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The Metabolic Syndrome: Prevalence, Associated Factors, and Impact on Survival among Older Persons in Rural Bangladesh

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Abstract

Objectives: To describe the prevalence of the metabolic syndrome (MetS) among older persons in rural Bangladesh, to investigate whether the prevalence varies by age, sex, literacy, marital status, nutritional status and socio-economic status, and to assess the impact of MetS on survival.

Methods: The study consisted of 456 persons who were aged ≥60 years living in a rural area of Bangladesh during July 2003–March 2004. Data were collected through interview, clinical examination, and laboratory tests, and their survival status until 30th June 2009 was ascertained through the Matlab surveillance system. We defined MetS following the NCEP ATP III criteria, with minor modifications, i.e., presence of any three of the following: hypertension (BP ≥130/85 mm Hg); random blood glucose (RBG) level ≥7.0 mmol/L; hyper-triglyceridemia (≥2.28 mmol/L); low level of HDL-cholesterol (<1.04 mmol/L for men and <1.29 mmol/L for women); and BMI ≥25.0 kg/m^2. Data were analysed with logistic regressions for the influential factors of MetS, and with Cox models for the association of MetS with the survival status.

Findings: The overall prevalence of MetS was 19.5%, 20.8% in women, and 18.0% in men. Asset-index and nutritional status were independently associated with MetS. During 4.93 years of follow-up, 18.2% died. In the presence of high RBG, MetS has a significant negative effect on survival (69.4% vs 95.2%, log rank p = 0.02).

Conclusion: This study highlights the importance of the metabolic syndrome in rural Bangladesh. Our findings suggest that there is a need for screening programmes involving the metabolic syndrome to prevent diabetes and cardiovascular diseases.

Competing Interests: The authors have declared that no competing interests exist.

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Introduction

The metabolic syndrome (MetS) is a constellation of obesity, hyperglycaemia, decreased high density lipoprotein (HDL), increased triglyceride, and high blood pressure [1]. The MetS, as a driver of current epidemics of diabetes [2] and cardiovascular diseases (CVD) [3], has become a major challenge to public health around the world. The association of MetS with myocardial infarction (MI), stroke, and diabetes, has been extensively documented [4] and CVD is the major cause of death in the developing world [5]. Importantly, about 80% of the global burden of CVD related death occurs in low- and middle-income countries [6].

World-wide, the prevalence of MetS ranges from 10% to 50% [7]. The detection, prevention, and treatment of the MetS components should become an important approach for the reduction of the cardiovascular disease burden in the general population [8]. Hence, the identification of the population at risk is of utmost importance.

In recent years, several studies [9–15] have shown the increasing importance of MetS in low-income countries, but few studies have focused on rural populations. In this population-based study of persons aged 60 years and above living in rural Bangladesh, we seek (1) to determine the prevalence of MetS, (2) to examine factors related to MetS, and (3) to assess the impact of MetS on survival.

Methods

Participants

Study participants were from the "Poverty and Health in Ageing", a collaborative project between Ageing Research Centre at Karolinska Institutet, Sweden and ICDDR,B, Bangladesh. This

is a cross-sectional study of elderly persons aged 60 years or more, conducted in Matlab, a rural sub-district of Bangladesh. Since 1966, icddr,b has maintained a Health and Demographic Surveillance System (HDSS) in this area which is divided into seven blocks and covers a population of approximately 220,000 across 142 villages, where regular update of all vital events is maintained. For this study, we selected two blocks, which are nearest to the main Matlab hospital.

Ethics Statement

Ethical approval was received from both Karolinska Institutet, Sweden and Institutional Review Board (IRB) ICDDR,B Bangladesh. Information about the study was provided to and informed consent was obtained from all participants.

Of the 850 randomly selected older persons from the two purposively selected blocks, 63 died before data collection, 38 refused to participate, 11 migrated, 93 could not be reached, 18 were registered twice in the surveillance database, and 2 persons were found to be under 60 years of age. Thus, 625 respondents were interviewed in their homes, of whom 473 participated in the clinical examination. Complete information for the current study was available for 456 persons, slightly more than 50% of the original sample. The non-participants (n = 169) were more likely to be women, older and with poor socio-economic status, but their health profile did not differ from the respondents [16].

Data collection

Between July 2003 and March 2004, data were collected in two sessions on two separate days. Data on demographics, socio-economic status, and self-reported morbidity were collected during a home interview by trained interviewers. Clinical examinations were conducted at the local ICDDR,B health centre by physicians and blood samples were taken for laboratory analyses.

Definition of the metabolic syndrome

We define the MetS following the criteria proposed by the Third Report of the National Cholesterol Education Program Expert Panel on the Detection, Evaluation, and Treatment of High Blood Cholesterol in Adults (NCEP ATP III) [17]. The NCEP ATP III criteria comprise 3 or more of the following: (1) fasting plasma glucose level of at least 110 mg/dL (6.1 mmol/L); (2) serum triglyceride level of at least 150 mg/dL (1.7 mmol/l) for men; (3) serum high-density lipoprotein (HDL) cholesterol level lower than 40 mg/dL (1.04 mmol/L) for men and lower than 50 mg/dL (1.29 mmol/L) for women; (4) Blood Pressure of at least 130/85 mm Hg or controlled with antihypertensive treatment; and/or (5) waist circumference of more than 102 cm (Adult Treatment Plan III 2001). The NCEP ATP III definition does not specify that any particular component be present and implies that if a person has several risk factors, even if they are not very severe, their joint contribution can still markedly increase the risk of coronary heart disease.

In this study, the MetS is defined as having any 3 of the following: 1) high blood glucose ≥7.0 mmol/L; 2) hypertriglyceridemia (triglyceride level ≥2.28 mmol/L); 3) low level of HDL cholesterol (<1.04 mmol/L for men and <1.29 mmol/L for women); 4) BMI ≥25.0 kg/m² and 5) hypertension (systolic BP ≥130 mm Hg or diastolic BP ≥85 mm Hg).

We used non-fasting blood sample for biochemical analysis because it was not possible to request the fasting state of the elderly people. Further we used a cut-off ≥200 mg/dL (≥2.28 mmol/L) to define high triglyceride, which is in line with other studies [18].

Literacy was defined as the ability to read and write in Bangla language. Asset index is used as proxy for socio-economic status of the respondents. Asset index data was collected separately from the surveillance database of HDSS of ICDDR,B. The asset index is based on household assets and housing characteristics, including such as bed, mattress, quilt, cooking pots, watch, chair, clothing cabinet, radio, television, bicycle, boat, cows and electricity. Using a variable reduction technique, these assets and characteristics were combined into a single variable. After ranking this variable from low to high, households were divided into 3 equally sized groups, the poverty tertiles. Details about the calculation of the asset index can be found elsewhere [19]. Marital status was categorized as married or single. Divorced, widows, widowers and never married persons were included in the single group, and the category married represents currently married persons. Nutritional status was assessed using the Mini Nutritional Assessment (MNA) [20]. The calculation of the nutritional status has been described in detail previously [16]. For this study we grouped the 'undernourished' and 'at risk of malnutrition' into 'not well-nourished'.

Height and weight were measured with the participant barefoot and lightly dressed. Body mass index was calculated as weight (kg) divided by height squared (m²). Blood pressure was measured by sphygmomanometer, after taking a 5-min rest, and with standard procedure. The sitting-position measurements were used in this study. Plasma lipids (high-density lipoprotein [HDL] cholesterol and triglycerides) and glucose were measured using standard enzymatic methods. Random blood glucose was measured by an ACCU-CHECK glucometer.

Mortality data

Data on survival status of all participants until 30th June 2009 are from the routine surveillance program of HDSU of ICDDR,B, in which ICD-10 is used to clarify the cause of death (ICD-10, WHO).

Data analyses

Descriptive analyses included mean and standard deviations (SD) for continuous variables. Prevalence and frequencies are expressed in terms of percentage. Categorical variables were compared by chi-square statistic. Logistic regression was used to examine factors related to MetS. Kaplan-Meyer survival analysis was used to examine the relationship of MetS, as well as its various components, with survival up to five years. Also, Cox model was applied for estimating the hazard ratio for mortality by MetS. All analyses were performed using the statistical software SPSS Statistics version 11.5 for Windows.

Results

Table 1 presents the characteristics of study participants, The mean age of the 456 participants was 69 years (SD 6.8; range 60–92), and 55% were female.

The prevalence of low HDL was 98.2%, in combination with the other components, this leaves only 0.4% (two individuals) without any MetS risk component. All five risk components were present in 0.9% of the participants (data not shown), and high blood pressure was prevalent 49.8% (Table 2). The prevalence of the MetS components did not differ significantly between men and women, except high triglycerides where women had a higher prevalence than men (p = 0.005) (Table 2). The overall prevalence of MetS was 19.5%, slightly higher prevalence in women (20.8%) compared to men (18.0%) (p = 0.26) (Table 3). The prevalence of MetS did not change consistently with increasing age (Table 3).

Asset index and nutritional status were found to be independently associated with MetS (Table 4).

Table 1. Characteristics of the study population (n = 456) by status of the metabolic syndrome.

Characteristics	Number of subjects, n (%)	The metabolic syndrome		
		Present	Absent	p-value
Age group, years				
60–69	273 (59.9)	56 (62.9)	217 (59.1)	
70+	183 (40.1)	33 (37.1)	150 (40.9)	0.298
Sex				
Men	206 (45.2)	37 (41.6)	169 (46.0)	
Women	250 (54.8)	52 (58.4)	198 (54.0)	0.261
Literacy				
Illiterate	272 (60.0)	48 (54.5)	224 (61.4)	
Literate	181 (40.0)	40 (45.5)	141 (38.6)	0.146
Marital status				
Single	194 (42.5)	38 (42.7)	156 (42.5)	
Married	262 (57.5)	51 (57.3)	211 (57.5)	0.533
Asset Index				
Lowest tertile	143 (33.1)	14 (16.7)	129 (37.1)	
Middle tertile	145 (33.6)	37 (44.0)	108 (31.0)	
Highest tertile	144 (33.3)	33 (39.3)	111 (31.9)	0.001
Smoking				
No	272 (59.8)	60 (67.4)	212 (57.9)	
Yes	183 (40.2)	29 (32.6)	154 (42.1)	0.064
Tobacco leaf				
No	134 (30.4)	32 (37.2)	102 (28.7)	
Yes	307 (69.6)	54 (62.8)	253 (71.3)	0.082
Nutritional status				
Not well nourished	388 (87.6)	63 (74.1)	325 (90.8)	
Well nourished	55 (12.4)	22 (25.9)	33 (9.2)	<0.001

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Of the 456 participants, 83 (18.2%) died during the follow-up of 4.93 years. During this time period 14 (3.1%) left the study area and were considered lost to follow up. Analyses of the survival status of this population suggested that those with MetS had a slightly lower survival rate (78.8%) compared to those without MetS (81.8%). This difference was however not statistically significant (log rank p = 0.55, df = 1) (Figure 1). Cox regression analyses suggested that the hazard ratio of death related to MetS

Table 2. Prevalence of different components of the metabolic syndrome by sex.

Components	Total, n (%)	Men, n (%)	Women, n (%)	p-value*
Low HDL	448 (98.2)	204 (99.0)	244 (97.6)	0.215
High blood pressure	227 (49.8)	102 (49.5)	125 (50.0)	0.496
High Random blood glucose	60 (13.2)	25 (12.1)	35 (14.0)	0.329
High triglyceride	89 (19.5)	29 (14.1)	60 (24.0)	0.005
High BMI	24 (5.3%)	7 (3.4)	17 (6.8)	0.078

*p-value is for comparison between men and women.
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was 1.17 (95% CI 0.70–1.98). The major cause of death in this sample was circulatory system related (61.4%); cerebro-vascular diseases being the most prevalent cause followed by ischemic heart disease and then hypertensive diseases. Deaths due to the circulatory system constituted 66.7% of the total number of deaths in the MetS group and 60% of the deaths in the non MetS group (not statistically significant).

In further analysis, we found that, in the presence of high RBG, MetS has a significant negative effect on survival (69.4% vs 95.2%, log rank p = 0.02, df = 1). Survival with the other individual components triglyceride, high blood pressure and high BMI did not reveal any significant differences (Figure 2).

Discussion

In this study we have found the overall prevalence of MetS was 19.5%, 20.8% in women, and 18.0% in men. Asset-index and nutritional status were independently associated with MetS. During 4.93 years of follow-up, 18.2% died. Cox regression analysis suggested that the hazard ratio of death related to MetS was 1.17 (95% CI 0.70–1.98). In the presence of high RBG, MetS has a significant negative effect on survival (69.4% vs 95.2%, log rank p = 0.02)

This study was based on a random sample of elderly individuals living in the community in Matlab, a rural area of Bangladesh. The prevalence of MetS was 19.5%, consistent with findings from other studies, e.g., the Botnia study in Finland and Sweden 22.6% [21] and 12% in the Risk Factors and Life Expectancy Study (RIFLE) study in Italy [22]. Recent studies from developing countries reported various prevalence rates depending on the criteria used in defining the MetS. In Iran, using the NCEP criteria, prevalence of MetS was estimated to be between 24% and 30%, depending on sex [23]. In India, 25% of subjects had the MetS by IDF criteria [24], another study reported the prevalence by NCEP criteria as 9.3% in rural central India [25]. In Seychelles, an island country of African region, according to the ATP, WHO and IDF definitions, the prevalence of MetS was, respectively, 24.0%, 25.0%, 25.1% in men and 32.2%, 24.6%, 35.4% in women [26]. In the semi-rural areas of Turkey the prevalence of MetS was 27.6% by NCEP criteria [27]. There is a scarcity of data regarding the prevalence of MetS in Bangladesh. However, in a study conducted amongst rural Bangladeshi women (≥18 years), the prevalence was low (<3%) [28]. Another prevalence study conducted on clinic based hypertensive patients (20–79 years) found prevalence of 64% [29]. This is the first population based data regarding prevalence of MetS among older persons of rural Bangladesh. This study underscores the importance of metabolic syndrome in rural Bangladesh as one in every five elderly subjects is affected by the syndrome. In our study we have found a slightly higher, although not significant, prevalence rate of MetS among the women, similar to some studies [30,22] and contrary to other [21].

The prevalence of high blood pressure was 50% and 49% among women and men respectively, which is a finding similar to figures reported in other studies [21,31]. We have found a very high prevalence of low HDL cholesterol in this population (98.2%). Evidence exists that Asian Indians have low HDL [32,33], and the level of HDL 2b, the most protective component of HDL is low in >90% of Asian Indians [34]. In a Bangladeshi sample of hypertensive women aged 20–79 years, the prevalence of low HDL cholesterol was more than 90% [29]. Another study conducted on Bangladeshi rural women aged 18 years and above reported the prevalence of low HDL cholesterol as 65% [28]. Among the South Asians, the prevalence of low HDL is higher

Table 3. Prevalence of the metabolic syndrome by age and gender.

Age group, years	Men			Women			Total		
	N	n	Prevalence (%)	N	n	Prevalence (%)	N	n	Prevalence (%)
60–64	60	12	32.4	79	15	28.8	139	27	30.3
65–69	65	11	29.7	69	18	34.6	134	29	32.6
70–74	41	7	18.9	43	8	15.4	84	15	16.9
≥75	40	7	18.9	59	11	21.2	99	18	20.2
Total	206	37	18.0	250	52	20.8	456	89	19.5

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Table 4. Unadjusted and adjusted odds ratios (OR) and 95% confidence intervals (CI) of Metabolic Syndrome: Results from logistic regression analyses.

	Metabolic syndrome	
	Unadjusted OR (95% CI)	Adjusted OR (95% CI)[a]
Age group, years		
60–69	1.00 (Ref)	1.00 (Ref)
70+	0.85 (0.53–1.38)	0.84 (0.48–1.46)
Sex		
Men	1.00 (Ref.)	1.00 (Ref.)
Women	1.20 (0.75–1.92)	0.90 (0.32–2.53)
*Literacy**		
Illiterate	1.00 (Ref.)	1.00 (Ref.)
Literate	1.32 (0.83–2.11)	1.09 (0.61–1.95)
*Marital Status**		
Single	1.00 (Ref.)	1.00 (Ref.)
Married	0.99 (0.62–1.59)	0.96 (0.47–1.97)
Asset index[#]		
Lowest tertile	1.0 (Ref.)	1.00 (Ref.)
Middle tertile	3.16 (1.62–6.14)	2.95 (1.41–6.15)
Highest tertile	2.74 (1.40–5.38)	2.78 (1.31–5.89)
Smoking		
No	1.00 (Ref.)	1.00 (Ref.)
Yes	0.67 (0.41–1.09)	0.58 (0.23–1.46)
Tobacco leaf		
No	1.00 (Ref.)	1.0 (Ref.)
Yes	0.68 (0.42–1.12)	0.81 (0.47–1.42)
Nutritional status§		
Not well-nourished	1.0 (Ref.)	1.0 (Ref.)
Well-nourished	3.44 (1.88–6.29)	3.05 (1.58–5.90)

OR = odds ratio; CI = confidence interval.
*Data on literacy and marital status were missing for 3 participants.
[#]Data on asset index was missing for 24 persons.
§Data on Nutritional status was missing for 13 persons.
[a]ORs (95% CIs) were derived from the model that included age, sex, literacy, marital status, asset index, smoking, tobacco leaf and nutritional status.
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among the people of Bangladesh (52%), nearly double to that of the Pakistanis (30%) and three times higher than that of the Indians (17%). In an African sample, the prevalence of dyslipidemia (TG >150 mg% or HDL cholesterol <40 mg%) was 92% among the persons with MetS [31].

In studying the determinants, we found that nutritional status and asset index were significantly associated with MetS. The absence of significant differences by age groups is contrasting prevalence studies performed in the west [22,35]. A likely reason is that people in Bangladesh with this syndrome develop coronary heart diseases and die at a younger age. Furthermore, it is evident that people from this region (South East Asia) are prone to developing CHD at a younger age, often before the age of 40 years [36].

The interesting relationship between socioeconomic status and MetS is sometimes mediated by behavioural factors, which are related to both MetS, and to socioeconomic status [37]. Contrary to some [38–40], but in line with others [41], we didn't find any association between smoking and MetS, neither between the use of tobacco leaf and MetS. Indeed, smoking tends to be associated with a decreased odds ratio of MetS. Because this analysis is based on cross-sectional data, it is likely that survival bias may, at least partly, account for the result, especially when both smoking and MetS were associated with high mortality. We found instead independent relationships of MetS with socioeconomic status, assessed by asset index; the respondents belonged to the middle and the highest tertiles are at significantly higher risk of having MetS, compared to the lowest, hence the poorest one third of the respondents. Factors associated with this relationship appear to be, paradoxically, things which many people would regard as improvements in their lives. They include higher consumption of meat; the respondents who belonged to the highest tertile were approximately four times more likely to consume meat daily compared to the people who belonged to the lowest, hence the poorest tertile in this study population, and milk consumption increased from 47% among the lowest tertile to 69% among the respondents belonged to the highest tertile. Well nourished people were at higher risk of MetS in this study. Evidence exists that better nutritional status is associated with higher socioeconomic status [16,42–43]. We also found a significant correlation between asset index and nutritional status (r = 0.149) (p = 0.002) in our study population. It was not possible to find the causal direction of relationships of asset index, well nourishment, and MetS, but the study confirms the positive associations of more wealth and well nourishment with the risk of MetS. More studies are warranted to explore a causal relationship of higher prevalence of MetS and better socio-economic status.
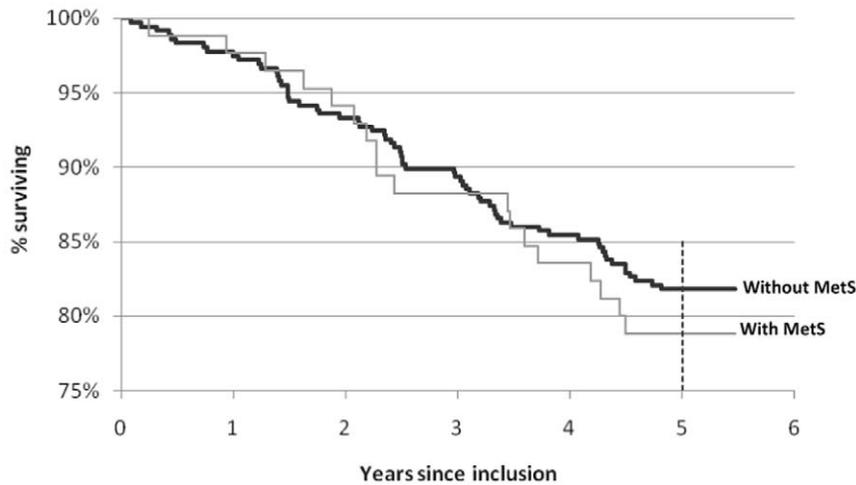
Figure 1. Survival curve of the elderly people by metabolic syndrome, up to 5 years.
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Multivariate logistic regression analyses were conducted to examine the association of independent variables (age, sex, literacy, marital status, smoking, use of tobacco leaf, nutrition and asset index) with each component of the MetS. Among the variables studied, association of age with hypertension and triglyceride was in opposite direction. The risk of high blood pressure is associated with higher age, whereas risk is reduced with higher age for high triglyceride. The overall association of nutrition and asset index with metabolic syndrome was mostly due to their association with high triglyceride and high BMI.

Overall, MetS was not associated with 5-year survival, although our analysis suggests a potential impact of MetS on poor survival among individuals with high RBG. Due to small sample size and relatively short follow up time the study lacks power to show significant difference in survival rates.

Further analyses were performed to explore if the results differ with changing the cutoff of components. We didn't find any difference in results. The prevalence of MetS ranged between 14.5 *ceteris paribus*, changing the cutoff for blood pressure from

$\geq$130 mm Hg to $\geq$140 mm Hg and 22.8 *ceteris paribus*, changing the cutoff for TG from $\geq$2.28 to $\geq$1.7 mmol/L. Nutrition and asset index remained statistically significant as before. The association of well nourishment with metabolic syndrome remained significant with a variation of odds ratio from 2.02 to 4.49 when changing the cutoffs of different components. Only when we change the cutoff for blood pressure from $\geq$130 mm Hg to $\geq$140 mm Hg, the wealthiest tertile become insignificant. Survival rates ranged between 75% to 79.4%.

Several limitations of the study should be mentioned. The cross-sectional design requires that caution should be taken before making causal interpretations on the basis of the findings. Waist circumference was not available, instead we used BMI as a proxy for abdominal adiposity in conformity with other studies that have used BMI to replace waist circumference [9,44–48]. Although measurements were based on non-fasting blood samples, which particularly affects triglyceride and glucose levels, other studies using non fasting measurement have found the predictivity for CHD comparable to studies that have used fasting measurements
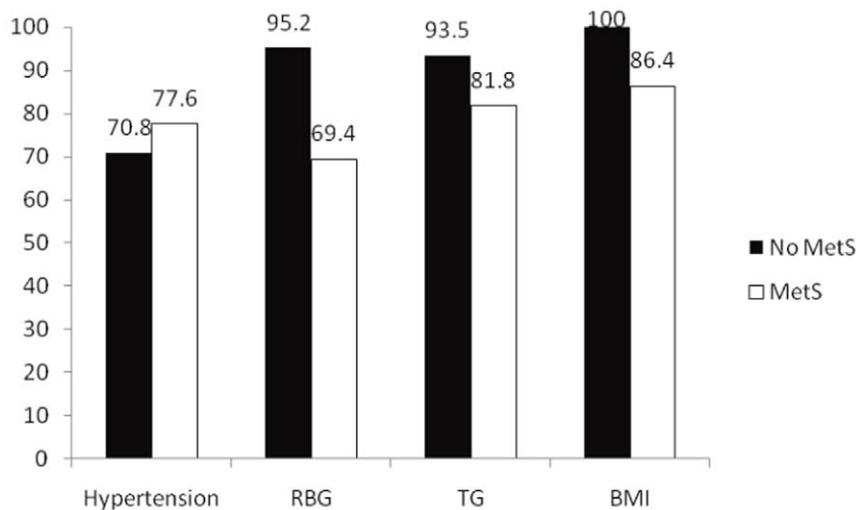
Figure 2. Five-years survival related to MetS by different components of MetS. (* p<0.05). RBG = Random Blood Glucose, TG = Triglyceride, BMI = Boby Mass Index.
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[18]. Non-fasting triglyceride levels are on the average 20% to 30% higher than fasting levels. We have used a cut-off $\geq$200 mg/dL ($\geq$2.28 mmol/L) to define high triglyceride, which is in line with other relevant studies [18]. The WHO criteria for diagnosis of the MetS is more complex because it takes into consideration microalbuminuria, plasma insulin level. NCEP definition of metabolic syndrome does not specify that any particular component be present. The NCEP criteria imply that if one has many risk factors, even if they are not very severe, their joint contribution can still markedly increase the risk of CHD.

Murray and Lopez (1996) predicted that CVD will increase in low- and middle-income countries, and that it will be the leading cause of death and disability worldwide by 2020 [49]. The economic and social costs of this burden will be great, particularly because many developing nations are still grappling with poverty-related diseases such as malnutrition, infectious diseases, and poor health care facilities. It is desirable to identify the warning signs of the MetS, thereby facilitating early education and intervention among these individuals. Additional prospective long-term studies are required to identify the combination of components of the MetS that identify more precisely persons who will develop type 2 diabetes and/or cardiovascular morbidity. Our findings highlight the importance of MetS and may be useful for designing future preventive actions against diabetes and cardiovascular diseases.

Acknowledgments

Author Contributions

Conceived and designed the experiments: MAK ÅW CQ ZNK PKS WL. Performed the experiments: MAK ÅW PKS ZNK. Analyzed the data: MAK WL. Contributed reagents/materials/analysis tools: MAK ÅW ZNK PKS. Wrote the paper: MAK.

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