 0.06	0.46, 0.47	0.55 ± 0.08	0.54,0.56	<0.001
SBP (mmHg)	112.8 ± 20.7	111.2, 114.4	118.3 ± 15.9	117.1, 119.6	<0.001
DBP (mmHg)	72.2 ± 12.6	71.3, 73.2	75.1 ± 10.2	74.3, 75.9	<0.001
MAP (mmHg)	85.8 ± 14.3	84.6, 86.9	89.5 ± 11.2	88.7, 90.4	<0.001
FBG (mmol/L)	4.8 ± 1.2	4.7, 4.9	6.4 ± 2.6	6.2, 6.6	<0.001
TG ((mg /dL)	120.8 ± 63.6	115.9, 125.7	167.6 ± 77.4	161.6, 173.5	<0.001
HDL ((mg /dL)	36.7 ± 3.8	36.4, 37.0	40.3 ± 8.8	39.6, 41.0	<0.001
CHOL ((mg /dL	143.5 ± 37.9	140.6, 146.4	142.6 ± 35.3	139.9, 145.3	0.658
LDL ((mg /dL)	68.2 ± 27.6	66.0, 70.3	77.1 ± 27.1	75.1, 79.2	<0.001

Note: BMI, body mass index, Chol, total cholesterol, DBP, diastolic blood pressure, FBG, fasting blood glucose (mmol/L), HDL, high density lipoproteins (mg /dL), MAP, mean arterial pressure (mmHg), SBP, systolic blood pressure (mmHg), TG, triglycerides, WHR, waist-to-hip ratio, WHtR, waist-to-height ratio; p value calculated by paired-t-test.

Table-2: *Comparisons of biophysical characteristics between men and women of the cohort at endpoint*

Variables	Men n = 254	Women n = 397	*p*
	Mean ± SD	Mean ± SD	
Age (Y)	46.9 ± 13.1	41.4 ±11.1	*.000*
Height (cm)	161.8 ± 6.0	151.1 ± 5.8	*.000*
Weight (kg)	53.7 ± 9.6	49.9 ± 10.3	*.000*
Waist (cm)	81.2 ± 10.8	88.4 ± 11.2	*.000*
Hip (cm)	86.2 ± 9.3	91.8 ± 10.0	*.000*
BMI (kg/m^2)	20.5 ± 3.3	21.8 ± 4.1	*.000*
WHR	0.94 ± 0.06	0.96 ± 0.06	*.000*
WHtR	0.50 ± 0.07	0.59 ± 0.07	*.000*
SBP (mmHg)	118.8 ± 14.7	118.1 ± 16.7	*.575*
DBP (mmHg)	74.6 ± 10.2	75.4 ± 10.1	*.320*
MAP (mmHg)	89.3 ± 10.8	89.6 ± 11.5	*.738*
FBG (mmol/L)	6.47 ± 2.6	6.3 ±2.6	*.481*
TG (mg/dl)	163.8 ± 75.2	170.0 ± 78.7	*.316*
CHOL (mg/dl)	141.7 ± 36.6	143.2 ± 34.5	*.577*
HDL (mg/dl)	40.5 ± 8.9	40.2 ± 8.7	*.724*
LDL (mg/dl)	76.9 ± 27.5	77.3 ± 26.8.8	*.847*

Note: BMI, body mass index, Chol, total cholesterol, DBP, diastolic blood pressure, FBG, fasting blood glucose (mmol/L), HDL, high density lipoproteins (mg /dL), MAP, mean arterial pressure (mmHg), SBP, systolic blood pressure (mmHg), TG, triglycerides, WHR, waist-to-hip ratio, WHtR, waist-to-height ratio; p value calculated by paired-t-test.

Correlations of the biophysical variables at baseline and endpoint are shown in Table-3 and 4, respectively. Obesity both general (BMI), and central (WHR, WHtR) had significant positive correlations with all blood pressure measures (SBP, DBP, MAP, for all p<0.001) though the correlations were not significant with FBG, TG, Chol and HDL at baseline (Table-3). For lipids, only cholesterol had significant positive correlation with SBP (p = 0.001) and MAP (p= 0.017) at baseline (Table-3). Similar significant positive correlations of obesity variables (BMI, WHR and WHtR) with the blood pressure measures (SBP, DBP, MAP) were found at endpoint (Table-4). Interestingly, though obesity did not correlate with metabolic components (FBG, cholesterol, TG, HDL) at baseline (Table-3), but at the endpoint (Table-4), TG correlated significantly with BMI and WHtR (p<0.001); and HDL had significant inverse correlation with BMI (r= - 0.09, p=0.015). Comparison of biophysical characteristics of the cohort with and without metabolic syndrome both at baseline (2011-2013) and at endpoint (2021-23) are shown in Table-5.

Figure-2 shows the prevalence of hypertension (SHTN, DHTN, MAHTN) in men and women at baseline (2011-13) and at endpoint in 2021-23. No significant difference was observed (p>0.05). The changes of prevalence of T2DM and MetSyn from baseline to endpoint are shown in Figure-3. At baseline, the prevalence of T2DM in men and women was 1.2% and 0.5% respectively while it increased to 6.7% and 4.3% at endpoint in 2021-2023. Over the decade, the prevalence of

Table-3: *Correlations of biophysical variables controlling for age and sex at baseline*

		BMI	WHR	WHtR	SBP	DBP	MAP	FBG	TG	Chol	HDL
	r	1.000	.226	.654	.154	.155	.165	.041	.041	.020	-.037
BMI	p	.	.000	.000	.000	.000	.000	.292	.294	.610	.342
	df		647	647	647	647	647	647	647	647	647
	r		1.000	.669	.156	.109	.139	.048	.063	-.011	.010
WHR	p		.	.000	.000	.006	.000	.225	.108	.787	.801
	df			647	647	647	647	647	647	647	647
	r			1.000	.237	.201	.232	.016	.067	.024	-.046
WHtR	p			.	.000	.000	.000	.680	.090	.539	.246
	df				647	647	647	647	647	647	647
	r				1.000	.754	.923	.053	.068	.110	-.054
SBP	p				.	.000	.000	.174	.086	.005	.168
	df					647	647	647	647	647	647
	r					1.000	.949	.029	.065	.071	-.074
DBP	p					.	.000	.457	.096	.073	.060
	df						647	647	647	647	647
	r						1.000	.043	.071	.094	-.069
MAP	p						.	.276	.071	.017	.077
	df							647	647	647	647
	r							1.000	.053	.037	.027
FBG	p							.	.174	.350	.485
	df								647	647	647
	r								1.000	.474	-.511
TG	p								.	.000	.000
	df									647	647
	r									1.000	-.430
Chol	p									.	.000
	df										647

Note: r, correlation coefficient, p, two-tailed significance, df, degree of freedom, BMI, body mass index (kg/m^2), Chol, total cholesterol, DBP, diastolic blood pressure, FBG, fasting blood glucose, HDL, high density lipoproteins, MAP, mean arterial pressure, SBP, systolic blood pressure, TG, triglycerides, WHR, waist-to-hip ratio, WHtR, waist-to-height ratio.

Table-4: *Correlations of biophysical variables controlling for age and sex at endpoint*

		BMI	WHR	WHtR	SBP	DBP	MAP	FBG	TG	Chol	HDL
	r	1.000	.239	.698	.202	.159	.191	-.007	.169	.068	-.095
BMI	p	.	.000	.000	.000	.000	.000	.861	.000	.085	.015
	df		647	647	647	647	647	647	647	647	647
	r		1.000	.492	.133	.139	.147	.050	.066	-.013	-.014
WHR	p		.	.000	.001	.000	.000	.199	.093	.746	.718
	df			647	647	647	647	647	647	647	647
	r			1.000	.210	.146	.187	.042	.126	.035	-.029
WHtR	p			.	.000	.000	.000	.280	.001	.370	.465
	df				647	647	647	647	647	647	647
	r				1.000	.727	.910	.130	.037	-.004	-.021
SBP	p				.	.000	.000	.001	.341	.919	.589
	df					647	647	647	647	647	647
	r					1.000	.946	.055	.033	-.036	-.073
DBP	p					.	.000	.162	.403	.358	.063
	df						647	647	647	647	647
	r						1.000	.095	.037	-.024	-.054
MAP	p						.	.016	.340	.547	.169
	df							647	647	647	647
	r							1.000	.048	.052	.062
FBG	p							.	.223	.183	.112
	df								647	647	647
	r								1.000	.412	-.033
TG	p								.	.000	.403
	df									647	647
	r									1.000	-.024
Chol	p									.	.538
	df										647

Note: r, Correlation coefficient, p, two-tailed significance, df, degree of freedom, BMI, body mass index, Chol, total cholesterol, DBP, diastolic blood pressure, FBG, fasting blood glucose, HDL, high density lipoproteins, MAP, mean arterial pressure, SBP, systolic blood pressure, TG, triglycerides, WHR, waist-to-hip ratio, WHtR, waist-to-height ratio.

T2DM increased significantly to 5.2% from 0.8% ($p<0.01$) and the estimated incidence of T2DM was 44.9 per 1000 people per decade. Development of MetSyn significantly ($p<0.05$) increased in both men and women over 10 years (endpoint) period compared to baseline in 2011-2013. The prevalence of MetSyn in the cohort was only 7.5% at baseline (2011-2013) which increased to 31.6% at endpoint in 2021-2023.The cohort revealed the incidence of MetSyn as 260.8 per 1000 population per decade. The women had higher incidence rate than men (W : M = 300.3 : 200.8) per 1000 people.

Table-5: *Comparisons of the study population (N=651) with and without metabolic syndrome (MetSyn) both at baseline (2011-2013) and at endpoint (2021-2023)*

Variables	MetSyn			MetSyn		
	Positive	Negative		Positive	Negative	
	(N=49, 7.5%)	(N=602,92.5%)	*p*	(N=206, 31.6%)	445, 68.4%)	*p*
	Mean ± SD	Mean ± SD		Mean ± SD	Mean ± SD	
BMI	21.7 ±4.3	19.5 ± 3.3	*.001*	23.4 ± 3.9	20.3 ± 3.3	*.000*
WHR	0.90 ± 0.09	0.85± 0.08	*.000*	0.97 ± 0.05	0.94 ± 0.07	*.000*
WHtR	0.52 ± 0.08	0.45 ± 0.06	*.000*	0.59 ±0.07	0.53 ± 0.07	*.000*
SBP	137.4 ± 20.8	110.9 ±19.4	*.000*	126.5 ± 16.3	114.6 ± 14.3	*.000*
DBP	86.7 ± 13.4	71.0 ± 11.8	*.000*	79.6 ± 10.2	73.0 ± 9.4	*.000*
FBG	5.4 ± 2.4	4.8 ± 1.1	*.088*	7.2 ± 3.6	5.9 ± 1.9	*.000*
Chol	169.8 ±48.4	141.4 ± 36.1	*.000*	151.4 ± 37.0	138.6 ± 33.8	*.000*
TG	220.3± 84.9	119.1 ± 63.5	*.000*	195.5 ± 70.02	159.8 ± 78.8	*.000*
HDL	33.5 ± 4.9	36.9 ± 3.6	*.000*	38.1 ± 7.6	41.3 ± 9.1	*.000*

Note: p value calculated by t-test

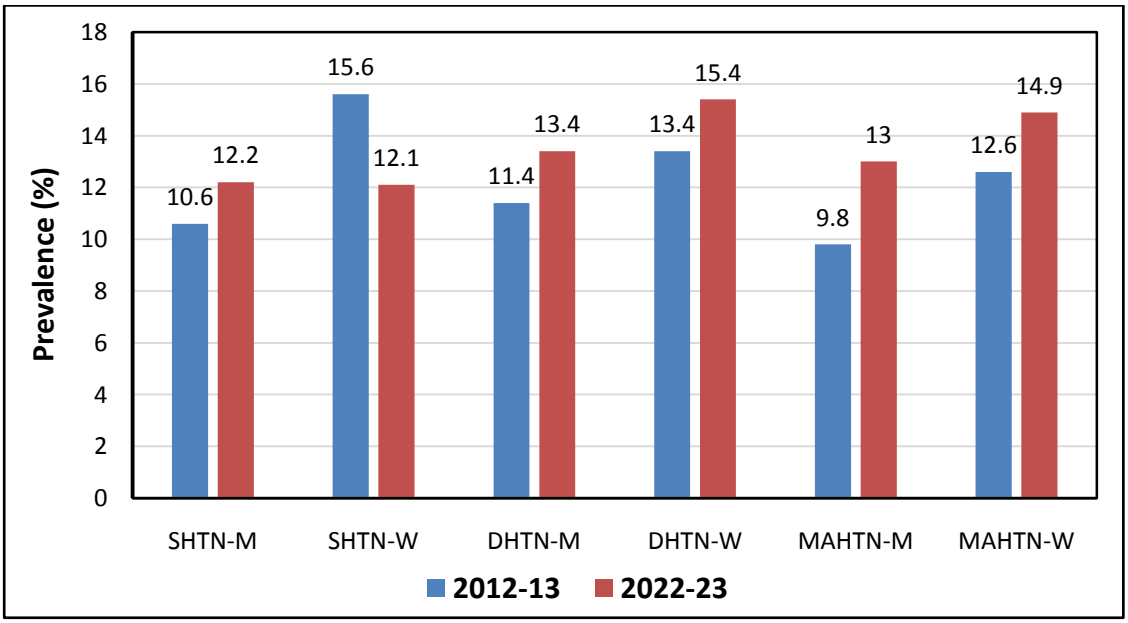

Figure-2: *Prevalence (%) of hypertension (SHTN, DHTN, MAHTN) in men and women at baseline (2011-13) and at endpoint (2021-23). M: men, W: women.*

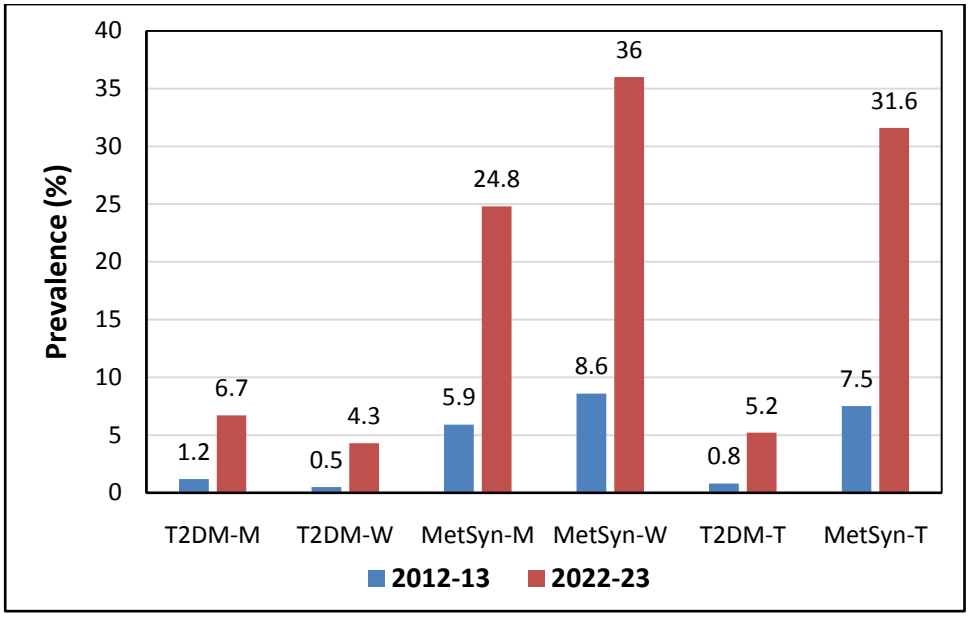

Figure-3: *Prevalence (%) of T2DM and metabolic syndrome (MetSyn) in men and women at baseline (2011-13) and at endpoint (2021-23). M: Men, W: Women, T: Total.*

Figure-4 and 5 depict whether increasing age of the cohort influenced the prevalence of hypertension, diabetes or MetSyn of the study population at baseline and at end point respectively. The prevalence trend with advancing age was not significant ($p>0.05$) at baseline for all components. In contrast, after a decade, at the endpoint (2021-23) only the increasing trend for sHTN was found significant ($p<0.01$).

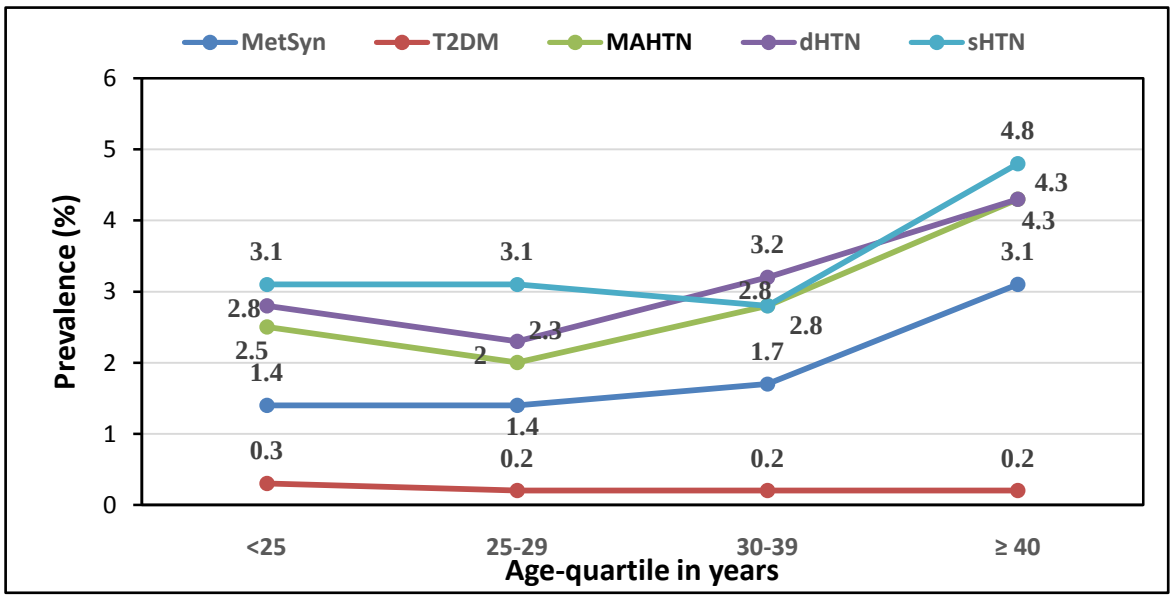

Figure-4: *Trend of prevalence (%) of hypertension (sHTN, dHTN, MAHTN), T2DM and metabolic syndrome (MetSyn) at baseline (2011-13) by age-quartile (<25, 25- 29, 30-39, ≥40 years)*

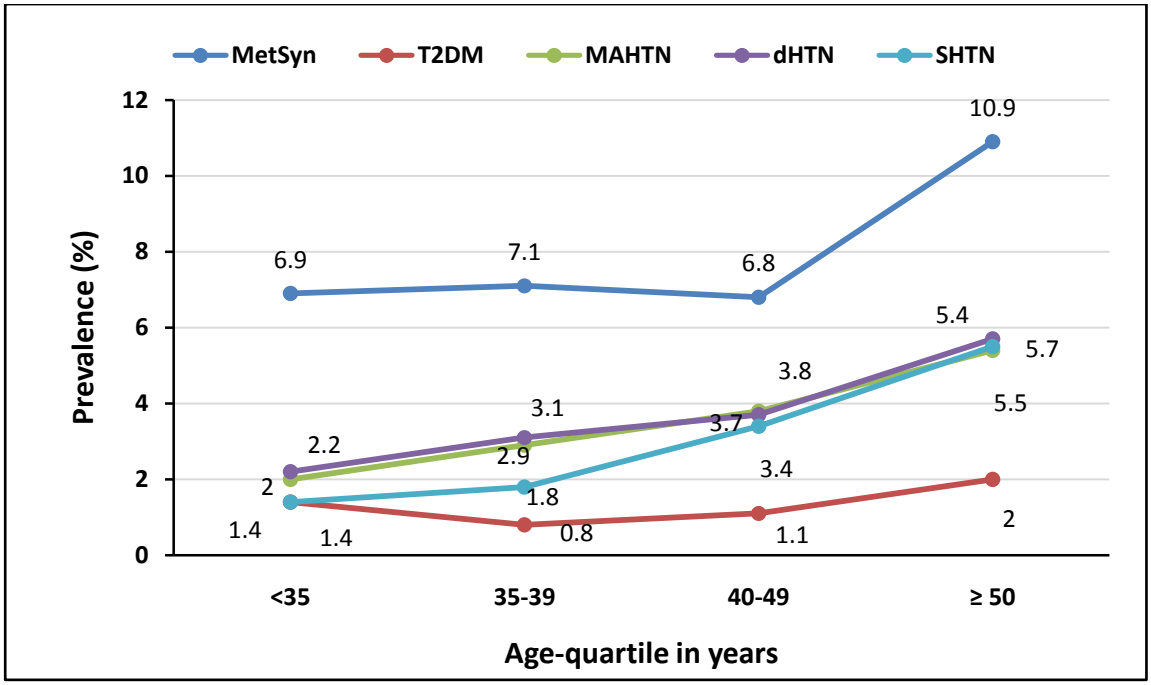

Figure-5: *Trend of prevalence (%) of hypertension (sHTN, dHTN, MAHTN), T2DM and metabolic syndrome (MetSyn) at endpoint (2021-23) by age-quartile (<25, 25- 29, 30-39, ≥40 years)*

Discussion

This study is first of its kind addressing the trend of cardiometabolic morbidity over a decade in a cohort of population in a rural community of Bangladesh. Most of the reported studies on cardiometabolic morbidity and mortality from South Asian countries encompassed urban population. The most important aspect of our study is that it showed an alarming and increasing trend of cardiometabolic risks and diseases in rural people that represents the vast majority of Bangladeshi population. There are a few published data on the status of cardiometabolic syndrome or diseases on rural population of Bangladesh for comparison. However, in south Asia a very elegant cohort was initiated in 2010 as Cardiometabolic Risk Reduction in South Asia (CARRS) [12]. The study also observed increasing trend of general and central obesity among Asian population (Chennai, Delhi and Karachi) [12].

In the present study, all blood pressure measures (sHTN, dHTN, MAHTN) increased significantly among our cohort population within a decade. This observation is consistent with the findings of a study involving a large cohort of over 16,000 adults in India [4]. In our study, the most notable was the high increase of prevalence of diabetes and MetSyn from baseline to endpoint over a period of 10 years. Similar changes of prevalence and incidence of diabetes and MetSyn in South Asians have been reported in other studies, but most of those studies were conducted either in urban or metropolitan population [4,5,13-15]. However, our study cohort consisted of only rural population. Our cohort participants had a significant and noticeable increase of Chol, TG and LDL including significant reduced level of HDL at endpoint from its baseline level. This finding is not inconsistent with the findings of studies conducted on other south Asian cohort [6,16].

Our study addressed major cardiometabolic risks prevalent among the rural population of Bangladesh which constitute 60% of the total population of the country. It revealed significant increase of obesity, hypertension, diabetes and metabolic syndrome in rural people over a period of ten years. The prevalence of both T2DM and MetSyn increased more than five times within a

decade. These findings invite the attention of all concerned to plan and take necessary preventive measures against this emerging health burden.

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Ethical declaration

The study protocol was approved by the Institutional Review Committee (IRC) of Bangladesh Diabetes Somity (BADAS). Informed written consent was obtained from each and every participant prior to the enrollment in the study.

Authors' contribution

NT and SA: contributed equally in protocol writing, data analysis and manuscript writing; MMT and NA: data collection and data entry; MAS: manuscript writing.

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