Persistent Increase of Prevalence of Metabolic Syndrome Among U.S. Adults: NHANES III to NHANES 1999–2006

ARUPENDRA MOZUMDAR, PHD
GARY LIGUORI, PHD

OBJECTIVE — To compare the prevalence in metabolic syndrome (MetSyn) between 1988–1994 and 1999–2006 among U.S. adults of different races or ethnicities.

RESEARCH DESIGN AND METHODS — Analysis of data on 6,423 adult men and nonpregnant women aged ≥20 years from Third National Health and Nutrition Examination Survey (NHANES III) and 6,962 participants from the combined NHANES 1999–2006 were done. The revised National Cholesterol Education Program Adult Treatment Panel III definition was used to calculate MetSyn.

RESULTS — Both the unadjusted prevalence (27.9 ± 1.1% to 34.1 ± 0.8%, $P < 0.001$) and age-adjusted prevalence (29.2 ± 1.0% to 34.2 ± 0.7%, $P < 0.001$) increased from NHANES III to NHANES 1999–2006, respectively. Although MetSyn prevalence was highest in Mexican Americans, significant increases in prevalence occurred among non-Hispanic whites and non-Hispanic blacks, especially among younger women.

CONCLUSIONS — The persistent increase of MetSyn among U.S. adults is a serious public health concern because it raises the likelihood of increased prevalence of type 2 diabetes.

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The metabolic syndrome (MetSyn) is a constellation of metabolic abnormalities and is associated with increased risk of developing diabetes (1), cardiovascular disease (2), and higher mortality from all causes (3). Among the few studies using nationally representative samples on MetSyn (4–9), Ford et al. (9) estimated an increasing trend of MetSyn prevalence by comparing the Third National Health and Nutrition Examination Survey (NHANES III) and NHANES 1999–2000 data. However, because of the smaller sample size of NHANES 1999–2000, the change in MetSyn prevalence for various subpopulations, which is necessary to track age and ethnicity specific trends, was not estimated. Therefore, the objective of this study is to compare the prevalence of MetSyn between NHANES III and NHANES 1999–2006 among U.S. adults of different races or ethnicities.

RESEARCH DESIGN AND METHODS

— We identified the cases of MetSyn using the revised American Heart Association/National Cholesterol Education Program Adult Treatment Panel III definition (10), including medication uses for appropriate MetSyn criteria. Data for this study were obtained from public-use datasets of the NHANES III, NHANES 1988–1994 (data release 11#1A), and four continuous NHANES data releases: 1999–2000, 2001–2002, 2003–2004, and 2005–2006. Details of survey and laboratory procedure of NHANES are published elsewhere (11–13). Data from NHANES 1999–2006 were combined for this study to produce estimates of MetSyn for demographic subpopulations (e.g., sex-age-race/ethnicity) with greater statistical reliability. Because the data on fasting triglycerides and fasting glucose were required to identify MetSyn and those measurements were done on a subsample population, the sample weights for the subsample were used in this study.

The appropriate sample weights for combined NHANES 1999–2006 were constructed using National Center for Health Statistics guidelines (14). To maintain the consistency of blood pressure data between the two surveys, the procedure described by Ford et al. (9) was followed.

The continuous NHANES measured fasting glucose and serum triglycerides from blood samples drawn in the morning; therefore, only participants who attended a morning examination session for NHANES III were included in this analysis. Otherwise, the sample includes men and nonpregnant women aged ≥20 years who fasted for at least 8 h. The number of participants in the final analysis was 6,423 for NHANES III and 6,962 for NHANES 1999–2006. Statistical analyses to calculate prevalence were performed using the survey procedures in SAS software version 9.1 (SAS Institute, Cary, NC). The statistical significance of the change in MetSyn prevalence between the two surveys was examined by Student *t* test, in which the square root of the sum of the squared standard errors was utilized to calculate the pooled standard error of the difference in the mean.

RESULTS

— The age-adjusted prevalence of four of the five metabolic abnormalities of MetSyn increased significantly between the surveys for women: abdominal obesity 46.0 ± 1.4% to 58.0 ± 1.1%, $P < 0.001$; hypertriglyceridemia 24.7 ± 1.2% to 27.6 ± 0.8%, $P = 0.042$; high blood pressure (HBP) 27.8 ± 0.9% to 36.6 ± 0.8%, $P < 0.001$; high fasting glucose 24.2 ± 1.2% to 29.2 ± 1.0%, $P = 0.002$. However, for men, age-adjusted prevalence significantly increased in abdominal obesity (30.4 ± 1.6% to 41.1 ± 1.1%, $P < 0.001$) and HBP (32.0 ± 0.8% to 40.0 ± 0.7%, $P < 0.001$) only. The

From the Department of Health, Nutrition and Exercise Sciences, North Dakota State University, Fargo, North Dakota.
Corresponding author: Gary Liguori, gary.liguori@ndsu.edu.
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A.M. and G.L. contributed equally to this study.

Table 1—*Age-specific (unadjusted) and age-adjusted (adjusted) prevalence of the metabolic syndrome among U.S. adults aged ≥20 years in the NHANES III and NHANES 1999–2006*

	NHANES III			NHANES 1999–2006					
	n	%	(SEM)	*n*	%	(SEM)	Absolute change %	Relative change %	*P*
Total									
Unadjusted	6,423	27.9	(1.1)	6,962	34.1	(0.8)	6.3	22.6	<0.001
Adjusted	6,423	29.2	(1.0)	6,962	34.2	(0.7)	5.0	17.0	<0.001
Men									
Unadjusted	3,059	29.3	(1.6)	3,582	34.2	(1.1)	4.9	16.8	0.012
Adjusted	3,059	31.4	(1.4)	3,582	34.9	(1.0)	3.5	11.2	0.046
Aged 20–39 years	1,217	15.7	(2.1)	1,229	20.2	(1.4)	4.4	28.1	0.080
Aged 40–59 years	839	36.3	(2.3)	1,114	41.2	(1.7)	5.0	13.7	0.083
Aged 60+ years	1,003	50.3	(2.3)	1,239	49.9	(2.0)	−0.4	−0.8	0.899
Women									
Unadjusted	3,364	26.5	(1.4)	3,380	34.1	(1.10)	7.5	28.4	<0.001
Adjusted	3,364	27.1	(1.2)	3,380	33.3	(1.0)	6.2	22.8	<0.001
Aged 20–39 years	1,447	10.7	(1.7)	1,061	16.7	(1.2)	6.0	55.5	0.003
Aged 40–59 years	943	30.2	(2.3)	1,113	36.3	(1.7)	6.2	20.4	0.033
Aged 60+ years	974	50.2	(2.2)	1,206	56.8	(1.9)	6.6	13.1	0.022
NHW									
Men									
Unadjusted	1,284	30.8	(2.0)	1,881	37.0	(1.3)	6.3	20.3	0.010
Adjusted	1,284	32.1	(1.9)	1,881	36.5	(1.2)	4.4	13.8	0.048
Aged 20–39 years	337	16.6	(2.8)	523	22.3	(2.0)	5.8	35.0	0.090
Aged 40–59 years	361	37.1	(3.0)	618	42.2	(2.0)	5.1	13.7	0.164
Aged 60+ years	586	50.4	(2.5)	740	51.4	(2.4)	1.0	2.1	0.762
Women									
Unadjusted	1,462	26.5	(1.6)	1,725	33.3	(1.4)	6.8	25.6	0.001
Adjusted	1,462	26.2	(1.4)	1,725	31.4	(1.3)	5.2	20.0	0.007
Aged 20–39 years	446	9.1	(1.9)	483	16.0	(1.8)	6.8	74.5	0.010
Aged 40–59 years	411	29.4	(2.7)	543	33.0	(2.2)	3.7	12.6	0.292
Aged 60+ years	605	50.2	(2.5)	699	55.2	(2.1)	5.0	9.9	0.121
NHB									
Men									
Unadjusted	762	20.2	(1.2)	634	22.0	(1.6)	1.8	8.8	0.372
Adjusted	762	23.1	(1.4)	634	24.9	(1.6)	1.9	8.0	0.388
Aged 20–39 years	375	13.9	(1.5)	261	11.9	(2.0)	−2.0	−14.1	0.439
Aged 40–59 years	210	24.3	(3.10)	192	26.6	(3.2)	2.3	9.3	0.613
Aged 60+ years	177	36.9	(3.3)	181	44.6	(3.3)	7.7	21.0	0.098
Women									
Unadjusted	913	26.4	(1.7)	656	34.3	(1.7)	7.9	30.0	0.001
Adjusted	913	30.6	(1.7)	656	36.5	(1.6)	5.9	19.3	0.014
Aged 20–39 years	472	12.6	(1.6)	244	18.9	(2.5)	6.3	49.8	0.036
Aged 40–59 years	268	35.6	(2.7)	230	40.7	(3.4)	5.1	14.2	0.241
Aged 60+ years	173	53.3	(4.0)	182	59.9	(2.7)	6.6	12.3	0.180
Mexican American									
Men									
Unadjusted	893	28.5	(2.2)	810	29.4	(2.2)	0.9	3.3	0.767
Adjusted	893	37.8	(2.1)	810	36.6	(1.9)	−1.2	−3.1	0.671
Aged 20–39 years	457	17.6	(2.7)	324	18.9	(2.8)	1.3	7.3	0.743
Aged 40–59 years	226	48.0	(3.5)	228	44.4	(3.0)	−3.6	−7.5	0.433
Aged 60+ years	210	56.1	(5.4)	258	54.5	(3.6)	−1.6	−2.8	0.810
Women									
Unadjusted	853	33.1	(1.6)	741	36.4	(2.2)	3.3	10.0	0.222
Adjusted	853	41.7	(1.7)	741	42.6	(1.7)	0.9	2.2	0.701
Aged 20–39 years	475	19.8	(1.9)	241	20.9	(2.9)	1.1	5.3	0.758
Aged 40–59 years	217	51.4	(3.2)	244	49.6	(3.3)	−1.8	−3.5	0.699
Aged 60+ years	161	63.6	(3.8)	256	68.6	(3.9)	5.1	8.0	0.352

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Table 1—*Continued*

	NHANES III			NHANES 1999–2006					
	n	%	(SEM)	*n*	%	(SEM)	Absolute change %	Relative change %	*P*
Other									
Men									
Unadjusted	120	25.8	(4.7)	257	28.9	(3.3)	3.1	12.0	0.590
Adjusted	120	30.5	(4.3)	257	31.9	(3.2)	1.4	4.5	0.798
Aged 20–39 years	48	9.1	(5.3)	121	17.5	(3.2)	8.4	92.8	0.177
Aged 40–59 years	42	33.5	(0.8)	76	46.5	(7.1)	13.0	38.9	0.316
Aged 60+ years	30	62.3	(0.5)	60	33.0	(4.8)	−29.3	−47.1	0.012
Women									
Unadjusted	136	22.7	(4.6)	258	37.9	(4.2)	15.2	67.1	0.015
Adjusted	136	24.0	(3.9)	258	39.3	(3.8)	15.3	63.6	0.005
Aged 20–39 years	54	15.6	(7.5)	93	14.8	(4.6)	−0.8	−4.9	0.931
Aged 40–59 years	47	21.7	(8.3)	96	48.8	(4.6)	27.1	124.4	0.005
Aged 60+ years	35	42.2	(7.7)	69	66.1	(6.8)	23.9	56.6	0.021

age-adjusted prevalence of low HDL cholesterol significantly decreased in both sexes (men: 36.4 ± 1.7% to 27.6 ± 1.0%, $P < 0.001$; women: 39.6 ± 1.4% to 33.8 ± 1.1%, $P = 0.001$) between the surveys.

Both age-adjusted and age-specific prevalence of MetSyn for NHANES 1999–2006 were significantly higher than for NHANES III (Table 1). The unadjusted ($P = 0.012$) and age-adjusted ($P = 0.046$) prevalence increased significantly between the two surveys for men; however, there was no significant change in any of the three age-groups. For women, both unadjusted and age-adjusted ($P < 0.001$) prevalence increased significantly between the two surveys, with a significant increase noted in all three age-groups. Among non-Hispanic White (NHW) subjects, both men and women showed significant increases in unadjusted (men: $P = 0.010$; women: $P = 0.001$) and age-adjusted (men: $P = 0.048$; women: $P = 0.007$) prevalence of MetSyn. However, when classified by age-groups, only women aged 20–39 years showed significant increase ($P = 0.010$). Prevalence of MetSyn did not change significantly among non-Hispanic Black (NHB) men ($P > 0.050$) between the two surveys, but NHB women aged 20–39 years showed a significant increase in prevalence ($P = 0.036$). The age-adjusted prevalence of MetSyn in NHANES 1999–2006 was highest among Mexican Americans (men: 36.6 ± 1.9%; women: 42.6 ± 1.7%) with little change in this group from NHANES III. Using the unadjusted prevalence rates from combined sample population of NHANES 1999–2006, we estimated that about 32.4 million men and 35.3 million women in U.S. had MetSyn. Among U.S. adults with MetSyn, ~50.6 million were NHW, ~6.3 million were NHB, and ~4.6 million were Mexican Americans.

The age-adjusted prevalence of U.S. adults reporting diabetes (other than pregnancy related) or having a fasting blood glucose ≥126 mg/dl significantly increased in both sexes (men: 8.1 ± 0.6% to 10.5 ± 0.6%, $P = 0.005$; women: 5.8 ± 0.6% to 8.5 ± 0.5%, $P = 0.001$) between the two surveys. The age-adjusted prevalence of MetSyn among U.S. men without diabetes did not change significantly (27.6 ± 1.4% to 30.6 ± 1.1%, $P = 0.08$); however, the prevalence significantly increased for women without diabetes (24.0 ± 1.2% to 29.4 ± 1.0%, $P = 0.001$), including women aged 20–39 years (10.0 ± 1.6% to 15.8 ± 1.2%, $P = 0.003$) and aged 40–59 years (25.8 ± 2.4% to 31.6 ± 1.7%, $P = 0.049$).

CONCLUSIONS — Ford et al. (9) estimated that ~50 million U.S. adults in 1990 and ~64 million in 2000 had MetSyn, representing a 28% increase in prevalence. From the combined NHANES 1999–2006 data, we estimated ~68 million U.S. adults had MetSyn, or a further increase of 6%. The prevalence of MetSyn in U.S. adults in 1999–2006 was 34.1 ± 0.8% (after age adjustment 34.2 ± 0.7%), which is a significant increase from 1988–1994, and more so in women (28.4%) than in men (16.8%). Further, in both NHW and NHB the prevalence of MetSyn significantly increased in women, particularly younger women (aged 20–39 years). The increased prevalence of MetSyn was primarily due to increases in abdominal obesity and HBP.

An increase in MetSyn prevalence is expected to be followed by an increase in diabetes prevalence, though of a lesser magnitude. Between the two surveys, there was a 4.3% increase in age-adjusted prevalence of MetSyn among adults without diabetes and a 2.6% increase in diabetes. As we continue to see an increase in MetSyn, especially in certain ethnic groups and younger women, we will see a concomitant increase in diabetes and its comorbidities and associated medical costs.

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