

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

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## ABSTRACT

**Objectives:** To examine cross-sectional associations of socioeconomic status (ie, income and education) with an 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 a 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 an MD ( $p<0.0001$ ) and to Olive oil and Vegetables dietary pattern in a multivariable model including age, sex, daily energy intake, body mass index, physical activity, smoking, alcohol consumption, education and marital status. The odds of having the highest adherence to an 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 an MD-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%,  $p<0.0001$ ). Income was associated with dietary patterns in all categories of education.

**Conclusions:** A higher income and education are independently associated with a greater adherence to MD-like eating patterns and a lower prevalence of obesity.

## ARTICLE SUMMARY

### Article focus

■ Examining cross-sectional associations of socioeconomic status (ie, income and education) with an adherence to a Mediterranean dietary pattern and obesity prevalence in a sample of Italian subjects.

### Key messages

- Higher income and education are independently associated with a greater adherence to Mediterranean diet-like eating patterns and a lower prevalence of obesity.
- Diet quality showed a continued improvement across a relatively small range of economic strata.
- These results may foster a discussion on healthy food accessibility in terms of economic costs.

### Strengths and limitations of this study

- The strengths are represented by the very large population sample and by the fact that this topic was addressed by using two a priori Mediterranean scores and the a posteriori dietary patterns derived from the principal components analysis. This leads to overcoming the limitations each of these approaches may present. A major limitation is that people self-reported their own income and a high percentage of non-respondent subjects.

## INTRODUCTION

Mediterranean diet (MD) has been shown to offer protection against cardiovascular diseases (CVD), some types of cancer and neurodegenerative diseases in observational epidemiological studies.<sup>1</sup> The Lyon Diet Heart Study, by a randomised dietary intervention, also showed the health benefits of an MD in secondary prevention.<sup>2-3</sup> The main

food components of the MD are vegetables, fruits, cereals and fish and olive oil as the main fat sources and a moderate amount of red wine. Recently, the UNESCO committee inscribed it on the list of Intangible Heritage.<sup>4</sup>

Despite the widely proven benefits of the diet discovered by Ancel Keys<sup>5</sup> in the 50s, the Southern European countries in which MD originated are rapidly withdrawing from this eating pattern orienting their food choices towards products typical of the Western diet which is rich in refined grains, saturated fats, sugars, red and processed meat.<sup>6</sup> The reasons why people keep on drifting from one dietary regimen to another remain open to several hypotheses.<sup>7</sup> Social changes appear to have contributed to radical reversal in dietary habits in Western and Southern European societies although developing countries are slightly turning to westernised diets as well.<sup>8</sup>

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.<sup>9</sup>

Many studies suggest that diet quality follows a socio-economic gradient highlighting how disadvantaged people present higher rates of obesity, diabetes, CVD and some types of cancer.<sup>10</sup>

The abandoning of MD is also considered as a possible cause of the increasing obesity pandemic.<sup>11</sup> Several studies took a step forward to see whether there is an association between diet cost and obesity, and found that a higher adherence to healthy dietary patterns is linked to higher monetary costs and is inversely associated with body mass index (BMI) and obesity.<sup>12</sup>

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

## MATERIAL AND METHODS

### Study population

The Moli-sani Project is a population-based cohort study which randomly recruited 24 325 citizens of Molise, a region placed between Central and Southern Italy. The study enrolled men and women aged  $\geq 35$  years, between March 2005 and April 2010, randomly recruited from subjects included in the city-hall registries of Molise.<sup>13</sup> 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 tumour events.

After exclusion of subjects reporting a personal history of CVD (angina, myocardial infarction, heart failure,

revascularisation procedures and stroke) (5.7%), cancer (3.1%) or diabetes (6%) and of those for whom no information on income (30.7%) was available, 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 entire Moli-sani Project population in terms of Mediterranean dietary patterns and socioeconomic features, whereas the mean age of the sample was slightly lower ( $53.3 \pm 11$  vs  $55 \pm 12$ ) and had a higher number of men (50% vs 48%) in the entire sample.

### Dietary information

The validated Italian EPIC food frequency questionnaire was used for evaluating the food intake.<sup>14 15</sup> The questionnaire, computerised with tailor-made software, allowed to interview participants in an interactive way, including illustrations of sample dishes of definite sizes or by a reference to standard portions. To simplify the interpretation of data and to minimise within-person variations in intake of individual food items, 188 food items were classified into 45 predefined food groups on the basis of similar nutrient characteristics or culinary usage (see online supplementary appendix S2; 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.<sup>16</sup> Three main factors emerged, in agreement with previous findings in the same population.<sup>16</sup> The first pattern, identified as 'Olive Oil and Vegetables', was characterised by high-positive loadings for olive oil, vegetables, legumes, soups, fruits and fish. The second pattern, named as 'Pasta and Meat', was characterised by high-positive loadings for pasta, cooked tomatoes, red meat, animal fats and alcoholic beverages, and negative loadings for breakfast cereals and yogurt. The 'Eggs and Sweets' pattern was characterised by high-positive loadings for eggs, margarines, processed meat and sugar and sweets.

We evaluated the adherence to an MD by using the Mediterranean Diet Score (MDS) elaborated by Trichopoulou *et al.*<sup>17</sup> Scoring was based on the intake of the following nine items: vegetables, legumes, fruits and nuts, dairy products, cereals, meat and meat products, fish, alcohol and the ratio of monounsaturated:saturated fats. 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 g/day and women who consumed 5–25 g/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) the scoring of which is based on the intake of 11 items:

a high intake of six typical Mediterranean foods (pasta; typical Mediterranean vegetables such as raw tomatoes, leafy vegetables, onions, and garlic, salads, and fruiting vegetables; fruit; legumes; olive oil and fish); a low intake of four non-Mediterranean foods (soft drinks, butter, red meat and potatoes); and alcohol consumption. If the consumption of typical Mediterranean foods was in the third tertile of the distribution, the person received 1 point; all other intakes received 0 points. If the 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 g/day; abstainers and persons who consumed >12 g/day received 0 points. Possible scores ranged from 0 to 11.<sup>18</sup> Such an Italian index was conceived to a better capture of healthy eating including foods, such as pasta, more typically available in Italy.

### Data collection

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

Serum lipids and glucose were assayed by enzymatic reaction methods using an automatic analyser (ILab 350, Instrumentation Laboratory (IL), Milan, Italy). Low-density lipoprotein-cholesterol was calculated according to Friedewald. High-sensitivity C reactive protein (CRP) was measured in a fresh serum, by a latex particle-enhanced immunoturbidimetric assay (IL Coagulation Systems on ACL9000). Interday and intraday coefficients of variables were 5.5% and 4.17%, respectively.

### Socioeconomic 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) and high (>40 000 Euro/year).

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

SES was expressed as a score based on five variables: dwelling ownership and ratio between the number of rooms and number of living-in family members (rooms per person), both currently and during childhood – and availability of hot water at home during childhood. The five components were dichotomised according to the median value, and a score of 1 was attributed to the category supposed to be the marker of a higher social

status in comparison with the opposite category: thus, we assigned a score of 1 to people living in a house with room density/living-in family members > 0.6 or dwelling ownership or with availability of hot water, and a score 0 to people with room density/living-in family members ≤ 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 versus others (divorced, unmarried and widower).

### Statistical analysis

Values for continuous variables are means ± SD. 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. A 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), OR with a corresponding 95% CI were calculated to quantify the association of income or education levels with adherence to MD-like eating scores or obesity. A high adherence to an 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 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 or ≤ 3 for the lower adherence category.

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

## RESULTS

### Income groups

Table 1 shows the characteristics of the entire 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 BP, CRP, triglycerides and blood glucose. Obesity prevalence (BMI > 30 kg/m<sup>2</sup>) varied according to the income; it was higher in the lowest-income group (36%) and lower in the highest-income category (20%, p < 0.0001 table 1).

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

Higher income groups were significantly associated with a greater adherence to both score indexes, namely MDS (p < 0.0001) and IMI (p < 0.0001) in the model adjusted for age, sex, daily energy intake, BMI, physical

**Table 1** Characteristics of the entire 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=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)	<0.0001
Sex (males, n, %)	6590 (49.7%)	348 (35.5%)	2834 (49.3%)	2117 (51.4%)	1291 (53.5%)	<0.0001
BMI (kg/m <sup>2</sup> )	27.7 (4.6)	28.7 (5.3)	28.2 (4.7)	27.3 (4.3)	27.0 (4.0)	<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 (mm Hg)	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 (mm Hg)	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)	<0.0001
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)	<0.0001
Smokers n, %						
Never	6370 (48.1%)	558 (56.9%)	2838 (49.4%)	1901 (46.2%)	1073 (44.5%)	<0.0001
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)	<0.0001
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%)	<0.0001
Hypertension (n, %)	4469 (33.7%)	452 (46.2%)	2006 (34.9%)	1259 (30.6%)	752 (31.2%)	0.79

\*p Value adjusted for sex, age, energy intake and marital status.  
BMI, body mass index; CRP, C reactive protein; LDL, low-density lipoprotein.

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;  $\beta=0.063$ ,  $SE\pm 0.021$ ,  $p=0.0028$  for people  $\leq 65$  years and  $\beta=0.17$ ,  $SE\pm 0.051$ ,  $p=0.0008$ , for people  $>65$  years).

Subjects in the lower-income categories showed poor adherence to the Olive oil and Vegetables dietary pattern ( $p<0.0001$ ), while 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, an analysis of single foods consumption by income categories showed that people with a higher income reported higher intake of the basic components of an MD, that is fish, fruits, legumes and a lower consumption of animal fats, processed meat and white meat the frequency of consumption of which is more typical of the Western dietary model.

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

Regarding alcohol consumption (table 2), the highest income group appeared to include the highest prevalence of moderate drinkers (41.7% vs 27.5%, recorded in the lowest-income group) as already found in a sample of Danish population.<sup>20</sup>

### SES 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.



**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=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)	<0.0001
Italian Mediterranean index (IMI)	3.26 (1.71)	3.20 (1.64)	3.15 (1.68)	3.30 (1.71)	3.49 (1.79)	<0.0001
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)	<0.0001
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)	<0.0001
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)	<0.0001
Energy intake (kcal/day)	2177.4 (640.7)	2062.5 (704.1)	2186.3 (649.0)	2190.6 (627.8)	2180.4 (610.7)	0.58
Alcohol intake (g/day)	16.5 (22.4)	16.1 (25.8)	18.2 (24.5)	15.3 (20.3)	14.9 (18.6)	<0.0001
Moderate drinkers (n, %)	4303 (33.3%)	261 (27.5%)	1646 (29.2%)	1419 (35.3%)	977 (41.7%)	<0.0001
Wine consumption (ml/day)	135.5 (188.7)	133.3 (209.6)	148.9 (203.7)	125.5 (175.4)	121.8 (160.4)	<0.0001
Olive oil (g/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 (g/day)	1.26 (1.41)	1.21 (1.37)	1.34 (1.45)	1.25 (1.41)	1.11 (1.31)	<0.0001
Fish (g/day)	20.9 (17.0)	17.5 (15.5)	19.4 (16.3)	22.1 (17.4)	23.9 (18.0)	<0.0001
Processed meat (g/day)	30.4 (20.9)	27.4 (20.0)	31.5 (21.8)	30.7 (20.5)	28.6 (19.9)	<0.0001
Cooked vegetables (g/day)	73.5 (43.4)	71.2 (42.8)	74.8 (44.0)	74.0 (42.5)	70.6 (43.4)	0.0006
Legumes (g/day)	28.3 (22.1)	27.1 (20.3)	27.1 (21.6)	28.4 (21.9)	31.3 (24.2)	<0.0001
Nuts and seeds (g/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 (g/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 (g/day)	26.4 (18.8)	29.6 (19.8)	28.1 (19.3)	25.3 (17.8)	23.2 (18.1)	<0.0001
Fruits (g/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 (g/day)	11.0 (10.1)	8.9 (8.8)	10.7 (9.9)	11.7 (10.7)	11.5 (10.0)	<0.0001
Vegetable oils (no olive; g/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; g/day)	198.3 (101.9)	193.5 (104.5)	201.3 (103.3)	196.3 (99.2)	196.8 (101.9)	0.0004
Sugar (g/day)	11.0 (10.4)	10.3 (9.7)	11.2 (10.9)	11.1 (10.3)	10.4 (9.8)	<0.0001

\*p Values adjusted for sex, age, energy intake, body mass index, physical activity, smoking, alcohol consumption and marital status.

Odds of having a 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 (table 3).

### Stratification by education

As less-educated people may show a lower adherence to an MD owing to the lack of knowledge about healthy habits,<sup>21</sup> we performed additional analyses stratified for educational level.

Either in lower ( $\leq 8$ ), medium ( $> 8$  and  $\leq 13$ ) and highly ( $> 13$  years of studies) educated groups,

adherence to an MD followed the gradient of income categories (table 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 the 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 groups (MDS: p=0.0067 and IMI: p=0.0010).

**Table 3** ORs of having a high adherence to Mediterranean diet according to income, education and socioeconomic status

Income	Mediterranean score		OR	(95% CI)	Italian Mediterranean Index		OR	(95% CI)
	Low (n=3843)	High (n=3518)			Low (n=4704)	High (n=3089)		
<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%)	1.28	(1.04 to 1.57)	2161 (45.9%)	1201 (38.9%)	1.07	(0.87 to 1.32)
>25 000<40 000	1153 (30.0%)	1116 (31.7%)	1.51	(1.21 to 1.88)	1436 (30.5%)	995 (32.2%)	1.34	(1.07 to 1.69)
>40 000	686 (17.9%)	701 (19.9%)	1.54	(1.21 to 1.97)	754 (16.0%)	684 (22.1%)	1.72	(1.34 to 2.21)
			(p for trend=0.0002)				(p for trend<0.0001)	
Education level								
Low	1775 (46.2%)	1571 (44.7%)	-1-	(referent)	2250 (47.8%)	1307 (42.3%)	-1-	(referent)
Medium	1504 (39.1%)	1421 (40.4%)	1.26	(1.11 to 1.43)	1860 (39.6%)	1283 (41.5%)	1.16	(1.02 to 1.31)
High	564 (14.7%)	525 (14.9)	1.27	(1.06 to 1.52)	592 (12.6%)	499 (16.1%)	1.33	(1.11 to 1.60)
			(p for trend=0.0020)				(p for trend=0.0009)	
Socioeconomic status								
Low	1097 (29.1%)	1097 (32.2%)	-1-	(referent)	1462 (32.2%)	927 (30.9%)	-1-	(referent)
Medium	1155 (31.1%)	1095 (32.1%)	0.94	(0.83 to 1.07)	1414 (31.1%)	930 (31.0%)	1.00	(0.88 to 1.14)
High	1475 (39.8%)	1218 (35.7%)	0.88	(0.77 to 1.00)	1664 (36.7%)	1144 (38.1%)	0.98	(0.86 to 1.12)
			(p for trend=0.054)				(p for trend=0.82)	

**Income/education, an MD and obesity**

Finally, we evaluated the impact of income and education on the diet quality and then on obesity in a unique statistical model. OR of being obese decreased according to income (OR=0.72, 95%CI 0.59 to 0.86 for the highest-income vs the lowest-income group) and education level (OR=0.53, 95%CI 0.45 to 0.61 for the highest vs the lowest education level). These ORs remained unchanged when in the model diet quality (measured as Mediterranean scores) was included. Moreover, the association between income or education and obesity was equally observed in both the highest and lowest MD adherence categories as defined in tables 3 and 4 (the four terms for interactions among income or education with MDS or IMI were all p>0.35).

**DISCUSSION**

People with a 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 IMI), and the a posteriori dietary patterns derived from the PCA. Evidence on the health benefits of the MD is based on several studies and meta-analyses.<sup>1 7 21</sup> However, adherence to this healthy eating pattern is rapidly disappearing in the countries of Southern Europe where it originated and persisted for centuries, including the areas of Northern Africa in which there is an increasing prevalence of metabolic disorders and consequent CVD mainly owing to the changing lifestyle and/or habits.<sup>22</sup> SES 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.<sup>23</sup>

Our results agree with the conclusions reported in the review by Darmon and Drewnowski<sup>10</sup> that higher-quality diets are mainly consumed by better educated and more affluent people, while lower socioeconomic groups tend to have lower-quality diets thus exposing themselves to a

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

	Income categories				p Value*
	<10 000	>10 000 <25 000	>25 000 <40 000	>40 000	
Lower Education (n=6101, 46.0%)	(n=829)	(n=3745)	(n=1260)	(n=267)	
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=5236, 39.5%)	(n=137)	(n=1746)	(n=2184)	(n=1169)	
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)	<0.0001
Higher Education (n=1922, 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 Values adjusted for sex, age, energy intake, body mass index, physical activity, smoking, alcohol consumption and marital status.

higher risk of developing diet-related diseases. Similar conclusions were reached by other investigations too<sup>24</sup> suggesting that low socioeconomic groups end up 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.<sup>9</sup> Indeed researchers in Spain showed that an 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.<sup>9</sup> Aggarwal *et al*<sup>25</sup> demonstrated that the well-known socioeconomic disparities in diet quality is mediated by the 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 a previous CVD that could represent an exceptional return on investment.<sup>26</sup>

Subjects with a lower income had a greater prevalence of obesity too. The association between obesity and socioeconomic factors has been previously observed<sup>27</sup> suggesting that the latter plays an important role in the risk of obesity and overweight not only in adults but also in children.<sup>28</sup> However, our data show that the strong association observed between a lower income or education with obesity was not mediated by the 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 different income and education categories appear not necessarily mediated by diet quality. However, the epidemiological evidence supporting a causal link between MDs and body weight is contrasting.<sup>29</sup>

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 for the assumption that dietary habits are strongly influenced by socioeconomic factors, in particular by income which appears to play an important role in determining people's food choices.<sup>30</sup> As far as education is concerned, previous studies found a relationship between higher levels of education and healthy diets.<sup>31</sup> In our research, education was found to be independently associated to MD and did not modify the association between income levels and a 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 taken the top position in the priority list of the public health experts all over the world since obesity has become a life-threatening epidemic. So far the traditional MD has proven to be an effective 'remedy' to the spreading of

major chronic diseases, 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 a large non-respondent group is very common in this type of investigations, especially among women and the elderly.<sup>32</sup> However, there was no difference between the entire Moli-sani population and the subsample analysed here as far as dietary habits and socioeconomic 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.<sup>13</sup> Yet, the main characteristics of our population sample are comparable to those of the Italian Cardiovascular Epidemiological Observatory,<sup>33</sup> a large survey including random samples of the general population recruited all over Italy; therefore our sample can be considered a representative at least of the whole Italian population.

### Strengths of this study

Our very large population sample is composed of subjects coming from quite a homogeneous environment with no marked differences in terms of socioeconomic disparities, different from metropolitan areas, where previous studies found huge gaps among social classes and related health statuses at relatively small distances from the city centre.<sup>34</sup> Bearing this in mind, the differences we observed in the adherence to MD according to income indicate that also in an environment homogeneous both for genetics and lifestyles, income and education can still play a role in influencing dietary choices. Furthermore, the 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, while the 'richest' group is composed of subjects with more than 40 000 Euro/net/year. Such differences among income classes are quite restrained and recall what has already been 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 an 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 IMI), and the a posteriori dietary patterns derived from the PCA. This leads to overcoming 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 a discussion on healthy food accessibility in terms of economic costs. The cost of an MD seem to represent a real obstacle to a 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,<sup>10</sup> the promotion of high-cost foods to low-income people without taking food costs into account is not likely to be successful.

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