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Prevalence of Metabolic Syndrome and its Related Risk Factors in the City of Oran, Algeria: the ISOR Study

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Background: Aging and lifestyle changes had led to an epidemiological transition, with a significant impact on the incidence of cardiovascular diseases in North Africa.

Objective: The aim of this study was to determine the prevalence of metabolic syndrome and its associated factors, which were unknown, among an urban population in Algeria.

Methods: During 2007-2009, 787 individuals aged 30-64 years, randomly selected from the list of insured persons residing in the city of Oran, participated in a clinical, anthropometric and biological survey. Participants were classified according to the National Cholesterol Education Program - Adult Treatment Panel (NCEP-ATP) III definition of metabolic syndrome.

Results: The prevalence of metabolic syndrome was 20%, higher in women than men (25.9 vs 13.7%; $P<.0001$). Among the components of the syndrome, the most common risk factors observed in women were a low high-density lipoprotein (HDL) cholesterol concentration (60.4% vs 44.2% in men) and abdominal obesity (46.8% vs 30.1% in men) whereas men displayed more high blood pressure (42.5% vs 34.8% in women). In men, metabolic syndrome was more frequent in married and highly educated participants. In contrast, women with a high level of education and who had an intermediate level of physical activity seemed to be protected.

Conclusions: Metabolic syndrome, prevalent in the urban population of North Algeria, is associated with a high proportion of low HDL-cholesterol and abdominal obesity, especially among women. There is a need for prevention strategies involving promotion of physical activity for the whole population

Introduction

Metabolic syndrome is an important clustering of metabolic abnormalities and anthropometric characteristics. Being partially or fully expressed, the characteristics include high blood pressure, low level of high-density lipoprotein (HDL) cholesterol, high triglycerides level, high plasma glucose concentration, and abdominal obesity.[1,2] Metabolic syndrome, a major risk in type 2 diabetes and cardiovascular diseases, is underlined by insulin resistance or hyperinsulinemiae.[3-5] It is also associated with other causes of mortality and has become a global health problem with an economic burden in both developing and developed countries.[6,7]

In 2001 and for the first time, the Third Report of National Cholesterol Education Program Expert Panel on Detection, Evaluation, and treatment of High Blood Cholesterol in Adults (Adult Treatment Panel III) (NCEP-ATP III) drew attention to the importance of metabolic syndrome and provided a working definition of this syndrome.[8] According to these criteria, metabolic syndrome prevalence varies from 8.2%[9] to 41.1%[10] among adults throughout the world. However, most data on metabolic syndrome are based on studies from Western countries.

Metabolic syndrome is a multifactorial disease that implicates both environmental and genetic factors. Several modifiable risk factors including obesity, low level of physical activity, high alcohol intake, cigarette smoking, and certain deleterious dietary factors, are associated with a higher risk of this disease

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and its consequences.[11-13] According to the American Diabetes Association and the ATP III, the primary goals in treating metabolic syndrome focus on lifestyle changes with prevention of type 2 diabetes and cardiovascular events.[8]

In Algeria (North Africa), a socioeconomic, nutritional and epidemiological transition has been ongoing for three decades. Several environmental factors including rapid urbanization, physical inactivity and new dietary patterns contribute to the increase in different chronic diseases and abnormalities constituting metabolic syndrome. A national study conducted in 2005 showed a high prevalence of hypertension (24.9%) and diabetes (12.2%) in the adult Algerian population.[14] Overweight has also become a real public health problem, particularly in women where 66.5% are overweight and 30.1% are obese.[15] Cardiovascular diseases and diabetes accounted respectively for 26.1% and 4.4% of deaths in 2002.[16] However, very few data on metabolic syndrome are available in Algeria.[17]

The aim of our study was to assess the prevalence of metabolic syndrome … and to describe the prevalence of its related risk factors … in the city of Oran (North Algeria).

The aim of our study, InSulinorésistance á ORan (ISOR) Study, was to assess the prevalence of metabolic syndrome according to the NCEP ATP III diagnostic criteria, and to describe the prevalence of its related risk factors among a sample of 787 insured adults living in the city of Oran (North Algeria).

Methods

Participant Characteristics

The ISOR study was carried out in the city of Oran, an urban area located in the northwest region of Algeria; it is the second largest city in Algeria and one of the most important in northern Africa. According to the 2008 National Census in Oran, approximately 685,300 individuals lived in Oran. The ISOR study is a population-based, cross-sectional study, conducted between 2007 and 2009 at the medical laboratory of social insurance (CNAS). The participants (n=1428) were selected at random from social security rolls, were aged between 30 and 64 years, and lived within the city of Oran. Individuals who were pregnant, or with fever, infection, complicated type 2 diabetes, chronic disease (cancer, renal failure, etc.) and those who were under treatment (corticoids, immunosuppressive drugs) were excluded (n=287). Also, 277 subjects (19.4 %) did not respond by the third request and 77 of the eligible subjects refused to participate. In all, 787 subjects (378 men and 409 women) met the inclusion criteria for a participation rate of 55.1%.

The study's objectives and procedures were approved by the independent ethics committee at the Algerian National Agency for the Development of Health Research (ATRSS, ex-ANDRS). The subjects consented freely to participation in the study and all health examinations and treatment were free of charge. Data were analyxed anonymously. Other details of the studies have been described elsewhere.[18]

Those with body mass index (BMI) > 30 kg/m² were classified as obese. Type 2 diabetes was defined according to the American Diabetes Association (ADA) definition (ie, fasting plasma glucose ≥ 7.0 mmol/L and/or treatment for diabetes including diet and/or oral antidiabetic drugs and/or insulin to achieve glycemic control).[19] Hypertension was defined according to the WHO criteria (average systolic blood pressure [SBP] > 140 mm Hg and/or average diastolic blood pressure [DBP] > 90 mm Hg) and/or self-reported current treatment for hypertension with antihypertensive medication.[20]

The identification of metabolic syndrome was based on the NCEP-ATPIII diagnostic criteria[8] where at least three of the following factors have to be present: abdominal obesity (waist circumference > 102 cm in men and 88 cm in women); hypertriglyceridemia (serum triglycerides level > 1.69 mmol/L (150 mg/dL) (fibrate treatment excluded); low HDL-cholesterol (<1.04 mmol/L [40 mg/dL] in men and 1.29 mmol/L [50 mg/dL] in women), high blood pressure (SBP> 135 mm Hg and/or DBP> 85 mm Hg or treatment for hypertension) and high fasting glucose (serum glucose level > 6.1 mmol/L [110 mg/dL] or treatment for diabetes).

Statistical Analysis

Statistical analyses were performed with SAS software (version 9.1, SAS Institute Inc, Cary, NC, USA). Intergroup comparisons of means were performed with a general linear model. Data on triglyc-

Table 1. Anthropometric, biochemical and clinical characteristics of the participants

Parameters		All, n=787		Men, n=378		Women, n=409		
		Mean	SD	Mean	SD	Mean	SD	P
Age, yrs		44.0	10.1	45.0	10.9	43.0	9.3	<.0001
Height, cm		165.5	9.6	172.8	6.4	158.6	6.7	<.0001
Weight, kg		71.3	14.6	73.5	14.2	69.3	14.7	<.0001
BMI, kg/m²		26.1	5.1	24.6	4.2	27.5	5.5	<.0001
Waist, cm		87.7	12.4	89.1	11.5	86.4	13.0	<.0001
Waist-to-hip ratio		.86	.09	.90	.07	.83	.09	<.0001
Fasting plasma glucose, mmol/L		5.34	1.85	5.49	1.84	5.20	1.85	<.0001
Fasting insulin, µUI/mL		8.44	6.54	7.14	5.93	9.64	6.84	<.0001
HOMA-IR		2.08	2.27	1.80	2.05	2.33	2.43	<.0001
HOMA-B		132.43	126.31	96.72	94.51	165.42	142.15	<.0001
Total cholesterol, mmol/L		4.45	.91	4.45	.76	4.44	1.03	.92
Triglycerides, mmol/L		1.17	.51	1.21	.55	1.13	.47	.04
HDL-cholesterol, mmol/L		1.25	.31	1.27	.30	1.23	.32	.10
LDL-cholesterol, mmol/L		2.68	.87	2.64	.73	2.72	1.10	.19
SBP, mm Hg		123.6	18.1	125.4	17.7	122.1	18.4	.01
DBP, mm Hg		76.9	9.9	77.7	9.7	76.1	10.0	.02
		n	%	n	%	n	%	
Inbreeding		197	25.9	92	25.0	107	26.8	.57
Hypertension	known	97	12.3	34	9.0	63	15.4	<.0001
	total	160	20.3	80	21.2	80	19.6	.58
Type 2 diabetes	known	59	7.5	30	7.9	29	7.1	.15
	total	80	10.6	42	11.6	38	9.7	.39
Obesity		167	21.2	34	9.0	133	32.5	<.0001
Metabolic syndrome		155	20.0	51	13.7	104	25.9	<.0001

Data are expressed as the mean ± SD; P is used for comparison between men and women.

erides, glucose and insulin levels, Homeostatic Model Assessment of Insulin Resistance (HOMA-IR) and Homeostatic Model Assessment of Beta-cell function (HOMA-B) were log-transformed to obtain a normal distribution. Estimated means were subsequently back–transformed for presentation in the tables. Chi-squared tests were used for categorical variables. Odds ratios were obtained by multivariate logistic regression analyses. The threshold for statistical significance was set to $P<.05$.

Results

General Characteristics of Participants

Many anthropometric, biochemical and clinical characteristics showed significant differences when comparing men and women (Table 1). Men displayed higher levels of blood pressure for both SBP and DBP, fasting plasma glucose and triglycerides, and had higher waist circumference and waist-to-hip ratio than women. Women were found to have a higher BMI, higher levels of fasting plasma insulin, HOMA-IR and HOMA-B than men. Obesity was more frequent in women (32.5%) than in men (9%). The overall prevalence of metabolic syndrome was 20%, and was higher in women than in men. Both men and women had similar prevalence rates of type 2 diabetes (~11%) and hypertension (~24%), however, among hypertensive men, 63.4% were unaware of their hypertension status. Finally, inbreeding was found among more than a quarter of the sample (~26%).

Prevalence of Metabolic Syndrome and its Components

The prevalence of metabolic syndrome increased with age *(P*<.0001), with the highest prevalence among those aged 60–64 years (35.8%) (Table 2). As expected, the frequencies of all the abnormalities of metabolic syndrome increased with age. Low HDL-cholesterol levels, high blood pressure and abdominal obesity are the most frequent components present in the whole sample. Men had a high proportion of hypertension (42.5%) whereas women presented more low HDL-cholesterol levels (60.4%) and abdominal obesity (46.8%). HDL-cholesterol levels are negatively correlated with waist circumference (r=-.21, $P<.0001$). However, the concentration of HDL cholesterol was lower in women than in men when

Table 2. Prevalence of metabolic syndrome and its clinical abnormalities according to age-groups and sex

	Age-group	N	MetS, %	Abdominal Adiposity, %	High Triglycerides, %	Low HDL-Cholesterol, %	High Blood Pressure, %	High Fasting Glucose, %
All	30-39	314	9.9	20.1	9.5	44.6	22.3	12.1
	40-49	226	19.0	33.6	14.2	48.2	38.9	15.5
	50-59	167	34.1	41.9	17.4	46.1	52.1	32.9
	60-64	67	35.8	35.8	17.9	23.9	79.1	49.2
	Overall	774	20.0	30.1	13.3	44.2	38.5	20.8
Men	30-39	146	8.2	9.6	15.7	26.7	30.8	17.1
	40-49	93	9.7	11.8	16.1	28.0	35.5	20.4
	50-59	84	20.2	13.1	17.9	30.9	48.8	27.4
	60-64	49	26.2	18.4	18.4	16.3	79.6	42.9
	Overall	372	13.7	12.1	16.7	26.6	42.5	23.7
Women	30-39	168	11.3	29.2	4.2	60.1	14.9	7.7
	40-49	133	25.6	48.9	12.8	62.4	41.3	12.0
	50-59	83	48.2	71.1	16.9	61.4	55.4	38.5
	60-64	18	61.1	83.3	16.7	44.4	77.8	66.7
	Overall	402	25.9	46.8	10.2	60.4	34.8	18.2

waist circumference was higher than 72 cm. Thus, for 86% of the women, the HDL-cholesterol was lower than in men. Similar results have been obtained with BMI (data not shown).

Environmental Risk Factors

Concerning environmental risk factors of metabolic syndrome, there was no evidence of influence of household income on metabolic syndrome in the whole sample *(P*=.89). In contrast, being older increased the risk to develop metabolic syndrome by five-fold among all participants, by four-fold in men and 12-fold in women. In the same way, unemployment increased the risk by two-fold among all participants and in women (Table 3). Education was associated with a decreased risk of metabolic syndrome by two-fold for both all participants and women. In contrast, highly educated men (professional or university) had an increased risk of metabolic syndrome. Moreover, in men, marriage increased metabolic syndrome risk by four. Physical activity decreased the metabolic risk by 61% among all participants. Strangely, smoking status was associated with a decreased metabolic syndrome risk, but this association disappeared after further adjustment for age and BMI.

Discussion

Metabolic syndrome, as defined by the NCEP-ATPIII criteria, is a growing health problem affecting all populations in various proportions. To our knowledge, our study is the first population-based study of metabolic syndrome and its relationships with risk factors conducted in Algeria. The prevalence of metabolic syndrome and associated risk factors were analyzed among adults living in the city of Oran. Given that social insurance covers more than 70% of the inhabitants in Oran, the ISOR sample can be considered as a representative of the Algerian urban population.

The prevalence (20%) of metabolic syndrome in the ISOR study is similar to that reported for the French population (20%),[21] and the Arab population from Gaza[22] and North America (23%).[23] It is lower than in other Mediterranean countries such as Tunisia[24] (30%), Turkey[25] (33.4%) and Iran.[26]

In the ISOR study, the prevalence of metabolic syndrome was twice as high among women compared with men (25.9% vs 13.7%). This sex difference is similar to that reported in the Arab world and the Mediterranean and Eastern regions.[22,24-26] In contrast, the European studies show a higher prevalence of metabolic syndrome among men than women[9,21,27] while no sex difference is observed in the US population.[7]

This sex difference may be explained by the different distribution of metabolic syndrome components. As a matter of fact, we observed very important differences between sexes. The prevalence of low HDL-cholesterol and abdominal obesity were higher in women compared with men (60.4 vs 26.6% and 46.8 vs 12.1%, respectively). However, in comparison with men, 84% of women in the ISOR study had lower concentrations of HDL-cholesterol, while in the Caucasian population, women had higher concentrations.[28,29] In addition, the cut-off advocated by NCEP-ATPIII is

Table 3: Risk of metabolic syndrome according to demographic, socioeconomic and lifestyle factors

	All, n=774				Men, n=372				Women, n=402			
	MetS, n (%)	No MetS, n (%)	OR [95% CI]	P	MetS, n (%)	No MetS, n (%)	OR [95% CI]	P	MetS, n (%)	No MetS, n (%)	OR [95% CI]	P
Sex												
Men	51 (13.5)	321 (86.5)	ref									
Women	104 (25.4)	298 (74.6)	2.20 [1.52-3.18]	<.0001								
Age group												
30-39	31 (9.9)	283 (90.1)	ref		12 (8.2)	134 (91.8)	ref		19 (11.3)	149 (88.7)	ref	
40-49	43 (19.0)	183 (81.0)	2.14 [1.30-3.53]	<.0001	9 (9.7)	84 (90.3)	1.20 [.48-2.96]	.70	34 (25.6)	99 (74.4)	2.69 [1.45-4.99]	<.0001
50-59	57 (34.1)	110 (65.9)	4.73 [2.9- 7.72]	<.0001	17 (20.2)	67 (79.8)	2.83 [1.28-6.27]	.01	40 (48.2)	43 (51.8)	7.29 [3.83-13.87]	<.0001
60-64	24 (35.8)	43 (64.2)	5.09 [2.74-9.49]	<.0001	13 (26.5)	36 (73.5)	4.03 [1.69-3.59]	<.0001	11 (61.1)	7 (38.9)	12.32 [4.26-35.6]	<.0001
Marital status												
Unmarried	48 (17.0)	234 (83.0)	ref		4 (4.7)	82 (95.3)	ref		44 (22.5)	152 (77.6)	ref	
Married	107 (21.9)	382 (78.1)	1.37 [.94-1.99]	.10	47 (16.6)	236 (83.4)	4.08 [1.43-11.68]	<.0001	60 (29.1)	146 (70.9)	1.42 [.90-2.23]	.13
Education												
None or primary	51 (30.2)	118 (69.8)	ref		7 (10.1)	62 (89.9)	ref		44 (44.0)	56 (56.0)	ref	
Intermediate	31 (17.9)	142 (82.1)	.51 [.30-.84]	<.0001	7 (9.5)	67 (90.5)	.93 [.31-2.79]	.89	24 (24.2)	75 (75.8)	.41 [.22-.75]	<.0001
Secondary	23 (17.6)	108 (82.4)	.49 [.28-.86]	.013	4 (6.9)	54 (93.1)	.66 [.18-2.36]	.52	19 (26.0)	54 (74.0)	.45 [.23-.86]	.016
Professional	24 (14.7)	139 (85.3)	.40 [.23-.69]	<.0001	15 (16.3)	77 (83.7)	1.73 [.66-4.49]	.26	9 (12.7)	62 (87.3)	.18 [.08-.41]	<.0001
University	26 (19.1)	110 (80.9)	.55 [.32-.94]	.03	18 (22.8)	61 (77.2)	2.61 [1.02-6.70]	.05	8 (14.0)	49 (86.0)	.21 [.09-.48]	<.0001
Employment												
Yes	57 (14.3)	343 (85.7)	ref		31 (12.6)	216 (87.4)	ref		26 (17.0)	127 (83.0)	ref	
No	96 (26.2)	270 (73.8)	2.14 [1.49-3.08]	<.0001	20 (16.1)	104 (83.9)	1.34 [.73-2.46]	.34	76 (31.4)	166 (68.6)	2.24 [1.35-3.69]	<.0001
Household income												
High	17 (21.3)	63 (78.7)	ref		8 (20.0)	32 (80.0)	ref		9 (22.5)	31 (77.5)	ref	
Intermediate	76 (19.0)	325 (81.0)	.87 [.48-1.56]	.63	24 (14.1)	146 (85.9)	.66 [.27-1.60]	.35	52 (22.5)	179 (77.5)	1.00 [.45-2.23]	.99
Low	53 (20.5)	205 (79.5)	.96 [.52-1.77]	.89	18 (12.1)	131 (87.9)	.55 [.22-1.38]	.20	35 (32.1)	74 (67.9)	1.63 [.70-3.79]	.26
Current smokers												
No	146 (22.5)	503 (77.5)	ref		42 (16.7)	209 (83.3)	ref		104 (26.1)	294 (73.9)	ref	
Yes	9 (7.4)	-113 (92.6)	.27 [.14-.55]	<.0001	9 (7.6)	110 (92.4)	.41 [.19-.87]	.02	0 (0)	3 (100.0)	NC	
Physical activity												
Absence	35 (25.6)	102 (74.5)	ref		7 (15.2)	39 (84.8)	ref		28 (30.8)	63 (69.2)	ref	
Low	96 (22.0)	341 (78.0)	.82 [.52-1.28]	.38	33 (15.6)	179 (84.4)	1.03 [.42-2.49]	.95	63 (28.0)	162 (72.0)	.87 [.51-1.49]	.62
Intermediate	22 (11.8)	165 (88.2)	.39 [.22-.70]	<.0001	11 (10.4)	95 (89.6)	.65 [.23-1.79]	.40	11 (13.6)	70 (86.4)	.35 [.16-.77]	<.0001
High	2 (15.4)	11 (84.6)	.53 [.11-2.51]	.42	0 (0)	8 (100.0)	0	.98	2 (40.0)	3 (60.0)	1.50 [.24-9.48]	.67

NC; not calculable.

more drastic for women than men. All this explains the raised prevalence of low HDL-cholesterol in Algerian women. Concerning waist circumference, the differences could be attributed to diet[17] and multiple pregnancies, which are typical to Algerian women. In addition, the postmenopausal weight gain increases insulin resistance and central obesity.[30] In our study, 32.5% of women had more than four pregnancies and 26.6% were menopaused.

Other sex differences were observed in high blood pressure and high triglycerides levels, which were more elevated in men compared with women, (42.5% vs 34.8% and 16.7 % vs 10.2% respectively). Similar to North African populations,[31] known hypertension was better in women (65.6%) than in men (36.6%). Indeed, women used health services more than men.[14]

The prevalence (20%) of metabolic syndrome in the ISOR study is similar to that reported for the French population (20%)…

The high level of triglycerides was first related to smoking, especially among men (32%) and could not be attributed to alcohol since only 3.2% said they consumed alcohol.

Regarding risk factors, our results showed that age has the expected impact on the occurrence of metabolic syndrome. Indeed, in the ISOR study, the prevalence of metabolic syndrome increased dramatically with age in both sexes, from 10% in the 30–39 age-group to more than 34% among adults aged > 50 years, particularly in women where almost 50% were affected. Similar results have been reported in many studies on other populations.[32,33] As previously described,[34] marital status increased the risk of metabolic syndrome in married men.

Our results also suggest that in women, metabolic syndrome is strongly associated with education level and occupation. In spite of the fact that women's employment is higher in the city of Oran (38.1%) compared with employment overall in Algeria (10.2%),[14] metabolic syndrome is nevertheless associated with unemployed women in Oran. In men, occupation is not related to metabolic syndrome. Similar sex- specific differences have been observed in many studies.[24,34]

Education level has generally been reported to have a strong effect on health behaviors and lifestyle choices. Metabolic syndrome has, in general, a strong and negative association with the level of education in women.[34] In our study, a high education degree was associated with metabolic syndrome in men, while it protected women. Similar results were reported in the Mediterranean region[24,34,35] and America.[36,37] In women, high education levels have been associated with healthy diet and regular physical activity,[38] while in men, education levels are associated with an unhealthy lifestyle including less physical activity and more energy intake.[24] The socioeconomic indicators are often taken into account in the relationship with metabolic syndrome as a low socioeconomic status is associated with high risk of cardiovascular diseases.[37] In the ISOR sample, metabolic syndrome affects people regardless of household income.[34,35]

Among environmental factors, urbanization is associated worldwide with unhealthy lifestyles including unhealthy food habits.[39,40] In Algeria during these past three decades, lifestyle has changed, especially in urban areas. As in other populations, modern life has induced a reduced physical activity associated with modifications in dietary patterns leading to increasing obesity, diabetes and hypertension. Physical inactivity is known to be an important risk factor of metabolic syndrome and obesity.[39-42] In the ISOR study, physical activity level was low in 74.2% of subjects, especially in women (78.6%) but was shown to be protective against metabolic syndrome. Physical activity is generally at low level among women, especially in the Maghreb and the Middle East countries according to the social practices.[43,44] In these countries, women display many sedentary occupations and are often restricted to housework with no practice of sport or even walking.[42]

As smoking has an effect on metabolic parameters and blood pressure, it is generally associated with metabolic syndrome.[45,46] However, our results show a protective effect in men, which disappears after adjusting for age and BMI.

Although our study was carried out in an urban population, the frequency of inbreeding remains high. But, it was lower than that found in the other countries of the Maghreb, Morocco (29%-39%) and Tunisia (40-49%).[47] However, no relationship was found with metabolic syndrome (data not shown).

The main limitation of our study was the average size of the sample, which may have limited the power of the results. Secondly, this study took

place in one city in Algeria and may limit the extrapolation to other cities. Finally, a cross-sectional design does not allow inferences to be drawn with respect to the causal relationships among variables. Despite this, the study provided important data regarding the prevalence and correlates of sex-specific risk factors of metabolic syndrome among adults in an urban setting.

Conclusions

We determined the prevalence of the main cardiometabolic risk factors in a representative group of an urban Algerian population. The high prevalence of the components of metabolic syndrome will probably continue to rise in Algeria, and will have serious implications for national health care costs. Sex-specific differences suggest that metabolic syndrome is associated with various factors, among men and women. It may be useful to redefine through longitudinal studies, ethnicity-specific cut-off values for waist circumference and HDL-cholesterol levels. Our results suggest that potential behavioral interventions for the prevention of metabolic syndrome in adults should include the promotion of physical activity, as well as a healthy nutrition. Regarding medical practice, the screening of patients at high cardiovascular risk should be reinforced, especially in men for whom the use of medical care is lower than in women as indicated by the high proportion of undiagnosed hypertension.

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Conflicts

No conflicts of interest reported

Author Contributions

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