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Review Article ***Open Access***

METABOLIC SYNDROME-CONCEPTS AND CRITERIAS: A REVIEW

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Metabolic syndrome, defined as a "constellation of an interconnected physiological, biochemical, clinical and metabolic factors that directly increases the risk of atherosclerotic cardiovascular disease, Type 2 Diabetes Mellitus and all cause mortality" is one of the most escalating public health problems effecting populations worldwide. At present it is gaining recognition because of increasing understanding of its association with cardiovascular mortality and morbidity. Present review is an attempt to glance into the historical prospects of the syndrome and describe the characteristics of the four most extensively accepted criteria's documented by WHO (1998), EGIR (1999), NCEP-ATPIII (2005, Revised), IDF (2005). The common components of the metabolic syndrome included in these defining criteria's include insulin resistance, abdominal obesity, lipid abnormalities and elevated blood pressure however, their defining components and diagnostic thresholds are emphasized differently highlighting the need to evolve criteria which is uniform for all the populations worldwide which will help in comparing different populations.

Keywords: Metabolic syndrome, Insulin resistance syndrome, Prevalence

INTRODUCTION

Nutrition, demographic, epidemiological and socioeconomic transitions are occurring in many developing countries .Continuing under nutrition and escalating over nutrition has created double jeopardy of communicable and non communicable diseases (Misra, 2002; and Reddy, 2002).It is a major escalating public health challenge worldwide (Zimmet and Alberti, 2008) .

Metabolic syndrome is defined by a constellation of an interconnected physiological, biochemical, clinical and metabolic factors that directly increases the risk of atherosclerotic cardiovascular disease (ASCVD), Type 2Diabetes Mellitus and all cause mortality (Grundy *et al.*, 2005; and Wilson *et al.*, 2005). It is a clinical challenge worldwide in the wake of urbanization, surplus energy intake, increasing obesity and sedentary life habits (Kaur, 2014). The underlying causes of the syndrome are genetic and environmental, overweight, obesity, and physical inactivity, which lead to insulin resistance, hyperinsulinemia, endothelial dysfunction and inflammation (Ridker *et al.*, 2003). Affected individuals have a two to five of developing Type 2 diabetes and to suffer cardiovascular related mortality leading to a great impact on public health costs and planning (Eckel *et al.*, 2005; and Alberti *et al.*, 2009).

METHODOLOGY

Relevant articles were identified by searching the PubMed, Science Direct, Google Scholar, NCBI and Medline databases. Research articles including cross-sectional, behavioural and longitudinal studies, reviews were selected. Key words such as "Metabolic Syndrome", "Insulin Resistance Syndrome", "Prevalence" were used in the search strategy (Figure 1).

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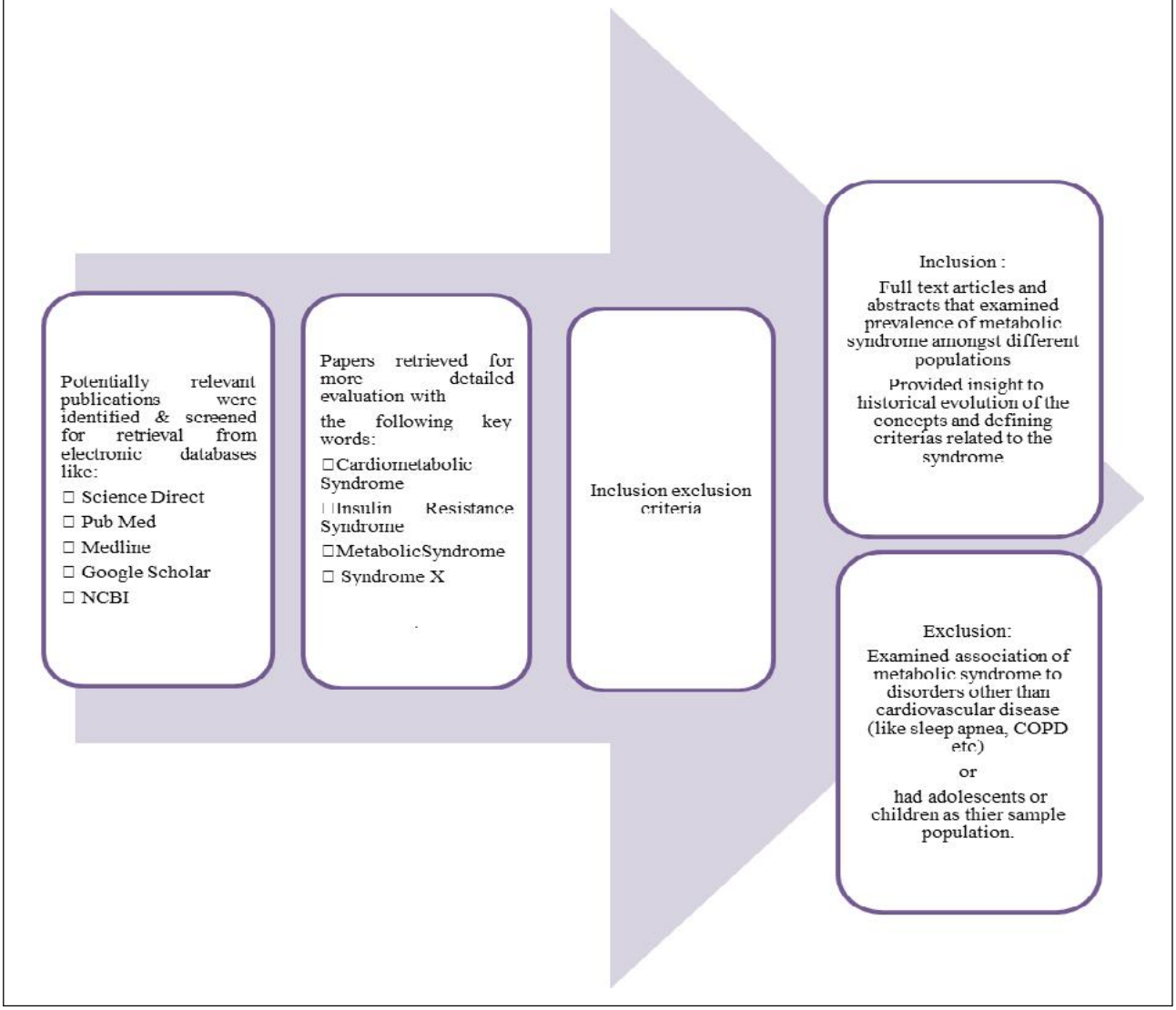
Figure 1: Flow Chart for Study Selection Process



Studies considered for inclusion in this review were full text articles and abstracts that examined prevalence of metabolic syndrome and had adults as their sample population. Articles which were not in English were translated and then used for the present review. We excluded studies that examined association of metabolic syndrome to disorders other than cardiovascular disease (like sleep apnea, COPD, etc.), or were conducted on children or adolescents as sample population.

Since the review is an attempt to highlight the historical insight associated with the development of the concepts and criterias of the syndrome, attempts were made to retrieve earliest possible documentations.

RESULTS AND DISCUSSIONS

Historical Insight

Although the present era of 'Metabolic Syndrome' or Insulin Resistance Syndrome' seems to have started few decades ago with the description of Syndrome X by Reaven in the late 1980's the history of this syndrome is much longer (Sarafidis and Nisson, 2006), where it started off as a concept rather than diagnosis (Shaw and Chilsom, 2003). It was as early as 250 years ago, long before Metabolic Syndrome description when the Italian physician and anatomist Morgagni identified the association between visceral obesity, hypertension (arterial hypertension), atherosclerosis, the high level of uric acid in the blood and

the frequent respiratory disorders during sleep (the obstructive sleep apnea) (Crepaldi and Stefania, 2006).

Nicole Paulesci 1920, has said about obesity and diabetes that most frequently the obese people become glycosuric, as if the two affections (obesity and fat diabetes) represent two consequent phases of the same pathological process (Milici, 2010). Few years later its existence was demonstrated by a Swedish physician Kylin in 1923 where he described syndrome characterized by hypertension, hyperglycemia, obesity and hyperurecemia (Oladejo, 2011). He identified a triad of hypertension, hyperglycemia and gout in his patients (Dang and Deswal, 2014). In 1927, Maranon, the founder of modern endocrinology in Spain precisely described that arterial hypertension and obesity is a pre-diabetic condition. He also believed that food is essential for preventing and treating these metabolic disturbances (Sharma *et al.*, 2015). French Physician Jean Vague drew attention to upper body adiposity (android or male type obesity) as obesity phenotype that was commonly associated with abnormalities found in Type II diabetes and cardiovascular disease (Vague, 1947). Thereafter, almost two decades later, Avogadro, Crepaldi and co-workers presented an abstract at the annual meeting of the European Association for the study of diabetes (1965) where they reported the positive affect of hypocaloric, low carbohydrate diet on obese patients with diabetes, hypercholesterolemia and hyperglyceredemia and confirmed a strict relationship among these three metabolic disorders (Okafor, 2012). This frequent simultaneous presence of obesity, high blood fat, diabetes and hypertension was termed as 'Plurimetabolic Syndrome' (Crepaldi and Maggi, 2006).

This was followed by a Dresden Study where Herman Haller pioneered the term 'Metabolic Syndrome' in his scientific literature as association of obesity, diabetes mellitus, hyperlipoproteinemia, hyperurecemia, stenosis hepatitis) with increase of viscosity of the blood and plasma as well as disturbances of coagulation together with other factors of risk further the development of arteriosclerosis or has directing influence on it (Haller, 1977). Singer, in the very same year suggested that hyperlipoproteinemia are frequently associated with other metabolic diseases (obesity, gout, diabetes mellitus, and hypertension) and so called Metabolic Syndrome (Singer, 1977). A year later Gerald & Philips conceptualized that "Constellation of Abnormalities", i.e., glucose intolerance and hyperinsulinemia, hyperglycemia and hypertension is associated with myocardial infarction, obesity and ageing (Philips, 1978). In 1985, Michael Modan proposed that hyperinsulinemia was the link between hypertension, obesity and glucose intolerance. They signified that insulin resistance and/or hyperinsulinemia are present in the majority of hypertensives, constitute a common pathophysiologic features of obesity, glucose intolerance and hypertension, possibly explaining their ubiquitous association (Modan *et al.*, 1985).

It was in 1988, when Reaven, an endocrinologist from Stanford University at the banting lecture of American Diabetes Association linked the constellation of metabolic abnormalities to insulin resistance as a key component .He described "a cluster of risk factors for diabetes and cardiovascular disease" and named it "Syndrome X". However, he missed obesity/visceral obesity from the definition which was later added as a crucial abnormality (Reaven, 1988; and Kaur, 2014). Syndrome X has also been called 'Reaven's Syndrome' (Leslie, 2005). The syndrome was renamed as the "Deadly Quartet" in by Kaplan (1989) where he referred the term to the four clinical findings, i.e., obesity, Insulin resistance/intolerance, hypertriglycerdemia and hypertension which are common and coexist oftenly and are associated with cardiovascular mortality and morbidity (Kaplan, 1989). Since then number of studies depicted the broad spectrum of metabolic disorders. In 1991, Defronzo and Ferrannini renamed Syndrome X as IRS (Insulin Resistance syndrome) proposing that Insulin Resistance appears to be a syndrome associated with clustering metabolic disorders including NIDDM, Obesity, Hypertension, lipid abnormalities and atherosclerotic cardiovascular disease (Defronzo and Ferrannini, 1991). Later, Namakura *et al.* studied associations between intra-abdominal visceral fat accumulation and coronary risk factors and proposed the term "Visceral fat syndrome" that encompasses fat accumulation, glucose intolerance,

Table 1: Synonyms for Metabolic Syndrome

Insulin Resistance Syndrome
Cardiometabolic Syndrome
Plurimetabolic Syndrome
Syndrome X
The Deadly Quartet
Visceral Fat Syndrome
Atherogenic Metabolic Triad

Table 2: Defining Criterias for Metabolic Syndrome

Criteria	WHO (1998)	EGIR (1999)	NCEP-ATPIII (2005, Revised)	IDF (2005)
Mandatory component	Insulin Resistance /Diabetes/IGT/IFG/T2 DM or other evidence of IR*	Hyperinsulinemia$ (Plasma Insulin >75th percentile	None	Central obesity (defined as waist circumference with ethnicity-specific values‡) But; if BMI is > 30 kg/m^2 central obesity can be assumed and WC doesn't need to be measured
Other additional components	Plus Any 2 of the following:	Plus Any 2 of the following:	Any 3 of the following:	Plus Any 2 of the following:
	WHR	**WC**	**WC**	**BP/HTN**
	>0.90 (men), 0.85 (women) or BMI >30 Kg/m^2	>94 cm (men) >80 cm (women)	>102 cm (men) >88 cm (women)	≥130/85 mmHg or BP ≥130/85 mmHg or treatment of previously diagnosed HTN
	HTN	**TG**	**TG**	**HDL**
	≥140/90 mmHg	≥177 mg/dl or	>150 mg/dl or R_x	<40 mg/dl or <1.03 mmol/L (men) <50 mg/dl or <1.29 mmol/L (women)
	Dyslipidemia			
	TG	**HDL-C**	**BP**	**Raised TGL**
	150 mg/dl (or greater) or ≥1.7 mmol/L	<39 mg/dl in men or women	≥130/85 mmHg or R_x	≥150 mg/dl or ≥1.7 mmol/L or specific treatment for this lipid abnormality
	HDL-C	**BP**	**HDL**	**Raised fasting plasma glucose**
	<35 mg/dl or <0.9 mmol/L (men) <39 mg/dl or <1.0 mmol/L (women)	≥140/90 mmHg or on anti-hypertensive drugs	<40 mg/dl (men) <50 mg/dl (women) or R_x	≥100 mg/dl (5.6 mmol/L) or previously diagnosed type 2 diabetes (If above 5.6 mmol/L/100 mg/dL, OGTT is strongly recommended but is not necessary to define the presence of the syndrome
	Microalbuminuria	**Fasting glucose**	**Fasting Glucose**	
	(Albumin: creatinine ratio >30 mg/g or greater) or urinary albumin excretion rate ≥20 g/min	110 mg/dl or greater.	100 mg/dl or greater or R_x	

Note: **IR (Other evince of IR (Family history of type 2 diabetes, age, ethnicity, sedentary lifestyle); R_x: pharmacological treatment; $hyperinsulinemia: reliable only in patient without diabetes; ‡Waist circumference specific for each population (IDF, 2005; South Asian/Chinese/Japanese: Men90 cm and Women-80 cm; Europids: Men94 cm and Women-80 cm; In USA, the ATP III values (102 cm male; 88 cm female) are likely to continue to be used for clinical purposes.*

hyperlipidemia and hypertension (Nakamura *et al.*, 1994). In Lamarche *et al.* (1998) reported a combination of hyperinsulinemia, elevated adipolipoprotein B, and small dense Low Density Lipoprotein (LDL) cholesterol as the "Atherogenic Metabolic Triad" (Lamarche *et al.*, 1998; and Oda, 2008).

Present Day Defining Criteria for Metabolic Syndrome

In an effort to define clinical criteria for the metabolic syndrome many International expert groups have recommended different clinical criteria for the metabolic syndrome (Table 2). The most extensively accepted criteria's are documented by:

- World Health Organization, WHO (1998)
- European Group for the study of Insulin Resistance, EGIR (1999)
- National Cholesterol Education Program–Adult Treatment Panel III, NCEP-ATPIII (2005, Revised)
- International Diabetes Federation, IDF (2005)

The major components of the metabolic syndrome included in these definitions are similar, but components and their diagnostic threshold values are emphasized differently in different definitions (Qiao, 2006).

World health organization first developed its definition in 1998 (Alberti and Zimmet, 1998) tying together the key components of Insulin Resistance, obesity, dislipidemia and hypertension. The definition mandates that IR to be present ,without it even if all the other criteria were met, the patient would not have metabolic syndrome (Huang, 2009). Potential disadvantage of WHO criteria is that special testing of glucose status beyond routine clinical assessment may be necessary to diagnose metabolic syndrome (Grundy *et al.*, 2004).

One year later, European Group for the study of Insulin resistance proposed a modification to the WHO definition (Balkau and Charles, 1999). EGIR focused more on abdominal obesity than did WHO but in contrast to WHO, it excluded patients with Type II diabetes mellitus from their syndrome because Insulin Resistance was viewed primarily as a risk factor for Diabetes (Parikh and Mohan, 2012). It excluded microalbuminuria as an integral component of the syndrome ,in addition waist circumference and not BMI was regarded as the main indicator to assess obesity (94 cm in men and 80 cm in women) (Balkau and Charles, 1999).

NCEP ATPIII presented a new approach that was less 'glucocentric' and treated all components with equal importance, i.e., central obesity, hypertriglycerdemia, HDL, hypertension, and fasting plasma glucose. Waist circumference was used to assess obesity but higher cut offs were used to assess the same (i.e., 102 cm for men and 88 cm for women). International Diabetes federation mandates the presence of 'central obesity' to be an essential component for the presence of metabolic syndrome defined as waist circumference waist ethnicity specific values (Table 3).

Table 3: Ethnic Specific Values for Waist Circumference (IDF, 2005) (Gender and Ethnic Group Specific)

Country/Ethnic Group	Waist Circumference (as Measure of Central Obesity)	
Europids*	Male	≥94 cm
	Female	≥80 cm
South Asians**	Male	≥90 cm
	Female	≥80 cm
Chinese	Male	≥90 cm
	Female	≥80 cm
Japanese***	Male	≥90 cm
	Female	≥80 cm
Ethnic South and Central Americans	Using South Asian recommendations until more specific data are available	
Sub-Saharan Africans	Use European data until more specific data are available	
Eastern Mediterranean and Middle East (Arab) population	Use European data until more specific data are available	

Note: *In the USA, the ATP III values (102 cm male; 88 cm female) are likely to continue to be used for clinical purposes; **Based on a Chinese, Malay and Asian Indian population; ***Subsequent data analyses suggest that Asian values (male, 90 cm; female 80 cm) should be used for Japanese populations until more data are available.

Worldwide

The prevalence of MS is increasing in epidemic proportions in both developed countries and developing countries (Cornier *et al.*, 2008). Table 4 represents the prevalence of

Table 4: Prevalence of Metabolic Syndrome Worldwide

Author	Year €	State/Population	Sample Size (n)	Prevalence (%)	Criteria Used*
Tan *et al*	2004	Singapore	4723	17.9	*M-NCEP-ATPIII
		(used data from Singapore National Health Survey)		Female 15.35	
				Male 20.9	
OH &Associates	2004	South Korea	774	22.9	*M-NCEP-ATPIII
		(Urban population)		Female 16.8	
				Male 29	
Sidorenkov	2010	Russia	3705	15.6	NCEP-ATPIII
		(adults 18-19 years) used survey data conducted in 2000, Arkhagelak)		Female 19.8	
				Male 11.5	
Metelskaya *et al*	2012	Russia	1788	34.2	NCEP-ATPIII
		(Elderly population 55 years and above)		Female 41.7	
				Male 26.8	
Ali *et al*	2012	Pakistan	1329	63.7	*IDF
		(≥18 years, attending routine annual physical checkups)		Female 57.8	
				Male 66.2	
Binno *et al*	2015	Italy	9647	29	AHA-NHLBI
		(Ogliastra)		Female 31.8	
				Male 26.4	
Bonora *et al*	2003	Italy	888	34.1	WHO
		(40-79 years)		Female35.9	
				Male 32.9	
Kaykhaei *et al*	2012	Iran (Zahadan)	1802	21	NCEP-ATPIII
		(≥19 years)		Female 24.9	
				Male15.4	
Riedger *et al*	2011	Canada	1800	17.7	ATPIII
		(≥18 years)		Female 19.5	
				Male 15.9	
Ervin	2003	United States	3423	34	NCEP-ATPIII
		NHANES (2003-2006)		Female 32.6	
				Male 35.1	

Table 4 (Cont.)

Loizou *et al*	2006	Cyprus (20-80 Years)	1200	22.2 Female 18.3 Male 26.5	NCEP-ATPIII
Ogbera	2010	South Africa (35-85 years diabetic population)	963	86 Female 86 Male 83	IDF
Athyros *et al*	2005	Greece (≥18 years)	4153	23.6 Female 22.8 Male 24.4	NCEP-ATPIII
Pannier *et al*	2006	France (aged 18-80 years)	101697	8.15 Female 6.1 Male 10.2	NCEP-ATPIII 2001
Al Daghri *et al*	2010	Saudi Arab (18-55 years)	2850	35.3 Female 34.1 Male 36.6	NCEP-ATPIII
Bhowmik *et al*	2015	Bangladesh (≥20 years rural population)	2293	30.7 Female 30.5 Male 30.5	*NCEP-ATPIII
Vozarova de courten *et al*	2003	Slovakia (Gypsies and non gypsies)	570	Gypsies 20 Non - gypsies 4	WHO
Al-lawati & associates	2003	Oman (>20 years)	1419	21 Female 23 Male 19.5	NCEP-ATPIII
Soewondo *et al*	2010	Indonesia (25-64 years)	1591	28.4 Female 30.4 Male 25.4	*NCEP-ATPIII
Katulanda *et al*	2012	Sri Lanka (Adults over 18 years of age)	4,485	27.1 Female 28.3 Male 18.4	*IDF
Wang *et al*	2013	China (adults aged ≥32 years)	22,457	33.9 Female 32.5 Male 35.1	*IDF

Note: *Asian specific cut off used to diagnose metabolic syndrome in Asian population/s; €date of publishing.

metabolic syndrome in different parts of the world; however, these are reliant on the different defining criteria taken into consideration.

Other important factors that appear to affect the prevalence are ethnicity, socioeconomic status, gender and lifestyle habits.

India

Metabolic syndrome is a crucial factor in causation of diabetes and coronary artery disease in Asian Indians. The prevalence of metabolic syndrome varies by the criteria used and the population studied with greater prevalence in urban areas and in people with diabetes and obesity (Reddy *et al.*, 2006). Significant difference exist in the prevalence of various component of the metabolic syndrome within an urban environment and this appears to be influenced by socio-economic status (Mohan *et al.*, 2001). Table 5 depicts the prevalence of metabolic syndrome in different regions of India across different populations.

Table 5: Prevalence of Metabolic Syndrome in India

Author	Year €	State/Population	Sample Size (n)	Prevalence (%)	Criteria Used*
Prasad *et al*	2012	Orissa	509	43.2	IDF
		Eastern India		Females 52.5	
				Males 34.2	
Sathyanarayan and Subbalakshmi	2012	Old age homes	189	57.67	IDF
				Females 61.01	
				Males 52.11	
Thiruvagounder *et al*	2010	Salem (patients attending routine medical checkups)	1558	27.62	NCEP-ATPIII
				Females 27.04	
				Males 33.17	
Kanjilal	2008	Mumbai	2316	40.3	ATPIII
		Bangalore			
		(IARS Families)			
Pathania *et al*	2013	Ambala, Haryana	1200	9.2	IDF
				Females 11.64	
				Males 6.45	
Deepa *et al*	2007	CURES-Chennai	23001	25.8	IDF
Bansal and Joshi	2015	Delhi (Muslim Population)	406	75.12	NCEP-ATPIII
				Females 77.58	
				Males 67.6	
Kaur	2014	Punjab	351	17.38	NCEP-ATPIII
				Females 57.38	
				Males 42.63	
Kamble *et al*	2010	Aji (Rural Wardha, village of PHC)	300	9.3	NCEP-ATPIII
				Females 10.7	
				Males 8.2	
Gupta *et al*	2004	Urban Indian population	1091	31.6	NCEP-ATPIII
				Females 39.9	
				Males 22.9	
Surana *et al*	2008	Mumbai	5088	77.2	NCEP-ATPIII
		(Diabetic population)		Females 87.71	
				Males 69.33	

Table 5 (Cont.)

Sawant *et al*	2011	Mumbai (adults attending cardiac evaluation camps)	548	19.52 Females 12.6 Males 25.16	NCEP-ATPIII
Mangat *et al*	2010	Chandigarh (urban and rural slum population)	605	47.4 Females 59.6 Males 40.4	IDF
Chow *et al*	2007	Andhra Pradesh	4535	28.2 Females 23.9 Males 32.5	NCEP-ATPIII
Yadav *et al*	2013	Gwalior Chambal (Diabetic participants)	700	57.7 Females 70.4 Males 52.7	IDF
Raman *et al*	2010	Chennai (Diabetic Type II)	1414	73.3 Females 83.3 Males 65.3	IDF
Reddy *et al*	2006	10 Industrial Companies, India	19973	26.6 Females 36.3 Males 20.9	NCEP-ATPIII
Ismail *et al*	2016	Kerala (Tribal area, Kannur district)	120	28.3 Females 32.5 Males 21	NCEP-ATPIII
Walvekar *et al*	2015	Karnataka Bank employees (only males)	73	Males 45.2	NCEP-ATPIII
Padmavathi *et al*	2013	Adults attending OPD, routine medical checkup	206	46.3 Females 42.2 Males 45	NCEP-ATPIII
Peixoto *et al*	2014	Goa (rural population)	325	36.9 Females 39.8 Males 33.6	*NCEP-ATPIII
Jain *et al*	2015	Gujarat (apparently healthy adults 20-40 years)	1500	16 Females 10.8 Males 21.5	NCEP-ATPIII
Madan and Narsaria	2016	Mumbai (Apparently healthy men 18-65 years)	313	Males 39.9	*NCEP-ATPIII

Note: *Asian specific cut off used to diagnose metabolic syndrome; €date of publishing.

Can and Bersot (2007) asserted the agreement among WHO, EGIR definition was very good. Metabolic syndrome that do not require measurement of insulin levels (NCEP, ACEE and IDF) identify twice more patients with insulin resistance and increased Framingham risk score and are more useful than the definition that require measurement of insulin levels (WHO, EGIR). Both WHO and ATPIII definitions yielded similar estimates for the entire population

but masked difference for various population sub groups (i.e., in African–American men) (Ford and Giles, 2003). The results of the study conducted by Vinluan et al, 2012, show that all the definitions of metabolic syndrome with the exception of EGIR are associated with increased risks of cardiovascular events in elderly subjects. Only the modified WHO definition significantly (didn't include microalbuminuria) predicts all three endpoints, total cardiovascular events, coronary and cerebrovascular events. In an attempt to assess the performance of five different criterias of metabolic syndrome the level of agreement appears to be poor though IDF criteria shows a fair level of agreement with the WHO criteria (Onesi and Ignatius, 2014). Misra *et al.* (2005) showed the candidate definition MS 4 which included modified cut-offs of waist circumference (90 cms in men and >80 cm), BMI (>23 Kg/m^2) and SST (>18 mm) in addition to the criteria a given by ATP definition demonstrated the maximum percentage of prevalence and gain in prevalence. Bhowmik *et al.* (2015), noted a higher prevalence of metabolic syndrome in Bangladeshi population using NCEP definition and was strongly associated with diabetes, hypertension and CVD. In a cross sectional study conducted by Moy and Bulgiba (2010), it was observed that modified NCEP-ATP III criteria may be more suitable in the diagnosis of metabolic syndrome for the Malay Cohort in Kuala Lumpur. In the rural Chinese population, the JIS, IDF and CDs criteria may not be more suitable than WHO and updated NCEPATPIII definition for screening high risk individuals and estimating the risk of CHD and stroke from metabolic syndrome especially in Men.

CONCLUSION

The review summarizes the different evolutionary and evolving concepts related to the syndrome and provides insight to the most widely used defining criteria's at present. Each one of the stated criteria has its own defining components and those which are common to all have different threshold values to identify and define metabolic syndrome that may or may not be specific to different ethnic populations. These differences make it difficult to analyze and compare the prevalence across different studies/ population groups.

Data across different populations shows an increasing trend of the prevalence of the deadly syndrome in both the developed and developing nations urging a need to develop a uniform criterion that is applicable to all populations which will help in comparing different studies/population and to aptly recognize people at risk.

REFERENCES

- "International Diabetes Federation Epidemiology Task Force Consensus Group: The IDF Consensus Worldwide Definition of the Metabolic Syndrome", *International Diabetes Federation Brussels,* 2005.
- Alberti K and Zimmet P (1998), "Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications, Part 1: Diagnosis and Classification of Diabetes Mellitus", Report of a WHO Consultation, *Diabetic Med.*, Vol. 15, pp. 539-553.
- Alberti K G and Zimmet P Z (1998), "Definition, Diagnosis and Classification of Diabetes Mellitus and its Complications, Part 1: Diagnosis and Classification of Diabetes Mellitus Provisional Report of a WHO Consultation", *Diabet Med.*, Vol. 15, pp. 539-553.
- Alberti K G M M, Eckel R H, Grundy S M *et al.* (2009), "Harmonizing the Metabolic Syndrome: A Joint Interim Statement of the International Diabetes Federation Task Force on Epidemiology and Prevention", National Heart, Lung and Blood Institute, American Heart Association, World Heart Federation, International Atherosclerosis Society, and International Association for the Study of Obesity, *Circulation*, Vol. 120, No. 16, pp. 1640-1645.
- Ali N S, Khuwaja A K, Adnan-ur-Rahman and Nanji K (2012), "Retrospective Analysis of Metabolic Syndrome: Prevalence and Distribution in Executive Population in Urban Pakistan", *International Journal of Family Medicine*, Article ID 649383, p. 8, doi:10.1155/ 2012/649383.
- Al-Lawati J A, Mohammed A J, Al-Hinai H Q *et al.* (2003), "Prevalence of the Metabolic Syndrome Among Omani Adults", *Diabetes Care*, Vol. 26, pp. 1781-1785.
- Athyros V G, Bouloukos V I, Pehlivanidis A N, Papageorgiou A A, Dionysopoulou S G, Symeonidis A N *et al.* (2005), "The Prevalence of the Metabolic Syndrome in Greece: The MetS-Greece Multicentre Study", *Diabetes Obes Metab.*, Vol. 7, pp. 397-405.
- Balkau B and Charles M A (1999), "The European Group for the Study of Insulin Resistance (EGIR): Comment on the Provisional Report from the WHO Consultation", *Diabet Med.*, Vol. 16, pp. 442-443.
- Bansal A and Joshi P (2015), "Predictor of Metabolic Syndrome: A Community Study from Urban Delhi,

India", *Journal of Human Sciences*, Vol. 12, No. 1, pp. 1451-1462.

- Bhowmik B, Afsana F, Siddiquee T, Munir S B, Sheikh F, Wright E and Hussain A (2015), "Comparison of the Prevalence of Metabolic Syndrome and its Association with Diabetes and Cardiovascular Disease in the Rural Population of Bangladesh Using the Modified National Cholesterol Education Program Expert Panel Adult Treatment Panel III and International Diabetes Federation Definitions", *Journal of Diabetes Investigation*, Vol. 6, No. 3, pp. 280-288.
- Biino G, Concas M P, Cena H *et al.* (2015), "Dissecting Metabolic Syndrome Components: Data from an Epidemiologic Survey in a Genetic Isolate", *Springer Plus*, Vol. 4, p. 324.
- Bonora E, Kiechl S, Willeit J, Oberhollenzer F, Egger G, Bonadonna R C and Muggeo M (2003), "Metabolic Syndrome: Epidemiology and More Extensive Phenotypic Description, Cross-Sectional Data from the Bruneck Study", *International Journal of Obesity-Related Metabolic Disorders*, Vol. 27, pp. 1283--1289.
- Can A S and Bersot T P (2007), "Analysis of Agreement Among Definitions of Metabolic Syndrome in Nondiabetic Turkish Adults: A Methodological Study", *BMC Public Health*, Vol. 7, p. 353.
- Chow C K, Naidu S, Raju K, Raju R, Joshi R, Sullivan D, Celermajer D S and Neal B C (2008), "Significant Lipid, Adiposity and Metabolic Abnormalities Amongst 4535 Indians from a Developing Region of Rural Andhra Pradesh", *Atherosclerosis*, Vol. 196, pp. 943-952.
- Cornier M A *et al.* (2008), "The Metabolic Syndrome", *Endocr Rev.*, Vol. 29, No. 7, pp. 777-822.
- Crepaldi Gaetano and Maggi Stefania (2006), "The Metabolic Syndrome: A Historical Context", *Diabetes Voice*, Vol. 51, pp. 8-10.
- Crepaldi Gaetano and Maggi Stefania (2006), "The Metabolic Syndrome: A Historical Context", *Diabetes Voice*, Vol. 51, pp. 8-10.
- Dang A S and Deswal R (2014), "The Metabolic Syndrome: Time for Addressal", *J Health Res Rev*, Vol. 1, pp. 59-65.
- Deepa M, Farooq S, Datta M, Deepa R and Mohan V (2015), "Prevalence of Metabolic Syndrome Using WHO, ATPIII and IDF Definitions in Asian Indians: The Chennai Urban Rural Epidemiology Study (CURES-34)", *Diabetes*, Vol. 23, No. 2, pp. 127-134.
- DeFronzo R A (1991), "Ferrannini E: Insulin Resistance, A Multifaceted Syndrome Responsible for NIDDM, Obesity, Hypertension, Dyslipidemia and Atherosclerotic Cardiovascular Disease", *Diabetes Care*, Vol. 14, pp. 173-194.
- Eckel R H, Grundy S M and Zimmet P Z (2005), " The Metabolic Syndrome", *The Lancet*, Vol. 365, No. 9468, pp. 1415-1428.
- Ervin R B (2009), "Prevalence of Metabolic Syndrome Among Adults 20 Years of Age and Over by Sex, Age, Race, Ethnicity and Body Mass Index: United States, 2003-2006", *Natl Health Stat Report.*, pp. 1-7.
- Ford E S and Giles W H (2003), "A Comparison of the Prevalence of the Metabolic Syndrome Using Two Proposed Definitions", *Diabetes Care*, Vol. 26, No. 3, pp. 575-581.
- Grundy S M, Brewer H B Jr, Cleeman J I, Smith S C Jr and Lenfant C (2004), "Definition of Metabolic Syndrome: Report of the National Heart, Lung and Blood Institute/American Heart Association Conference on Scientific Issues Related to Definition", *Arterioscler Thromb Vasc Biol.*,Vol. 24, pp. e13-e18.
- Grundy S M, Cleeman J I, Daniels S R *et al.* (2005), "Diagnosis and Management of the Metabolic Syndrome: an American Heart Association/National Heart, Lung and Blood Institute Scientific Statement", *Circulation*, Vol. 112, No. 17, pp. 2735-2752.
- Gupta R, Deedwania P C, Gupta A, Rastogi S, Panwar R B and Kothari K (2004), "Prevalence of Metabolic Syndrome in an Indian Urban Population", *Int J Cardiol.*, Vol. 97, pp. 257-261.
- Haller H and Hanefeld M (1975), "Synoptische Betrachtung Etabolischer Risikofaktoren", Haller H, Hanefeld M and Jaross W (Eds.), *Lipidstoffwechselstörungen*, pp. 254-264.
- Huang P L (2009), "A Comprehensive Definition for Metabolic Syndrome", *Disease Models & Mechanisms*, Vol. 2, Nos. 5-6, pp. 231-237.
- Jain S R, Shah K H, Acharya H N, Barot K and Sharma K H (2015), "Prevalence and Predictors of Metabolic

Syndrome in Young Asymptomatic Gujarati Population", *Int J Chronic Dis.*, p. 365217.

- Kamble P, Deshmukh P R and Garg N (2010), "Metabolic Syndrome in Adult Population of Rural Wardha, Central India", *The Indian Journal of Medical Research*, Vol. 132, No. 6, pp. 701-705.
- Kanjilal S, Shanker J, Rao V S, Khadrinarasimhaih N B, Mukherjee M, Iyengar S S and Kakkar V V (2008), "Prevalence and Component Analysis of Metabolic Syndrome: An Indian Atherosclerosis Research Study Perspective", *Vascular Health and Risk Management*, Vol. 4, No. 1, pp. 189-197.
- Kaplan N M (1989), "The Deadly Quartet, Upper-Body Obesity, Glucose Intolerance, Hypertriglyceridemia and Hypertension", *Archives of Internal Medicine*, Vol. 149, No. 7, pp. 1514-1520.
- Katulanda P, Ranasinghe P, Jayawardana R, Sheriff R, and Matthews D R (2012), "Metabolic Syndrome Among Sri Lankan Adults: Prevalence Patterns and Correlates", *Diabetology & Metabolic Syndrome*, Vol. 4, p. 24.
- Kaur J (2014), "A Comprehensive Review on Metabolic Syndrome", Cardiology Research and Practice, 943162.
- Kaykhaei M, Hashemi M, Narouie B, Shikhzadeh A, Jahantigh M, Shirzaei E and Ansari H (2012), "Prevalence of Metabolic Syndrome in Adult Population from Zahedan, Southeast Iran", *Iranian Journal of Public Health*, Vol. 41, No. 2, pp. 70-76.
- Lamarche B, Tchernof A, Mauriege P, Cantin B, Dagenais G R and Lupien P J (1998), "Despre´s J P: Fasting Insulin and Apolipoprotein B Levels and Low-Density Lipoprotein Particle Size as Risk Factors for Ischemic Heart Disease", *JAMA*, Vol. 279, pp. 1955-1961.
- Leslie B R (2005), "Metabolic Syndrome: Historical Perspectives", *Am J Med Sci*, Vol. 330, pp. 264-268.
- Loizou T, Pouloukas S, Tountas C *et al.* (2006), "An Epidemiologic Study on the Prevalence of Diabetes, Glucose Intolerance and Metabolic Syndrome in the Adult Population of the Republic of Cyprus", *Diabetes Care*, Vol. 29.
- Madan J G and Narsaria A M (2016), "Prevalence of Metabolic Syndrome in Mumbai City, India", *J Obes Metab Res.*, Vol. 3, pp. 16-22.
- Mangat C, Goel N K, Walia D K, Agarwal N, Sharma M K, Kaur J *et al.* (2010), "Metabolic Syndrome: A Challenging Health Issue in Highly Urbanized Union Territory of North India", *Diabetol Metab Syndr.*, Vol. 2, p. 19.
- Metelskaya V A, Shkolnikova M A, Shalnova S A, Andreev E M, Deev A D, Jdanov D A and Vaupel J W (2012), "Prevalence, Components and Correlates of Metabolic Syndrome Among Elderly Muscovites: Metabolic Syndrome in Elderly Muscovites", *Archives of Gerontology and Geriatrics*, Vol. 55, No. 2, pp. 231-237.
- Milici N A (2010), "Short History of the Metabolic Syndrome Definitions", *Proc Rom Acad*, Vol. 1, pp. 13-22.
- Misra A (2002), "Overnutrition and Nutritional Deficiency Contribute to Metabolic Syndrome and Atherosclerosis in Asian Indians", *Nutrition*, Vol. 18, pp. 702-703.
- Misra A, Wasir J S and Pandey R M (2005), "An Evaluation of Candidate Definitions of the Metabolic Syndrome in Adult Asian Indians", *Diabetes Care*, Vol. 28, pp. 398-403.
- Modan M, Halkin H, Almog S, Lusky A, Eshkol A, Shefi M, Shitrit A and Fuchs Z (1985), "Hyperinsulinemia, A Link Between Hypertension, Obesity and Glucose Intolerance", *Journal of Clinical Investigation*, Vol. 75, No. 3, pp. 809-817.
- Mohan V, Shanthirani S, Deepa R, Premaatha G, Sastry N G and Saroja Rintra (2001), "Urban Differences in the Prevalence of the Metabolic Syndrome in Southern India: The Chennai Urban Population Study (CUPS No. 4)", *Diabet Med.*, Vol. 18, No. 4, pp. 280-287.
- Moy F M and Bulgiba A (2010), "The Modified NCEP ATP III Criteria Maybe Better than the IDF Criteria in Diagnosing Metabolic Syndrome Among Malays in Kuala Lumpur", *BMC Public Health*, Vol. 10, p. 678.
- Nakamura T, Tokunaga K, Shimomura I, Nishida M, Yoshida S, Kotani K, Islam A H, Keno Y, Kobatake T and Nagai Y (1994), "Contribution of Visceral Fat Accumulation to the Development of Coronary Artery Disease in Non-Obese Men", *Atherosclerosis*, Vol. 107, pp. 239-246.

- Oda E (2008), "The Metabolic Syndrome as a Concept of Adipose Tissue Disease", *Hypertens Res*, Vol. 31, pp. 1283-1291.
- Ogbera A O (2010), "Prevalence and Gender Distribution of the Metabolic Syndrome", *Diabetology & Metabolic Syndrome*, Vol. 2, p. 1.
- Oh J Y, Hong Y S and Sung Y A (2004), "Prevalence and Factor Analysis of Metabolic Syndrome in an Urban Korean Population", *Diabetes Care*, Vol. 27, pp. 2027-2032.
- Okafor C I (2012), "The Metabolic Syndrome in Africa: Current Trends", *Indian Journal of Endocrinology and Metabolism*, Vol. 16, No. 1, pp. 56-66.
- Oladejo A O (2011), "Overview of the Metabolic Syndrome: An Emerging Pandmic of Public Health Significance", *Annals of Ibadan Postgraduate Medicine*, Vol. 9, No. 2, pp. 78-82.
- Onesi S O and Ignatius U E (2014), "Metabolic Syndrome: Performance of Five Different Diagnostic Criterias", *Indian Journal of Endocrinology and Metabolism*, Vol. 18, No. 4, pp. 496-501, http://doi.org/10.4103/2230-8210.137494
- Padmavathi P, Sailaja E, Renuka E, Gnana Desigan and Balu Mahendran K (2013), "Prevalence of Metabolic Syndrome", *International Journal of Research in Pharmaceutical and Biomedical Sciences*, Vol. 4, pp. 1-4.
- Pannier B, Thomas F, Eschwege E, Bean K, Benetos A, Leocmach Y, Danchin N and Guize L (2006), "Cardiovascular Risk Markers Associated with the Metabolic Syndrome in a Large French Population: The "SYMFONIE" Study", *Diabetes & Metabolism*, Vol. 32, No. 5, Pt. 1, pp. 467-474.
- Parikh R M and Mohan V (2012), "Changing Definitions of Metabolic Syndrome", *Indian Journal of Endocrinology and Metabolism*, Vol. 16, No. 1, pp. 7-12.
- Pathania D, Bunger R, Mishra P, Pathak R and Arora A A (2013), "Study to Assess Prevalence of Metabolic Syndrome and its Socio Demographic Risk Factors in Rural Area of District Ambala, Haryana", *J Community Med Health Educ.*, Vol. 3, p. 226.
- Peixoto C and Shah H K (2014), "Prevalence of Metabolic Syndrome Among Adult Population in a Rural Area of Goa", *J Pub Health Med Res*, Vol. 2, No. 1, pp. 34-37.
- Phillips G B (1978), "Sex Hormones, Risk Factors and Cardiovascular Disease", *Am J Med*, Vol. 65, No. 1, pp. 7-11.
- Prasad D S, Kabir Z, Dash A K and Das B C (2012), "Prevalence and Risk Factors for Metabolic Syndrome in Asian Indians: A Community Study from Urban Eastern India", *Journal of Cardiovascular Disease Research*, Vol. 3, No. 3, pp. 204-211.
- Qiao Q (2006), "Comparison of Different Definitions of the Metabolic Syndrome in Relation to Cardiovascular Mortality in European Men and Women", *Diabetologia.*, Vol. 49, pp. 2837-2846.
- Raman R, Gupta A, Pal S S, Ganesan S, Venkatesh K, Kulothungan V and Sharma T (2010), "Prevalence of Metabolic Syndrome and its Influence on Microvascular Complications in the Indian Population with Type 2 Diabetes Mellitus, Sankara Nethralaya Diabetic Retinopathy Epidemiology and Molecular Genetic Study (SN-DREAMS, Report 14)", *Diabetology & Metabolic Syndrome*, Vol. 2, p. 67.
- Reaven G M (1988), "Role of Insulin Resistance in Human Disease", *Diabetes*, Vol. 37, No. 12, pp. 1595-1607.
- Reddy K S (2002), "Cardiovascular Diseases in the Developing Countries: Dimensions, Determinants, Dynamics and Directions for Public Health Action", *Public Health Nutr*, Vol. 5, pp. 231-237.
- Reddy K S, Prabhakaran D, Chaturvedi V *et al.* (2006), "Methods for Establishing a Surveillance System for Cardiovascular Diseases in Indian Industrial Populations", *Bull World Health Organ.*, Vol. 84, No. 6, pp. 461-469.
- Ridker P M, Buring J E, Cook N R and Rifai N (2003), "C-Reactive Protein, the Metabolic Syndrome and Risk of Incident Cardiovascular Events: an 8-Year Follow-Up of 14 719 Initially Healthy American Women", *Circulation*, Vol. 107, No. 3, pp. 391-397.
- Riediger N D and Clara I (2011), "Prevalence of Metabolic Syndrome in the Canadian Adult Population", *CMAJ/:Canadian Medical Association Journal*, Vol. 183, No. 15, pp. e1127-e1134.

- Sarafidis P A and Nilsson P M (2006), "The Metabolic Syndrome: A Glance at its History", *J Hypertens*, Vol. 24, No. 4, pp. 621-626.
- Satyanarayan Rao K N and Subbalakshmi N K (2012), "Prevalence of Metabolic Syndrome and Co Morbid Conditions in Inmates of Old Age Homes", *NUJHS*, Vol. 2, No. 4, pp. 22-27.
- Sharma K, Behera R, Agrawal D and Kumar S (2015), "Metabolic Syndrome: Evolution, Etiopathogenesis and Recent Trends in its Management", *Research Journal of Pharmaceutical, Biological and Chemical Sciences*, Vol. 6, No. 1, pp. 377-410.
- Shaw J E and Alberti K G M M (2006), "Point, Impaired Fasting Glucose: The Case for the New American Diabetes Association Criterion", *Diabetes Care*, Vol. 29, No. 5, pp. 1170-1172.
- Sidorenkov O, Nilssen O, Brenn T, Martiushov S, Arkhipovsky V L and Grjibovski A M (2010), "Prevalence of the Metabolic Syndrome and its Components in Northwest Russia: The Arkhangelsk Study", *BMC Public Health*, Vol. 10, pp. 23-10, 1186/ 1471-2458-10-23.
- Singer P (1977), "Diagnosis of Primary Hyperlipoproteinemias", *Z Gesamte Inn Med*, Vol. 32, pp. 129-133.
- Soewondo P *et al.* (2010), "Prevalence of Metabolic Syndrome Using NCEP/ATP III Criteria in Jakarta, Indonesia: The Jakarta Primary Non-Communicable Disease Risk Factors Surveillance 2006", *Acta Med Indones.*, Vol. 42, No. 4, pp. 199-203.
- Surana S P, Shah D B, Gala K *et al.* (2008), "Prevalence of Metabolic Syndrome in an Urban Indian Diabetic Population Using the NCEP ATP III Guidelines", *Journal of Association of Physicians of India*, Vol. 56, pp. 865-868.
- Thiruvagounder M, Khan S and Sheriff D S (2010), "The Prevalence of Metabolic Syndrome in a Local Population in India", *Biochemia Medica.*, Vol. 20, No. 2, pp. 249-252.
- Thiruvagounder M, Khan S and Sheriff D S (2010), "The Prevalence of Metabolic Syndrome in a Local Population in India", *Biochemia Medica.*, Vol. 20, No. 2, pp. 249-252.
- Vague J (1947), "Sexual Differentiation: A Factor Affecting the Forms of Obesity", *Presse Medicale*, Vol. 30, pp. S39-S40.
- Vinluan C M, Zreikat H H, Levy J R and Cheang K I (2012), "Comparison of Different Metabolic Syndrome Definitions and Risks of Incident Cardiovascular Events in the Elderly", *Metabolism*, Vol. 61, No. 3, pp. 302-309.
- Vozarova de Courten B, de Courten M, Hanson R L, Zahorakova A, Egyenes H P, Tataranni P A *et al.* (2003), "Higher Prevalence of Type 2 Diabetes, Metabolic Syndrome and Cardiovascular Diseases in Gypsies than in Nongypsies in Slovakia", *Diabetes Res Clin Pract.*, Vol. 62, No. 2, pp. 95-103.
- Walvekar S *et al.* (2015), "Association of Obesity and Cardiometabolic Syndrome in Bank Employees: A Cross Sectional Study", *JKIMSU.*, Vol. 4, No. 1, pp. 115-122.
- Wang G-R, Li L, Pan Y-H, Tian G-D, Lin W-L, Li Z and Berger N A (2013), "Prevalence of Metabolic Syndrome Among Urban Communit Residents in China", *BMC Public Health*, Vol. 13, p. 599.
- Wilson P W F, D'Agostino R B, Parise H, Sullivan L and Meigs J B (2005), "Metabolic Syndrome as a Precursor of Cardiovascular Disease and Type 2 Diabetes Mellitus", *Circulation*, Vol. 112, No. 20, pp. 3066-3072.
- Yadav D, Mahajan S, Subramanian S K, Bisen P S, Chung C H and Prasad G (2013), "Prevalence of Metabolic Syndrome in Type 2 Diabetes Mellitus Using NCEP-ATPIII, IDF and WHO Definition and Its Agreement in Gwalior Chambal Region of Central India", *Global Journal of Health Science*, Vol. 5, No. 6, pp. 142-155.
- Zimmet P and Alberti G (2008), "The Metabolic Syndrome: Progress Towards One Definition for an Epidemic of Our Time", *Nat Clin Pract Endocrinol Metab.*, Vol. 4, No. 5, p. 239.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