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Metabolic syndrome: Changes in mediterranean and mesoamerican diet due to socioeconomic factors in Mexico and Italy

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Abstract.
BACKGROUND: Metabolic Syndrome and its components have become a more frequent cause of disability and premature death in the world.
OBJECTIVE: investigated why the prevalence of Metabolic Syndrome components have increased at a different pace in Mexico and Italy, evaluated changes in traditional Mediterranean and Mexican dietary patterns and analysed some socio economic conditions relating with Metabolic Syndrome.
METHODS: Using a Food Balance Sheet (FAO), a hierarchical cluster analysis was developed to define dietary patterns for the period 1961 to 2011. The means of each food group from two countries were compared using a Student's test for independent samples. The observed differences were analysed using the Mann-Whitney U test. Pearson's (s) correlation was performed to explore the relationship between Human Development and Gross Domestic Product in the following conditions: global overweight/obesity, abdominal obesity in women and men, the prevalence of diabetes mellitus and hypertension.
RESULTS: Total energy availability increased in both countries. Energy derived from cereals decreased, whereas energy from fats, foods of animal origin and vegetable oils increased. Unlike Mexico, apparent sugars consumption did not increase in Italy and olive oil was consumed the most.
CONCLUSIONS: Both countries have changed the traditional diet and some correlations between economic conditions and health were statistically significant. Mexico showed a greater disadvantage in socio-economic indicators. It is important to boost education that promotes healthy eating habits and living conditions.

Keywords: Dietary patterns, components of metabolic syndrome, socio economic conditions

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1. Introduction

The aim of this study is to investigate why the prevalence of the Metabolic Syndrome components has increased at a different pace in Mexico and Italy. The study evaluates changes in the availability of food (kcal/person/day), changes in traditional dietary patterns and analyses the relation between some socio-economic conditions and the progression of these problems. Metabolic syndrome consists of a cluster of conditions including obesity, overweight, dyslipidemia, hyperglycemia and hypertension. These risk factors are associated with each other with a higher frequency than is expected by chance and are all cardiovascular risk factors (Wilson et al. 1999). The main trigger for this conglomeration of atherogenic, metabolic, prothrombotic and proinflammatory factors is obesity [1–3]. Obesity has a strong genetic component [4–6], interacting with environmental exposure [7, 8]. In this regard, the World Health Organisation (WHO) states that the global prevalence of obesity has doubled between 1980 and 2014 [9]. By 2014, 10% of men and 14% of women 18 years or older were obese. More than 42 million children under five years were overweight in 2013. Levels of obesity among adult men and women in the European Union (EU) have tripled since the 1980s, to stand at almost the same level as in the US [10, 11]. In The Third Atlas of Cardiovascular Disease, the prevalence of overweight and obesity in Italy is recorded as moving from 61.7% in the years 1998–2002, to 64.3% in the years 2008–2012 [12].

In Mexico overweight and obesity have reached epidemic proportions in all age and social groups. Prevalence of overweight and obesity in adults was 71.3% in 2012. Obesity increased by 15.2% in Mexico over the previous 12 years. Moreover, according to ENSANUT (2012) the prevalence of obesity in adults (BMI $\geq 30\,kg/m^2$) was 32.4% [13]. Obesity and non-communicable diseases (NCDs), such as Metabolic Syndrome, diabetes mellitus, hypertension, cardiovascular disease, stroke and some cancers have become a more frequent cause of disability and premature death in both developed and developing countries. According to several studies the prevalence of Metabolic Syndrome in Italy ranged from 18.0% to 34% between 1998 and 2012 [12, 14, 15]. Studies conducted in Southern Italy showed the prevalence of Metabolic Syndrome between 12% and 23% of MetS [16, 17].

In Mexico, several studies using the NCEP-ATP III approach report that the prevalence of Metabolic Syndrome ranged from 26.0% to 46.5% between 2004 and 2010 [18]. This information reveals that although the prevalence of Metabolic Syndrome in Italy has decreased, it can be considered high. Metabolic Syndrome is a significant public health problem for the Mexican population. However, the information available on Metabolic Syndrome in most world countries is inconsistent and varies according to the used criteria. We used the prevalence of some of its components in Italy and Mexico: overweight/obesity global, abdominal obesity in women and men, diabetes mellitus and hypertension [11, 13].

The present study took the above into consideration. To gain a deeper appreciation of increased Metabolic Syndrome components, one must go beyond the influence of specific foods or isolated nutrients and research dietary patterns in the population. We believe that changes in traditional eating patterns and in the availability of food (kcal/person/day) can only provide a partial interpretation of the causes of increased obesity and Metabolic Syndrome.

This study contends that the genetic component, population ageing and the decline of physical activity also play a significant role. Moreover, by referencing established indicators such as the Human Development Index (HDI) and Gross Domestic Product (GDP) the study argues that the recent rise in social and economic inequalities could account for the change in eating patterns and, in interpreting the higher prevalence of these diseases and the differences observable between the two countries.

2. Material and methods

This study proposes an ecological approach based on the Food Balance Sheet (FBS) published by the Food and Agriculture Organization (FAO) [19].

FBS data show food availability, apparent food consumption or average apparent consumption of quantities and the main food groups for human consumption in different countries per year. The values reported are a ratio constructed from the difference between the production of a particular food over those imports, minus exports where the food is used as an ingredient or in animal feed. The result is divided among the population. This information does not provide data access and actual consumption of food, or show differences in population groups such as age, sex, and location. However, since the HBA are produced each year, they enable comparisons between countries to be made and reveal trends in food consumption in a country over time [19].

The study examined the evolution of food availability in Mexico and Italy [19], for the period 1961–2011. Using details of kcal per person per day (kcal/person/day), a hierarchical cluster analysis was performed to define dietary patterns in each country. Years were categorized in kcal/person/day according to the food that had a larger apparent consumption throughout the study period (1961–2011). Subsequently, we executed a K-means cluster analysis was executed by case iteration grouping method based on a dendrogram and the results obtained suggested a classification for three clusters. Then we analysed the historical iteration for K-means, the displacement of the centre or centroid of each component and the distribution of each group of cluster years and calculated the proportions of kcal/person/day each food brought to the average of each dietary pattern. The results obtained for each foodstuff were analysed by ANOVA test with *post hoc* analysis by the Kruskal-Wallis intercluster test, setting the level of statistical significance at $P < 0.05$. Afterwards, the means of each food group from the two countries were compared using a Student's t test for independent samples. The observed differences between the two countries were then analysed using the Mann-Whitney U test. Using World Bank data from 1990 to 2012 [20], Pearson's (s) correlation was also performed to explore the relationship between the Human Development Index (HDI) and the Gross Domestic Product (GDP) and the prevalence of the following: overweight/obesity global (OOG), abdominal obesity in women (AOW) and men (AOM), prevalence of the following: diabetes mellitus (DM) and hypertension (AHT) in Mexico [12] and in Italy for the period 1990 to 2012 [13]. The significant value of $p < 0.05$ was considered statistically.

3. Results

We built three different dietary patterns for each country throughout the study period (see Tables 1 and 2). Eating patterns were organized according to food groups shaped by greater food availability or apparent consumption (Tables 1 and 2). ANOVA testing of cluster analyses showed statistically significant differences between three dietary patterns in each country in all foods groups except in Sugar & Sweeteners in Italy [21] (Table 3). There were also statistically significant differences between both countries in all food except sugar and eggs, in the first and third period respectively (Table 4).

The most substantial changes observed in both countries were as follows:

a. The increase in total energy availability in the Italian diet from the period 1961–2011 was 429 kcal/person/day (3153 to 3582), while the Mexican diet showed an increase of 662 (2371 to 3033) in the same period (Tables 1 and 2).
b. Decrease availability of cereals (9.4% in Italy and 10% in Mexico) (Tables 1 and 2).
c. Increase in the availability of animal fat (in both countries the availability doubled), foods of animal origin (Mexico 4.4% and Italy 7.0%) and vegetable oils (Mexico 2.4% and Italy 5%) (Tables 1 and 2).
d. Substantial increase in meat (beef, pork and poultry) was observed in both countries a (Italy 4.6% and Mexico 2% (Tables 1 and 2). In Mexico poultry increased 4 steps (Table 2).
e. The increase in milk was most significant in Italy, while in pattern II and III wine exceeded (Table 1).
f. Fruits and vegetables showed a slight increase in the period, however their consumption was much higher in Italy (7.5% to 7.7%) than in Mexico (3.9% to 4.5%) (Tables 1 and 2).

Table 1
Dietary patterns according to the general food groups in kcal/person/day in Italy from 1961 to 2011

Food groups/Dietary patterns	I 1961–1969		II 1970–1981		III 1982–2011	
	Kcal/per/day 3153	%	Kcal/per/day 3493	%	Kcal/per/day 3582	%
Cereals	1301	41.4	1304	37.5	1138	**32.0**
Animal fats and vegetable oil	458	14.6	605	17.4	768	**21.6**
Animal fat	75	2.4	110	3.2	158	4.4
Vegetable oils**	383	12.2	495	14.2	610	17.2
Food of animal origin	449	14.3	614	**17.7**	751	**21.1**
Meat	197	6.3	301	8.7	387	10.9
Milk – excluding butter*	192	6.1	244	7.0	276	7.8
Eggs	37	1.2	44	1.3	46	1.3
Fish and sea products	23	0.7	25	0.7	42	1.2
Sugar and sweeteners	268	8.5	321	9.2	291	**8.2**
Legumes	53	1.7	39	1.1	47	1.3
Fruits and vegetables	241	7.7	242	7.0	267	7.5

Source: Constructed by the authors from the Food Balance Sheets FAO. United Nations for Food and Agriculture. Statistical Databases. URL: http://faoestat.fao.org 1961–2011. *Milk exceeded wine in pattern II and III (Wine: Pattern I 6.6%, pattern II 5.5% and pattern III 2.9%. **A significant increase was observed in the consumption of soybean oil (1.2% to 3.1)% and sunflower oil (0.8% to 2.3%), but the most apparent consumption was olive oil (7.4%to 8.3%).

Table 2
Dietary patterns according to the general food groups in kcal/person/day in Mexico from 1961 to 2011

Food groups/Dietary patterns	I 1961–1968		II 1969–1978		III 1979–2011	
	Kcal/per/day 2371	%	Kcal/per/day 2635	%	Kcal/per/day 3033	%
Cereals	1331	56.1	1380	52.4	1394	**46.0**
Animal fats and vegetable oil	163	6.9	183	6.9	768	**10.3**
Animal fat	26	1.1	34	1.3	64	2.1
Vegetable oils*	137	5.8	149	5.7	249	8.2
Food of animal origin	251	10.6	333	**12.6**	456	**15.0**
Meat**	141	5.9	163	6.2	238	7.8
Milk – excluding butter	91	3.8	141	5.4	153	5.0
Eggs	14	0.6	22	0.8	45	1.5
Fish and sea products	5	0.2	7	0.3	20	0.7
Sugar and sweeteners	278	11.7	379	14.2	458	15.1
Legumes***	147	5.8	136	4.5	108	3.4
Fruits and vegetables	93	3.9	103	3.9	138	4.5

Source: Constructed by the authors from the Food Balance Sheets FAO. United Nations for Food and Agriculture. Statistical Databases. URL: http://faoestat.fao.org 1961–2011. *Sunflower, soybean and corn. **Poultry increased 4 steps from 0.6% to 2.4%. ***Beans decresed from 5.8% to 3.4%.

Table 3
ANOVA Test of Cluster Analyses between Mexico and Italy. 1961–2011

Food Groups	ANOVA Test of Cluster Analyses by Country				Kruskal-Wallis Tests Intercluster	
	Intercluster – Mexico		Intercluster – Italy		Mexico	Italy
	F	Sig.	F	Sig.	Sig.	Sig.
Grand Total	314.482	0.000	104.883	0.000	0.000	0.000
Cereals – Excluding Beer	6.477	0.003	46.452	0.000	0.005	0.000
Sugar & Sweeteners	172.853	0.000	26.589	0.000	0.000	**0.449**
Vegetable Oils	155.480	0.000	247.274	0.000	0.000	0.000
Vegetables	53.391	0.000	19.479	0.000	0.000	0.000
Fruits – Excluding Wine	52.235	0.000	12.406	0.000	0.000	0.002
Meat	38.349	0.000	185.063	0.000	0.000	0.000
Animal fats	102.057	0.000	139.024	0.000	0.000	0.000
Milk – Excluding Butter	53.812	0.000	64.096	0.000	0.000	0.000
Eggs	45.241	0.000	101.322	0.000	0.000	0.000
Fish Seafood	234.475	0.000	138.837	0.000	0.000	0.000

Source: Analysed by the authors from the Food Balance Sheets FAO. United Nations for Food and Agriculture. Statistical Databases. URL: http://faoestat.fao.org 1961–2011.

Table 4
Inter pattern differences Mexico-Italy

	(Mann Whitnney U test)				
	All Years		I	II	II
Food Group	F	Sig. T	Sig. U	Sig. U	Sig. U
Grand Total	16.186	0.000	0.000	0.000	0.000
Cereals – Excluding Beer	51.049	0.000	0.006	0.000	0.000
Sugar & Sweeteners	47.737	0.000	**0.258**	0.000	0.000
Vegetable Oils	19.458	0.000	0.000	0.000	0.000
Vegetables	5.429	0.000	0.000	0.000	0.000
Fruits – Excluding Wine	0.949	0.000	0.000	0.000	0.000
Meat	9.111	0.000	0.000	0.000	0.000
Animal fats	31.876	0.000	0.000	0.000	0.000
Milk – Excluding Butter	4.893	0.000	0.000	0.000	0.000
Eggs	85.976	0.001	0.000	0.000	**0.190**
Fish Seafood	17.888	0.000	0.000	0.000	0.000

Source: Analysed by the authors from the Food Balance Sheets FAO. United Nations for Food and Agriculture. Statistical Databases. URL: http://faoestat.fao.org 1961–2011.

The most important differences between both countries were as follows:

a. Sugar availability in Mexico showed important increases (11.7% to 15.1%), whereas in Italy this availability was unchanged and low (8.2% to 8.5%) (Tables 1 and 2).
b. An important increase was observed in the availability of vegetable oils in both countries (Tables 1 and 2). The consumption of soybean oil and sunflower oil increased in Italy, however the most apparent consumption was olive oil (Tables 1).

c. The availability of legumes, particularly beans, decreased considerably in Mexico. In Italy there were no important differences (Tables 1 and 2).
d. In Mexico there was an important increase in egg consumption, from 0.6% to 1.5% (Table 2).

Table 5
Gini coefficient, Human Development Index and the Gross Domestic Product and overweight/obesity global, abdominal obesity in women and men, prevalence of diabetes mellitus and hypertension in Mexico and Italy for the period 1990 to 2012

Country		Indicator									
		Health									
	Economic	OOG		AOW		AOM		DM		AHT	
		r	p	r	p	r	p	r	p	r	p
Mexico	IHD	0.9096	<0.05	0.8434	<0.05	0.9035	<0.05	0.9726	<0.05	0.8892	<0.05
	GDP	0.9780	<0.05	0.9002	<0.05	0.9472	<0.05	0.9729	<0.05	0.8202	ns
Italy	IHD	1	<0.05	1	<0.05	1	<0.05	–1	<0.05	–1	<0.05
	GDP	1	<0.05	1	<0.05	1	<0.05	–1	<0.05	–1	<0.05

*OGO = Overweight/Global Obesity. AOW = Abdominal Obesity women. AOM = Abdominal Obesity men. DM = Diabetes mellitus. AHT = Arterial Hypertnesion. **HDI = Human Development Index. GDP = Gross Domestic Product.

According to Table 5, in the case of Mexico, HDI showed a directly proportional relation to all health indicators, implying that where there are better economical, educational and health conditions (HDI components). The frequency of the diseases was higher. GDP was similar to HID, except the correlation with AHT was not statistically significant, even where the *r* value was greater than 0.8.

For Italy, the correlation with HID, GDP and obesity suggested that the better economical conditions, the higher the prevalence of obesity, as was the case in México. However, both economical indicators showed a statistically significant negative correlation with respect to diabetes and hypertension, i.e. the frequency of these diseases was lower by improving living conditions (Table 5).

4. Discussion

Based on the claim that obesity is the leading cause of Metabolic Syndrome components, the study argues that there are two key factors in interpreting the high prevalence of these diseases and the observable differences between the two countries; the abandonment of the traditional diet and the adoption of a high-energy density diet. We consider that changes in eating patterns and in the availability of food (kcal/person/day) are due to socio-economic aspects such as HDI (health, education and income) and GDP (Table 6).

According with the WHO, the prevalence of overweight and obesity increases with the income level of the countries. The prevalence of obesity in high-income and upper-middle-income countries is more than double that

Table 6
Economical indicator for Mexico and Italy. 2014

	HDI 2014	Life Expectancy Years 2014	Overall mortality rate %	Per capita income €
Mexico	0.756	73.5	4.9	8,137
Italy	0.873	82.9	9.8	26,500

Source: http://datos.bancomundial.org/indicador/SI.POV.GINI?page=2. http://databank.bancomundial.org/data/reports.aspx?Code=NY.GDP.PCAP.CD&id=af3ce82b&report_name=Popular_indicators&populartype=series&ispopular=y#.

of low-income countries. For diabetes low-income countries showed the lowest prevalence and upper-middle-income countries showed the highest prevalence. On the other hand, the prevalence of raised blood pressure was higher in low-income countries compared to middle-income and high-in-come countries [9].

According to the WHO, HDI and GDP In this study for Mexico suggest that where there are better economical conditions, frequency of disease is greater (obesity, diabetes) except the correlation whit AHT. In line with the above, in Mexico's 2012 ENSANUT survey shows that prevalence of diabetes, AHT and Obesity is highest in the high socioeconomically levels, in urban areas compared with rural areas and in the richest regions. The relationship between socio economic conditions and disease have not an immediately impact on health. However, there is beginning to occur in the poorest groups [13]. Possible explanations are the change in eating patterns due to socioeconomic conditions, the increased availability of ultra processed and processed food and their lower cost compared to than natural foods [22]. It is also documented that high-income populations spend more on healthy food than those with less money [23]. In this regard, education and income level play a fundamental role.

In Italy HID and GDP shows that where economics conditions are better, there is higher prevalence of obesity. The frequency of diabetes and hypertension was lowered by improving living conditions. It can be assumed that there are better life conditions (education, income, etc.) are reflected in the distribution of these diseases, particularly in diabetes and hypertension. Several authors have commented that there where is high socioeconomic and cultural status, older and more educated people show a higher adherence to Mediterranean diet and a lower prevalence of obesity [24–26].

Whereas the prevalence Metabolic Syndrome components in the Italian population are considered high, for the Mexican population it is a serious public health problem.

In this regard, the results of this study show that food habits in both countries have deviated from the traditional pattern of the 1960s. These traditional diets are generally considered to be the Mediterranean and Mexican or Mesoamerican diet respectively and have tended to move towards the so-called *westernized* food pattern.

The evolution of dietary patterns between the two countries shows similar tendencies, with some important exceptions in Italy, such as the availability of sugar, meat and milk, and the variety of fruits and vegetables, but not in the magnitude of the changes. It is noteworthy that between 1961 and 2011 Italy's kcal/per/day increase was only 429 (Table 1).

The Mediterranean diet is characterised by an abundance of plant foods, moderate amounts of dairy products, small to moderate amounts of fish and poultry, small amounts of red meat, and olive oil as the main source of fat in the diet. High consumption of foods containing mono and polyunsaturated fatty acids, dietary fibre and bioactive polyphenols from olive oil [27–29], as well as, nuts, fruits, vegetables, cereals, fish, low fat meat, eggs and moderate wine, are associated with better health. These foods have a protective effect against non-communicable diseases such as diabetes, including metabolic and cardiovascular risk. Reduced Stroke, Parkinson's disease and Alzheimer's disease incidence and the mortality from cardiovascular diseases and mortality from cancer [30–39]. This study reveals that olive oil has the highest apparent consumption among vegetable oils in Italy, and high variety of vegetables and fruits are observed in the diet. However, according to several studies indicating partial abandonment of the 'Mediterranean diet' in Italy [31, 32, 40], a reduced availability of cereals and legumes and an increase in the availability of animal fat and animal origin foods was observed [20].

The high increase of apparent consumption In Mexico between 1961 and 2011 (662 kcal/per/day) (Table 2) does not necessarily imply adequate food intake since the composition shows reduced consumption of corn and beans, a low supply of fruits and vegetables and a considerable increase in the availability of sugar, vegetable oils (sunflower, soybean, corn), animal fat and foods of animal origin. Mexican eating patterns formed over millennia by different cultures, coincide remarkably with current principles of healthy eating. The benefits of the Mexican diet have been widely studied. This diet consists mainly of corn and beans, a wide variety of fruits and vegetables and a moderate intake of animal products, sugar and fats. In nutritional terms, the traditional Mexican diet is a good source of energy, complex carbohydrates and protein from corn and beans combined. Vitamins and minerals are provided by fruits and vegetables as well as by the daily consumption of chilli [41–43].

In this regard, it is worth noting that in the 1980's, qualitative changes in the production, processing, distribution, and marketing of food took place as a result of industrialization, urbanization, economic development and the globalization of markets. This in turn has resulted in manufactured food products sold on a worldwide market with little regulation from the State, particularly in Mexico [23, 44, 45, 46].

Thus the world has experienced tremendous changes that have negatively impacted food patterns. These changes have had harmful consequences for the health and nutritional status of populations, first in industrialized regions and later in developing countries [23, 47–52]. The changes described, combined with the adoption of a sedentary lifestyle have led to the so-called *nutritional* or *dietary transition* [47].

Italy's advantage in economic indicators supports the view that the differences in prevalence of Metabolic Syndrome components and the changes in dietary patterns are largely due to the economic conditions of each country (Table 6).

5. Conclusions

The study concludes that changes observed in eating habits could have contributed to the metabolic heath of the population in Italy and Mexico. In the former country only some of the changes in dietary patterns have had negative effects. However, actions should be reinforced to avoid this trend continuing.

In Mexico all changes have produced negative effects. Alterations in dietary patterns represent a serious problem for the population and action must be taken against this trend. In both countries, but particularly in Mexico, it is important to introduce public policies that improve the socio economic conditions reflected in the HDI and GDP, to boost education that promotes healthy eating habits, and to improve living conditions, food quality and health care. The implications of these conclusions are that promoting balanced diets and healthy lifestyles and reducing the global burden of non-communicable diseases require a multisectorial approach with the participation of different sectors of society. The effort must include controls protecting consumers from misleading information in advertising and inadequate or incomplete information on health benefits. Likewise, it is essential to control the production and marketing of ultra-processed food and products with no or minimal nutritional value, through tighter government regulations. A exhaustive exploration of socio-economic conditions and their relation with Metabolic Syndrome components is needed.

The present study is based on aggregated data, such as FBSs. The uses and limitations of the FAO's FBSs should be considered when interpreting the results. FBSs provide useful data for comparing countries and examining the evolution of diets over time.

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Conflict of interest

The authors declare that they have no conflict of interest.
This article does not contain any studies with human participants or animals performed by any of the authors.

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