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Low income is associated with poor adherence to Mediterranean Diet and higher prevalence of obesity: results from the Moli-sani study

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ABSTRACT

Objectives: To assess differences in eating patterns among adult Italians with different socio-economic status, with particular focus on income.

Design: Cross-sectional study on a sample of Italian subjects enrolled in the Moli-sani Project, a population-based cohort study.

The Italian EPIC food frequency questionnaire was used to determine food intake. Adherence to Mediterranean diet (MD) was appraised according to the Mediterranean score elaborated by Trichopoulou (MDS) and the novel Italian Mediterranean Index (IMI) and to an *a posteriori* score derived from principal component analysis. Four income categories were identified.

Setting: Molise region, Italy

Participants: 13,262 subjects (mean age 53±11, 50% men) enrolled in the Moli-sani Project which randomly recruited 24,318 citizens (age ≥35).

Main outcomes: Dietary patterns and risk factors for cardiovascular disease.

Results: Higher income groups were significantly associated with greater adherence to MD ($p<.0001$) and to Olive oil and Vegetables dietary pattern in multivariable model including age, sex, daily energy intake, BMI, physical activity, smoking, alcohol consumption and education. The odds of having highest adherence to MD clearly increased according to income levels. People having the highest income had 56% (95% CI: 24% to 96%, MDS) or 68% (95% CI: 33% to 112%, IMI) higher probability to stick to a Mediterranean diet-like eating pattern than those in the lowest income group. Obesity prevalence was higher in the lowest-income group (36%) in comparison with the highest- income category (20%, $p <.0001$). Similar results were found for high educated group.

Conclusions: Higher income and education are associated with greater adherence to Mediterranean diet-like eating patterns and lower prevalence of obesity**.** The increasing prices of the basic Mediterranean food items seem to represent a real obstacle to healthy diet driving people to choose

alternative ways of eating usually inspired by the need to save money in everyday life.

INTRODUCTION

Mediterranean Diet (MD) has been shown to offer protection against cardiovascular disease, some types of cancer, and neurodegenerative diseases (1,2) and recently the UNESCO committee inscribed it on the list of Intangible Heritage (3). The main food components of the MD are vegetables, fruits, cereals, fish, olive oil as main fat source and moderate red wine consumption. Despite the widely proven benefits of the diet discovered by Ancel Keys (4) in the Fifties, the Southern European countries in which Mediterranean diet originated are rapidly withdrawing from this eating pattern orienting their food choices toward products typical of the Western diet (WD) which is rich in refined grains, saturated fats, sugars, red and processed meat. The reasons why people keep on drifting from one dietary regimen to another remain open to several hypotheses (2). Social changes appear to have contributed to radical reversal in dietary habits in Western and Southern Europe societies although developing countries are slightly turning into westernized diets as well (5).

Increasing prices of many of the basic food items of MD seem to have led people to give up this eating pattern in favour of less expensive products which allow to save money but are definitively unhealthy (6).

Many studies suggest that diet quality follows a socio-economic gradient highlighting how disadvantaged people present higher rates of obesity, diabetes, cardiovascular disease and some types of cancer (7).

The abandon of MD is also considered as a possible cause of the increasing obesity pandemic (8). Several studies made a further step forward in order to see whether there is an association between diet cost and obesity, finding out that higher adherence to healthy dietary patterns is linked to higher monetary costs and is inversely associated with BMI and obesity (9).

The aim of the present study was to assess possible differences in eating patterns among adult Italians with different socio-economic status, with particular focus on low-income, in order to

reinforce the assumption that encouraging people to adopt healthy eating behaviours is not just a matter of good willing but mainly an issue which should lead to concrete measures of intervention in terms of economic availability. Our study aimed also at evaluating a potential relationship between low-income and obesity or overweight.

MATERIAL AND METHODS

Study population

The Moli-sani Project is a population-based cohort study which randomly recruited 24,325 citizens of the Molise, a region placed between Central and Southern Italy. Between March 2005 and April 2010, the study enrolled men and women aged ≥35 years, randomly recruited from subjects included in the city-hall registries of Molise (10). Exclusion criteria were pregnancy, disturbances in understanding/ willing processes, ongoing poly-traumas or coma, refusal to sign the informed consent.

After exclusion of subjects reporting cardiovascular disease (5.7%), cancer (3.1%) or diabetes (6.0%) and of those for whom there were no information available on income (30.7%) because they refused to answer or did not know about this issue, 13,262 subjects were analysed. The latter subjects were comparable with the whole Moli-sani Project population in terms of Mediterranean dietary patterns and socio-economic features, whereas mean age of the sample was slightly lower (53.3 ± 11 vs 55.0 ± 12) and had a higher prevalence of men (50% vs 48%) compared with the whole population.

Dietary information

The validated Italian EPIC food frequency questionnaire was used to determine food intake (11, 12). The questionnaire, computerized with tailor-made software, allowed to interview participants in an interactive way, including illustrations of sample dishes of definite sizes or by reference to

standard portion sizes. To simplify interpretation of data and to minimize within-person variations in intakes of individual foods, 188 food items were classified into 45 predefined food groups on the basis of similar nutrient characteristics or culinary usage (Appendix 2). (Web only file).

Moderate alcohol intake was defined as regularly drinking less than two or one drinks a day, respectively for men and women.

Food consumption patterns were generated by using Principal Components Analysis (PCA) conducted on the correlation matrix of 45 food groups (13). Three main factors emerged, in agreement with previous findings in the same population (13) . The first pattern, identified as ''Olive Oil and Vegetables'', was characterized by high positive loadings for olive oil, vegetables, legumes, soups, fruits and fish. The second pattern, named ''Pasta and Meat'', was characterized by high positive loadings for pasta, cooked tomatoes, red meat, animal fats and alcoholic beverages, and negative loadings of breakfast cereals and yogurt. The ''Eggs and Sweets'' pattern was characterized by high positive loadings for eggs, margarines, processed meat and sugar and sweets.

We evaluated the adherence to the Mediterranean diet by using the Mediterranean Diet Score (MDS) elaborated by Trichopoulou et al (14) which is obtained by assigning a value of 0 or 1 to each of 9 indicated components (vegetables, legumes, fruits, cereals, fish, meat, dietary products, ethanol, lipids) with the use of the sex-specific median as cut-off. The total Mediterranean- diet score ranged from 0, which indicates the minimal adherence to the traditional Mediterranean diet, to 9, namely the maximal adherence.

We also used the new Italian Mediterranean Index (IMI) whose score is based on the intake of 11 items (pasta, vegetables, fruits, legumes, olive oil, fish, soft drinks, butter, red meat, and potatoes, alcohol) ranged from 0 to 11 (15). Such Italian Index was conceived to capture healthy eating in the context of foods typically available in Italy.

Data collection

Body Mass Index (BMI) was calculated as kg/m^2. Waist circumferences were measured according to the NIH, Heart, Lung, and Blood guidelines (16). Blood pressure (BP) was measured by an automatic device (OMRON-HEM-705CP) 3 times on the non-dominant arm and the average of the last 2 values was taken as the BP. Hypertension, diabetes and dyslipidemia were defined as self-reported health professional–diagnosis and anti-hypertensive, anti-diabetics or lipid-lowering medication use. Physical activity was assessed by a structured questionnaire (24 questions on working time, leisure time and sport participation) and expressed as daily energy expenditure in metabolic equivalent task-hours (MET/d).

Serum lipids and glucose were assayed by enzymatic reaction methods using an automatic analyzer (ILab 350, Instrumentation laboratory (IL), Milan, Italy). LDL-cholesterol was calculated according to Friedewald. High sensitivity C reactive protein (CRP) was measured in fresh serum, by a latex particle-enhanced immunoturbidimetric assay (IL Coagulation Systems on ACL9000). Inter- and intra-day CV were 5.5% and 4.17%, respectively.

Socio-economic variables

Income categories were considered as low (< 10,000 euro/ year, gross), low-medium (> 10,000 < 25,000 euro/year), medium – high (> 25,000 < 40,000 euro/year), high (> 40,000 euro/ year). Socio-economic status (SES) was expressed as a score based on 5 variables: dwelling ownership and ratio between the number of living-in family members and number of rooms (People Room Density), both currently and at childhood - and availability of hot water at home at childhood. The five components were dichotomized according to the median value, and a score of one was attributed to the category supposed to be marker of higher social status in comparison with the opposite category: thus we assigned a score of 1 to people living in a house with living-in family members/room density > 0.6 or dwelling ownership or with availability of hot water and a score 0

to people with living-in family members/room density≤0.6, no dwelling ownership or with unavailability of hot water. Education Level was divided in two categories: ≤8 years of studies (0 point) and >8 years of studies (1 point).

Statistical analysis

Values for continuous variables are means ± Standard Deviation. CRP was transformed into natural logarithm to reduce positive skewness, but data were reported untransformed for clarity. Analysis of variance for continuous or categorical variables was applied to test the associations in Table 1. Multivariable analysis of variance was used for testing the association of adherence to Mediterranean diet scores, dietary patterns or dietary variables (considered as the dependent variables) with categories of income or SES components. By using multivariable logistic regression analysis, odds ratio (ORs) with corresponding 95% confidence intervals (95% CI) were calculated to quantify the association of income or education levels with adherence to Mediterranean diet-like eating scores. High adherence to MD, as stated by the Medscore, was defined when the score was ≥6 points whereas a low adherence when the score was ≤3 points. Subjects with intermediate values (4 or 5 points) were excluded from this analysis in order to focus on the two extreme categories of adherence. The same was done for the IMI score but the cut-off was ≥5 for the higher adherence or ≤3 for the lower adherence category.

The data analysis was generated using SAS/STAT software, Version 9.1.3 of the SAS System for Windows©2009. SAS Institute Inc. and SAS are registered trademarks of SAS Institute Inc., Cary, NC, USA.

RESULTS

Income groups

Table 1 shows the characteristics of the whole population by income categories. People in the uppermost income group were 53.5% men and showed a better health profile, having significantly lower values of BMI, systolic blood pressure, C-reactive protein, triglycerides, blood glucose. Obesity prevalence (BMI > 30 Kg/m^2) differed according to income; it was higher in the lowest-income group (36%) and lower in the highest- income category (20%, p <.0001 Tab. 1).

In Table 2 the association among income levels, dietary habits and single food groups are reported. Subjects in the lower income categories showed poor adherence to the Olive oil and Vegetables dietary pattern (p<.0001) whereas a greater adherence to the Western type pattern was observed. Higher income groups were significantly associated with greater adherence to both score indexes, namely MDS (p<.0001) and IMI (p<.0001) in the model adjusted for age, sex , daily energy intake, BMI, physical activity, smoking and alcohol consumption.

In addition, analysis of single foods consumption by income categories showed that people with the higher income reported higher intake of the basic components of the Mediterranean diet, that is fish, fruits, legumes and reduced consumption of animal fats, processed meat, white meat whose frequent consumption is more typical of a Western dietary model.

The odds of having highest adherence to the Mediterranean diet, that raised both with MDS and IMI scores, clearly increased according to income levels (Tab. 4). People having the highest income had 56% (MDS) or 68% (IMI) statistically significant higher probability to stick to a Mediterranean diet-like eating pattern than those in the lowest income group (Tab. 4).

Regarding alcohol consumption, the highest income group resulted to include the highest prevalence of moderate drinkers (41.7% versus 27.5% recorded in the lowest income group) as already found in a study on a sample of Danish population (17) .

Socio-economic status and education

People in the highest SES category showed a higher adherence to IMI ($p = 0.0042$) whereas no difference was found in relation to the MDS ($p = 0.82$). Higher education (> 8 years) was associated with higher adherence as well (Tab. 3).

Odds for association of higher education with higher adherence to MDS or IMI were 1.22 and 1.20 respectively ($p < 0.0024$). ORs were adjusted for sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption (Tab. 4).

Stratification by education

As less educated people may show lower adherence because of lack of knowledge about healthy habits (18), we performed additional analyses stratified for educational level.

Both in higher (>8 years of studies) and lower (< = 8) educated groups adherence to Mediterranean diet (evaluated both by IMI and MDS score) followed the gradient of income categories (Tab. 5).

DISCUSSION

We found that people with higher income and higher levels of education have a greater adherence to Mediterranean diet-like eating patterns, as measured by three different parameters: two *a priori* Mediterranean scores (the traditional one introduced by Trichopoulou and a novel Italian Mediterranean index), and the *a posteriori* dietary patterns derived from principal components analysis. Evidence on the health benefits of the Mediterranean diet is based on several studies and meta-analyses (1, 2,18). However, adherence to this healthy eating pattern is rapidly disappearing in the countries of Southern Europe where it originated and persisted during centuries, including the areas of Northern Africa in which there is an increasing prevalence of metabolic disorders and consequent cardiovascular disease mainly due to the changing in lifestyle habits (19). Socio-economic status has been included among the factors related to chronic disease onset, and

disparities in dietary habits by social class have been advocated to explain at least in part the higher CVD risk factors profile observed among low SES groups (20).

Our results agree with what reported in the review by Darmon et al. (7) that higher-quality diets are mainly consumed by better educated and more affluent people while lower socio-economic groups tend to have lower quality diets thus exposing themselves to a higher risk to develop diet-related diseases. Similar conclusions were reached by other investigations (21) suggesting that low socio-economic groups end with having poorer diets. These findings could be supported, at least in part, by the increasing prices of some of the key foods of the MD (6). Indeed researchers in Spain showed that Mediterranean diet is definitely more expensive to follow than western dietary patterns suggesting that this may represent a strong economic obstacle to be considered when counselling people about the opportunity to follow a healthy diet because cost may become a prohibitive factor (6). Aggrawal et al. (22) demonstrated that the well-known socio-economic disparities in diet quality is mediated by food cost confirming that lower SES groups tend to consume more energy dense and nutrient poor diets.

We have also found that subjects with lower income have also a greater prevalence of obesity. The association between obesity and SES has been already highlighted by previous studies (23) ascribing to SES an important role in determining the risk of obesity and overweight not only in adults but also in children (24). Our data suggest that the strong association observed between lower income and SES levels could be partially mediated by poor adherence to healthy dietary pattern recorded in the lowest socio-economic groups which reported lower values with both the Mediterranean scores.

It is quite clear that accumulating proofs on the benefits of Mediterranean- like diets could no longer be the only task of prevention strategies which should also try to set the conditions allowing people to stick to healthier dietary habits.

This study contributes to provide further evidence to the assumption that dietary habits are strongly influenced by socio-economic status, in particular by income which appears to play an important role in determining people's eating choices. For what concerns education, previous studies found a relationship between higher levels of education and healthy diets (25). In our research, education resulted to be independently associated to Mediterranean diet and did not modify the association between income levels and healthy dietary pattern as shown in the stratified analysis by education levels.

The promotion of healthy lifestyles and diets to prevent weight gain and related diseases has jumped to the top of the priority list of the public health experts all over the world since obesity has become a threatening epidemic. So far the traditional Mediterranean diet has proven to be an effective "remedy" to the spreading of the major chronic disease, obesity and mortality. Our study highlights the strong linkage among low income, poor adherence to MD and consequent obesity prevalence.

We started our study wondering about what makes so hard for people to choose healthy food instead of bad products, putting at risk their own health. We excluded it could be just a matter of personal choice or taste, neither an issue related to the lack of knowledge about the healthy benefits of MD worldwide recognized and also well disseminated in the lay press.

Limitations of this study

A major limitation of the present study is that people self-reported their own income which is a quite sensitive issue. Indeed we recorded a high percentage (30.7%) of non-respondent subjects who refused to declare or did not know their personal income. Such large non-respondent group is very common in this type of investigation, especially for women and elderly (26). However, there was no difference between the whole Moli-sani population and the subsample used for the present analysis in dietary habits and socio-economic variables. Moreover, we also evaluated other

economic variables, less prone to reporting bias, that showed similar association with Mediterranean indices and dietary patterns.

Another inherent limit is represented by the cross-sectional nature of our study.

In addition, caution is needed in extending the results presented here to larger contexts since data were collected in a region located between Central and Southern Italy, Mediterranean by tradition and culture (10). Yet, the main characteristics of our sample are comparable to those of the Italian Cardiovascular Epidemiological Observatory (27) a large survey including random samples of the general population all over Italy; therefore our sample could be considered representative at least of the Italian population.

Strengths of this study

Our population sample is made of subjects coming from a quite homogenous environment with no marked differences in terms of socioeconomic disparities, differently from metropolitan areas, where previous studies have found huge gaps among social classes and related health status at relatively small distances from the city centre (28). Bearing this in mind, the differences we observed in the adherence to Mediterranean diet according to income indicate that also in a homogeneous environment, both for genetic and lifestyles, income and education can still play a role in influencing dietary choices. Furthermore, diet quality showed a continued improvement across a relatively small range of economic strata. Our "poorest" are represented by people earning less than 10,000 euro/gross per year whilst the "richest" group is made of subjects with more than 40,000 euro/gross per year. Such differences among income classes are quite restrained and recall what already said for the pretty homogeneous environment where our sample comes from. We are not dealing with real huge differences both for socioeconomic and income issues. Despite this homogeneity, we did note notable changes in diet quality among the groups.

The differences we observed across the income strata would likely become even more evident in Mediterranean importing countries where getting typical Mediterranean diet products is more difficult and expensive.

In addition, for the first time this topic was addressed by using two *a priori* Mediterranean scores (the traditional one introduced by Trichopoulou and a novel Italian Mediterranean index), and the *a posteriori* dietary patterns derived from principal components analysis.

CONCLUSION

Our data clearly indicate that eating "mediterraneanly" is also, if not mainly, a matter of healthy food accessibility in terms of economic costs. The increasing prices of the basic Mediterranean food items seem to represent a real obstacle to healthy diet driving people to choose alternative ways of eating usually inspired by the need to save money in everyday life. Public health policies shall take into account the fact that correct dietary habits need to be promoted by allowing people to choose the best for their own health. It is definitely an interdisciplinary issue which shall call to action every single actor of modern societies otherwise condemned to increase their already heavy burden of chronic diseases. As already noted by others who dealt with this topic, the promotion of high-cost foods to low-income people without taking food costs into account is not likely to be successful (7).

Table 1 Characteristics of the whole population and by four income categories

		Income Categories				
	All (n=13,262)	**< 10,000 (n = 980, 7.4%)**	**> 10,000 < 25,000 (n = 5751, 43.4%)**	**> 25,000 < 40,000 (n= 4120, 31.1%)**	**> 40,000 (n = 2411, 18.2%)**	**P value***
Age (years)	53.3 (10.6)	60.1 (12.7)	54.0 (11.2)	51.4 (9.5)	52.3 (8.8)	<.0001
Sex (males, n, %)	6590 (49.7%)	348 (35.5%)	2834 (49.3%)	2117 (51.4%)	1291 (53.5%)	<.0001
BMI (kg/m^2)	27.7 (4.6)	28.7 (5.3)	28.2 (4.7)	27.3 (4.3)	27.0 (4.0)	<.0001
WH-ratio	0.91 (0.07)	0.92 (0.079)	0.91 (0.075)	0.91 (0.075)	0.91 (0.074)	0.019
Systolic blood pressure (mmHg)	139.0 (20.1)	143.4 (21.0)	140.1 (20.4)	137.3 (19.6)	137.4 (19.2)	0.0053
Diastolic blood pressure (mmHg)	82.7 (9.6)	81.7 (9.7)	82.8 (9.4)	82.7 (9.7)	82.8 (10.0)	0.0038
Total physical activity (MET-h /day)	43.4 (8.7)	44.8 (10.4)	45.0 (9.7)	42.5 (7.9)	40.4 (5.2)	<.0001
Leisure time PA (MET-h /day)	2.18 (1.88)	1.81 (1.67)	2.10 (1.78)	2.22 (1.96)	2.28 (1.94)	0.20
Working PA (MET-h /day)	14.6 (12.2)	22.4 (19.1)	18.8 (14.3)	12.7 (10.4)	10.2 (6.4)	<.0001
Smokers n, %						
Never	6370 (48.1%)	558 (56.9%)	2838 (49.4%)	1901 (46.2%)	1073 (44.5%)	<.0001
Current	3296 (25.0%)	222 (22.6%)	1418 (24.7%)	1060 (25.8%)	596 (24.7%)	
Former	3585 (27.5%)	200 (20.4%)	1490 (25.9%)	1154 (28.0%)	741 (30.7%)	
Total cholesterol (mg/dL)	212.3 (40.2)	214.3 (41.9)	212.8 (40.4)	211.8 (40.4)	211.0 (38.7)	0.64
HDL (mg/dL)	57.0 (14.5)	58.4 (14.4)	57.2 (14.4)	56.6 (14.5)	56.8 (14.6)	0.35
LDL (mg/dL)	130.3 (33.6)	130.8 (35.7)	130.3 (33.8)	130.2 (33.6)	130.1 (32.7)	0.65
CRP (mg/dL)	2.4 (3.0)	3.0 (3.7)	2.6 (3.1)	2.2 (2.9)	2.1 (2.7)	<.0001
Triglycerides (mg/dL)	127.0 (83.8)	129.1 (87.0)	129.1 (84.5)	126.1 (85.0)	122.6 (78.4)	0.0002
Blood glucose (mg/dL)	96.8 (17.0)	97.7 (20.4)	97.2 (16.8)	96.4 (16.5)	96.4 (16.4)	0.17
Obesity (n, %)	3563 (26.9%)	352 (36.0%)	1733 (30.1%)	988 (24.0%)	490 (20.3%)	<.0001
Hypertension (n, %)	6891 (52.0%)	628 (64.1%)	3092 (53.9%)	1978 (48.1%)	1193 (49.6%)	0.59

* P value adjusted for sex, age and energy intake

Table 2 Mediterranean diet adherence and dietary consumption in the whole population and by four income categories

		Income categories				
	All (n=13,262)	**< 10,000 (n = 980, 7.4%)**	**> 10,000 < 25,000 (n = 5751, 43.4%)**	**> 25,000 < 40,000 (n= 4120, 31.1%)**	**> 40,000 (n = 2411, 18.2%)**	**P value ***
Mediterranean score (MDS)	4.44 (1.64)	4.32 (1.61)	4.40 (1.62)	4.46 (1.62)	4.53 (1.70)	<.0001
Italian Mediterranean index (IMI)	3.26 (1.71)	3.20 (1.64)	3.15 (1.68)	3.30 (1.71)	3.49 (1.79)	<.0001
Dietary Pattern 1 (Olive Oil and Vegetables)	0.042 (0.95)	-0.066 (0.92)	0.021 (0.94)	0.070 (0.95)	0.091 (0.97)	<.0001
Dietary Pattern 2 (Pasta and Meat)	0.036 (0.95)	0.0078 (0.91)	0.093 (0.95)	0.0053 (0.95)	- 0.036 (0.97)	<.0001
Dietary Pattern 3 (Eggs and sweets)	0.015 (0.85)	-0.13 (0.88)	0.040 (0.86)	0.044 (0.85)	-0.033 (0.82)	<.0001
Energy intake (kcal/day)	2177.4 (640.7)	2062.5 (704.1)	2186.3 (649.0)	2190.6 (627.8)	2180.4 (610.7)	0.50
Alcohol intake (gr/day)	16.5 (22.4)	16.1 (25.8)	18.2 (24.5)	15.3 (20.3)	14.9 (18.6)	<.0001
Moderate drinkers (n, %)	4303 (33.3%)	261 (27.5%)	1646 (29.2%)	1419 (35.3%)	977 (41.7%)	<.0001
Olive oil (gr/day)	24.2 (9.2)	22.9 (9.0)	24.4 (9.3)	24.4 (9.2)	24.0 (9.1)	0.0009
Animal fat (gr/day)	1.26 (1.41)	1.21 (1.37)	1.34 (1.45)	1.25 (1.41)	1.11 (1.31)	<.0001
Fish (gr/day)	20.9 (17.0)	17.5 (15.5)	19.4 (16.3)	22.1 (17.4)	23.9 (18.0)	<.0001
Processed meat (gr/day)	30.4 (20.9)	27.4 (20.0)	31.5 (21.8)	30.7 (20.5)	28.6 (19.9)	<.0001
Cooked vegetables (gr/day)	73.5 (43.4)	71.2 (42.8)	74.8 (44.0)	74.0 (42.5)	70.6 (43.4)	0.0005
Legumes (gr/day)	28.3 (22.1)	27.1 (20.3)	27.1 (21.6)	28.4 (21.9)	31.3 (24.2)	<.0001
Nuts and seeds (gr/day)	0.89 (2.3)	0.90 (3.2)	0.87 (2.3)	0.88 (2.1)	0.94 (2.2)	0.71
Red meat (gr/day)	47.8 (26.0)	44.7 (26.3)	48.8 (25.9)	47.9 (25.8)	46.8 (26.3)	0.0087
White meat (gr/day)	26.4 (18.8)	29.6 (19.8)	28.1 (19.3)	25.3 (17.8)	23.2 (18.1)	<.0001
Fruits (gr/day)	358.5 (204.3)	362.7 (211.1)	354.9 (201.2)	355.7 (198.9)	370.3 (217.0)	0.0034

*P value adjusted for sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption

Table 3 Characteristics of the whole population and by socio-economic status and education

	SES categories				Educational levels		
	Low (n=4081, 31.8%)	Low-medium (n=3955, 30.8%)	High (n=4803, 37.4%)	P value*	< = 8 years (n = 6098, 46%)	> 8 years (n=7158, 54%)	P value*
Age (years)	55.9 (10.3)	54.4 (10.9)	50.0 (9.8)	<.0001	56.1 (11.4)	51.0 (9.4)	<.0001
Sex (males, n, %)	2097 (51.4%)	1920 (48.5%)	2377 (49.5%)	<.0001	2982 (48.9%)	3607 (50.4%)	<.0001
BMI (kg/m^2)	28.2 (4.6)	27.9 (4.5)	27.1 (4.5)	<.0001	28.6 (4.7)	26.9 (4.3)	<.0001
WH-ratio	0.92 (0.073)	0.91 (0.077)	0.90 (0.075)	0.16	0.92 (0.075)	0.90 (0.075)	0.87
Systolic blood pressure (mmHg)	141.9 (20.7)	139.8 (20.0)	135.6 (19.0)	0.26	142.0 (20.4)	136.3 (19.3)	0.66
Diastolic blood pressure (mmHg)	83.1 (9.6)	82.7 (9.5)	82.1 (9.7)	0.89	82.9 (9.5)	82.4 (9.8)	<.0001
Physical activity (MET-h /day)	44.1 (8.9)	43.5 (8.8)	42.7 (8.4)	<.0001	45.6 (10.3)	41.5 (6.5)	<.0001
Leisure time PA (MET-h /day)	2.14 (1.81)	2.10 (1.79)	2.22 (1.95)	0.80	2.10 (1.84)	2.21 (1.90)	0.91
Working PA (MET-h /day)	16.5 (13.2)	15.1 (13.0)	13.2 (11.0)	<.0001	21.7 (15.4)	11.1 (8.2)	<.0001
Smokers n, %							
Never	1880 (46.1%)	1961 (49.6%)	2320 (48.3%)	0.0002	3047 (50.0%)	3321 (46.4%)	<.0001
Current	1049 (25.7%)	910 (23.0%)	1227 (25.6%)		1456 (23.9%)	1839 (25.7%)	
Former	1146 (28.1%)	1083 (27.4%)	1253 (26.1%)		1593 (26.1%)	1992 (27.8%)	
Total cholesterol (mg/dL)	212.4 (40.5)	212.7 (40.7)	211.9 (39.7)	0.0022	213.9 (41.1)	210.9 (39.4)	0.46
HDL (mg/dL)	56.3 (14.1)	57.2 (14.5)	57.5 (14.7)	0.0003	57.1 (14.4)	57.0 (14.6)	0.33
LDL (mg/dL)	130.4 (34.0)	130.4 (33.7)	130.2 (33.4)	0.014	131.0 (34.6)	129.6 (32.8)	0.13
CRP (mg/dL)	2.6 (3.1)	2.4 (2.9)	2.2 (3.0)	0.079	2.7 (3.2)	2.2 (2.8)	0.13
Triglycerides (mg/dL)	131.0 (87.9)	127.5 (83.2)	122.8 (80.9)	0.50	131.6 (87.2)	123.0 (80.6)	0.16
Blood glucose (mg/dL)	98.4 (18.4)	96.9 (17.2)	95.5 (14.8)	0.013	98.0 (17.5)	95.9 (16.4)	0.84
Obesity (n, %)	1215 (31.8%)	1122 (30.8%)	1112 (23.1%)	<.0001	2038 (33.4%)	1523 (21.3%)	<.0001
Hypertension (n, %)	2392 (58.7%)	2141 (54.2%)	2114 (44.1%)	0.85	3600 (59.1%)	3289 (46.0%)	0.97
Mediterranean score (MDS)	4.51 (1.61)	4.45 (1.64)	4.38 (1.65)	0.82	4.43 (1.62)	4.45 (1.65)	<.0001
Italian Mediterranean index (IMI)	3.23 (1.70)	3.25 (1.70)	3.30 (1.73)	0.0042	3.18 (1.67)	3.33 (1.74)	<.0001

*P value adjusted for sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption

Table 4 Odds ratios of having high adherence to Mediterranean diet according to income and education

	Mediterranean score				Italian Mediterranean Index			
	Low	High			Low	High		
Income	**(n=3843)**	**(n=3518)**	**OR**	**(95%CI)**	**(n=4704)**	**(n=3089)**	**OR**	**(95%CI)**
< 10,000	310 (8.1%)	231 (6.6%)	-1-	(referent)	353 (7.5%)	209 (6.8%)	-1-	(referent)
> 10,000 < 25,000	1694 (44.1%)	1470 (41.8%)	1.32	(1.08-1.61)	2161 (45.9%)	1201 (38.9%)	1.06	(0.86-1.30)
> 25,000 < 40,000	1153 (30.0%)	1116 (31.7%)	1.57	(1.27-1.93)	1436 (30.5%)	995 (32.2%)	1.31	(1.05-1.62)
> 40,000	686 (17.9%)	701 (19.9%)	1.56	(1.24-1.96)	754 (16.0%)	684 (22.1%)	1.68	(1.33-2.12)
Education level								
Low	1775 (46.2%)	1571 (44.7%)	-1-	(referent)	2250 (47.8%)	1307 (42.3%)	-1-	(referent)
High	2068 (53.8%)	1946 (55.3%)	1.22	(1.09-1.37)	2452 (52.2%)	1782 (57.7%)	1.20	(1.07-1.35)

The logistic model included income and education categories and sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption

Table 5 Mediterranean diet adherence according to four income levels and stratified by education

	Income Categories				
	< 10,000	**> 10,000 < 25,000**	**> 25,000 < 40,000**	**> 40,000**	
Higher Education (n = 7158)	**(n=150)**	**(n=2004)**	**(n=2860)**	**(n=2144)**	**P value ***
Mediterranean Diet	4.29 (1.70)	4.35 (1.60)	4.47 (1.62)	4.53 (1.71)	0.0065
Italian Mediterranean Index	3.26 (1.78)	3.18 (1.69)	3.33 (1.72)	3.49 (1.79)	<.0001
Lower Education (n = 6101)	**(n = 829)**	**(n = 3745)**	**(n = 1260)**	**(n = 267)**	
Mediterranean Diet	4.33 (1.60)	4.43 (1.64)	4.44 (1.60)	4.60 (1.64)	0.0094
Italian Mediterranean Index	3.19 (1.61)	3.13 (1.67)	3.22 (1.69)	3.54 (1.73)	0.0003

*p value adjusted for sex, age, total energy intake, BMI, physical activity, smoking, alcohol consumption

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CONTRIBUTORS: (MB, AB, LI designed the research; FDL, MB, managed data collection; MB, ADC analyzed the data; MB, AB wrote the paper, MBD, GdG, LI originally inspired the research, obtained the financial support and critically reviewed the manuscript). All Authors had full access to all of the data in the study and take responsibility for the integrity of the data and the accuracy of the data analysis. None of the Authors had a personal or financial conflict of interest.

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All Authors are independent from funders.

COMPETING INTEREST

None

ETHICAL ISSUES: The Moli-sani study was approved by the Ethics Committee of the Catholic University of Rome. Participants signed the informed consent before taking part in the study.

DATA SHARING: no additional data available.

APPENDIX 1

Moli-sani project Investigators

Chairperson: Licia Iacoviello (Campobasso, Italy)

Steering Committee: Maria Benedetta Donati and Giovanni de Gaetano (Campobasso, Italy) (Chairpersons), Simona Giampaoli (Roma, Italy)

Safety and data monitoring Committee: Jos Vermylen (Leuven, Belgio), Chairman, Ignacio De Paula Carrasco (Roma, Italy), Enrico Garaci (Roma, Italy)

Event adjudicating Committee: Deodato Assanelli (Brescia, Italy), Francesco Alessandrini (Campobasso, Italy), Vincenzo Centritto (Campobasso, Italy), Paola Muti (Roma, Italy), Holger Schünemann (Hamilton, Canada), Pasquale Spagnuolo (Termoli, Italy), Dante Staniscia (Termoli, Italy), Sergio Storti (Campobasso, Italy)

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APPENDIX 2 Food grouping used in the dietary pattern analyses

Foods or food groups	Food items
Potatoes	Potatoes
Cooked vegetables	Leafy vegetables, root vegetables, cabbages, onion, carrots, mushrooms, egg plants, artichokes, sweet peppers, spinach, pumpkins, canned vegetables in oil, picked vegetables
Raw vegetables	Raw leafy vegetables, raw tomatoes
Tomatoes (cooked)	Tomato sauces, tomatoes
Legumes	Beans, lentils, peas, chick peas
Fruit	Apples, pears, kiwi, bananas, grapes, peaches, apricots, oranges, tangerines, plums, strawberries, melon, khaki, figs, cherries
Nuts and dried fruit	Peanuts, almonds, hazelnuts, walnuts, dried figs, dried dates, prune
Olives	Olives
Milk	Milk
Yogurt	Yogurt
Fresh cheese	Mozzarella, ricotta cheese, taleggio cheese, gorgonzola cheese, melted cheese slices, other soft cream cheese
Seasoned cheese	Fontina cheese, emmenthal, gruyere, parmesan, caciocavallo cheese, other seasoned cheese
Pasta and other grains	Pasta, yellow maize meal
Rice	Rice
Bread	White bread, bread with oil and other bread
Crisp bread, rusks	Breads sticks, crisp bread
Breakfast cereals	Breakfast cereals
Salty biscuits	Crackers
Red meat	Beef, pork, lamb, horse, game, veal, other meats
White meat	Chicken, turkey, rabbit
Processed meat	Sausages, ham, bologna sausage, dried beef, salami

Offals	Liver, offals
Canned fish	Canned tuna fish and other fish
Crustaceans, molluscs	Crustaceans, molluscs
Fish	Other fish
Egg	Eggs
Vegetables oils	Seed oils (except olive oils)
Olive oil	Olive oil
Butter	Butter
Margarines	Margarines
Animal fats	Visible fat from meat, poultry skin, fat from ham
Sugar & sweets	Sugar, honey, cakes, ice cream, confections, pastry, pudding
Fruit juices	Orange juice, grapefruit juices, other fruit juices
Soft drinks	Soft drinks
Coffee	Coffee
Tea	Tea
Other sauces	Dressing sauces for pasta other than tomato sauce
Mayonnaises	Mayonnaises
Soups	Vegetable soups
Bouillon	Meat and stock-cube broth
Snacks	Vegetable quiche
Pizza	Pizza
Wine	Red wine, rosé wine, white wine
Spirits	Alcoholic beverages other than wine or beer
Beer	Beer

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract **Yes**	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale **Yes**	2	Explain the scientific background and rationale for the investigation being reported
Objectives **Yes**	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design **Yes**	4	Present key elements of study design early in the paper
Setting **Ref 10 and 13**	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants **Yes**	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables **Yes**	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement **Yes**	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias **Yes**	9	Describe any efforts to address potential sources of bias
Study size **Ref 10**	10	Explain how the study size was arrived at
Quantitative variables **Yes**	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods **Yes**	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants **Yes**	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data **Yes**	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data **Not applicable**	15*	Report numbers of outcome events or summary measures
Main results **Yes**	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were

		adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses **Yes**	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results **Yes**	18	Summarise key results with reference to study objectives
Limitations **Yes**	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation **Yes**	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability **Yes**	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding **Yes**	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

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Low income is associated with poor adherence to Mediterranean Diet and higher prevalence of obesity: cross-sectional results from the Moli-sani study

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Low income is associated with poor adherence to Mediterranean Diet and higher prevalence of obesity: cross-sectional results from the Moli-sani study

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Keywords: Obesity; Diet, Mediterranean; Social Class; Public Health; Cardiovascular Diseases

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ABSTRACT

Objectives: To examine cross-sectional associations of socio-economic status (i.e., income and education) with adherence to a Mediterranean dietary pattern and obesity prevalence.

Design: Cross-sectional study on a sample of Italian subjects enrolled in the Moli-sani Project, a population-based cohort study.

The Italian EPIC food frequency questionnaire was used to determine food intake. Adherence to Mediterranean diet (MD) was appraised according to both the Mediterranean score elaborated by Trichopoulou (MDS) and the novel Italian Mediterranean Index (IMI) and to the *a posteriori* scores derived from principal component analysis. Four income categories were identified.

Setting: Molise region, Italy

Participants: 13,262 subjects (mean age 53±11, 50% men) out of 24,318 citizens (age ≥35). randomly enrolled in the Moli-sani Project.

Main outcomes: Dietary patterns and risk factors for cardiovascular disease.

Results: Household higher income were significantly associated with greater adherence to MD ($p<.0001$) and to Olive oil and Vegetables dietary pattern in multivariable model including age, sex, daily energy intake, BMI, physical activity, smoking, alcohol consumption, education and marital status. The odds of having highest adherence to MD clearly increased according to income levels. People having the highest income had 54% (95% CI: 21% to 97%, MDS) or 72% (95% CI: 34% to 121%, IMI) higher probability to stick to a Mediterranean diet-like eating pattern than those in the lowest income group. Obesity prevalence was higher in the lowest-income group (36%) in comparison with the highest- income category (20%, $p <.0001$). Income was associated with dietary patterns in all categories of education.

Conclusions: Higher income and education are independently associated with greater adherence to Mediterranean diet-like eating patterns and lower prevalence of obesity**.**

INTRODUCTION

Mediterranean Diet (MD) has been shown to offer protection against cardiovascular disease, some types of cancer, and neurodegenerative diseases in observational epidemiological studies (1). The Lyon Diet Heart Study, by a randomised dietary intervention, also showed the health benefit of MD in secondary prevention (2,3). The main food components of the MD are vegetables, fruits, cereals, fish, olive oil as main fat source and moderate red wine consumption. Recently the UNESCO committee inscribed it on the list of Intangible Heritage (4).

Despite the widely proven benefits of the diet discovered by Ancel Keys (5) in the Fifties, the Southern European countries in which Mediterranean diet originated are rapidly withdrawing from this eating pattern orienting their food choices toward products typical of the Western diet (WD) which is rich in refined grains, saturated fats, sugars, red and processed meat (6). The reasons why people keep on drifting from one dietary regimen to another remain open to several hypotheses (7). Social changes appear to have contributed to radical reversal in dietary habits in Western and Southern Europe societies although developing countries are slightly turning into westernized diets as well (8).

The cost of MD seem to have led people to give up this eating pattern in favour of less expensive products which allow to save money but are definitively unhealthy (9).

Many studies suggest that diet quality follows a socio-economic gradient highlighting how disadvantaged people present higher rates of obesity, diabetes, cardiovascular disease and some types of cancer (10).

The abandon of MD is also considered as a possible cause of the increasing obesity pandemic (11). Several studies made a further step forward in order to see whether there is an association between diet cost and obesity, finding out that higher adherence to healthy dietary patterns is linked to higher monetary costs and is inversely associated with BMI and obesity (12).

The aim of the present study was to examine cross-sectional associations of socio-economic status (i.e., income and education) with adherence to a Mediterranean dietary pattern, with the perspective that encouraging people to adopt healthy eating behaviours would not be just a matter of good willing but mainly an issue to develop concrete measures of intervention in terms of economic availability. Moreover, our study investigated a potential relationship between low-income, Mediterranean diet and obesity.

MATERIAL AND METHODS

Study population

The Moli-sani Project is a population-based cohort study which randomly recruited 24,325 citizens of the Molise, a region placed between Central and Southern Italy. Between March 2005 and April 2010, the study enrolled men and women aged ≥35 years, randomly recruited from subjects included in the city-hall registries of Molise (13). Exclusion criteria were pregnancy, disturbances in understanding/ willing processes, ongoing poly-traumas or coma, refusal to sign the informed consent. The cohort will be followed-up for incident cardiovascular and tumor events.

After exclusion of subjects reporting personal history of cardiovascular disease (angina, myocardial infarction, heart failure, revascularization procedures and stroke) (5.7%), cancer (3.1%) or diabetes (6.0%) and of those for whom there were no information available on income (30.7%) mainly because they refused to answer or did not possess any reliable information on this issue, 13,262 subjects were analysed. The latter were comparable with the whole Moli-sani Project population in terms of Mediterranean dietary patterns and socio-economic features, whereas mean age of the sample was slightly lower (53.3 ± 11 vs 55.0 ± 12) and had a higher prevalence of men (50% vs 48%) compared with the whole population sample.

Dietary information

The validated Italian EPIC food frequency questionnaire was used to evaluate food intake (14, 15). The questionnaire, computerized with tailor-made software, allowed to interview participants in an interactive way, including illustrations of sample dishes of definite sizes or by reference to standard portion sizes. To simplify interpretation of data and to minimize within-person variations in intakes of individual foods, 188 food items were classified into 45 predefined food groups on the basis of similar nutrient characteristics or culinary usage (Appendix 2). (Web only file).

Moderate alcohol intake was defined as regularly drinking less than two or one drinks a day, by men and women, respectively.

Food consumption patterns were generated by using Principal Components Analysis (PCA) conducted on the correlation matrix of 45 food groups (16). Three main factors emerged, in agreement with previous findings in the same population (16). The first pattern, identified as ‘‘Olive Oil and Vegetables’’, was characterized by high positive loadings for olive oil, vegetables, legumes, soups, fruits and fish. The second pattern, named ‘‘Pasta and Meat’’, was characterized by high positive loadings for pasta, cooked tomatoes, red meat, animal fats and alcoholic beverages, and negative loadings of breakfast cereals and yogurt. The ‘‘Eggs and Sweets’’ pattern was characterized by high positive loadings for eggs, margarines, processed meat and sugar and sweets.

We evaluated the adherence to the Mediterranean diet by using the Mediterranean Diet Score (MDS) elaborated by Trichopoulou et al (17). Scoring was based on the intake of the following 9 items: vegetables, legumes, fruit and nuts, dairy products, cereals, meat and meat products, fish, alcohol, and the ratio of monounsaturated:saturated fat. For most items, consumption above the study median received 1 point; all other intakes received 0 points. For dairy products, meat and meat products, consumption below the median received 1 point. Medians are gender specific. For ethanol, men who consumed 10–50 gr/day and women who consumed 5–25 gr/day received 1 point; otherwise, the score was 0. The possible scores ranged between 0 and 9, the latter reflecting the maximal adherence.

We also used a new Italian Mediterranean Index (IMI) whose score is based on the intake of 11 items: high intake of 6 typical Mediterranean foods (pasta; typical Mediterranean vegetables such as raw tomatoes, leafy vegetables, onion, and garlic, salad, and fruiting vegetables; fruit; legumes; olive oil; and fish); low intake of 4 non-Mediterranean foods (soft drinks, butter, red meat, and potatoes); and alcohol consumption. If consumption of typical Mediterranean foods was in the 3rd tertile of the distribution, the person received 1 point; all other intakes received 0 points. If consumption of non-Mediterranean foods was in the first tertile of the distribution, the person received 1 point. Ethanol received 1 point for intake up to 12 gr/day; abstainers and persons who consumed >12 gr/day received 0 points. Possible scores ranged from 0 to 11(18). Such Italian Index was conceived to better capture healthy eating including foods, such as pasta, more typically available in Italy.

Data collection

Body Mass Index (BMI) was calculated as kg/m^2. Waist circumferences were measured according to the NIH, Heart, Lung, and Blood guidelines (19). Blood pressure was measured by an automatic device (OMRON-HEM-705CP) three times on the non-dominant arm, with the patient lying down for about 5 minutes. Hypertension was defined as systolic BP≥160 mm Hg and/or diastolic BP≥95 mm Hg, or using pharmacological treatment. Physical activity was assessed by a structured questionnaire (24 questions on working and leisure time and sport participation) and expressed as daily energy expenditure in metabolic equivalent task-hours (MET/d).

Serum lipids and glucose were assayed by enzymatic reaction methods using an automatic analyzer (ILab 350, Instrumentation Laboratory (IL), Milan, Italy). LDL-cholesterol was calculated according to Friedewald. High sensitivity C reactive protein (CRP) was measured in fresh serum, by a latex particle-enhanced immunoturbidimetric assay (IL Coagulation Systems on ACL9000). Inter- and intra-day CV were 5.5% and 4.17%, respectively.

Socio-economic variables

Household net income categories were considered as low (<10,000 euro/ year), low-medium (>10,000 <25,000 euro/year), medium – high (>25,000< 40,000 euro/year), high (>40,000 euro/year).

Education level was divided into three categories: ≤8 (low) , >8 and ≤13(medium) and >13 (high) years of studies.

Socio-economic status (SES) was expressed as a score based on 5 variables: dwelling ownership and ratio between the number of living-in family members and number of rooms (People Room Density), both currently and at childhood - and availability of hot water at home at childhood. The five components were dichotomized according to the median value, and a score of one was attributed to the category supposed to be marker of higher social status in comparison with the opposite category: thus we assigned a score of 1 to people living in a house with living-in family members/room density > 0.6 or dwelling ownership or with availability of hot water and a score 0 to people with living-in family members/room density≤0.6, no dwelling ownership or with unavailability of hot water. The SES score did not include income and education. Marital status was considered as married or live-in partner *vs* others (divorced, unmarried, widower).

Statistical analysis

Values for continuous variables are means ± Standard Deviation. CRP was transformed into natural logarithm to reduce positive skewness, but data were reported untransformed for clarity. Analysis of variance for continuous or categorical variables was applied to test the associations in Table 1. Multivariable analysis of variance with appropriate terms for interaction was used for testing the association of adherence to MD scores, dietary patterns or dietary variables (considered as the

dependent variables) with categories of income or SES components. By using multivariable logistic regression analysis (with appropriate terms for interaction), odds ratio (ORs) with corresponding 95% confidence intervals (95% CI) were calculated to quantify the association of income or education levels with adherence to MD-like eating scores or obesity. High adherence to MD, as stated by the Medscore, was defined when the score was ≥6 points whereas a low adherence when the score was ≤3 points. Subjects with intermediate values (4 or 5 points) were excluded from this analysis in order to focus on the two extreme categories of adherence. The same was done for the IMI score, but the cut-off was ≥5 for the higher adherence or ≤3 for the lower adherence category. The data analysis was generated using SAS/STAT software, Version 9.1.3 of the SAS System for Windows©2009. SAS Institute Inc. and SAS are registered trademarks of SAS Institute Inc., Cary, NC, USA.

RESULTS

Income groups

Table 1 shows the characteristics of the whole population by income categories. People in the uppermost income group were 53.5% men and showed a better health profile, having significantly lower values of BMI, systolic blood pressure, C-reactive protein, triglycerides and blood glucose. Obesity prevalence (BMI > 30 Kg/m^2) differed according to income; it was higher in the lowest-income group (36%) and lower in the highest- income category (20%, p <.0001 Tab. 1).

In Table 2 the association among income levels, dietary habits and single food groups are reported. Higher income groups were significantly associated with greater adherence to both score indexes, namely MDS (p<.0001) and IMI (p<.0001) in the model adjusted for age, sex, daily energy intake, BMI, physical activity, smoking, alcohol consumption and marital status.

Similar data were obtained after stratification by gender (p for interaction=0.24 for MDS and p for interaction =0.41 for IMI) and age (p for interaction=0.43 for IMI). However, the increasing

adherence to MD according to income was more pronounced in the elderly when it was measured as MSD (p for interaction=0.0002 ; β = 0.063, SE±0.021, p=0.0028 for people ≤ 65 years and β = 0.17, SE±0.051, p =0.0008, for people > 65 years).

Subjects in the lower income categories showed poor adherence to the Olive oil and Vegetables dietary pattern (p<.0001) whereas a greater adherence to the Western type pattern (Dietary pattern 3) was observed. Similar results were observed after stratification for gender and age (data not shown).

In addition, analysis of single foods consumption by income categories showed that people with the higher income reported higher intake of the basic components of the MD, that is fish, fruits, legumes and reduced consumption of animal fats, processed meat and white meat whose frequent consumption is more typical of a Western dietary model.

The odds of having highest adherence to the MD, that raised with both MDS and IMI scores, clearly increased according to income levels (Tab. 3). People having the highest income had 54% (MDS) or 72% (IMI) statistically significant higher probability to stick to a MD-like eating pattern than those in the lowest income group (Tab. 3).

Regarding alcohol consumption (Tab.2), the highest income group appeared to include the highest prevalence of moderate drinkers (41.7% versus 27.5% recorded in the lowest income group) as already found on a sample of Danish population (17).

Socio-economic status and education

Income fairly correlated with SES (Spearman correlation coefficients = 0.24, p< 0.0001) and education (r=0.51, p<0.0001) whereas correlation between SES and education was r=0.34, p<0.0001.

Education was positively associated with adherence to MD, measured by both MDS (p=0.034) and IMI (p=0.0014), while SES was not (p=0.19 for MDS and p=0.78 for IMI) in the fully adjusted model also including education and income.

Odds of having higher adherence according to education levels were 1.26 and 1.27 (p for trend=0.0020) for MDS and 1.16 and 1.33 (p for trend=0.0009) for IMI (Tab.4).

Stratification by education

As less educated people may show lower adherence because of lack of knowledge about healthy habits (21), we performed additional analyses stratified for educational level.

Either in lower (< = 8), medium (>8 and ≤13) and higher (>13 years of studies) educated groups adherence to Mediterranean diet followed the gradient of income categories (Tab. 4), with the exception of the uppermost educated group, when the MDS score was used (p=0,067). However the interaction test was not significant for either score. Accordingly, education was related to dietary pattern independently from income. Indeed, by dividing income levels into two main categories (low and low-medium VS high and high-medium), in the fully adjusted model, education was positively associated with dietary patterns both in the lowest (MDS: p=0.032 and IMI: p=0.0025) and in the highest income group (MDS: p=0.0067 and IMI: p=0.0010).

Income/education, Mediterranean diet and obesity

Finally, we evaluated the association of income and education on diet quality and then on obesity in a unique statistical model. Odds ratio of having obesity decreased according to income (OR=0.72, 95%CI: 0.59 to 0.86 for highest versus lowest income group) and education level (OR=0.53, 95%CI: 0.45 to 0.61 for highest versus lowest education level). These odds ratios remained unchanged when in the model diet quality (measured as Mediterranean scores) was included.

Moreover, the association between income or education with obesity was equally observed in both

highest and lowest MD adherence categories as defined in Table 3 (the four terms for interactions among income or education with MDS or IMI were all p>0.35).

DISCUSSION

People with higher income and higher levels of education had a greater adherence to MD-like eating patterns, as measured by three different parameters: two *a priori* Mediterranean scores (the traditional one introduced by Trichopoulou and a more recent Italian Mediterranean index), and the *a posteriori* dietary patterns derived from principal components analysis. Evidence on the health benefits of the MD is based on several studies and meta-analyses (1,7,21). However, adherence to this healthy eating pattern is rapidly disappearing in the countries of Southern Europe where it originated and persisted during centuries, including the areas of Northern Africa in which there is an increasing prevalence of metabolic disorders and consequent cardiovascular disease mainly due to the changing in lifestyle habits (22). Socio-economic status has been included among the factors related to chronic disease onset, and disparities in dietary habits by social class have been advocated to explain at least in part the higher CVD risk factors profile observed among low SES groups (23). Our results agree with the conclusions reported in the review by Darmon et al. (10) that higher-quality diets are mainly consumed by better educated and more affluent people while lower socio-economic groups tend to have lower quality diets thus exposing themselves to a higher risk to develop diet-related diseases. Similar conclusions were reached by other investigations too (24) suggesting that low socio-economic groups end with having poorer diets. These findings are supported, at least in part, by the fact that following a Mediterranean dietary style could represent a matter of money (9). Indeed researchers in Spain showed that MD is definitely more expensive to follow than Western dietary patterns: this may represent a strong economic obstacle when counselling people about the opportunity to follow a healthy diet because cost may become a prohibitive factor (9). Aggrawal et al. (25) demonstrated that the well-known socio-economic

disparities in diet quality is mediated by food cost confirming that lower SES groups tend to consume more energy dense and nutrient poor diets. However, the economic advantages of a Mediterranean way of eating in terms of cost-effectiveness should be highlighted as shown in patients with previous CVD, that could represent an exceptional return on investment (26).

Subjects with lower income had a greater prevalence of obesity too. The association between obesity and socioeconomic factors has been previously observed (27) suggesting that the latter play an important role in the risk of obesity and overweight not only in adults but also in children (28). However our data show that the strong association observed between lower income or education with obesity was not mediated by diet quality. Indeed, an additional analysis combining the impacts of education or income on diet quality and then on obesity in a unique statistical model, showed that the association remained unchanged when diet quality was included. According to these results, the changes in obesity rates observed in the different income and education categories appear not necessarily mediated by diet quality. However, the epidemiological evidence supporting a causal link between Mediterranean diets and body weight is contrasting (29).

It is quite clear that accumulating proofs on the benefits of Mediterranean- like diets is an insufficient prevention strategy as conditions allowing people to stick to healthier dietary habits should also be clearly identified.

This study contributes to provide further evidence to the assumption that dietary habits are strongly influenced by socio-economic factors, in particular by income which appears to play an important role in determining people's eating choices (30). As far as education is concerned, previous studies found a relationship between higher levels of education and healthy diets (31). In our research, education resulted to be independently associated to MD and did not modify the association between income levels and healthy dietary pattern as shown in the stratified analysis by education levels.

The promotion of healthy lifestyles and diets to prevent weight gain and related diseases has jumped to the top of the priority list of the public health experts all over the world since obesity has become a threatening epidemic. So far the traditional MD has proven to be an effective "remedy" to the spreading of the major chronic disease, obesity and mortality. Our study highlights the strong linkage among low income, poor adherence to MD and obesity prevalence.

Limitations of this study

A major limitation of the present study is that people self-reported their own income which is a quite sensitive issue. Indeed we recorded a high percentage (30.7%) of non-respondent subjects who refused to declare or did not know their family income. Yet such large non-respondent group is very common in this type of investigation, especially among women and elderly (32) However, there was no difference between the whole Moli-sani population and the subsample analyzed here as far as dietary habits and socio-economic variables were concerned.

Another inherent limit is represented by the cross-sectional nature of our study.

In addition, caution is needed in extending the results presented here to larger contexts since data were collected in a region located between Central and Southern Italy, Mediterranean by tradition and culture (13). Yet, the main characteristics of our population sample are comparable to those of the Italian Cardiovascular Epidemiological Observatory (33), a large survey including random samples of the general population recruited all over Italy; therefore our sample can be considered representative at least of the whole Italian population.

Strengths of this study

Our very large population sample is made of subjects coming from a quite homogenous environment with no marked differences in terms of socioeconomic disparities, differently from metropolitan areas, where previous studies found huge gaps among social classes and related health

status at relatively small distances from the city centre (34). Bearing this in mind, the differences we observed in the adherence to Mediterranean diet according to income indicate that also in a environment homogeneous both for genetic and lifestyles, income and education can still play a role in influencing dietary choices. Furthermore, diet quality showed a continued improvement across a relatively small range of economic strata. Our "poorest" are represented by people earning less than 10,000 euro/net per year whilst the "richest" group is made of subjects with more than 40,000 euro/net per year. Such differences among income classes are quite restrained and recall what already said for the pretty homogeneous environment where our sample comes from. We are not dealing with real huge socioeconomic and income differences. Despite this homogeneity, we did observe notable changes in diet quality among different groups.

The differences observed across the income strata would likely become even more evident in MD importing countries where getting typical Mediterranean products is more difficult and expensive.

In addition, apparently for the first time this topic was addressed by using two *a priori* Mediterranean scores (the traditional one introduced by Trichopoulou and a novel Italian Mediterranean index), and the *a posteriori* dietary patterns derived from principal components analysis. This leads to overcome the limitations each of these approaches may present. Indeed, the "a priori" scores only reflect some aspects of diet and do not account for correlations between score components. Instead, the "a posteriori" approaches have the weakness of low reproducibility, different populations having different non-predefined dietary patterns. Therefore, the use of an index based on the foods actually available to Italians and traditional Italian cooking styles should improve the ability of the index to classify the Italian cohort.

CONCLUSIONS

Our data suggest consistent associations of income and education with dietary patterns and may foster discussion on healthy food accessibility in terms of economic costs. The cost of MD seem to represent a real obstacle to healthy diet driving people to choose alternative ways of eating usually inspired by the need to save money in everyday life. Public health policies shall take into account the fact that correct dietary habits need to be promoted by allowing people to choose the best for their own health. It is definitely an interdisciplinary issue which shall call to action every single actor of modern societies otherwise condemned to increase their already heavy burden of chronic diseases. As already noted by others who dealt with this topic (10), the promotion of high-cost foods to low-income people without taking food costs into account is not likely to be successful.

Table 1 Characteristics of the whole population as a whole and according to four income categories

		Income Categories				
	All (n=13,262)	**< 10,000 (n = 980, 7.4%)**	**> 10,000 < 25,000 (n = 5,751, 43.4%)**	**> 25,000 < 40,000 (n= 4,120, 31.1%)**	**> 40,000 (n = 2,411, 18.2%)**	**P value***
Age (years)	53.3 (10.6)	60.1 (12.7)	54.0 (11.2)	51.4 (9.5)	52.3 (8.8)	<.0001
Sex (males, n, %)	6,590 (49.7%)	348 (35.5%)	2,834 (49.3%)	2,117 (51.4%)	1,291 (53.5%)	<.0001
BMI (kg/m^2)	27.7 (4.6)	28.7 (5.3)	28.2 (4.7)	27.3 (4.3)	27.0 (4.0)	<.0001
WH-ratio	0.91 (0.07)	0.92 (0.079)	0.91 (0.075)	0.91 (0.075)	0.91 (0.074)	0.019
Systolic blood pressure (mmHg)	139.0 (20.1)	143.4 (21.0)	140.1 (20.4)	137.3 (19.6)	137.4 (19.2)	0.0053
Diastolic blood pressure (mmHg)	82.7 (9.6)	81.7 (9.7)	82.8 (9.4)	82.7 (9.7)	82.8 (10.0)	0.0038
Total physical activity (MET-h /day)	43.4 (8.7)	44.8 (10.4)	45.0 (9.7)	42.5 (7.9)	40.4 (5.2)	<.0001
Leisure time PA (MET-h /day)	2.18 (1.88)	1.81 (1.67)	2.10 (1.78)	2.22 (1.96)	2.28 (1.94)	0.20
Working PA (MET-h /day)	14.6 (12.2)	22.4 (19.1)	18.8 (14.3)	12.7 (10.4)	10.2 (6.4)	<.0001
Smokers n, %						
Never	6,370 (48.1%)	558 (56.9%)	2,838 (49.4%)	1,901 (46.2%)	1,073 (44.5%)	<.0001
Current	3,296 (25.0%)	222 (22.6%)	1,418 (24.7%)	1,060 (25.8%)	596 (24.7%)	
Former	3,585 (27.5%)	200 (20.4%)	1,490 (25.9%)	1,154 (28.0%)	741 (30.7%)	
Total cholesterol (mg/dL)	212.3 (40.2)	214.3 (41.9)	212.8 (40.4)	211.8 (40.4)	211.0 (38.7)	0.64
HDL (mg/dL)	57.0 (14.5)	58.4 (14.4)	57.2 (14.4)	56.6 (14.5)	56.8 (14.6)	0.35
LDL (mg/dL)	130.3 (33.6)	130.8 (35.7)	130.3 (33.8)	130.2 (33.6)	130.1 (32.7)	0.65
CRP (mg/dL)	2.4 (3.0)	3.0 (3.7)	2.6 (3.1)	2.2 (2.9)	2.1 (2.7)	<.0001
Triglycerides (mg/dL)	127.0 (83.8)	129.1 (87.0)	129.1 (84.5)	126.1 (85.0)	122.6 (78.4)	0.0002
Blood glucose (mg/dL)	96.8 (17.0)	97.7 (20.4)	97.2 (16.8)	96.4 (16.5)	96.4 (16.4)	0.17
Obesity (n, %)	3,563 (26.9%)	352 (36.0%)	1,733 (30.1%)	988 (24.0%)	490 (20.3%)	<.0001
Hypertension (n, %)	4,469 (33.7%)	452 (46.2%)	2,006 (34.9%)	1,259 (30.6%)	752 (31.2%)	0.79

* P value adjusted for sex, age, energy intake and marital status

Table 2 Mediterranean diet adherence and dietary consumption as a whole and according to four income categories

		Income categories				
	All (n=13,262)	**< 10,000 (n = 980, 7.4%)**	**> 10,000 < 25,000 (n = 5,751, 43.4%)**	**> 25,000 < 40,000 (n= 4,120, 31.1%)**	**> 40,000 (n = 2,411, 18.2%)**	**P value ***
Mediterranean score (MDS)	4.44 (1.64)	4.32 (1.61)	4.40 (1.62)	4.46 (1.62)	4.53 (1.70)	<.0001
Italian Mediterranean index (IMI)	3.26 (1.71)	3.20 (1.64)	3.15 (1.68)	3.30 (1.71)	3.49 (1.79)	<.0001
Dietary Pattern 1 (Olive Oil and Vegetables)	0.042 (0.95)	-0.066 (0.92)	0.021 (0.94)	0.070 (0.95)	0.091 (0.97)	<.0001
Dietary Pattern 2 (Pasta and Meat)	0.036 (0.95)	0.0078 (0.91)	0.093 (0.95)	0.0053 (0.95)	- 0.036 (0.97)	<.0001
Dietary Pattern 3 (Eggs and sweets)	0.015 (0.85)	-0.13 (0.88)	0.040 (0.86)	0.044 (0.85)	-0.033 (0.82)	<.0001
Energy intake (kcal/day)	2177.4 (640.7)	2,062.5 (704.1)	2,186.3 (649.0)	2,190.6 (627.8)	2,180.4 (610.7)	0.58
Alcohol intake (gr/day)	16.5 (22.4)	16.1 (25.8)	18.2 (24.5)	15.3 (20.3)	14.9 (18.6)	<.0001
Moderate drinkers (n, %)	4,303 (33.3%)	261 (27.5%)	1,646 (29.2%)	1,419 (35.3%)	977 (41.7%)	<.0001
Wine consumption (ml/day)	135.5 (188.7)	133.3 (209.6)	148.9 (203.7)	125.5 (175.4)	121.8 (160.4)	<.0001
Olive oil (gr/day)	24.2 (9.2)	22.9 (9.0)	24.4 (9.3)	24.4 (9.2)	24.0 (9.1)	0.0034
Animal fat (gr/day)	1.26 (1.41)	1.21 (1.37)	1.34 (1.45)	1.25 (1.41)	1.11 (1.31)	<.0001
Fish (gr/day)	20.9 (17.0)	17.5 (15.5)	19.4 (16.3)	22.1 (17.4)	23.9 (18.0)	<.0001
Processed meat (gr/day)	30.4 (20.9)	27.4 (20.0)	31.5 (21.8)	30.7 (20.5)	28.6 (19.9)	<.0001
Cooked vegetables (gr/day)	73.5 (43.4)	71.2 (42.8)	74.8 (44.0)	74.0 (42.5)	70.6 (43.4)	0.0006
Legumes (gr/day)	28.3 (22.1)	27.1 (20.3)	27.1 (21.6)	28.4 (21.9)	31.3 (24.2)	<.0001
Nuts and seeds (gr/day)	0.89 (2.3)	0.90 (3.2)	0.87 (2.3)	0.88 (2.1)	0.94 (2.2)	0.34
Red meat (gr/day)	47.8 (26.0)	44.7 (26.3)	48.8 (25.9)	47.9 (25.8)	46.8 (26.3)	0.0008
White meat (gr/day)	26.4 (18.8)	29.6 (19.8)	28.1 (19.3)	25.3 (17.8)	23.2 (18.1)	<.0001
Fruits (gr/day)	358.5 (204.3)	362.7 (211.1)	354.9 (201.2)	355.7 (198.9)	370.3 (217.0)	0.015
Crustaceans, molluscs, seafood (gr/day)	11.0 (10.1)	8.9 (8.8)	10.7 (9.9)	11.7 (10.7)	11.5 (10.0)	<.0001
Vegetable oils (no olive; gr/day)	0.28 (0.81)	0.33 (1.23)	0.29 (0.79)	0.28 (0.69)	0.27 (0.84)	0.18
Refined grains (pasta and bread; (gr/day)	198.3 (101.9)	193.5 (104.5)	201.3 (103.3)	196.3 (99.2)	196.8 (101.9)	0.0004
Sugar (gr/day)	11.0 (10.4)	10.3 (9.7)	11.2 (10.9)	11.1 (10.3)	10.4 (9.8)	<.0001

*P value adjusted for sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption, marital status

Table 3 Odds ratios of having high adherence to Mediterranean diet according to income, education and socioeconomic status

	Mediterranean score				Italian Mediterranean Index			
Income	**Low (n=3,843)**	**High (n=3,518)**	**OR**	**(95% CI)**	**Low (n=4704)**	**High (n=3089)**	**OR**	**(95% CI)**
< 10,000	310 (8.1%)	231 (6.6%)	-1-	(referent)	353 (7.5%)	209 (6.8%)	-1-	(referent)
> 10,000 < 25,000	1,694 (44.1%)	1,470 (41.8%)	1.28	(1.04-1.57)	2,161 (45.9%)	1,201 (38.9%)	1.07	(0.87-1.32)
> 25,000 < 40,000	1,153 (30.0%)	1,116 (31.7%)	1.51	(1.21-1.88)	1,436 (30.5%)	995 (32.2%)	1.34	(1.07-1.69)
> 40,000	686 (17.9%)	701 (19.9%)	1.54	(1.21-1.97)	754 (16.0%)	684 (22.1%)	1.72	(1.34-2.21)
			(p for trend=0.0002)				(p for trend<.0001)	
Education level								
Low	1,775 (46.2%)	1,571 (44.7%)	-1-	(referent)	2,250 (47.8%)	1,307 (42.3%)	-1-	(referent)
Medium	1,504 (39.1%)	1,421 (40.4%)	1.26	(1.11-1.43)	1,860 (39.6%)	1,283 (41.5%)	1.16	(1.02-1.31)
High	564 (14.7%)	525 (14.9)	1.27	(1.06-1.52)	592 (12.6%)	499 (16.1%)	1.33	(1.11-1.60)
			(p for trend=0.0020)				**(p for trend=0.0009)**	
Socioeconomic status								
Low	1,097 (29.1%)	1,097 (32.2%)	-1-	(referent)	1,462 (32.2%)	927 (30.9%)	-1-	(referent)
Medium	1,155 (31.1%)	1,095 (32.1%)	0.94	(0.83-1.07)	1,414 (31.1%)	930 (31.0%)	1.00	(0.88-1.14)
High	1,475 (39.8%)	1,218 (35.7%)	0.88	(0.77-1.00)	1,664 (36.7%)	1,144 (38.1%)	0.98	(0.86-1.12)
			(p for trend=0.054)				(p for trend =0.82)	

The logistic model included income, education, socioeconomic status and sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption, marital status

Table 4 Mediterranean diet adherence according to four income levels and stratified by education

	Income Categories				
	< 10,000	**> 10,000 < 25,000**	**> 25,000 < 40,000**	**> 40,000**	
Lower Education (n = 6,101, 46.0%)	**(n=829)**	**(n=3,745)**	**(n=1,260)**	**(n=267)**	**P value ***
Mediterranean Diet	4.33 (1.60)	4.43 (1.63)	4.44 (1.60)	4.59 (1.64)	0.040
Italian Mediterranean Index	3.19 (1.61)	3.13 (1.67)	3.22 (1.69)	3.54 (1.73)	0.0002
Medium Education (n = 5,236, 39.5%)	**(n=137)**	**(n=1,746)**	**(n=2,184)**	**(n=1,169)**	
Mediterranean Diet	4.16 (1.64)	4.33 (1.60)	4.50 (1.63)	4.54 (1.67)	0.0041
Italian Mediterranean Index	3.21 (1.67)	3.14 (1.69)	3.33 (1.73)	3.43 (1.81)	<.0001
Higher Education (n = 1,922, 14.5%)	**(n=13)**	**(n=258)**	**(n=676)**	**(n=975)**	
Mediterranean Diet	5.61 (1.85)	4.43 (1.61)	4.38 (1.60)	4.50 (1.76)	0.067
Italian Mediterranean Index	3.77 (2.68)	3.43 (1.63)	3.33 (1.70)	3.56 (1.77)	0.041

*P value adjusted for sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption, marital status

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All Authors are independent from funders.

COMPETING INTEREST

None

ETHICAL ISSUES: The Moli-sani study was approved by the Ethics Committee of the Catholic University of Rome. Participants signed the informed consent before taking part in the study.

DATA SHARING: no additional data available.

APPENDIX 1

Moli-sani project Investigators

Steering Committee: Licia Iacoviello , Chairperson, Maria Benedetta Donati and Giovanni de Gaetano (Campobasso,Italy), Simona Giampaoli (Roma, Italy)

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Event adjudicating Committee: Deodato Assanelli (Brescia, Italy), Francesco Alessandrini, Vincenzo Centritto and Sergio Storti (Campobasso, Italy)), Paola Muti (Roma, Italy), Holger Schünemann (Hamilton, Ontario, Canada), Pasquale Spagnuolo and Dante Staniscia (Termoli, Italy),

Scientific and organizing secretariat: Francesco Zito (Coordinator, Campobasso and Termoli, Italy), Americo Bonanni , Chiara Cerletti, Amalia De Curtis, Augusto Di Castelnuovo, Licia Iacoviello, Roberto Lorenzet, Antonio Mascioli, Marco Olivieri and Domenico Rotilio (Campobasso, Italy).

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Call Center: Giovanna Galuppo (till June 2009), Maura Di Lillo (till March 2009), Concetta Castaldi (till September 2008), Dolores D'Angelo (till May 2008) and Rosanna Ramacciato (till May 2008) (Campobasso, Italy)**:**

APPENDIX 2 Food grouping used in the dietary pattern analyses

Foods or food groups	Food items
Potatoes	Potatoes
Cooked vegetables	Leafy vegetables, root vegetables, cabbages, onion, carrots, mushrooms, egg plants, artichokes, sweet peppers, spinach, pumpkins, canned vegetables in oil, picked vegetables
Raw vegetables	Raw leafy vegetables, raw tomatoes
Tomatoes (cooked)	Tomato sauces, tomatoes
Legumes	Beans, lentils, peas, chick peas
Fruit	Apples, pears, kiwi, bananas, grapes, peaches, apricots, oranges, tangerines, plums, strawberries, melon, khaki, figs, cherries
Nuts and dried fruit	Peanuts, almonds, hazelnuts, walnuts, dried figs, dried dates, prune
Olives	Olives
Milk	Milk
Yogurt	Yogurt
Fresh cheese	Mozzarella, ricotta cheese, taleggio cheese, gorgonzola cheese, melted cheese slices, other soft cream cheese
Seasoned cheese	Fontina cheese, emmenthal, gruyere, parmesan, caciocavallo cheese, other seasoned cheese
Pasta and other grains	Pasta, yellow maize meal
Rice	Rice
Bread	White bread, bread with oil and other bread
Crisp bread, rusks	Breads sticks, crisp bread
Breakfast cereals	Breakfast cereals
Salty biscuits	Crackers
Red meat	Beef, pork, lamb, horse, game, veal, other meats
White meat	Chicken, turkey, rabbit
Processed meat	Sausages, ham, bologna sausage, dried beef, salami

Offals	Liver, offals
Canned fish	Canned tuna fish and other fish
Crustaceans, molluscs	Crustaceans, molluscs
Fish	Other fish
Egg	Eggs
Vegetables oils	Seed oils (except olive oils)
Olive oil	Olive oil
Butter	Butter
Margarines	Margarines
Animal fats	Visible fat from meat, poultry skin, fat from ham
Sugar & sweets	Sugar, honey, cakes, ice cream, confections, pastry, pudding
Fruit juices	Orange juice, grapefruit juices, other fruit juices
Soft drinks	Soft drinks
Coffee	Coffee
Tea	Tea
Other sauces	Dressing sauces for pasta other than tomato sauce
Mayonnaises	Mayonnaises
Soups	Vegetable soups
Bouillon	Meat and stock-cube broth
Snacks	Vegetable quiche
Pizza	Pizza
Wine	Red wine, rosé wine, white wine
Spirits	Alcoholic beverages other than wine or beer
Beer	Beer

STROBE Statement—Checklist of items that should be included in reports of ***cross-sectional studies***

	Item No	Recommendation
Title and abstract **Yes**	1	(*a*) Indicate the study's design with a commonly used term in the title or the abstract
		(*b*) Provide in the abstract an informative and balanced summary of what was done and what was found
Introduction		
Background/rationale **Yes**	2	Explain the scientific background and rationale for the investigation being reported
Objectives **Yes**	3	State specific objectives, including any prespecified hypotheses
Methods		
Study design **Yes**	4	Present key elements of study design early in the paper
Setting **Ref 13 and 16**	5	Describe the setting, locations, and relevant dates, including periods of recruitment, exposure, follow-up, and data collection
Participants **Yes**	6	(*a*) Give the eligibility criteria, and the sources and methods of selection of participants
Variables **Yes**	7	Clearly define all outcomes, exposures, predictors, potential confounders, and effect modifiers. Give diagnostic criteria, if applicable
Data sources/ measurement **Yes**	8*	For each variable of interest, give sources of data and details of methods of assessment (measurement). Describe comparability of assessment methods if there is more than one group
Bias **Yes**	9	Describe any efforts to address potential sources of bias
Study size **Ref 13**	10	Explain how the study size was arrived at
Quantitative variables **Yes**	11	Explain how quantitative variables were handled in the analyses. If applicable, describe which groupings were chosen and why
Statistical methods **Yes**	12	(*a*) Describe all statistical methods, including those used to control for confounding
		(*b*) Describe any methods used to examine subgroups and interactions
		(*c*) Explain how missing data were addressed
		(*d*) If applicable, describe analytical methods taking account of sampling strategy
		(*e*) Describe any sensitivity analyses
Results		
Participants **Yes**	13*	(a) Report numbers of individuals at each stage of study—eg numbers potentially eligible, examined for eligibility, confirmed eligible, included in the study, completing follow-up, and analysed
		(b) Give reasons for non-participation at each stage
		(c) Consider use of a flow diagram
Descriptive data **Yes**	14*	(a) Give characteristics of study participants (eg demographic, clinical, social) and information on exposures and potential confounders
		(b) Indicate number of participants with missing data for each variable of interest
Outcome data **Not applicable**	15*	Report numbers of outcome events or summary measures
Main results **Yes**	16	(*a*) Give unadjusted estimates and, if applicable, confounder-adjusted estimates and their precision (eg, 95% confidence interval). Make clear which confounders were

		adjusted for and why they were included
		(*b*) Report category boundaries when continuous variables were categorized
		(*c*) If relevant, consider translating estimates of relative risk into absolute risk for a meaningful time period
Other analyses **Yes**	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Discussion		
Key results **Yes**	18	Summarise key results with reference to study objectives
Limitations **Yes**	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Interpretation **Yes**	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Generalisability **Yes**	21	Discuss the generalisability (external validity) of the study results
Other information		
Funding **Yes**	22	Give the source of funding and the role of the funders for the present study and, if applicable, for the original study on which the present article is based

*Give information separately for exposed and unexposed groups.

Note: An Explanation and Elaboration article discusses each checklist item and gives methodological background and published examples of transparent reporting. The STROBE checklist is best used in conjunction with this article (freely available on the Web sites of PLoS Medicine at http://www.plosmedicine.org/, Annals of Internal Medicine at http://www.annals.org/, and Epidemiology at http://www.epidem.com/). Information on the STROBE Initiative is available at www.strobe-statement.org.

Low income is associated with poor adherence to Mediterranean Diet and higher prevalence of obesity: cross-sectional results from the Moli-sani study

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Keywords: Obesity; Diet, Mediterranean; Social Class; Public Health; Cardiovascular Diseases

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ABSTRACT

Objectives: ~~To assess differences in eating patterns among adult Italians with different socio-economic status, with particular focus on income.~~ To examine cross-sectional associations of socio-economic status (i.e., income and education) with adherence to a Mediterranean dietary pattern and obesity prevalence.

Design: Cross-sectional study on a sample of Italian subjects enrolled in the Moli-sani Project, a population-based cohort study.

The Italian EPIC food frequency questionnaire was used to determine food intake. Adherence to Mediterranean diet (MD) was appraised according to both the Mediterranean score elaborated by Trichopoulou (MDS) and the novel Italian Mediterranean Index (IMI) and to the *a posteriori* scores derived from principal component analysis. Four income categories were identified.

Setting: Molise region, Italy

Participants: 13,262 subjects (mean age 53±11, 50% men) out of 24,318 citizens (age ≥35). randomly enrolled in the Moli-sani Project.

Main outcomes: Dietary patterns and risk factors for cardiovascular disease.

Results: Household higher income ~~groups~~ were significantly associated with greater adherence to MD (p<.0001) and to Olive oil and Vegetables dietary pattern in multivariable model including age, sex, daily energy intake, BMI, physical activity, smoking, alcohol consumption, education and marital status. The odds of having highest adherence to MD clearly increased according to income levels. People having the highest income had 5~~4~~6% (95% CI: 2~~1~~4% to 9~~7~~6%, MDS) or ~~68~~72% (95% CI: 3~~4~~3% to ~~112~~121%, IMI) higher probability to stick to a Mediterranean diet-like eating pattern than those in the lowest income group. Obesity prevalence was higher in the lowest-income group (36%) in comparison with the highest- income category (20%, p <.0001). Income was associated with dietary patterns in all categories of education.

~~Similar results were found for high educated group.~~

Conclusions: Higher income and education are independently associated with greater adherence to Mediterranean diet-like eating patterns and lower prevalence of obesity**.** ~~The increasing prices of the basic Mediterranean food items seem to represent a real obstacle to healthy diet driving people to choose alternative ways of eating usually inspired by the need to save money in everyday life.~~

INTRODUCTION

Mediterranean Diet (MD) has been shown to offer protection against cardiovascular disease~~-~~, some types of cancer, and neurodegenerative diseases in observational epidemiological studies (1). The Lyon Diet Heart Study, by a randomised dietary intervention, also showed the health benefit of MD ~~editerranean~~ in secondary prevention (2,3). ~~Rand recently the UNESCO committee inscribed it on the list of Intangible Heritage (54).~~ The main food components of the MD are vegetables, fruits, cereals, fish, olive oil as main fat source and moderate red wine consumption. Recently the UNESCO committee inscribed it on the list of Intangible Heritage (4).

Despite the widely proven benefits of the diet discovered by Ancel Keys (5) in the Fifties, the Southern European countries in which Mediterranean diet originated are rapidly withdrawing from this eating pattern orienting their food choices toward products typical of the Western diet (WD) which is rich in refined grains, saturated fats, sugars, red and processed meat (6). The reasons why people keep on drifting from one dietary regimen to another remain open to several hypotheses (7). Social changes appear to have contributed to radical reversal in dietary habits in Western and Southern Europe societies although developing countries are slightly turning into westernized diets as well (8~~5~~).

~~Increasing prices~~~~Prices of many of the basic food items~~The cost of MD seem to have led people to give up this eating pattern in favour of less expensive products which allow to save money but are definitively unhealthy (9).

Many studies suggest that diet quality follows a socio-economic gradient highlighting how disadvantaged people present higher rates of obesity, diabetes, cardiovascular disease and some types of cancer (10).

The abandon of MD is also considered as a possible cause of the increasing obesity pandemic (11).

Several studies made a further step forward in order to see whether there is an association between

diet cost and obesity, finding out that higher adherence to healthy dietary patterns is linked to higher monetary costs and is inversely associated with BMI and obesity (12).

The aim of the present study was to ~~assess~~ examine cross-sectional associations of socio-economic status (i.e., income and education) with adherence to a Mediterranean dietary pattern~~possible differences in eating patterns among adult Italians with different socio-economic status, with particular focus on low-income~~, with the perspective that ~~in order to reinforce the assumption that~~ encouraging people to adopt healthy eating behaviours would not be just a matter of good willing but mainly an issue to develop ~~which should lead to~~ concrete measures of intervention in terms of economic availability. Moreover, ~~Our~~ our study ~~aimed also at evaluating~~investigated a potential relationship between low-income, Mediterranean diet and obesity.

MATERIAL AND METHODS

Study population

The Moli-sani Project is a population-based cohort study which randomly recruited 24,325 citizens of the Molise, a region placed between Central and Southern Italy. Between March 2005 and April 2010, the study enrolled men and women aged ≥35 years, randomly recruited from subjects included in the city-hall registries of Molise (13). Exclusion criteria were pregnancy, disturbances in understanding/ willing processes, ongoing poly-traumas or coma, refusal to sign the informed consent. The cohort will be followed-up for incident cardiovascular and tumor events.

After exclusion of subjects reporting personal history of cardiovascular disease (angina, myocardial infarction, heart failure, revascularization procedures and~~,~~ stroke) (5.7%), cancer (3.1%) or diabetes (6.0%) and of those for whom there were no information available on income (30.7%) mainly because they refused to answer or did not possess any reliable information on this issue, 13,262 subjects were analysed. The latter were comparable with the whole Moli-sani Project population in terms of Mediterranean dietary patterns and socio-economic features, whereas mean age of the

sample was slightly lower (53.3 ± 11 vs 55.0 ± 12) and had a higher prevalence of men (50% vs 48%) compared with the whole population sample.

Dietary information

The validated Italian EPIC food frequency questionnaire was used to evaluate food intake (14, 15). The questionnaire, computerized with tailor-made software, allowed to interview participants in an interactive way, including illustrations of sample dishes of definite sizes or by reference to standard portion sizes. To simplify interpretation of data and to minimize within-person variations in intakes of individual foods, 188 food items were classified into 45 predefined food groups on the basis of similar nutrient characteristics or culinary usage (Appendix 2). (Web only file).

Moderate alcohol intake was defined as regularly drinking less than two or one drinks a day, by men and women, respectively.

Food consumption patterns were generated by using Principal Components Analysis (PCA) conducted on the correlation matrix of 45 food groups (16). Three main factors emerged, in agreement with previous findings in the same population (16). The first pattern, identified as ‘‘Olive Oil and Vegetables’’, was characterized by high positive loadings for olive oil, vegetables, legumes, soups, fruits and fish. The second pattern, named ‘‘Pasta and Meat’’, was characterized by high positive loadings for pasta, cooked tomatoes, red meat, animal fats and alcoholic beverages, and negative loadings of breakfast cereals and yogurt. The ‘‘Eggs and Sweets’’ pattern was characterized by high positive loadings for eggs, margarines, processed meat and sugar and sweets.

We evaluated the adherence to the Mediterranean diet by using the Mediterranean Diet Score (MDS) elaborated by Trichopoulou et al (17). Scoring was based on the intake of the following 9 items: vegetables, legumes, fruit and nuts, dairy products, cereals, meat and meat products, fish, alcohol, and the ratio of monounsaturated:saturated fat. For most items, consumption above the study median received 1 point; all other intakes received 0 points. For dairy products, meat and

meat products, consumption below the median received 1 point. Medians are gender specific. For ethanol, men who consumed 10–50 gr/day and women who consumed 5–25 gr/day received 1 point; otherwise, the score was 0. The ~~range of~~ possible scores ranged between ~~was~~ 0 and~~to~~ 9,~~which is obtained by assigning a value of 0 or 1 to each of 9 indicated components (vegetables, legumes, fruits, cereals, fish, meat, dietary products, ethanol, lipids) with the use of the sex-specific median as cut-off. The total Mediterranean diet score ranged from 0, which indicates the minimal adherence to the traditional Mediterranean diet, to 9,~~ the latter reflecting ~~namely~~ the maximal adherence.

We also used a new Italian Mediterranean Index (IMI) whose score ~~is based on the intake of 11 items (pasta, vegetables, fruits, legumes, olive oil, fish, soft drinks, butter, red meat, and potatoes, alcohol) ranged from 0 to 11 (15).~~ is based on the intake of 11 items: high intake~~s~~ of 6 typical Mediterranean foods (pasta; typical Mediterranean vegetables such as raw tomatoes, leafy vegetables, onion, and garlic, salad, and fruiting vegetables; fruit; legumes; olive oil; and fish); low intake~~s~~ of 4 non-Mediterranean foods (soft drinks, butter, red meat, and potatoes); and alcohol consumption. If consumption of typical Mediterranean foods was in the 3rd tertile of the distribution, the person received 1 point; all other intakes received 0 points. If consumption of non-Mediterranean foods was in the first tertile of the distribution, the person received 1 point. Ethanol received 1 point for intake up to 12 gr/day; abstainers and persons who consumed >12 gr/day received 0 points. Possible scores ranged from 0 to 11(18). Such Italian Index was conceived to better capture healthy eating including foods, such as pasta, more typically available in Italy.

Data collection

Body Mass Index (BMI) was calculated as kg/m^2. Waist circumferences were measured according to the NIH, Heart, Lung, and Blood guidelines (19). Blood pressure was measured by an automatic device (OMRON-HEM-705CP) three times on the non-dominant arm, with the patient lying down

for about 5 minutes. Hypertension was defined as systolic BP≥160 mm Hg and/or diastolic BP≥95 mm Hg, or using pharmacological treatment. Physical activity was assessed by a structured questionnaire (24 questions on working and leisure time and sport participation) and expressed as daily energy expenditure in metabolic equivalent task-hours (MET/d).

Serum lipids and glucose were assayed by enzymatic reaction methods using an automatic analyzer (ILab 350, Instrumentation Laboratory (IL), Milan, Italy). LDL-cholesterol was calculated according to Friedewald. High sensitivity C reactive protein (CRP) was measured in fresh serum, by a latex particle-enhanced immunoturbidimetric assay (IL Coagulation Systems on ACL9000). Inter- and intra-day CV were 5.5% and 4.17%, respectively.

Socio-economic variables

~~Individual~~ Household net ~~I~~income categories were considered as low (<10,000 euro/ year~~gro~~), low-medium (>10,000 <25,000 euro/year), medium – high (>25,000< 40,000 euro/year), high (>40,000 euro/year).

Education l~~L~~evel was divided into three categories: ≤8 (low) ~~years of studies (0 point)~~, >8 -and ~~<~~≤~~8~~13(medium) ~~-years~~and ~~-of studies (1 point)~~>13- (high) years of studies.

Socio-economic status (SES) was expressed as a score based on 5 variables: dwelling ownership and ratio between the number of living-in family members and number of rooms (People Room Density), both currently and at childhood - and availability of hot water at home at childhood. The five components were dichotomized according to the median value, and a score of one was attributed to the category supposed to be marker of higher social status in comparison with the opposite category: thus we assigned a score of 1 to people living in a house with living-in family members/room density > 0.6 or dwelling ownership or with availability of hot water and a score 0 to people with living-in family members/room density≤0.6, no dwelling ownership or with

unavailability of hot water. The SES score did not include income and education. Marital status was considered as married or live-in partner *vs* others (divorced, unmarried, widower).

~~Education Level was divided in two categories: ≤8 years of studies (0 point) and >8 years of studies (1 point).~~

Statistical analysis

Values for continuous variables are means ± Standard Deviation. CRP was transformed into natural logarithm to reduce positive skewness, but data were reported untransformed for clarity. Analysis of variance for continuous or categorical variables was applied to test the associations in Table 1. Multivariable analysis of variance with appropriate terms for interaction was used for testing the association of adherence to MD scores, dietary patterns or dietary variables (considered as the dependent variables) with categories of income or SES components. By using multivariable logistic regression analysis (with appropriate terms for interaction), odds ratio (ORs) with corresponding 95% confidence intervals (95% CI) were calculated to quantify the association of income or education levels -with adherence to MD-like eating scores or obesity. High adherence to MD, as stated by the Medscore, was defined when the score was ≥6 points whereas a low adherence when the score was ≤3 points. Subjects with intermediate values (4 or 5 points) were excluded from this analysis in order to focus on the two extreme categories of adherence. The same was done for the IMI score, but the cut-off was ≥5 for the higher adherence or ≤3 for the lower adherence category. The data analysis was generated using SAS/STAT software, Version 9.1.3 of the SAS System for Windows©2009. SAS Institute Inc. and SAS are registered trademarks of SAS Institute Inc., Cary, NC, USA.

RESULTS

Income groups

Table 1 shows the characteristics of the whole population by income categories. People in the uppermost income group were 53.5% men and showed a better health profile, having significantly lower values of BMI, systolic blood pressure, C-reactive protein, triglycerides and blood glucose. Obesity prevalence (BMI > 30 Kg/m^2) differed according to income; it was higher in the lowest-income group (36%) and lower in the highest- income category (20%, p <.0001 Tab. 1).

In Table 2 the association among income levels, dietary habits and single food groups are reported.

~~Subjects in the lower income categories showed poor adherence to the Olive oil and Vegetables dietary pattern (p<.0001) whereas a greater adherence to the Western type pattern (Dietary pattern 3) was observed.~~

Higher income groups were significantly associated with greater adherence to both score indexes, namely MDS (p<.0001) and IMI (p<.0001) in the model adjusted for age, sex, daily energy intake, BMI, physical activity, smoking, alcohol consumption and marital status.

Similar data were obtained after stratification by gender (p for interaction=0.24 for MDS and p for interaction =0.41 for IMI) and age (p for interaction=0.43 for IMI). However, the increasing adherence to MD according to income was more pronounced in the elderly when it was measured as MSD (p for interaction=0.0002 ; β = 0.063, SE±0.021, p=0.0028 for people ≤ 65 years and β = 0.17, SE±0.051, p =0.0008, for people > 65 years).

Subjects in the lower income categories showed poor adherence to the Olive oil and Vegetables dietary pattern (p<.0001) whereas a greater adherence to the Western type pattern (Dietary pattern 3) was observed. Similar results were observed after stratification for gender and age (data not shown).

In addition, analysis of single foods consumption by income categories showed that people with the higher income reported higher intake of the basic components of the MD, that is fish, fruits,

legumes and reduced consumption of animal fats, processed meat and white meat whose frequent consumption is more typical of a Western dietary model.

The odds of having highest adherence to the MD, that raised with both MDS and IMI scores, clearly increased according to income levels (Tab. 34). People having the highest income had -5546% (MDS) or 7268% (IMI) statistically significant higher probability to stick to a MD-like eating pattern than those in the lowest income group (Tab. 34).

Regarding alcohol consumption (Tab.2), the highest income group appeared to include the highest prevalence of moderate drinkers (41.7% versus 27.5% recorded in the lowest income group) as already found on a sample of Danish population (17).

Socio-economic status and education

Income fairly correlated with SES (Spearman correlation coefficients = 0.24, p< 0.0001) and education (r=0.51, p<0.0001) whereas correlation between SES and education was r=0.34, p<0.0001.

Education was positively associated with adherence to MD, measured by both MDS (p=0.034) and IMI (p=0.0014), while SES was not (p=0.19 for MDS and p=0.78 for IMI) in the fully adjusted model also including education and income.

Odds of having higher adherence according to education levels were 1.26 and 1.27 (p for trend=0.0020) for MDS and 1.16 and 1.33 (p for trend=0.0009) for IMI (Tab.4).

Stratification by education

As less educated people may show lower adherence because of lack of knowledge about healthy habits (2118), we performed additional analyses -stratified for educational level.

~~Both~~ Either in lower (< = 8), ~~higher~~ medium (>8 and ≤13 ~~years of studies~~) and higher (>13 years of studies) ~~lower (< = 8)~~ educated groups adherence to Mediterranean diet ~~(evaluated both by IMI~~

and MDS score) followed the gradient of income categories (Tab. 45), with the exception of the whereas the trend appears not significant in the uppermost educated group, at least for what concernswhen the MDS score was used (p=0,067). However the interaction test was not significant for either scores. Accordingly, education was related to dietary pattern independently from income. Indeed, by dividing income levels into two main categories (low and low-medium VS high and high-medium), in the fully adjusted model, education was positively associated with dietary patterns both in the lowest (MDS: p=0.032 and IMI: p=0.0025) and in the highest income group (MDS: p=0.0067 and IMI: p=0.0010).

Income/education, Mediterranean diet and obesity

Finally, we evaluated the association of income and education on diet quality and then on obesity in a unique statistical model. Odds ratio of having obesity decreased according to income (OR=0.72, 95%CI: 0.59 to 0.86 for highest versus lowest income group) -and education level (OR=0.53, 95%CI: 0.45 to 0.61 for highest versus lowest education level).- These odds ratios remained unchanged when in the model diet quality (measured as Mediterranean scores) was included. Moreover,- the association between income or education with obesity was equally observed in both highest and lowest MD adherence categories as defined in Table 3 (the four terms for interactions among income or education with MDS or IMI were all p>0.35).

DISCUSSION

People with higher income and higher levels of education had a greater adherence to MD-like eating patterns, as measured by three different parameters: two *a priori* Mediterranean scores (the traditional one introduced by Trichopoulou and a more recent Italian Mediterranean index), and the *a posteriori* dietary patterns derived from principal components analysis. Evidence on the health benefits of the MD is based on several studies and meta-analyses (1,7,21). However, adherence to

this healthy eating pattern is rapidly disappearing in the countries of Southern Europe where it originated and persisted during centuries, including the areas of Northern Africa in which there is an increasing prevalence of metabolic disorders and consequent cardiovascular disease mainly due to the changing in lifestyle habits (22). Socio-economic status has been included among the factors related to chronic disease onset, and disparities in dietary habits by social class have been advocated to explain at least in part the higher CVD risk factors profile observed among low SES groups (23). Our results agree with the conclusions reported in the review by Darmon et al. (10) that higher-quality diets are mainly consumed by better educated and more affluent people while lower socio-economic groups tend to have lower quality diets thus exposing themselves to a higher risk to develop diet-related diseases. Similar conclusions were reached by other investigations too (24) suggesting that low socio-economic groups end with having poorer diets. These findings are supported, at least in part, by the ~~increasing prices of some of the key foods of the MD~~ fact that following a Mediterranean dietary style could represent a matter of money (9). Indeed researchers in Spain showed that MD is definitely more expensive to follow than Western dietary patterns: this may represent a strong economic obstacle when counselling people about the opportunity to follow a healthy diet because cost may become a prohibitive factor (9). Aggrawal et al. (25) demonstrated that the well-known socio-economic disparities in diet quality is mediated by food cost confirming that lower SES groups tend to consume more energy dense and nutrient poor diets. However, the economic advantages of a Mediterranean way of eating in terms of cost-effectiveness should be highlighted as shown in patients with previous CVD, that could represent an exceptional return on investment (26).

Subjects with lower income had a greater prevalence of obesity too. The association between obesity and socioeconomic factors has been previously observed (27) suggesting that the latter -play an important role in the risk of obesity and overweight not only in adults but also in children (284). However our data show that the strong association observed between lower income or education

with obesity -was not -mediated by -diet quality. Indeed, an additional analysis combinge the impacts of education or income on diet quality and then on obesity in a unique statistical model, showed that both the association remained unchanged when in the model diet quality was included. According to these results, the changes in obesity rates observed in the different income and education categories appear not necessarily re-mediated by diet quality. However, the epidemiological evidence supporting a causal link between Mediterranean diets and body weight is contrasting (29).

It is quite clear that accumulating proofs on the benefits of Mediterranean- like diets is an insufficient could no longer be the only task of prevention strategyies as which should also try to set the conditions allowing people to stick to healthier dietary habits should also be clearly identified.

This study contributes to provide further evidence to the assumption that dietary habits are strongly influenced by socio-economic factors, in particular by income which appears to play an important role in determining people's eating choices (30). As far as education is concerned, previous studies found a relationship between higher levels of education and healthy diets (31). In our research, education resulted to be independently associated to MD and did not modify the association between income levels and healthy dietary pattern as shown in the stratified analysis by education levels.

The promotion of healthy lifestyles and diets to prevent weight gain and related diseases has jumped to the top of the priority list of the public health experts all over the world since obesity has become a threatening epidemic. So far the traditional MD has proven to be an effective "remedy" to the spreading of the major chronic disease, obesity and mortality. Our study highlights the strong linkage among low income, poor adherence to MD and consequent obesity prevalence.

~~We started our study wondering about what makes so hard for people to choose healthy food instead of bad products, putting at risk their own health. We excluded it could be just a matter of personal choice or taste, neither an issue related to the lack of knowledge about the healthy benefits of MD worldwide recognized and also well disseminated in the lay press.~~

Limitations of this study

A major limitation of the present study is that people self-reported their own income which is a quite sensitive issue. Indeed we recorded a high percentage (30.7%) of non-respondent subjects who refused to declare or did not know their ~~personal~~ family income. Yet such large non-respondent group is very common in this type of investigation, especially among women and elderly (32) However, there was no difference between the whole Moli-sani population and the subsample analyzed here as far as dietary habits and socio-economic variables were concerned. Another inherent limit is represented by the cross-sectional nature of our study.

In addition, caution is needed in extending the results presented here to larger contexts since data were collected in a region located between Central and Southern Italy, Mediterranean by tradition and culture (13). Yet, the main characteristics of our population sample are comparable to those of the Italian Cardiovascular Epidemiological Observatory (33), a large survey including random samples of the general population recruited all over Italy; therefore our sample can be considered representative at least of the whole Italian population.

Strengths of this study

Our very large population sample is made of subjects coming from a quite homogenous environment with no marked differences in terms of socioeconomic disparities, differently from metropolitan areas, where previous studies found huge gaps among social classes and related health status at relatively small distances from the city centre (34). Bearing this in mind, the differences we

observed in the adherence to Mediterranean diet according to income indicate that also in a environment homogeneous both for genetic and lifestyles, income and education can still play a role in influencing dietary choices. Furthermore, diet quality showed a continued improvement across a relatively small range of economic strata. Our "poorest" are represented by people earning less than 10,000 euro/net per year whilst the "richest" group is made of subjects with more than 40,000 euro/net per year. Such differences among income classes are quite restrained and recall what already said for the pretty homogeneous environment where our sample comes from. We are not dealing with real huge socioeconomic and income differences. Despite this homogeneity, we did observe notable changes in diet quality among different groups.

The differences observed across the income strata would likely become even more evident in MD importing countries where getting typical Mediterranean products is more difficult and expensive. In addition, apparently for the first time this topic was addressed by using two *a priori* Mediterranean scores (the traditional one introduced by Trichopoulou and a novel Italian Mediterranean index), and the *a posteriori* dietary patterns derived from principal components analysis. This leads to overcome the limitations each of these approaches may present. Indeed, the "a priori" scores only reflect some aspects of diet and do not account for correlations between score components. Instead, the "a posteriori" approaches have the weakness of low reproducibility, ~~:~~ different populations havinge different non-predefined dietary patterns. Therefore, the use of an index based on the foods actually available to Italians and traditional Italian cooking styles should improve the ability of the index to classify the Italian cohort.

CONCLUSIONS

Our data suggest consistent associations of income and education with dietary patterns ~~clearly indicate that eating "mediterraneanly" is also, if not mainly, a matter of~~and may foster ~~offer~~

discussion on healthy food accessibility in terms of economic costs. The cost of ~~increasing prices of the basic~~ MD seem to represent a real obstacle to healthy diet driving people to choose alternative ways of eating usually inspired by the need to save money in everyday life. Public health policies shall take into account the fact that correct dietary habits need to be promoted by allowing people to choose the best for their own health. It is definitely an interdisciplinary issue which shall call to action every single actor of modern societies otherwise condemned to increase their already heavy burden of chronic diseases. As already noted by others who dealt with this topic (10), the promotion of high-cost foods to low-income people without taking food costs into account is not likely to be successful.

Table 1 Characteristics of the whole population as a whole and according to four income categories

	Income Categories					
	All (n=13,262)	**< 10,000 (n = 980, 7.4%)**	**> 10,000 < 25,000 (n = 5,751, 43.4%)**	**> 25,000 < 40,000 (n= 4,120, 31.1%)**	**> 40,000 (n = 2,411, 18.2%)**	**P value***
Age (years)	53.3 (10.6)	60.1 (12.7)	54.0 (11.2)	51.4 (9.5)	52.3 (8.8)	<.0001
Sex (males, n, %)	6,590 (49.7%)	348 (35.5%)	2,834 (49.3%)	2,117 (51.4%)	1,291 (53.5%)	<.0001
BMI (kg/m^2)	27.7 (4.6)	28.7 (5.3)	28.2 (4.7)	27.3 (4.3)	27.0 (4.0)	<.0001
WH-ratio	0.91 (0.07)	0.92 (0.079)	0.91 (0.075)	0.91 (0.075)	0.91 (0.074)	0.019
Systolic blood pressure (mmHg)	139.0 (20.1)	143.4 (21.0)	140.1 (20.4)	137.3 (19.6)	137.4 (19.2)	0.0053
Diastolic blood pressure (mmHg)	82.7 (9.6)	81.7 (9.7)	82.8 (9.4)	82.7 (9.7)	82.8 (10.0)	0.0038
Total physical activity (MET-h /day)	43.4 (8.7)	44.8 (10.4)	45.0 (9.7)	42.5 (7.9)	40.4 (5.2)	<.0001
Leisure time PA (MET-h /day)	2.18 (1.88)	1.81 (1.67)	2.10 (1.78)	2.22 (1.96)	2.28 (1.94)	0.20
Working PA (MET-h /day)	14.6 (12.2)	22.4 (19.1)	18.8 (14.3)	12.7 (10.4)	10.2 (6.4)	<.0001
Smokers n, %						
Never	6,370 (48.1%)	558 (56.9%)	2,838 (49.4%)	1,901 (46.2%)	1,073 (44.5%)	<.0001
Current	3,296 (25.0%)	222 (22.6%)	1,418 (24.7%)	1,060 (25.8%)	596 (24.7%)	
Former	3,585 (27.5%)	200 (20.4%)	1,490 (25.9%)	1,154 (28.0%)	741 (30.7%)	
Total cholesterol (mg/dL)	212.3 (40.2)	214.3 (41.9)	212.8 (40.4)	211.8 (40.4)	211.0 (38.7)	0.64
HDL (mg/dL)	57.0 (14.5)	58.4 (14.4)	57.2 (14.4)	56.6 (14.5)	56.8 (14.6)	0.35
LDL (mg/dL)	130.3 (33.6)	130.8 (35.7)	130.3 (33.8)	130.2 (33.6)	130.1 (32.7)	0.65
CRP (mg/dL)	2.4 (3.0)	3.0 (3.7)	2.6 (3.1)	2.2 (2.9)	2.1 (2.7)	<.0001
Triglycerides (mg/dL)	127.0 (83.8)	129.1 (87.0)	129.1 (84.5)	126.1 (85.0)	122.6 (78.4)	0.0002
Blood glucose (mg/dL)	96.8 (17.0)	97.7 (20.4)	97.2 (16.8)	96.4 (16.5)	96.4 (16.4)	0.17
Obesity (n, %)	3,563 (26.9%)	352 (36.0%)	1,733 (30.1%)	988 (24.0%)	490 (20.3%)	<.0001
Hypertension (n, %)	4,469 (33.7%)	452 (46.2%)	2,006 (34.9%)	1,259 (30.6%)	752 (31.2%)	0.79

* P value adjusted for sex, age, energy intake and marital status

Table 2 Mediterranean diet adherence and dietary consumption as a whole and according to four income categories

		Income categories				
	All (n=13,262)	**< 10,000 (n = 980, 7.4%)**	**> 10,000 < 25,000 (n = 5,751, 43.4%)**	**> 25,000 < 40,000 (n= 4,120, 31.1%)**	**> 40,000 (n = 2,411, 18.2%)**	**P value ***
Mediterranean score (MDS)	4.44 (1.64)	4.32 (1.61)	4.40 (1.62)	4.46 (1.62)	4.53 (1.70)	<.0001
Italian Mediterranean index (IMI)	3.26 (1.71)	3.20 (1.64)	3.15 (1.68)	3.30 (1.71)	3.49 (1.79)	<.0001
Dietary Pattern 1 (Olive Oil and Vegetables)	0.042 (0.95)	-0.066 (0.92)	0.021 (0.94)	0.070 (0.95)	0.091 (0.97)	<.0001
Dietary Pattern 2 (Pasta and Meat)	0.036 (0.95)	0.0078 (0.91)	0.093 (0.95)	0.0053 (0.95)	- 0.036 (0.97)	<.0001
Dietary Pattern 3 (Eggs and sweets)	0.015 (0.85)	-0.13 (0.88)	0.040 (0.86)	0.044 (0.85)	-0.033 (0.82)	<.0001
Energy intake (kcal/day)	2177.4 (640.7)	2,062.5 (704.1)	2,186.3 (649.0)	2,190.6 (627.8)	2,180.4 (610.7)	0.~~50~~58
Alcohol intake (gr/day)	16.5 (22.4)	16.1 (25.8)	18.2 (24.5)	15.3 (20.3)	14.9 (18.6)	<.0001
Moderate drinkers (n, %)	4,303 (33.3%)	261 (27.5%)	1,646 (29.2%)	1,419 (35.3%)	977 (41.7%)	<.0001
Wine consumption (ml/day)	135.5 (188.7)	133.3 (209.6)	148.9 (203.7)	125.5 (175.4)	121.8 (160.4)	<.0001
Olive oil (gr/day)	24.2 (9.2)	22.9 (9.0)	24.4 (9.3)	24.4 (9.2)	24.0 (9.1)	0.0034
Animal fat (gr/day)	1.26 (1.41)	1.21 (1.37)	1.34 (1.45)	1.25 (1.41)	1.11 (1.31)	<.0001
Fish (gr/day)	20.9 (17.0)	17.5 (15.5)	19.4 (16.3)	22.1 (17.4)	23.9 (18.0)	<.0001
Processed meat (gr/day)	30.4 (20.9)	27.4 (20.0)	31.5 (21.8)	30.7 (20.5)	28.6 (19.9)	<.0001
Cooked vegetables (gr/day)	73.5 (43.4)	71.2 (42.8)	74.8 (44.0)	74.0 (42.5)	70.6 (43.4)	0.0006
Legumes (gr/day)	28.3 (22.1)	27.1 (20.3)	27.1 (21.6)	28.4 (21.9)	31.3 (24.2)	<.0001
Nuts and seeds (gr/day)	0.89 (2.3)	0.90 (3.2)	0.87 (2.3)	0.88 (2.1)	0.94 (2.2)	0.34
Red meat (gr/day)	47.8 (26.0)	44.7 (26.3)	48.8 (25.9)	47.9 (25.8)	46.8 (26.3)	0.0008
White meat (gr/day)	26.4 (18.8)	29.6 (19.8)	28.1 (19.3)	25.3 (17.8)	23.2 (18.1)	<.0001
Fruits (gr/day)	358.5 (204.3)	362.7 (211.1)	354.9 (201.2)	355.7 (198.9)	370.3 (217.0)	0.015
Crustaceans, molluscs, seafood (gr/day)	11.0 (10.1)	8.9 (8.8)	10.7 (9.9)	11.7 (10.7)	11.5 (10.0)	<.0001
Vegetable oils (no olive; gr/day)	0.28 (0.81)	0.33 (1.23)	0.29 (0.79)	0.28 (0.69)	0.27 (0.84)	0.18
Refined grains (pasta and bread; (gr/day)	198.3 (101.9)	193.5 (104.5)	201.3 (103.3)	196.3 (99.2)	196.8 (101.9)	0.0004
Sugar (gr/day)	11.0 (10.4)	10.3 (9.7)	11.2 (10.9)	11.1 (10.3)	10.4 (9.8)	<.0001

*P value adjusted for sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption, marital status

Table 3 Odds ratios of having high adherence to Mediterranean diet according to income, education and ~~s~~Socioeconomic status

	Mediterranean score				Italian Mediterranean Index			
Income	**Low (n=3,843)**	**High (n=3,518)**	**OR**	**(95%CI)**	**Low (n=4704)**	**High (n=3089)**	**OR**	**(95%CI)**
< 10,000	310 (8.1%)	231 (6.6%)	-1-	(referent)	353 (7.5%)	209 (6.8%)	-1-	(referent)
> 10,000 < 25,000	1,694 (44.1%)	1,470 (41.8%)	1.28	(1.04-1.57)	2,161 (45.9%)	1,201 (38.9%)	1.07	(0.87-1.32)
> 25,000 < 40,000	1,153 (30.0%)	1,116 (31.7%)	1.51	(1.21-1.88)	1,436 (30.5%)	995 (32.2%)	1.34	(1.07-1.69)
> 40,000	686 (17.9%)	701 (19.9%)	1.54	(1.21-1.97)	754 (16.0%)	684 (22.1%)	1.72	(1.34-2.21)
			(p for trend=0.0002)				(p for trend<.0001)	
Education level								
Low	1,775 (46.2%)	1,571 (44.7%)	-1-	(referent)	2,250 (47.8%)	1,307 (42.3%)	-1-	(referent)
Medium	1,504 (39.1%)	1,421 (40.4%)	1.26	(1.11-1.43)	1,860 (39.6%)	1,283 (41.5%)	1.16	(1.02-1.31)
High	564 (14.7%)	525 (14.9)	1.27	(1.06-1.52)	592 (12.6%)	499 (16.1%)	1.33	(1.11-1.60)
			(p for trend=0.0020)				**(p for trend=0.0009)**	
Socioeconomic status								
Low	1,097 (29.1%)	1,097 (32.2%)	-1-	(referent)	1,462 (32.2%)	927 (30.9%)	-1-	(referent)
Medium	1,155 (31.1%)	1,095 (32.1%)	0.94	(0.83-1.07)	1,414 (31.1%)	930 (31.0%)	1.00	(0.88-1.14)
High	1,475 (39.8%)	1,218 (35.7%)	0.88	(0.77-1.00)	1,664 (36.7%)	1,144 (38.1%)	0.98	(0.86-1.12)
			(p for trend=0.054)				(p for trend =0.82)	

The logistic model included income, education, socioeconomic status and sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption, marital status

Table 4 Mediterranean diet adherence according to four income levels and stratified by education

	Income Categories				
	< 10,000	**> 10,000 < 25,000**	**> 25,000 < 40,000**	**> 40,000**	
Lower Education (n = 6,101, 46.0%)	**(n=829)**	**(n=3,745)**	**(n=1,260)**	**(n=267)**	**P value ***
Mediterranean Diet	4.33 (1.60)	4.43 (1.63)	4.44 (1.60)	4.59 (1.64)	0.040
Italian Mediterranean Index	3.19 (1.61)	3.13 (1.67)	3.22 (1.69)	3.54 (1.73)	0.0002
Medium Education (n = 5,236, 39.5%)	**(n=137)**	**(n=1,746)**	**(n=2,184)**	**(n=1,169)**	
Mediterranean Diet	4.16 (1.64)	4.33 (1.60)	4.50 (1.63)	4.54 (1.67)	0.0041
Italian Mediterranean Index	3.21 (1.67)	3.14 (1.69)	3.33 (1.73)	3.43 (1.81)	<.0001
Higher Education (n = 1,922, 14.5%)	**(n=13)**	**(n=258)**	**(n=676)**	**(n=975)**	
Mediterranean Diet	5.61 (1.85)	4.43 (1.61)	4.38 (1.60)	4.50 (1.76)	0.067
Italian Mediterranean Index	3.77 (2.68)	3.43 (1.63)	3.33 (1.70)	3.56 (1.77)	0.041

*P value adjusted for sex, age, energy intake, BMI, physical activity, smoking, alcohol consumption, marital status

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COMPETING INTEREST

None

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