



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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4 **Low income is associated with poor adherence to Mediterranean Diet and higher prevalence**
5 **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

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

For peer review only

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

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4 reinforce the assumption that encouraging people to adopt healthy eating behaviours is not just a
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6 matter of good willing but mainly an issue which should lead to concrete measures of intervention
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8 in terms of economic availability. Our study aimed also at evaluating a potential relationship
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10 between low-income and obesity or overweight.
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12 13 14 15 **MATERIAL AND METHODS**

16 17 **Study population**

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19 The Moli-sani Project is a population-based cohort study which randomly recruited 24,325 citizens
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21 of the Molise, a region placed between Central and Southern Italy. Between March 2005 and April
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23 2010, the study enrolled men and women aged ≥ 35 years, randomly recruited from subjects
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25 included in the city-hall registries of Molise (10). Exclusion criteria were pregnancy, disturbances
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27 in understanding/ willing processes, ongoing poly-traumas or coma, refusal to sign the informed
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29 consent.
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33 After exclusion of subjects reporting cardiovascular disease (5.7%), cancer (3.1%) or diabetes
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35 (6.0%) and of those for whom there were no information available on income (30.7%) because they
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37 refused to answer or did not know about this issue, 13,262 subjects were analysed. The latter
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39 subjects were comparable with the whole Moli-sani Project population in terms of Mediterranean
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41 dietary patterns and socio-economic features, whereas mean age of the sample was slightly lower
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43 (53.3 ± 11 vs 55.0 ± 12) and had a higher prevalence of men (50% vs 48%) compared with the
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45 whole population.
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48 49 50 **Dietary information**

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52 The validated Italian EPIC food frequency questionnaire was used to determine food intake (11,
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54 12). The questionnaire, computerized with tailor-made software, allowed to interview participants
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56 in an interactive way, including illustrations of sample dishes of definite sizes or by reference to
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4 standard portion sizes. To simplify interpretation of data and to minimize within-person variations
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6 in intakes of individual foods, 188 food items were classified into 45 predefined food groups on the
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8 basis of similar nutrient characteristics or culinary usage (Appendix 2). (Web only file).

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

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14 Food consumption patterns were generated by using Principal Components Analysis (PCA)
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16 conducted on the correlation matrix of 45 food groups (13). Three main factors emerged, in
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18 agreement with previous findings in the same population (13) . The first pattern, identified as
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20 “Olive Oil and Vegetables”, was characterized by high positive loadings for olive oil, vegetables,
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22 legumes, soups, fruits and fish. The second pattern, named “Pasta and Meat”, was characterized by
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24 high positive loadings for pasta, cooked tomatoes, red meat, animal fats and alcoholic beverages,
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26 and negative loadings of breakfast cereals and yogurt. The “Eggs and Sweets” pattern was
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28 characterized by high positive loadings for eggs, margarines, processed meat and sugar and sweets.
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32 We evaluated the adherence to the Mediterranean diet by using the Mediterranean Diet Score
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34 (MDS) elaborated by Trichopoulou et al (14) which is obtained by assigning a value of 0 or 1 to
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36 each of 9 indicated components (vegetables, legumes, fruits, cereals, fish, meat, dietary products,
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38 ethanol, lipids) with the use of the sex-specific median as cut-off. The total Mediterranean- diet
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40 score ranged from 0, which indicates the minimal adherence to the traditional Mediterranean diet, to
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42 9, namely the maximal adherence.
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46 We also used the new Italian Mediterranean Index (IMI) whose score is based on the intake of 11
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48 items (pasta, vegetables, fruits, legumes, olive oil, fish, soft drinks, butter, red meat, and potatoes,
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50 alcohol) ranged from 0 to 11 (15). Such Italian Index was conceived to capture healthy eating in
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52 the context of foods typically available in Italy.
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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

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4 to people with living-in family members/room density \leq 0.6, no dwelling ownership or with
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6 unavailability of hot water. Education Level was divided in two categories: \leq 8 years of studies (0
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8 point) and $>$ 8 years of studies (1 point).
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10 11 12 13 **Statistical analysis**

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15 Values for continuous variables are means \pm Standard Deviation. CRP was transformed into natural
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17 logarithm to reduce positive skewness, but data were reported untransformed for clarity. Analysis of
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19 variance for continuous or categorical variables was applied to test the associations in Table 1.
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22 Multivariable analysis of variance was used for testing the association of adherence to
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24 Mediterranean diet scores, dietary patterns or dietary variables (considered as the dependent
25
26 variables) with categories of income or SES components. By using multivariable logistic regression
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28 analysis, odds ratio (ORs) with corresponding 95% confidence intervals (95% CI) were calculated
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30 to quantify the association of income or education levels with adherence to Mediterranean diet-like
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32 eating scores. High adherence to MD, as stated by the Medscore, was defined when the score was
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34 \geq 6 points whereas a low adherence when the score was \leq 3 points. Subjects with intermediate values
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36 (4 or 5 points) were excluded from this analysis in order to focus on the two extreme categories of
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38 adherence. The same was done for the IMI score but the cut-off was \geq 5 for the higher adherence or
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40 \leq 3 for the lower adherence category.
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44 The data analysis was generated using SAS/STAT software, Version 9.1.3 of the SAS System for
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46 Windows©2009. SAS Institute Inc. and SAS are registered trademarks of SAS Institute Inc., Cary,
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48 NC, USA.
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50 51 52 53 **RESULTS**

54 55 **Income groups** 56 57 58 59 60

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4 Table 1 shows the characteristics of the whole population by income categories. People in the
5
6 uppermost income group were 53.5% men and showed a better health profile, having significantly
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8 lower values of BMI, systolic blood pressure, C-reactive protein, triglycerides, blood glucose.

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10 Obesity prevalence (BMI > 30 Kg/m²) differed according to income; it was higher in the lowest-
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12 income group (36%) and lower in the highest- income category (20%, p <.0001 Tab. 1).

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

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

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

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28 In addition, analysis of single foods consumption by income categories showed that people with the
29
30 higher income reported higher intake of the basic components of the Mediterranean diet, that is fish,
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32 fruits, legumes and reduced consumption of animal fats, processed meat, white meat whose frequent
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34 consumption is more typical of a Western dietary model.

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37 The odds of having highest adherence to the Mediterranean diet, that raised both with MDS and
38
39 IMI scores, clearly increased according to income levels (Tab. 4). People having the highest income
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41 had 56% (MDS) or 68% (IMI) statistically significant higher probability to stick to a
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43 Mediterranean diet-like eating pattern than those in the lowest income group (Tab. 4).

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

51 52 53 54 55 **Socio-economic status and education**

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4 People in the highest SES category showed a higher adherence to IMI ($p = 0.0042$) whereas no
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6 difference was found in relation to the MDS ($p = 0.82$). Higher education (> 8 years) was associated
7
8 with higher adherence as well (Tab. 3).
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10 Odds for association of higher education with higher adherence to MDS or IMI were 1.22 and 1.20
11
12 respectively ($p < 0.0024$). ORs were adjusted for sex, age, energy intake, BMI, physical activity,
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14 smoking, alcohol consumption (Tab. 4).
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20 **Stratification by education**

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22 As less educated people may show lower adherence because of lack of knowledge about healthy
23
24 habits (18), we performed additional analyses stratified for educational level.
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26 Both in higher (>8 years of studies) and lower (≤ 8) educated groups adherence to
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28 Mediterranean diet (evaluated both by IMI and MDS score) followed the gradient of income
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30 categories (Tab. 5).
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35 **DISCUSSION**

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37 We found that people with higher income and higher levels of education have a greater adherence to
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39 Mediterranean diet-like eating patterns, as measured by three different parameters: two *a priori*
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41 Mediterranean scores (the traditional one introduced by Trichopoulou and a novel Italian
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43 Mediterranean index), and the *a posteriori* dietary patterns derived from principal components
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45 analysis. Evidence on the health benefits of the Mediterranean diet is based on several studies and
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47 meta-analyses (1, 2,18). However, adherence to this healthy eating pattern is rapidly disappearing in
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49 the countries of Southern Europe where it originated and persisted during centuries, including the
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51 areas of Northern Africa in which there is an increasing prevalence of metabolic disorders and
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53 consequent cardiovascular disease mainly due to the changing in lifestyle habits (19). Socio-
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55 economic status has been included among the factors related to chronic disease onset, and
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4 disparities in dietary habits by social class have been advocated to explain at least in part the higher
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6 CVD risk factors profile observed among low SES groups (20).
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9 Our results agree with what reported in the review by Darmon et al. (7) that higher-quality diets are
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11 mainly consumed by better educated and more affluent people while lower socio-economic groups
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13 tend to have lower quality diets thus exposing themselves to a higher risk to develop diet-related
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15 diseases. Similar conclusions were reached by other investigations (21) suggesting that low socio-
16
17 economic groups end with having poorer diets. These findings could be supported, at least in part,
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19 by the increasing prices of some of the key foods of the MD (6). Indeed researchers in Spain
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21 showed that Mediterranean diet is definitely more expensive to follow than western dietary patterns
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23 suggesting that this may represent a strong economic obstacle to be considered when counselling
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25 people about the opportunity to follow a healthy diet because cost may become a prohibitive factor
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27 (6). Aggrawal et al. (22) demonstrated that the well-known socio-economic disparities in diet
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29 quality is mediated by food cost confirming that lower SES groups tend to consume more energy
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31 dense and nutrient poor diets.
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35 We have also found that subjects with lower income have also a greater prevalence of obesity. The
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37 association between obesity and SES has been already highlighted by previous studies (23)
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39 ascribing to SES an important role in determining the risk of obesity and overweight not only in
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41 adults but also in children (24). Our data suggest that the strong association observed between lower
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43 income and SES levels could be partially mediated by poor adherence to healthy dietary pattern
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45 recorded in the lowest socio-economic groups which reported lower values with both the
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47 Mediterranean scores.
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51 It is quite clear that accumulating proofs on the benefits of Mediterranean- like diets could no
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53 longer be the only task of prevention strategies which should also try to set the conditions allowing
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55 people to stick to healthier dietary habits.
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4 This study contributes to provide further evidence to the assumption that dietary habits are strongly
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6 influenced by socio-economic status, in particular by income which appears to play an important
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8 role in determining people's eating choices. For what concerns education, previous studies found a
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10 relationship between higher levels of education and healthy diets (25). In our research, education
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12 resulted to be independently associated to Mediterranean diet and did not modify the association
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14 between income levels and healthy dietary pattern as shown in the stratified analysis by education
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16 levels.
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19 The promotion of healthy lifestyles and diets to prevent weight gain and related diseases has
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21 jumped to the top of the priority list of the public health experts all over the world since obesity has
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23 become a threatening epidemic. So far the traditional Mediterranean diet has proven to be an
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25 effective "remedy" to the spreading of the major chronic disease, obesity and mortality. Our study
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27 highlights the strong linkage among low income, poor adherence to MD and consequent obesity
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29 prevalence.
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32 We started our study wondering about what makes so hard for people to choose healthy food
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34 instead of bad products, putting at risk their own health. We excluded it could be just a matter of
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36 personal choice or taste, neither an issue related to the lack of knowledge about the healthy benefits
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38 of MD worldwide recognized and also well disseminated in the lay press.
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44 **Limitations of this study**

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46 A major limitation of the present study is that people self-reported their own income which is a
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48 quite sensitive issue. Indeed we recorded a high percentage (30.7%) of non-respondent subjects
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50 who refused to declare or did not know their personal income. Such large non-respondent group is
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52 very common in this type of investigation, especially for women and elderly (26). However, there
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54 was no difference between the whole Moli-sani population and the subsample used for the present
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56 analysis in dietary habits and socio-economic variables. Moreover, we also evaluated other
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4 economic variables, less prone to reporting bias, that showed similar association with
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6 Mediterranean indices and dietary patterns.
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8 Another inherent limit is represented by the cross-sectional nature of our study.
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10 In addition, caution is needed in extending the results presented here to larger contexts since data
11 were collected in a region located between Central and Southern Italy, Mediterranean by tradition
12 and culture (10). Yet, the main characteristics of our sample are comparable to those of the Italian
13 Cardiovascular Epidemiological Observatory (27) a large survey including random samples of the
14 general population all over Italy; therefore our sample could be considered representative at least of
15 the Italian population.
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24 25 26 **Strengths of this study** 27

28 Our population sample is made of subjects coming from a quite homogenous environment with no
29 marked differences in terms of socioeconomic disparities, differently from metropolitan areas,
30 where previous studies have found huge gaps among social classes and related health status at
31 relatively small distances from the city centre (28). Bearing this in mind, the differences we
32 observed in the adherence to Mediterranean diet according to income indicate that also in a
33 homogeneous environment, both for genetic and lifestyles, income and education can still play a
34 role in influencing dietary choices. Furthermore, diet quality showed a continued improvement
35 across a relatively small range of economic strata. Our “poorest” are represented by people earning
36 less than 10,000 euro/gross per year whilst the “richest” group is made of subjects with more than
37 40,000 euro/gross per year. Such differences among income classes are quite restrained and recall
38 what already said for the pretty homogeneous environment where our sample comes from. We are
39 not dealing with real huge differences both for socioeconomic and income issues. Despite this
40 homogeneity, we did note notable changes in diet quality among the groups.
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4 The differences we observed across the income strata would likely become even more evident in
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6 Mediterranean importing countries where getting typical Mediterranean diet products is more
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8 difficult and expensive.
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11 In addition, for the first time this topic was addressed by using two *a priori* Mediterranean scores
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13 (the traditional one introduced by Trichopoulou and a novel Italian Mediterranean index), and the *a*
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15 *posteriori* dietary patterns derived from principal components analysis.
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18 19 20 **CONCLUSION**

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22 Our data clearly indicate that eating “mediterraneanly” is also, if not mainly, a matter of healthy
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24 food accessibility in terms of economic costs. The increasing prices of the basic Mediterranean food
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26 items seem to represent a real obstacle to healthy diet driving people to choose alternative ways of
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28 eating usually inspired by the need to save money in everyday life. Public health policies shall take
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30 into account the fact that correct dietary habits need to be promoted by allowing people to choose
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32 the best for their own health. It is definitely an interdisciplinary issue which shall call to action
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34 every single actor of modern societies otherwise condemned to increase their already heavy burden
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36 of chronic diseases. As already noted by others who dealt with this topic, the promotion of high-
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38 cost foods to low-income people without taking food costs into account is not likely to be successful
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Table 1 Characteristics of the whole population and by four income categories

	Income Categories					P value*
	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%)	
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, %						
<i>Never</i>	6370 (48.1%)	558 (56.9%)	2838 (49.4%)	1901 (46.2%)	1073 (44.5%)	<.0001
<i>Current</i>	3296 (25.0%)	222 (22.6%)	1418 (24.7%)	1060 (25.8%)	596 (24.7%)	
<i>Former</i>	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			P value*	Educational levels		P value*
	Low (n=4081, 31.8%)	Low-medium (n=3955, 30.8%)	High (n=4803, 37.4%)		<= 8 years (n = 6098, 46%)	> 8 years (n=7158, 54%)	
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, %							
<i>Never</i>	1880 (46.1%)	1961 (49.6%)	2320 (48.3%)	0.0002	3047 (50.0%)	3321 (46.4%)	<.0001
<i>Current</i>	1049 (25.7%)	910 (23.0%)	1227 (25.6%)		1456 (23.9%)	1839 (25.7%)	
<i>Former</i>	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 (n=3843)	High (n=3518)	OR	(95%CI)	Low (n=4704)	High (n=3089)	OR	(95%CI)
Income								
< 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				P value *
	< 10,000	> 10,000 < 25,000	> 25,000 < 40,000	> 40,000	
Higher Education (n = 7158)	(n=150)	(n=2004)	(n=2860)	(n=2144)	
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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4 **CONTRIBUTORS:** (MB, AB, LI designed the research; FDL, MB, managed data collection; MB,
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6 ADC analyzed the data; MB, AB wrote the paper, MBD, GdG, LI originally inspired the research,
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8 obtained the financial support and critically reviewed the manuscript). All Authors had full access
9
10 to all of the data in the study and take responsibility for the integrity of the data and the accuracy of
11
12 the data analysis. None of the Authors had a personal or financial conflict of interest.
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14

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25 in study design, collection, analysis, and interpretation of data; in the writing of the report; and in
26
27 the decision to submit the article for publication.
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30 All Authors are independent from funders.
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33 34 35 **COMPETING INTEREST**

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37 None
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44 University of Rome. Participants signed the informed consent before taking part in the study.
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48 **DATA SHARING:** no additional data available.
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APPENDIX 1

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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, pickled 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

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3		
4	Offals	Liver, offals
5		
6	Canned fish	Canned tuna fish and other fish
7		
8	Crustaceans,	
9	molluscs	Crustaceans, molluscs
10		
11	Fish	Other fish
12		
13	Egg	Eggs
14		
15	Vegetables oils	Seed oils (except olive oils)
16		
17	Olive oil	Olive oil
18		
19	Butter	Butter
20		
21	Margarines	Margarines
22		
23	Animal fats	Visible fat from meat, poultry skin, fat from ham
24		
25	Sugar & sweets	Sugar, honey, cakes, ice cream, confections, pastry, pudding
26		
27	Fruit juices	Orange juice, grapefruit juices, other fruit juices
28		
29	Soft drinks	Soft drinks
30		
31	Coffee	Coffee
32		
33	Tea	Tea
34		
35	Other sauces	Dressing sauces for pasta other than tomato sauce
36		
37	Mayonnaises	Mayonnaises
38		
39	Soups	Vegetable soups
40		
41	Bouillon	Meat and stock-cube broth
42		
43	Snacks	Vegetable quiche
44		
45	Pizza	Pizza
46		
47	Wine	Red wine, rosé wine, white wine
48		
49	Spirits	Alcoholic beverages other than wine or beer
50		
51	Beer	Beer

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

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

		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	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Yes		
Discussion		
Key results	18	Summarise key results with reference to study objectives
Yes		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Yes		
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Yes		
Generalisability	21	Discuss the generalisability (external validity) of the study results
Yes		
Other information		
Funding	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
Yes		

*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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4 **Low income is associated with poor adherence to Mediterranean Diet and higher prevalence**
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6 **of obesity: cross-sectional results from the Moli-sani study**
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9

10 Marialaura Bonaccio, research fellow*§, Americo Bonanni, research fellow *, Augusto Di
11 Castelnuovo, postdoctoral researcher**, Francesca De Lucia, postdoctoral researcher*, Maria
12 Benedetta Donati, scientific coordinator***§, Giovanni de Gaetano, head of department***§ and
13 Licia Iacoviello, head of laboratory**§ on behalf of the Moli-sani Project Investigators°
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28 °MOLI-SANI Project Investigators are listed in the Appendix 1 (Web only file)
29
30
31
32

33 **Keywords:** Obesity; Diet, Mediterranean; Social Class; Public Health; Cardiovascular Diseases
34

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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).

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4 The aim of the present study was to examine cross-sectional associations of socio-economic status
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6 (i.e., income and education) with adherence to a Mediterranean dietary pattern, with the perspective
7
8 that encouraging people to adopt healthy eating behaviours would not be just a matter of good
9
10 willing but mainly an issue to develop concrete measures of intervention in terms of economic
11
12 availability. Moreover, our study investigated a potential relationship between low-income,
13
14 Mediterranean diet and obesity.
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19

20 MATERIAL AND METHODS

21 Study population

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23 The Moli-sani Project is a population-based cohort study which randomly recruited 24,325 citizens
24
25 of the Molise, a region placed between Central and Southern Italy. Between March 2005 and April
26
27 2010, the study enrolled men and women aged ≥ 35 years, randomly recruited from subjects
28
29 included in the city-hall registries of Molise (13). Exclusion criteria were pregnancy, disturbances
30
31 in understanding/ willing processes, ongoing poly-traumas or coma, refusal to sign the informed
32
33 consent. The cohort will be followed-up for incident cardiovascular and tumor events.
34
35
36

37 After exclusion of subjects reporting personal history of cardiovascular disease (angina, myocardial
38
39 infarction, heart failure, revascularization procedures and stroke) (5.7%), cancer (3.1%) or diabetes
40
41 (6.0%) and of those for whom there were no information available on income (30.7%) mainly
42
43 because they refused to answer or did not possess any reliable information on this issue, 13,262
44
45 subjects were analysed. The latter were comparable with the whole Moli-sani Project population in
46
47 terms of Mediterranean dietary patterns and socio-economic features, whereas mean age of the
48
49 sample was slightly lower (53.3 ± 11 vs 55.0 ± 12) and had a higher prevalence of men (50% vs
50
51 48%) compared with the whole population sample.
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56 Dietary information

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4 The validated Italian EPIC food frequency questionnaire was used to evaluate food intake (14, 15).

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6 The questionnaire, computerized with tailor-made software, allowed to interview participants in an
7
8 interactive way, including illustrations of sample dishes of definite sizes or by reference to standard
9
10 portion sizes. To simplify interpretation of data and to minimize within-person variations in intakes
11
12 of individual foods, 188 food items were classified into 45 predefined food groups on the basis of
13
14 similar nutrient characteristics or culinary usage (Appendix 2). (Web only file).

15
16
17 Moderate alcohol intake was defined as regularly drinking less than two or one drinks a day, by
18
19 men and women, respectively.
20

21
22 Food consumption patterns were generated by using Principal Components Analysis (PCA)
23
24 conducted on the correlation matrix of 45 food groups (16). Three main factors emerged, in
25
26 agreement with previous findings in the same population (16). The first pattern, identified as “Olive
27
28 Oil and Vegetables”, was characterized by high positive loadings for olive oil, vegetables, legumes,
29
30 soups, fruits and fish. The second pattern, named “Pasta and Meat”, was characterized by high
31
32 positive loadings for pasta, cooked tomatoes, red meat, animal fats and alcoholic beverages, and
33
34 negative loadings of breakfast cereals and yogurt. The “Eggs and Sweets” pattern was
35
36 characterized by high positive loadings for eggs, margarines, processed meat and sugar and sweets.
37
38

39 We evaluated the adherence to the Mediterranean diet by using the Mediterranean Diet Score
40
41 (MDS) elaborated by Trichopoulou et al (17). Scoring was based on the intake of the following 9
42
43 items: vegetables, legumes, fruit and nuts, dairy products, cereals, meat and meat products, fish,
44
45 alcohol, and the ratio of monounsaturated:saturated fat. For most items, consumption above the
46
47 study median received 1 point; all other intakes received 0 points. For dairy products, meat and
48
49 meat products, consumption below the median received 1 point. Medians are gender specific. For
50
51 ethanol, men who consumed 10–50 gr/day and women who consumed 5–25 gr/day received 1
52
53 point; otherwise, the score was 0. The possible scores ranged between 0 and 9, the latter reflecting
54
55 the maximal adherence.
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4 We also used a new Italian Mediterranean Index (IMI) whose score is based on the intake of 11
5
6 items: high intake of 6 typical Mediterranean foods (pasta; typical Mediterranean vegetables such as
7
8 raw tomatoes, leafy vegetables, onion, and garlic, salad, and fruiting vegetables; fruit; legumes;
9
10 olive oil; and fish); low intake of 4 non-Mediterranean foods (soft drinks, butter, red meat, and
11
12 potatoes); and alcohol consumption. If consumption of typical Mediterranean foods was in the 3rd
13
14 tertile of the distribution, the person received 1 point; all other intakes received 0 points. If
15
16 consumption of non-Mediterranean foods was in the first tertile of the distribution, the person
17
18 received 1 point. Ethanol received 1 point for intake up to 12 gr/day; abstainers and persons who
19
20 consumed >12 gr/day received 0 points. Possible scores ranged from 0 to 11(18). Such Italian
21
22 Index was conceived to better capture healthy eating including foods, such as pasta, more typically
23
24 available in Italy.
25
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30

31 **Data collection**

32
33 Body Mass Index (BMI) was calculated as kg/m^2 . Waist circumferences were measured according
34
35 to the NIH, Heart, Lung, and Blood guidelines (19). Blood pressure was measured by an automatic
36
37 device (OMRON-HEM-705CP) three times on the non-dominant arm, with the patient lying down
38
39 for about 5 minutes. Hypertension was defined as systolic $\text{BP} \geq 160$ mm Hg and/or diastolic $\text{BP} \geq 95$
40
41 mm Hg, or using pharmacological treatment. Physical activity was assessed by a structured
42
43 questionnaire (24 questions on working and leisure time and sport participation) and expressed as
44
45 daily energy expenditure in metabolic equivalent task-hours (MET/d).
46
47

48
49 Serum lipids and glucose were assayed by enzymatic reaction methods using an automatic analyzer
50
51 (ILab 350, Instrumentation Laboratory (IL), Milan, Italy). LDL-cholesterol was calculated
52
53 according to Friedewald. High sensitivity C reactive protein (CRP) was measured in fresh serum, by
54
55 a latex particle-enhanced immunoturbidimetric assay (IL Coagulation Systems on ACL9000). Inter-
56
57 and intra-day CV were 5.5% and 4.17%, respectively.
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60

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 \pm 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

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4 dependent variables) with categories of income or SES components. By using multivariable logistic
5
6 regression analysis (with appropriate terms for interaction), odds ratio (ORs) with corresponding
7
8 95% confidence intervals (95% CI) were calculated to quantify the association of income or
9
10 education levels with adherence to MD-like eating scores or obesity. High adherence to MD, as
11
12 stated by the Medscore, was defined when the score was ≥ 6 points whereas a low adherence when
13
14 the score was ≤ 3 points. Subjects with intermediate values (4 or 5 points) were excluded from this
15
16 analysis in order to focus on the two extreme categories of adherence. The same was done for the
17
18 IMI score, but the cut-off was ≥ 5 for the higher adherence or ≤ 3 for the lower adherence category.
19
20 The data analysis was generated using SAS/STAT software, Version 9.1.3 of the SAS System for
21
22 Windows©2009. SAS Institute Inc. and SAS are registered trademarks of SAS Institute Inc., Cary,
23
24 NC, USA.
25
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31 RESULTS

32 Income groups

33
34 Table 1 shows the characteristics of the whole population by income categories. People in the
35
36 uppermost income group were 53.5% men and showed a better health profile, having significantly
37
38 lower values of BMI, systolic blood pressure, C-reactive protein, triglycerides and blood glucose.
39
40 Obesity prevalence ($\text{BMI} > 30 \text{ Kg/m}^2$) differed according to income; it was higher in the lowest-
41
42 income group (36%) and lower in the highest- income category (20%, $p < .0001$ Tab. 1).
43
44

45
46 In Table 2 the association among income levels, dietary habits and single food groups are reported.
47
48 Higher income groups were significantly associated with greater adherence to both score indexes,
49
50 namely MDS ($p < .0001$) and IMI ($p < .0001$) in the model adjusted for age, sex, daily energy intake,
51
52 BMI, physical activity, smoking, alcohol consumption and marital status.
53
54

55
56 Similar data were obtained after stratification by gender (p for interaction=0.24 for MDS and p for
57
58 interaction =0.41 for IMI) and age (p for interaction=0.43 for IMI). However, the increasing
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4 adherence to MD according to income was more pronounced in the elderly when it was measured as
5
6 MSD (p for interaction=0.0002 ; $\beta = 0.063$, SE±0.021, p=0.0028 for people ≤ 65 years and $\beta =$
7
8 0.17, SE±0.051, p =0.0008, for people > 65 years).

9
10 Subjects in the lower income categories showed poor adherence to the Olive oil and Vegetables
11
12 dietary pattern (p<.0001) whereas a greater adherence to the Western type pattern (Dietary pattern
13
14 3) was observed. Similar results were observed after stratification for gender and age (data not
15
16 shown).
17
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19

20
21 In addition, analysis of single foods consumption by income categories showed that people with the
22
23 higher income reported higher intake of the basic components of the MD, that is fish, fruits,
24
25 legumes and reduced consumption of animal fats, processed meat and white meat whose frequent
26
27 consumption is more typical of a Western dietary model.
28
29

30
31 The odds of having highest adherence to the MD, that raised with both MDS and IMI scores, clearly
32
33 increased according to income levels (Tab. 3). People having the highest income had 54% (MDS)
34
35 or 72% (IMI) statistically significant higher probability to stick to a MD-like eating pattern than
36
37 those in the lowest income group (Tab. 3).
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39

40
41 Regarding alcohol consumption (Tab.2), the highest income group appeared to include the highest
42
43 prevalence of moderate drinkers (41.7% versus 27.5% recorded in the lowest income group) as
44
45 already found on a sample of Danish population (17).
46
47

48 **Socio-economic status and education**

49
50 Income fairly correlated with SES (Spearman correlation coefficients = 0.24, p< 0.0001) and
51
52 education (r=0.51, p<0.0001) whereas correlation between SES and education was r=0.34,
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54 p<0.0001.
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4 Education was positively associated with adherence to MD, measured by both MDS ($p=0.034$) and
5
6 IMI ($p=0.0014$), while SES was not ($p=0.19$ for MDS and $p=0.78$ for IMI) in the fully adjusted
7
8 model also including education and income.
9

10
11 Odds of having higher adherence according to education levels were 1.26 and 1.27 (p for
12
13 trend= 0.0020) for MDS and 1.16 and 1.33 (p for trend= 0.0009) for IMI (Tab.4).
14

15 16 17 **Stratification by education**

18
19 As less educated people may show lower adherence because of lack of knowledge about healthy
20
21 habits (21), we performed additional analyses stratified for educational level.
22

23
24 Either in lower (≤ 8), medium (>8 and ≤ 13) and higher (>13 years of studies) educated groups
25
26 adherence to Mediterranean diet followed the gradient of income categories (Tab. 4), with the
27
28 exception of the uppermost educated group, when the MDS score was used ($p=0,067$). However
29
30 the interaction test was not significant for either score. Accordingly, education was related to
31
32 dietary pattern independently from income. Indeed, by dividing income levels into two main
33
34 categories (low and low-medium VS high and high-medium), in the fully adjusted model, education
35
36 was positively associated with dietary patterns both in the lowest (MDS: $p=0.032$ and IMI:
37
38 $p=0.0025$) and in the highest income group (MDS: $p=0.0067$ and IMI: $p=0.0010$).
39
40
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42
43

44 **Income/education, Mediterranean diet and obesity**

45
46 Finally, we evaluated the association of income and education on diet quality and then on obesity in
47
48 a unique statistical model. Odds ratio of having obesity decreased according to income (OR= 0.72 ,
49
50 95%CI: 0.59 to 0.86 for highest versus lowest income group) and education level (OR= 0.53 ,
51
52 95%CI: 0.45 to 0.61 for highest versus lowest education level). These odds ratios remained
53
54 unchanged when in the model diet quality (measured as Mediterranean scores) was included.
55
56 Moreover, the association between income or education with obesity was equally observed in both
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4 highest and lowest MD adherence categories as defined in Table 3 (the four terms for interactions
5
6 among income or education with MDS or IMI were all $p>0.35$).
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9 10 11 **DISCUSSION**

12
13 People with higher income and higher levels of education had a greater adherence to MD-like
14
15 eating patterns, as measured by three different parameters: two *a priori* Mediterranean scores (the
16
17 traditional one introduced by Trichopoulou and a more recent Italian Mediterranean index), and the
18
19 *a posteriori* dietary patterns derived from principal components analysis. Evidence on the health
20
21 benefits of the MD is based on several studies and meta-analyses (1,7,21). However, adherence to
22
23 this healthy eating pattern is rapidly disappearing in the countries of Southern Europe where it
24
25 originated and persisted during centuries, including the areas of Northern Africa in which there is an
26
27 increasing prevalence of metabolic disorders and consequent cardiovascular disease mainly due to
28
29 the changing in lifestyle habits (22). Socio-economic status has been included among the factors
30
31 related to chronic disease onset, and disparities in dietary habits by social class have been advocated
32
33 to explain at least in part the higher CVD risk factors profile observed among low SES groups (23).
34
35 Our results agree with the conclusions reported in the review by Darmon et al. (10) that higher-
36
37 quality diets are mainly consumed by better educated and more affluent people while lower socio-
38
39 economic groups tend to have lower quality diets thus exposing themselves to a higher risk to
40
41 develop diet-related diseases. Similar conclusions were reached by other investigations too (24)
42
43 suggesting that low socio-economic groups end with having poorer diets. These findings are
44
45 supported, at least in part, by the fact that following a Mediterranean dietary style could represent a
46
47 matter of money (9). Indeed researchers in Spain showed that MD is definitely more expensive to
48
49 follow than Western dietary patterns: this may represent a strong economic obstacle when
50
51 counselling people about the opportunity to follow a healthy diet because cost may become a
52
53 prohibitive factor (9). Aggrawal et al. (25) demonstrated that the well-known socio-economic
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4 disparities in diet quality is mediated by food cost confirming that lower SES groups tend to
5
6 consume more energy dense and nutrient poor diets. However, the economic advantages of a
7
8 Mediterranean way of eating in terms of cost-effectiveness should be highlighted as shown in
9
10 patients with previous CVD, that could represent an exceptional return on investment (26).
11
12 Subjects with lower income had a greater prevalence of obesity too. The association between
13
14 obesity and socioeconomic factors has been previously observed (27) suggesting that the latter play
15
16 an important role in the risk of obesity and overweight not only in adults but also in children (28).
17
18 However our data show that the strong association observed between lower income or education
19
20 with obesity was not mediated by diet quality. Indeed, an additional analysis combining the impacts
21
22 of education or income on diet quality and then on obesity in a unique statistical model, showed that
23
24 the association remained unchanged when diet quality was included. According to these results, the
25
26 changes in obesity rates observed in the different income and education categories appear not
27
28 necessarily mediated by diet quality. However, the epidemiological evidence supporting a causal
29
30 link between Mediterranean diets and body weight is contrasting (29).
31
32 It is quite clear that accumulating proofs on the benefits of Mediterranean- like diets is an
33
34 insufficient prevention strategy as conditions allowing people to stick to healthier dietary habits
35
36 should also be clearly identified.
37
38 This study contributes to provide further evidence to the assumption that dietary habits are strongly
39
40 influenced by socio-economic factors, in particular by income which appears to play an important
41
42 role in determining people's eating choices (30). As far as education is concerned, previous studies
43
44 found a relationship between higher levels of education and healthy diets (31). In our research,
45
46 education resulted to be independently associated to MD and did not modify the association
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48 between income levels and healthy dietary pattern as shown in the stratified analysis by education
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50 levels.
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4 The promotion of healthy lifestyles and diets to prevent weight gain and related diseases has
5
6 jumped to the top of the priority list of the public health experts all over the world since obesity has
7
8 become a threatening epidemic. So far the traditional MD has proven to be an effective “remedy”
9
10 to the spreading of the major chronic disease, obesity and mortality. Our study highlights the strong
11
12 linkage among low income, poor adherence to MD and obesity prevalence.
13

14 15 16 17 **Limitations of this study**

18
19 A major limitation of the present study is that people self-reported their own income which is a
20
21 quite sensitive issue. Indeed we recorded a high percentage (30.7%) of non-respondent subjects
22
23 who refused to declare or did not know their family income. Yet such large non-respondent group is
24
25 very common in this type of investigation, especially among women and elderly (32) However,
26
27 there was no difference between the whole Moli-sani population and the subsample analyzed here
28
29 as far as dietary habits and socio-economic variables were concerned.
30
31

32
33 Another inherent limit is represented by the cross-sectional nature of our study.
34

35
36 In addition, caution is needed in extending the results presented here to larger contexts since data
37
38 were collected in a region located between Central and Southern Italy, Mediterranean by tradition
39
40 and culture (13). Yet, the main characteristics of our population sample are comparable to those of
41
42 the Italian Cardiovascular Epidemiological Observatory (33), a large survey including random
43
44 samples of the general population recruited all over Italy; therefore our sample can be considered
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46 representative at least of the whole Italian population.
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49 50 **Strengths of this study**

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52 Our very large population sample is made of subjects coming from a quite homogenous
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54 environment with no marked differences in terms of socioeconomic disparities, differently from
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56 metropolitan areas, where previous studies found huge gaps among social classes and related health
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4 status at relatively small distances from the city centre (34). Bearing this in mind, the differences we
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6 observed in the adherence to Mediterranean diet according to income indicate that also in a
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8 environment homogeneous both for genetic and lifestyles, income and education can still play a role
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10 in influencing dietary choices. Furthermore, diet quality showed a continued improvement across a
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12 relatively small range of economic strata. Our “poorest” are represented by people earning less than
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14 10,000 euro/net per year whilst the “richest” group is made of subjects with more than 40,000
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16 euro/net per year. Such differences among income classes are quite restrained and recall what
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18 already said for the pretty homogeneous environment where our sample comes from. We are not
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20 dealing with real huge socioeconomic and income differences. Despite this homogeneity, we did
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22 observe notable changes in diet quality among different groups.
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26 The differences observed across the income strata would likely become even more evident in MD
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28 importing countries where getting typical Mediterranean products is more difficult and expensive.
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30 In addition, apparently for the first time this topic was addressed by using two *a priori*
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32 Mediterranean scores (the traditional one introduced by Trichopoulou and a novel Italian
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34 Mediterranean index), and the *a posteriori* dietary patterns derived from principal components
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36 analysis. This leads to overcome the limitations each of these approaches may present. Indeed, the
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38 “a priori” scores only reflect some aspects of diet and do not account for correlations between score
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40 components. Instead, the “a posteriori” approaches have the weakness of low reproducibility,
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42 different populations having different non-predefined dietary patterns. Therefore, the use of an
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44 index based on the foods actually available to Italians and traditional Italian cooking styles should
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46 improve the ability of the index to classify the Italian cohort.
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55 CONCLUSIONS

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4 Our data suggest consistent associations of income and education with dietary patterns and may
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6 foster discussion on healthy food accessibility in terms of economic costs. The cost of MD seem to
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8 represent a real obstacle to healthy diet driving people to choose alternative ways of eating usually
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10 inspired by the need to save money in everyday life. Public health policies shall take into account
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12 the fact that correct dietary habits need to be promoted by allowing people to choose the best for
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14 their own health. It is definitely an interdisciplinary issue which shall call to action every single
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16 actor of modern societies otherwise condemned to increase their already heavy burden of chronic
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18 diseases. As already noted by others who dealt with this topic (10), the promotion of high-cost
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20 foods to low-income people without taking food costs into account is not likely to be successful.
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Table 1 Characteristics of the whole population as a whole and according to four income categories

	Income Categories					P value*
	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%)	
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, %						
<i>Never</i>	6,370 (48.1%)	558 (56.9%)	2,838 (49.4%)	1,901 (46.2%)	1,073 (44.5%)	<.0001
<i>Current</i>	3,296 (25.0%)	222 (22.6%)	1,418 (24.7%)	1,060 (25.8%)	596 (24.7%)	
<i>Former</i>	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					P value *
	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%)	
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			
	Low (n=3,843)	High (n=3,518)	OR	(95% CI)	Low (n=4704)	High (n=3089)	OR	(95% CI)
Income								
< 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				P value *
	< 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)	
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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4 **CONTRIBUTORS:** (MB, AB, LI designed the research; FDL, MB, managed data collection; MB,
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6 ADC analyzed the data; MB, AB wrote the paper, MBD, GdG, LI originally inspired the research,
7
8 obtained the financial support and critically reviewed the manuscript). All Authors had full access
9
10 to all data in the study and took responsibility for the integrity of the data and the accuracy of the
11
12 data analysis. None of the Authors had a personal or financial conflict of interest.
13
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29

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32

35 **COMPETING INTEREST**

36
37 None
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44 University of Rome. Participants signed the informed consent before taking part in the study.
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48 **DATA SHARING:** no additional data available.
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APPENDIX 1

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26 (till December 2008), Antonello Chiovitti (till March 2008), Federico Marracino (till December
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28 2007), Sergio Caccamo (till August 2006), Vanesa Caruso (till May 2006); *Electrocardiogram:*
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40 Sorella (till September 2008), Irene Di Stefano (till March 2008), Emanuela Plescia (till December
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42 2007), Alessandra Molinaro (till December 2006), and Christiana Cavone (till September 2005),
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44 (Campobasso and Termoli, Italy):
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50 **Call Center:** Giovanna Galuppo (till June 2009), Maura Di Lillo (till March 2009), Concetta
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52 Castaldi (till September 2008), Dolores D'Angelo (till May 2008) and Rosanna Ramacciato (till
53
54 May 2008) (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, pickled 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

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3		
4	Offals	Liver, offals
5		
6	Canned fish	Canned tuna fish and other fish
7		
8	Crustaceans,	
9	molluscs	Crustaceans, molluscs
10		
11	Fish	Other fish
12		
13	Egg	Eggs
14		
15	Vegetables oils	Seed oils (except olive oils)
16		
17	Olive oil	Olive oil
18		
19	Butter	Butter
20		
21	Margarines	Margarines
22		
23	Animal fats	Visible fat from meat, poultry skin, fat from ham
24		
25	Sugar & sweets	Sugar, honey, cakes, ice cream, confections, pastry, pudding
26		
27	Fruit juices	Orange juice, grapefruit juices, other fruit juices
28		
29	Soft drinks	Soft drinks
30		
31	Coffee	Coffee
32		
33	Tea	Tea
34		
35	Other sauces	Dressing sauces for pasta other than tomato sauce
36		
37	Mayonnaises	Mayonnaises
38		
39	Soups	Vegetable soups
40		
41	Bouillon	Meat and stock-cube broth
42		
43	Snacks	Vegetable quiche
44		
45	Pizza	Pizza
46		
47	Wine	Red wine, rosé wine, white wine
48		
49	Spirits	Alcoholic beverages other than wine or beer
50		
51	Beer	Beer
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STROBE Statement—Checklist of items that should be included in reports of *cross-sectional studies*

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

		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	17	Report other analyses done—eg analyses of subgroups and interactions, and sensitivity analyses
Yes		
Discussion		
Key results	18	Summarise key results with reference to study objectives
Yes		
Limitations	19	Discuss limitations of the study, taking into account sources of potential bias or imprecision. Discuss both direction and magnitude of any potential bias
Yes		
Interpretation	20	Give a cautious overall interpretation of results considering objectives, limitations, multiplicity of analyses, results from similar studies, and other relevant evidence
Yes		
Generalisability	21	Discuss the generalisability (external validity) of the study results
Yes		
Other information		
Funding	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
Yes		

*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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4 **Low income is associated with poor adherence to Mediterranean Diet and higher prevalence**
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6 **of obesity: cross-sectional results from the Moli-sani study**
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11 Marialaura Bonaccio, research fellow*§, Americo Bonanni, research fellow *, Augusto Di
12 Castelnuovo, postdoctoral researcher**, Francesca De Lucia, postdoctoral researcher*, Maria
13 Benedetta Donati, scientific coordinator***§, Giovanni de Gaetano, head of department***§ and
14 Licia Iacoviello, head of laboratory**§ on behalf of the Moli-sani Project Investigators°
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23

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25
26 86100 Campobasso and §Epicomed Research, 86100 Campobasso, Italy
27

28 °MOLI-SANI Project Investigators are listed in the Appendix 1 (Web only file)
29
30
31
32

33 **Keywords:** Obesity; Diet, Mediterranean; Social Class; Public Health; Cardiovascular Diseases
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35 **Word count:** 3,770
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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 546% (95% CI: 214% to 976%, MDS) or 6872% (95% CI: 343% to 112121%, 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.~~

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4 **Conclusions:** Higher income and education are [independently](#) associated with greater adherence to
5
6 Mediterranean diet-like eating patterns and lower prevalence of obesity. ~~The increasing prices of the~~
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8 ~~basic Mediterranean food items seem to represent a real obstacle to healthy diet driving people to~~
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10 ~~choose alternative ways of eating usually inspired by the need to save money in everyday life.~~
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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). ~~And 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).

~~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

1
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4 diet cost and obesity, finding out that higher adherence to healthy dietary patterns is linked to higher
5
6 monetary costs and is inversely associated with BMI and obesity (12).
7

8
9 The aim of the present study was to ~~assess-examine cross-sectional associations of socio-economic~~
10 ~~status (i.e., income and education) with adherence to a Mediterranean dietary pattern~~~~possible~~
11 ~~differences in eating patterns among adult Italians with different socio-economic status, with~~
12 ~~particular focus on low income, with the perspective that in order to reinforce the assumption that~~
13 encouraging people to adopt healthy eating behaviours would not be just a matter of good willing
14
15 but mainly an issue ~~to develop which should lead to~~ concrete measures of intervention in terms of
16 economic availability. ~~Moreover, Our-our~~ study ~~aimed also at evaluating~~~~investigated~~ a potential
17 relationship between low-income, Mediterranean diet and obesity.
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29 MATERIAL AND METHODS

30 Study population

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32 The Moli-sani Project is a population-based cohort study which randomly recruited 24,325 citizens
33 of the Molise, a region placed between Central and Southern Italy. Between March 2005 and April
34 2010, the study enrolled men and women aged ≥ 35 years, randomly recruited from subjects
35 included in the city-hall registries of Molise (13). Exclusion criteria were pregnancy, disturbances
36 in understanding/ willing processes, ongoing poly-traumas or coma, refusal to sign the informed
37 consent. The cohort will be followed-up for incident cardiovascular and tumor events.
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46 After exclusion of subjects reporting personal history of cardiovascular disease (angina, myocardial
47 infarction, heart failure, revascularization procedures and stroke) (5.7%), cancer (3.1%) or diabetes
48 (6.0%) and of those for whom there were no information available on income (30.7%) mainly
49 because they refused to answer or did not possess any reliable information on this issue, 13,262
50 subjects were analysed. The latter were comparable with the whole Moli-sani Project population in
51 terms of Mediterranean dietary patterns and socio-economic features, whereas mean age of the
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4 sample was slightly lower (53.3 ± 11 vs 55.0 ± 12) and had a higher prevalence of men (50% vs
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6 48%) compared with the whole population sample.
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10 **Dietary information**

11 The validated Italian EPIC food frequency questionnaire was used to evaluate food intake (14, 15).
12 The questionnaire, computerized with tailor-made software, allowed to interview participants in an
13 interactive way, including illustrations of sample dishes of definite sizes or by reference to standard
14 portion sizes. To simplify interpretation of data and to minimize within-person variations in intakes
15 of individual foods, 188 food items were classified into 45 predefined food groups on the basis of
16 similar nutrient characteristics or culinary usage (Appendix 2). (Web only file).
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25 Moderate alcohol intake was defined as regularly drinking less than two or one drinks a day, by
26 men and women, respectively.
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30 Food consumption patterns were generated by using Principal Components Analysis (PCA)
31 conducted on the correlation matrix of 45 food groups (16). Three main factors emerged, in
32 agreement with previous findings in the same population (16). The first pattern, identified as
33 “Olive Oil and Vegetables”, was characterized by high positive loadings for olive oil, vegetables,
34 legumes, soups, fruits and fish. The second pattern, named “Pasta and Meat”, was characterized by
35 high positive loadings for pasta, cooked tomatoes, red meat, animal fats and alcoholic beverages,
36 and negative loadings of breakfast cereals and yogurt. The “Eggs and Sweets” pattern was
37 characterized by high positive loadings for eggs, margarines, processed meat and sugar and sweets.
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48 We evaluated the adherence to the Mediterranean diet by using the Mediterranean Diet Score
49 (MDS) elaborated by Trichopoulou et al (17). Scoring was based on the intake of the following 9
50 items: vegetables, legumes, fruit and nuts, dairy products, cereals, meat and meat products, fish,
51 alcohol, and the ratio of monounsaturated:saturated fat. For most items, consumption above the
52 study median received 1 point; all other intakes received 0 points. For dairy products, meat and
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4 meat products, consumption below the median received 1 point. Medians are gender specific. For
5
6 ethanol, men who consumed 10–50 gr/day and women who consumed 5–25 gr/day received 1
7
8 point; otherwise, the score was 0. The range of possible scores ranged between was 0 and to 9, which
9
10 is obtained by assigning a value of 0 or 1 to each of 9 indicated components (vegetables, legumes,
11
12 fruits, cereals, fish, meat, dietary products, ethanol, lipids) with the use of the sex-specific median
13
14 as cut-off. The total Mediterranean diet score ranged from 0, which indicates the minimal
15
16 adherence to the traditional Mediterranean diet, to 9, the latter reflecting namely the maximal
17
18
19
20 adherence.

21
22 We also used a new Italian Mediterranean Index (IMI) whose score is based on the intake of 11
23
24 items (pasta, vegetables, fruits, legumes, olive oil, fish, soft drinks, butter, red meat, and potatoes,
25
26 alcohol) ranged from 0 to 11 (15). is based on the intake of 11 items: high intakes of 6 typical
27
28 Mediterranean foods (pasta; typical Mediterranean vegetables such as raw tomatoes, leafy
29
30 vegetables, onion, and garlic, salad, and fruiting vegetables; fruit; legumes; olive oil; and fish); low
31
32 intakes of 4 non-Mediterranean foods (soft drinks, butter, red meat, and potatoes); and alcohol
33
34 consumption. If consumption of typical Mediterranean foods was in the 3rd tertile of the
35
36 distribution, the person received 1 point; all other intakes received 0 points. If consumption of non-
37
38 Mediterranean foods was in the first tertile of the distribution, the person received 1 point. Ethanol
39
40 received 1 point for intake up to 12 gr/day; abstainers and persons who consumed >12 gr/day
41
42 received 0 points. Possible scores ranged from 0 to 11(18). Such Italian Index was conceived to
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46 better capture healthy eating including foods, such as pasta, more typically available in Italy.
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50 51 **Data collection**

52
53 Body Mass Index (BMI) was calculated as kg/m^2 . Waist circumferences were measured according
54
55 to the NIH, Heart, Lung, and Blood guidelines (19). Blood pressure was measured by an automatic
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57 device (OMRON-HEM-705CP) three times on the non-dominant arm, with the patient lying down
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4 for about 5 minutes. Hypertension was defined as systolic BP \geq 160 mm Hg and/or diastolic BP \geq 95
5
6 mm Hg, or using pharmacological treatment. Physical activity was assessed by a structured
7
8 questionnaire (24 questions on working and leisure time and sport participation) and expressed as
9
10 daily energy expenditure in metabolic equivalent task-hours (MET/d).

11
12 Serum lipids and glucose were assayed by enzymatic reaction methods using an automatic analyzer
13 (ILab 350, Instrumentation Laboratory (IL), Milan, Italy). LDL-cholesterol was calculated
14
15 according to Friedewald. High sensitivity C reactive protein (CRP) was measured in fresh serum, by
16
17 a latex particle-enhanced immunoturbidimetric assay (IL Coagulation Systems on ACL9000). Inter-
18
19 and intra-day CV were 5.5% and 4.17%, respectively.
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25

26 **Socio-economic variables**

27
28 Individual Household net H income categories were considered as low (<10,000 euro/ yeargro), low-
29
30 medium (>10,000 <25,000 euro/year), medium – high (>25,000< 40,000 euro/year), high (>40,000
31
32 euro/year).
33
34

35 Education Level was divided into three categories: <8 (low) years of studies (0 point), >8 -and
36
37 <=8-13(medium) -yearsand -of studies (1 point)>13- (high) years of studies.
38
39

40 Socio-economic status (SES) was expressed as a score based on 5 variables: dwelling ownership
41
42 and ratio between the number of living-in family members and number of rooms (People Room
43
44 Density), both currently and at childhood - and availability of hot water at home at childhood. The
45
46 five components were dichotomized according to the median value, and a score of one was
47
48 attributed to the category supposed to be marker of higher social status in comparison with the
49
50 opposite category: thus we assigned a score of 1 to people living in a house with living-in family
51
52 members/room density > 0.6 or dwelling ownership or with availability of hot water and a score 0
53
54 to people with living-in family members/room density \leq 0.6, no dwelling ownership or with
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4 unavailability of hot water. [The SES score did not include income and education. Marital status was](#)
5
6 [considered as married or live-in partner vs others \(divorced, unmarried, widower\).](#)

7
8 [Education Level was divided in two categories: ≤8 years of studies \(0 point\) and >8 years of](#)
9
10 [studies \(1 point\).](#)

15 **Statistical analysis**

16
17 Values for continuous variables are means ± Standard Deviation. CRP was transformed into natural
18
19 logarithm to reduce positive skewness, but data were reported untransformed for clarity. Analysis of
20
21 variance for continuous or categorical variables was applied to test the associations in Table 1.

22
23
24 Multivariable analysis of variance [with appropriate terms for interaction](#) was used for testing the
25
26 association of adherence to MD scores, dietary patterns or dietary variables (considered as the
27
28 dependent variables) with categories of income or SES components. By using multivariable logistic
29
30 regression analysis [\(with appropriate terms for interaction\)](#), odds ratio (ORs) with corresponding
31
32 95% confidence intervals (95% CI) were calculated to quantify the association of income or
33
34 education levels -with adherence to MD-like eating scores [or obesity](#). High adherence to MD, as
35
36 stated by the Medscore, was defined when the score was ≥6 points whereas a low adherence when
37
38 the score was ≤3 points. Subjects with intermediate values (4 or 5 points) were excluded from this
39
40 analysis in order to focus on the two extreme categories of adherence. The same was done for the
41
42 IMI score, but the cut-off was ≥5 for the higher adherence or ≤3 for the lower adherence category.
43
44
45
46 The data analysis was generated using SAS/STAT software, Version 9.1.3 of the SAS System for
47
48 Windows©2009. SAS Institute Inc. and SAS are registered trademarks of SAS Institute Inc., Cary,
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50 NC, USA.

55 **RESULTS**

57 **Income groups**

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4 Table 1 shows the characteristics of the whole population by income categories. People in the
5
6 uppermost income group were 53.5% men and showed a better health profile, having significantly
7
8 lower values of BMI, systolic blood pressure, C-reactive protein, triglycerides and blood glucose.
9
10 Obesity prevalence (BMI > 30 Kg/m²) differed according to income; it was higher in the lowest-
11
12 income group (36%) and lower in the highest- income category (20%, p <.0001 Tab. 1).

13
14
15 In Table 2 the association among income levels, dietary habits and single food groups are reported.

16
17 ~~Subjects in the lower income categories showed poor adherence to the Olive oil and Vegetables~~
18 ~~dietary pattern (p<.0001) whereas a greater adherence to the Western type pattern (Dietary pattern~~
19 ~~3) was observed.~~

20
21
22
23
24 Higher income groups were significantly associated with greater adherence to both score indexes,
25
26 namely MDS (p<.0001) and IMI (p<.0001) in the model adjusted for age, sex, daily energy intake,
27

28
29 BMI, physical activity, smoking, alcohol consumption and marital status.

30
31 ~~Similar data were obtained after stratification by gender (p for interaction=0.24 for MDS and p for~~
32 ~~interaction =0.41 for IMI) and age (-p for interaction=0.43 for IMI). However, the increasing~~
33 ~~adherence to MD according to income was more pronounced in the elderly when it was measured as~~
34 ~~MSD (p for interaction=0.0002 ; $\beta = 0.063$, SE±0.021, p=0.0028 for people ≤ 65 years and $\beta =$~~
35 ~~0.17, SE±0.051, p =0.0008, for people > 65 years).~~

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

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53 In addition, analysis of single foods consumption by income categories showed that people with the
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55 higher income reported higher intake of the basic components of the MD, that is fish, fruits,
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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 546% (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

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4 and MDS score) followed the gradient of income categories (Tab. 45), with the exception of the
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6 whereas the trend appears not significant in the uppermost educated group, at least for what
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8 concerns when the MDS score was used (p=0,067). However the interaction test was not significant
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10 for either scores. Accordingly, education was related to dietary pattern independently from income.

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13 Indeed, by dividing income levels into two main categories (low and low-medium VS high and
14 high-medium), in the fully adjusted model, education was positively associated with dietary patterns
15 both in the lowest (MDS: p=0.032 and IMI: p=0.0025) and in the highest income group (MDS:
16 p=0.0067 and IMI: p=0.0010).

23 Income/education, Mediterranean diet and obesity

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25 Finally, we evaluated the association of income and education on diet quality and then on obesity in
26
27 a unique statistical model. Odds ratio of having obesity decreased according to income (OR=0.72,
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29 95%CI: 0.59 to 0.86 for highest versus lowest income group) -and education level (OR=0.53,
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31 95%CI: 0.45 to 0.61 for highest versus lowest education level).- These odds ratios remained
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33 unchanged when in the model diet quality (measured as Mediterranean scores) was included.
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35 Moreover,- the association between income or education with obesity was equally observed in both
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37 highest and lowest MD adherence categories as defined in Table 3 (the four terms for interactions
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39 among income or education with MDS or IMI were all p>0.35).
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46 **DISCUSSION**

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48 People with higher income and higher levels of education had a greater adherence to MD-like
49 eating patterns, as measured by three different parameters: two *a priori* Mediterranean scores (the
50 traditional one introduced by Trichopoulou and a more recent Italian Mediterranean index), and the
51 *a posteriori* dietary patterns derived from principal components analysis. Evidence on the health
52 benefits of the MD is based on several studies and meta-analyses (1,7,21). However, adherence to
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4 this healthy eating pattern is rapidly disappearing in the countries of Southern Europe where it
5
6 originated and persisted during centuries, including the areas of Northern Africa in which there is an
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8 increasing prevalence of metabolic disorders and consequent cardiovascular disease mainly due to
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10 the changing in lifestyle habits (22). Socio-economic status has been included among the factors
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12 related to chronic disease onset, and disparities in dietary habits by social class have been advocated
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14 to explain at least in part the higher CVD risk factors profile observed among low SES groups (23).
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16 Our results agree with the conclusions reported in the review by Darmon et al. (10) that higher-
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18 quality diets are mainly consumed by better educated and more affluent people while lower socio-
19
20 economic groups tend to have lower quality diets thus exposing themselves to a higher risk to
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22 develop diet-related diseases. Similar conclusions were reached by other investigations too (24)
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24 suggesting that low socio-economic groups end with having poorer diets. These findings are
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26 supported, at least in part, by the increasing prices of some of the key foods of the MD fact that
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28 following a Mediterranean dietary style could represent a matter of money (9). Indeed researchers
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30 in Spain showed that MD is definitely more expensive to follow than Western dietary patterns: this
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32 may represent a strong economic obstacle when counselling people about the opportunity to follow
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34 a healthy diet because cost may become a prohibitive factor (9). Aggrawal et al. (25) demonstrated
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36 that the well-known socio-economic disparities in diet quality is mediated by food cost confirming
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38 that lower SES groups tend to consume more energy dense and nutrient poor diets. However, the
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40 economic advantages of a Mediterranean way of eating in terms of cost-effectiveness should be
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42 highlighted as shown in patients with previous CVD, that could represent an exceptional return on
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44 investment (26).

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51 Subjects with lower income had a greater prevalence of obesity too. The association between
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53 obesity and socioeconomic factors has been previously observed (27) suggesting that the latter -play
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55 an important role in the risk of obesity and overweight not only in adults but also in children (28).
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57 However our data show that the strong association observed between lower income or education
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4 with obesity -was not -mediated by -diet quality. Indeed, an additional analysis combinige the
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6 impacts of education or income on diet quality and then on obesity in a unique statistical model.
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8 showed that both the association remained unchanged when in the model diet quality was included.
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10 According to these results, the changes in obesity rates observed in the different income and
11 education categories appear not necessarily re-mediated by diet quality. However, the
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13 epidemiological evidence supporting a causal link between Mediterranean diets and body weight is
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15 contrasting (29).
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21 It is quite clear that accumulating proofs on the benefits of Mediterranean- like diets is an
22 insufficient could no longer be the only task of prevention strategyyies as which should also try to
23 set the conditions allowing people to stick to healthier dietary habits should also be clearly
24 identified.
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31 This study contributes to provide further evidence to the assumption that dietary habits are strongly
32 influenced by socio-economic factors, in particular by income which appears to play an important
33 role in determining people's eating choices (30). As far as education is concerned, previous studies
34 found a relationship between higher levels of education and healthy diets (31). In our research,
35 education resulted to be independently associated to MD and did not modify the association
36 between income levels and healthy dietary pattern as shown in the stratified analysis by education
37 levels.
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46 The promotion of healthy lifestyles and diets to prevent weight gain and related diseases has
47 jumped to the top of the priority list of the public health experts all over the world since obesity has
48 become a threatening epidemic. So far the traditional MD has proven to be an effective "remedy"
49 to the spreading of the major chronic disease, obesity and mortality. Our study highlights the strong
50 linkage among low income, poor adherence to MD and consequent obesity prevalence.
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4 We started our study wondering about what makes so hard for people to choose healthy food
5 instead of bad products, putting at risk their own health. We excluded it could be just a matter of
6 personal choice or taste, neither an issue related to the lack of knowledge about the healthy benefits
7 of MD worldwide recognized and also well disseminated in the lay press.
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13 14 15 **Limitations of this study**

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17 A major limitation of the present study is that people self-reported their own income which is a
18 quite sensitive issue. Indeed we recorded a high percentage (30.7%) of non-respondent subjects
19 who refused to declare or did not know their ~~personal~~ family income. Yet such large non-
20 respondent group is very common in this type of investigation, especially among women and
21 elderly (32) However, there was no difference between the whole Moli-sani population and the
22 subsample analyzed here as far as dietary habits and socio-economic variables were concerned.
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30 Another inherent limit is represented -by the cross-sectional nature of our study.
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33 In addition, caution is needed in extending the results presented here to larger contexts since data
34 were collected in a region located between Central and Southern Italy, Mediterranean by tradition
35 and culture (13). Yet, the main characteristics of our population sample are comparable to those of
36 the Italian Cardiovascular Epidemiological Observatory (33), a large survey including random
37 samples of the general population recruited all over Italy; therefore our sample can be considered
38 representative at least of the whole Italian population.
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49 **Strengths of this study**

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51 Our very large population sample is made of subjects coming from a quite homogenous
52 environment with no marked differences in terms of socioeconomic disparities, differently from
53 metropolitan areas, where previous studies found huge gaps among social classes and related health
54 status at relatively small distances from the city centre (34). Bearing this in mind, the differences we
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4 observed in the adherence to Mediterranean diet according to income indicate that also in a
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6 environment homogeneous both for genetic and lifestyles, income and education can still play a role
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8 in influencing dietary choices. Furthermore, diet quality showed a continued improvement across a
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10 relatively small range of economic strata. Our “poorest” are represented by people earning less than
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12 10,000 euro/net per year whilst the “richest” group is made of subjects with more than 40,000
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14 euro/net per year. Such differences among income classes are quite restrained and recall what
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16 already said for the pretty homogeneous environment where our sample comes from. We are not
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18 dealing with real huge socioeconomic and income differences. Despite this homogeneity, we did
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20 observe notable changes in diet quality among different groups.
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24 The differences observed across the income strata would likely become even more evident in MD
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26 importing countries where getting typical Mediterranean products is more difficult and expensive.

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28 In addition, apparently for the first time this topic was addressed by using two *a priori*

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30 Mediterranean scores (the traditional one introduced by Trichopoulou and a novel Italian

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32 Mediterranean index), and the *a posteriori* dietary patterns derived from principal components

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34 analysis. This leads to overcome the limitations each of these approaches may present. Indeed, the
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36 “a priori” scores only reflect some aspects of diet and do not account for correlations between score
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38 components. Instead, the “a posteriori” approaches have the weakness of low reproducibility, ÷
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40 different populations havinge different non-predefined dietary patterns. Therefore, the use of an
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42 index based on the foods actually available to Italians and traditional Italian cooking styles should
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44 improve the ability of the index to classify the Italian cohort.
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53 54 CONCLUSIONS

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56 Our data suggest consistent associations of income and education with dietary patterns clearly
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58 indicate that eating “mediterraneanly” is also, if not mainly, a matter of and may foster offer
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4 | discussion on healthy food accessibility in terms of economic costs. The cost of increasing prices
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6 | of the basic MD seem to represent a real obstacle to healthy diet driving people to choose
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8 | alternative ways of eating usually inspired by the need to save money in everyday life. Public
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10 | health policies shall take into account the fact that correct dietary habits need to be promoted by
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12 | allowing people to choose the best for their own health. It is definitely an interdisciplinary issue
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14 | which shall call to action every single actor of modern societies otherwise condemned to increase
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16 | their already heavy burden of chronic diseases. As already noted by others -who dealt with this topic
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18 | (10), the promotion of high-cost foods to low-income people without taking food costs into account
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20 | is not likely to be successful.
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Table 1 Characteristics of the whole population as a whole and according to four income categories

	Income Categories					P value*
	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%)	
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, %						
<i>Never</i>	6,370 (48.1%)	558 (56.9%)	2,838 (49.4%)	1,901 (46.2%)	1,073 (44.5%)	<.0001
<i>Current</i>	3,296 (25.0%)	222 (22.6%)	1,418 (24.7%)	1,060 (25.8%)	596 (24.7%)	
<i>Former</i>	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)	0.5058
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			
	Low (n=3,843)	High (n=3,518)	OR	(95%CI)	Low (n=4704)	High (n=3089)	OR	(95%CI)
Income								
< 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				P value *
	< 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)	
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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7
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