International Journal of Epidemiology, 2017, 1–10
doi: 10.1093/ije/dyx145
Original article

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High adherence to the Mediterranean diet is associated with cardiovascular protection in higher but not in lower socioeconomic groups: prospective findings from the Moli-sani study

Marialaura Bonaccio,[1]* Augusto Di Castelnuovo,[1] George Pounis,[1] Simona Costanzo,[1] Mariarosaria Persichillo,[1] Chiara Cerletti,[1] Maria Benedetta Donati,[1] Giovanni de Gaetano[1] and Licia Iacoviello[1,2] on behalf of the Moli-sani Study Investigators[†]

[1]Department of Epidemiology and Prevention, IRCCS Istituto Neurologico Mediterraneo NEUROMED, Pozzilli, Italy and [2]Department of Medicine and Surgery, University of Insubria, Varese, Italy

*Corresponding author. Department of Epidemiology and Prevention, IRCCS Istituto Neurologico Mediterraneo NEUROMED, Pozzilli (IS), Italy. E-mail: marialaura.bonaccio@neuromed.it
[†]The Moli-sani study Investigators are listed in the Appendix (available as Supplementary data at *IJE* online).

Editorial decision 29 June 2017; Accepted 3 July 2017

Abstract

Background: It is uncertain whether the cardiovascular benefits associated with Mediterranean diet (MD) may differ across socioeconomic groups.

Methods: Prospective analysis on 18991 men and women aged $\geq$35 years from the general population of the Moli-sani cohort (Italy). Adherence to MD was appraised by the Mediterranean diet score (MDS). Household income (euros/year) and educational level were used as indicators of socioeconomic status. Hazard ratios (HR) were calculated by multivariable Cox proportional hazard models.

Results: Over 4.3 years of follow-up, 252 cardiovascular disease (CVD) events occurred. Overall, a two-point increase in MDS was associated with 15% reduced CVD risk (95% confidence interval: 1% to 27%). Such association was evident in highly (HR = 0.43; 0.25–0.72) but not in less (HR = 0.94; 0.78–1.14) educated subjects (*P* for interaction = 0.042). Similarly, CVD advantages associated with the MD were confined to the high household income group (HR = 0.39; 0.23–0.66, and HR = 1.01; 0.79–1.29 for high- and low-income groups, respectively; *P* for interaction = 0.0098). In a subgroup of individuals of different socioeconomic status but sharing similar MDS, diet-related disparities were found as different intakes of antioxidants and polyphenols, fatty acids, micronutrients, dietary antioxidant capacity, dietary diversity, organic vegetables and whole grain bread consumption.

Conclusions: MD is associated with lower CVD risk but this relationship is confined to higher socioeconomic groups. In groups sharing similar scores of adherence to MD, diet-related disparities across socioeconomic groups persisted. These nutritional gaps may reasonably explain at least in part the socioeconomic pattern of CVD protection from the MD.

Key words: Cardiovascular disease, coronary heart disease, stroke, Mediterranean diet, socioeconomic status, interaction

Key Messages

- Adherence to the Mediterranean diet is inversely associated with cardiovascular risk.
- Cardiovascular advantages associated with the Mediterranean diet are confined to high socioeconomic status individuals.
- In groups sharing similar adherence to the Mediterranean diet, inequities in diet-related behaviours and nutrient intake still persist.

Introduction

Observational studies have documented the association of Mediterranean-like dietary patterns with reduced cardiovascular disease (CVD) incidence and mortality,[1–4] along with lower rates of cancer,[5] neurodegenerative diseases and all-cause mortality.[6,7] More recently, evidence on cardiovascular protection from an MD was provided also by intervention studies showing reduced risk of CVD after allocation to MD-like patterns both in primary[8] and in secondary cardiovascular prevention.[9] Diet quality exhibits a socioeconomic (SES) gradient, with less advantaged groups reporting lower adherence to healthy dietary patterns including an MD[10] generally associated with poor health outcomes and higher prevalence of non-dietary unhealthy behaviours, such as tobacco use and inadequate physical activity.[11]

So far, SES inequities in diet have been documented for several domains of dietary behaviours and beyond food and nutrient intake; disparities were found for nutrient density levels, percentage contribution of food to nutrition and energy and also for diet variety, access to organic foods and food purchasing behaviours.[12,13] During recent years, increased attention has been paid to the food processing pertinent to the MD which can influence the nutritional quality of foods, with consequent impact on future health outcomes, especially in relation to oxidative stress and inflammation.[14] Actually, when measuring adherence to an MD, a relatively large amount of diet-related information or dietary behaviours is left out, and nutritional gaps among SES groups may still hold even in the presence of an apparently similar adherence to the same eating pattern.[13]

The aim of the present study is 3-fold: first, to evaluate the association between adherence to the MD and the incidence of fatal and non-fatal CVD events among adults initially free from CVD and diabetes; second, to test whether the association of the MD with CVD differs across SES strata; finally, to explore possible persisting diet-related differences among SES groups reaching similar scores of adherence to the MD.

Methods

Study population

The Moli-sani study is a prospective cohort study of 24 325 men and women (aged $\geq$ 35) randomly recruited from the general population of a Southern Italian region from March 2005 to April 2010.[15] For the purpose of this study, individuals with a history of CVD (7.1%), diabetes (10.6%), those reporting implausible energy intakes (<800 kcal/day in men and <500 kcal/day in women or >4000 kcal/day in men and >3500 kcal/day in women; 3.2%), subjects with missing information on educational level (0.2%), unreliable medical or dietary questionnaires (1% and 3.9%, respectively), subjects lost to follow-up (0.2%) or with incomplete personal data (1.7%) were excluded from the analyses. The final sample consisted of 18 991 individuals.

The Moli-sani study complies with the Declaration of Helsinki and was approved by the ethical committee of the Catholic University in Rome, Italy. All participants provided written informed consent.

Ascertainment of cases

Primary fatal and nonfatal incident cases of CHD (unstable angina, myocardial infarction, coronary revascularization and sudden death from unspecified cardiac event) and cerebrovascular disease which occurred in the cohort during follow-up were ascertained by linkage of the study cohort to the hospital discharge files and to the regional Registro Nominativo delle Cause di Morte (ReNCaM) registry and death certificates (Istituto Nazionale di Statistica (ISTAT) form), by using the International Classification of Diseases, ninth revision (ICD-9). For CHD, ICD-9 codes 410–414 and/or reperfusion procedure (ICD-9 codes 36.0–36.9) and for cerebrovascular disease, ICD9 codes 430–432, 434, 436–438 or procedure codes for carotid revascularization (ICD 9 code 38.12) were considered.

Suspected CHD deaths were identified when ICD-9 codes 410–414 or 798 and 799 were reported as the underlying cause of death or codes 250, 401–405, 420–429 as the underlying cause of death, associated with codes 410–414 as a secondary cause of death. Suspected cerebrovascular deaths were identified when ICD-9 codes 430–438 were reported as the underlying, antecedent or direct cause of death. All events were validated using procedures of the American Heart Association (AHA), World Heart Federation (WHF), European Society of Cardiology (ESC), Centres for Disease Control (CDC) and National Heart, Lung, and Blood Institute (NHLBI) for epidemiology and clinical research studies.[16]

Ascertainment of risk factors at baseline

History of CVD included documented angina, myocardial infarction, revascularization procedures and cerebrovascular events. History of cancer included self-reported diagnosis of cancer. Hypertension was defined as systolic blood pressure $\geq$140 mm Hg or diastolic blood pressure $\geq$90 mmHg or treatment for hypertension. Hypercholesterola emia was defined as total cholesterol $\geq$240 mg/dl or use of specific medication.[17] Diabetes was defined as blood glucose $\geq$126 mg/dl or as specific pharmacological treatment.

Total physical activity was assessed by a structured questionnaire and expressed as daily energy expenditure in metabolic equivalent task-hours (MET-h/day). Body mass index (BMI) was calculated as kg/m^2. Subjects were classified as never-smokers, current smokers or ex-smokers (having quitted for at least 1 year).

Socioeconomic indicators

Socioeconomic information was self-reported and collected by structured questionnaires administered by trained personnel. Detailed information on both education and household income are available; however, in this study, categories were chosen by taking into account the relatively low number of incident CVD events which do not permit consideration of these socioeconomic indicators in greater detail. Education was based on the highest qualification attained and was categorized as up to lower secondary (approximately $\leq$8 years of study), upper secondary education ($\leq$13) and post-secondary or higher (>13). Household income, expressed as earned euros per year, was a four-level variable (<25 000; 25 000–40 000; >40 000 euro/year), with missing values collapsed into a non-respondent category. Marital status was considered as married/cohabiting, divorced/separated, single or widowed.

Dietary assessment and indices of diet quality

Food intake was assessed by the validated Italian EPIC food frequency questionnaire.[18] Adherence to the MD was defined according to the Mediterranean Diet Score.[7]

Food antioxidant content (FAC) was appraised by a score determining the content in antioxidant vitamins and phytochemicals of each food group and ranged from −99 to 99, with higher values indicating increased consumption of foods rich in antioxidants.[19] The polyphenol content of diet was measured by a polyphenol antioxidant content (PAC)-score calculated as in Pounis *et al.*[20] Total antioxidant capacity of diet (TAC) was assessed as in Di Giuseppe *et al.*[21]

Variety of fruit and/or vegetable intake was assessed by four (fruit, vegetables, vegetables subgroups and fruit/vegetable combined) different diet diversity scores, following approaches similar to those tested within EPIC cohorts.[22] Diversity was the total number of individual vegetable/fruit products eaten at least once in 2 weeks. Data on cooking procedures were collected for vegetables, meat and fish. A score was constructed to discriminate healthy (boiling, stewing) and hazardous (frying, roasting, grilling) cooking methods;[23] the healthier the procedure, the higher the score. Organic food intake was limited to organic vegetables and categorized as yes/no. Whole-grain products consumption was restricted to whole-grain bread intake (yes/no).

Statistical analysis

Means with standard deviations (SDs) and percentages were used to describe the characteristics of the study population. Multivariable hazard ratios (HRs) with 95% confidence intervals (95% CIs) were calculated by using Cox proportional hazards models to analyse the association between adherence to the MD and incident vascular outcomes. The multivariable models were adjusted for sex, age, smoking status, education, household income, marital status, BMI (categorical), total physical activity (ordered quintiles), hypertension and/or hypercholesterolaemia at baseline, energy intake and consumption of eggs and potatoes.

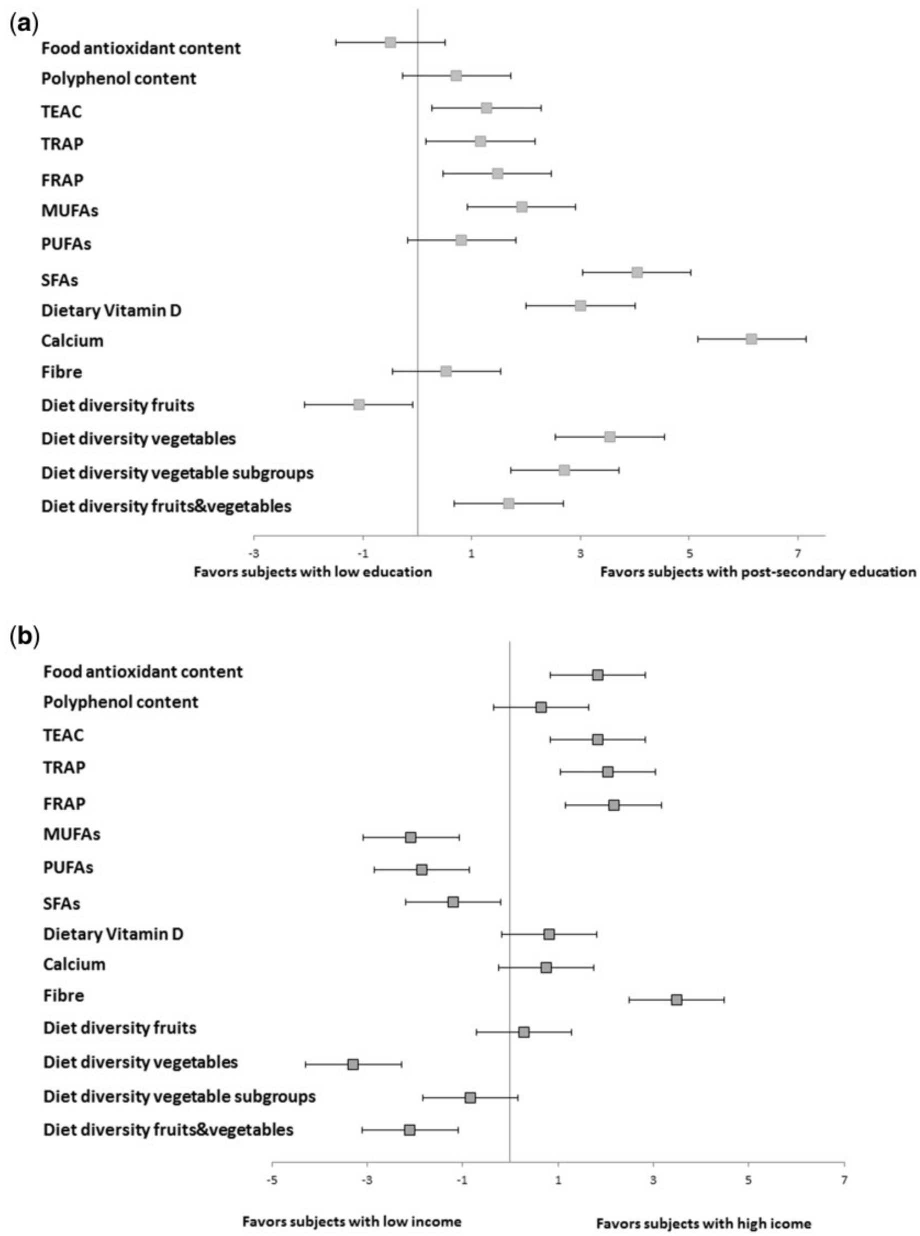

Figure 1. a. Mean differences in diet-related indices for highest vs lowest educational groups sharing similar adherence to the Mediterranean diet (MDS $\geq$ 6). Individuals with intermediate educational values were eliminated. Each difference was divided by its standard deviation. b. Mean differences in diet-related indices for highest vs lowest household income groups sharing similar adherence to the Mediterranean diet (MDS $\geq$ 6). Individuals with intermediate income values were eliminated. Each difference was divided by its standard deviation.

Appropriate multiplicative terms for testing interaction of education and income with adherence to the MD, as measured as two-point increase in the MDS, were included in the multivariable models (alternately adjusted for education or income) to test for a difference of effect of the MD across SES strata. Analyses on income were run on 13 226 subjects after exclusion of the non-respondent category. Differences in diet-related indices or behaviours across SES strata were calculated only among individuals reporting high adherence to the MD (MDS $\geq$ 6).

Figure 1a and b shows differences in diet-related indices (highest vs lowest educational or income groups), divided by standard deviation of the difference. In these figures, individuals with intermediate educational or income values were eliminated. Dummy variables for missing values of each variable of interest were created. The data analysis was generated using SAS/STAT software, Version 9.4 of the SAS System for Windows©2010. SAS Institute Inc. and SAS are registered trademarks of SAS Institute Inc., Cary, NC, USA.

Table 1. Characteristics of the study population according to increasing score of adherence to the Mediterranean diet

	Adherence to the Mediterranean diet			
	Poor (0–3)	Average (4–5)	High ($\geq$ 6)	*P*-value
N (%)	5812 (30.6)	8361 (44.0)	4818 (25.4)	-
Age (years, means ± SD)	52.4 (11.5)	54.4 (11.4)	56.0 (10.8)	<0.0001
Sex (men, %)	41.1	44.2	49.7	0.92
Income (€/year; %)				<0.0001
<25 000	34.2	36.3	35.4	
25 000–40 000	19.7	21.7	23.2	
>40 000	11.8	12.2	14.7	
Non-respondents	34.2	29.8	26.7	
Education (%)				<0.0001
Up to lower secondary	50.2	50.2	48.6	
Upper secondary	36.2	36.5	36.8	
Post-secondary or higher	13.6	13.3	14.6	
Marital status (%)				<0.0001
Married/cohabiting	83.8	86.1	87.7	
Separated/divorced	2.9	2.7	2.5	
Single	6.3	5.4	4.6	
Widowed	7.0	5.7	5.2	
BMI (%)				0.027
Normal (<25)	32.3	29.2	28.8	
Overweight ($\geq$25 <30)	41.2	43.8	44.7	
Obese ($\geq$30)	26.5	27.0	26.5	
Smokers (%)	24.4	24.0	23.0	0.0020
Total physical activity (means ± SD)	42.8 (8.1)	43.4 (8.6)	43.2 (8.6)	0.0004
Hypertension (%)	47.1	51.8	57.0	<0.0001
Hypercholesterolaemia (%)	27.4	27.5	32.0	0.0001
Cancer (%)	2.8	3.1	3.1	0.91
Aspirin use (%)	1.6	1.8	1.9	0.91
Blood glucose (mg/dl, means ± SD)	95.7 (11.5)	95.5 (11.6)	95.8 (11.5)	0.35
Energy intake (kcal/day, means ± SD)	1995 (531)	2094 (541)	2224 (517)	<0.0001

Means and *P*-values are adjusted for age, sex and energy intake.

Results

Mediterranean diet and CVD risk

Over a median follow-up of 4.3 years (lower to upper quartile: 3.5–5.4; 82718 person-years), we ascertained a total of 256 CVD events of which were 207 CHD and 49 were strokes. Baseline characteristics of the study population according to adherence to the MD are presented in Table 1.

Highest adherence to the MD (MDS $\geq$ 6) was associated with reduced risk of CVD in the model controlled for age, sex and energy intake (Table 2) and also after further adjustment for a number of possible confounders (multivariable HR = 0.67; 95% CI: 0.48–0.94). A two-point increase in the MDS was also related to lower risk of CVD (multivariable HR = 0.85; 95% CI: 0.73–0.99; Figure 2). The association of the MD with CHD or stroke risk reflected a similar protective trend but results did not reach statistical significance (Table 2).

Mediterranean diet and CVD risk in socioeconomic strata

A likely different association of the MD, expressed as two-point increase in the MDS, with CVD risk across SES strata was tested by including two separate terms of interaction (education*MDS or income*MDS) in the multivariable model further controlled for education or income; the *P*-value for interaction for education was 0.042 and for household income was 0.0098 (Figure 2). A two-point increment in the MDS was associated with lower CVD risk only in the group with a post-secondary education, in a model further controlled for income levels (HR = 0.43; 95% CI: 0.25–0.72), and no relationship was found for those with lower education (HR = 0.94; 95% CI: 0.78–1.14; Table 3). Similarly, the protection from an MD was only evident in the group with higher household income (HR = 0.39; 95% CI: 0.23–0.66 vs HR = 1.01; 95% CI: 0.79–1.29 of the lowest household income group; Table 3).

Table 2. Incidence and hazard ratios for combined CHD/stroke according to increasing score of adherence to the Mediterranean diet

	Adherence to the traditional MD			Two-point increase in MDS
	Poor (0–3)	Average (4–5)	High (≥6)	
N of subjects	5812	8361	4818	-
CHD + Stroke (*n* = 256)				
N of events/rate	79 (1.36%)	109 (1.30%)	68 (1.41%)	
Person-years	24189	36319	22210	
Model 1 (HR; 95% CI)	-1-	0.78 (0.58–1.04)	0.70 (0.50–0.97)	0.87 (0.74–1.01)
Model 2 (HR; 95% CI)	-1-	0.75 (0.56–1.01)	0.67 (0.48–0.94)	0.85 (0.73–0.99)
CHD (*n* = 207)				
N of events/rate	61 (1.05%)	90 (1.08%)	56 (1.16%)	
Person-years	24218	36344	22225	
Model 1 (HR; 95% CI)	-1-	0.83 (0.60–1.16)	0.75 (0.55–1.08)	0.89 (0.75–1.06)
Model 2 (HR; 95% CI)	-1-	0.80 (0.58–1.12)	0.71 (0.49–1.04)	0.87 (0.73–1.04)
Stroke (*n* = 49)				
N of events/rate	18 (0.31%)	19 (0.23%)	12 (0.25%)	
Person-years	24303	36502	22309	
Model 1 (HR; 95% CI)	-1-	0.59 (0.31–1.13)	0.54 (0.25–1.14)	0.78 (0.55–1.10)
Model 2 (HR; 95% CI)	-1-	0.59 (0.31–1.14)	0.54 (0.25–1.16)	0.77 (0.54–1.11)

Model 1 adjusted for age, sex and energy intake.

Model 2: as in model 1, further adjusted for egg and potato consumption, education, household income, marital status, BMI, total physical activity, smoking, hypertension, hypercholesterolaemia.

Indices of diet quality and diet-related behaviours across SES groups

In order to understand why CVD protection was confined to high-SES individuals, we examined possible gaps (as measured by additional indicators of diet quality or dietary behaviours) still persisting among SES groups sharing similar adherence to the MD (MDS ≥ 6). In the multivariable model additionally controlled for the MDS, educational groups still differed for some diet-related indicators such as diet variety for vegetables and vegetable subgroups that were all higher in highly educated as compared with less educated subjects (Table 4; Figure 1a). Subjects with post-secondary education also reported increased intake of organic vegetables and whole-grain bread as well as higher daily intake of mono-unsaturated and saturated fatty acids, vitamin D, calcium and fibre (Figure 1a). No difference was recorded for any of the indicators used to assess dietary antioxidant or polyphenol content or total antioxidant capacity of the diet, and disparities in cooking methods were limited to vegetable preparation that was healthier in those with higher education (Table 4). In addition, highly educated subjects were more likely to report higher fish intake and low meat/meat products consumption but less likely to report low intake of dairy products (Supplementary Table 5A, available as Supplementary data at *IJE* online). Dietary intake of polyphenols, antioxidants, fibre and indicators of TAC were all increased in the higher income group as compared with the lowest. Greater income was also associated with increased prevalence of whole-grain bread consumption, and the diversity in vegetable and fruit intake was slightly higher in the lowest income group along with daily intake of MUFAs and PUFAs (Table 4; Figure 1b). Differences in cooking procedures were identified for healthier methods in preparing vegetables but more hazardous procedures for meat (Table 4). Individuals with greater income reported higher consumption of fruits and nuts and fish, and lower intake of meat and meat products (Supplementary table 5B).

Discussion

In this large community-based Mediterranean population, higher adherence to MD was associated with lower risk of CVD in line with previous evidence.[2,3,24] However, this relationship was confined in fact to high-SES groups. Specifically, a two-point increase in the MDS was associated with 57% lower risk of CVD for subjects with post-secondary education, or 61% lower risk in the highest category of household income, whereas no relationship was found for less educated groups or in the lower income categories.

To the best of our knowledge, this is the first study to show that the association between Mediterranean diet and CVD risk differs across SES groups.

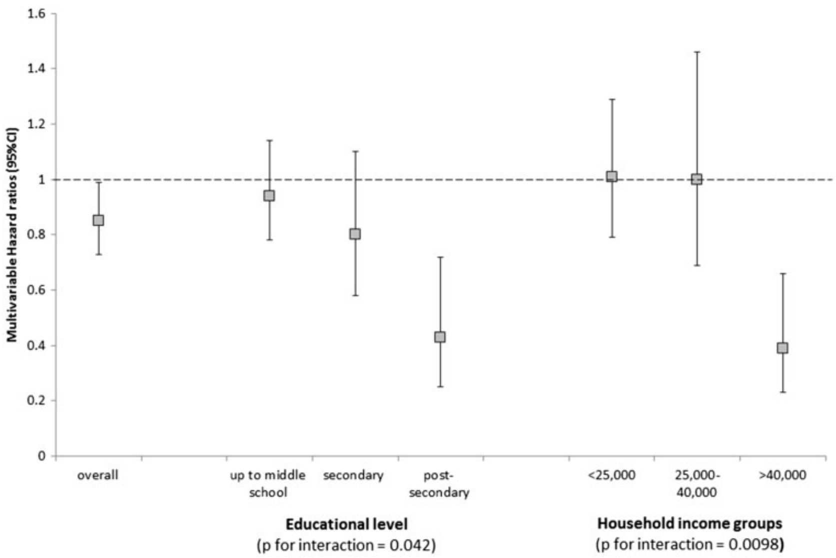

Figure 2. Cardiovascular risk (hazard ratio with 95% confidence intervals) associated with two-point increment in the MDS in the whole study population and across educational and household income groups.

Socioeconomic disparities in the composition of similar MDS

Given a comparable score of adherence to MD, both higher educational and higher income groups were more frequently found to consume higher intake of fish and lower amounts of meat. Many studies have documented the important role of the above-mentioned food groups in promoting favourable health effects[25] and reducing main CVD risk factors.[26] However, whether higher fish consumption and limited meat intake may contribute to the different CVD risk reduction across SES groups remain to be ascertained.

Socioeconomic disparities in nutrients and diet-related behaviours

Despite similar score of adherence to MD, post-secondary education was associated with higher diet variety for vegetables and vegetables subgroups, and with preference for whole-grain bread. Such educational gradient in food selection is in agreement with previous evidence indicating that higher SES groups are more likely to get in line with dietary recommendations.[27] High education was also related to greater consumption of organic vegetables, which has been previously shown to be strongly determined by SES,[13,28] although there is uncertainty on the actual health advantages deriving from organic food consumption.[29] Educational disparities emerged also for MUFAs, dietary vitamin D, calcium and fibre, whose higher intake is associated with more favourable cardiovascular health. We also found differences across income groups sharing similar scores of adherence to the MD for dietary polyphenol and antioxidant intake, total antioxidant capacity of the diet, and preference for whole-grain bread.

For both high-education and high-income individuals, disparities in food preparation were limited to healthier cooking methods for vegetables, which are possibly associated with increased overall antioxidant content.[14] Of note, high income was also associated with more hazardous cooking methods for beef (frying, roasting, grilling), and such high-temperature cooking techniques are more likely to propagate and accelerate formation of pro-inflammatory compounds associated with increased CVD risk.[23,30]

There are many studies indicating potential health benefits for each of these diet-related indices that in our study were found to vary consistently among SES groups, net of adherence to the MD. As highlighted in previous research, the nutritional properties of foods are closely dependent on external influences such as food processing and cooking procedures.[14] Foods that are not discriminated in epidemiological studies may substantially differ in their bioactive compounds content, with different health outcomes.[14] In our study, we also found that higher-SES subjects tend to consume more organic vegetables which can contain higher concentrations of antioxidants, lower concentrations of cadmium and a lower incidence of pesticide residues,[29] as compared with conventionally grown foods. We might then speculate that the quality of the bundle of foods that make up the MD actually differs across SES.

Unfortunately, our data derive from self-reported dietary intakes, thus we are not able to unequivocally establish

Table 3. CVD risk associated with two-point increment in the MDS stratified for educational level and household income groups

	Educational level			
	Up to lower secondary (≤8 years)	Upper secondary (>8 ≤ 13 years)	Postgraduate-higher (>13 years)	*P* for interaction
N of CVD events/*n* of subjects	170/9457	63/6926	23/2608	0.042
Event rate (%)	1.80	0.92	0.88	
CVD risk (HR; 95% CI[a]	0.94 (0.78–1.14)	0.80 (0.58–1.10)	0.43 (0.25–0.72)	
	Household income groups (€/year)[b]			
	<25 000	25 000–40 000	>40 000	*P* for interaction
N of CVD events/*n* of subjects	101/6730	47/4080	27/2416	0.0098
Event rate (%)	1.50	1.15	1.10	
CVD risk (HR; 95% CI)[a]	1.01 (0.79–1.29)	1.00 (0.69–1.46)	0.39 (0.23–0.66)	

[a]Hazard ratios from the model adjusted for age, sex, energy intake, egg and potato consumption, marital status, BMI, total physical activity, smoking, hypertension, hypercholesterolaemia. Analysis for education was further controlled for household income and vice versa.
[b]Analyses on income were run on 13 226 subjects after exclusion of the non-respondent category.

Table 4. Indices of diet quality and diet-related behaviours across educational (n = 4 818) and household income groups (n = 3 530) sharing similar score of adherence to the Mediterranean diet (MDS ≥ 6)

	Educational level				Household income groups (€/year)			
	Lower secondary (≤8 years)	Upper secondary (>8 ≤ 13 years)	Post-secondary/ higher (>13 years)	*P* for trend*	<25 000	25 000–40 000	>40 000	*P* for trend*
N of subjects	2340	1773	705		1706	1118	706	
Food antioxidant content (score)	33 (39)	34 (38)	35 (38)	0.69	33 (40)	35 (37)	37 (38)	0.015
Polyphenols intake (score)	8.4 (10.7)	9.1 (10.7)	9.4 (10.7)	0.12	8 (11)	8 (10)	10 (11)	0.031
TEAC	6.6 (2.7)	6.7 (2.5)	6.8 (2.3)	0.38	6.6 (2.6)	6.7 (2.5)	7.0 (2.5)	0.054
TRAP	9.4 (4.1)	9.6 (4.0)	9.7 (3.5)	0.47	9.5 (4.1)	9.7 (3.9)	10.1 (4.0)	0.033
FRAP	19.7 (8.0)	20.2 (7.8)	20.4 (6.8)	0.25	20.0 (8.0)	20.2 (7.6)	21.1 (7.7)	0.030
MUFAs	39.9 (10.7)	40.0 (10.4)	40.2 (10.7)	0.034	8.9 (2.4)	8.9 (2.3)	8.8 (2.3)	0.99
PUFAs	8.7 (2.4)	8.7 (2.3)	8.7 (2.3)	0.38	40.6 (11.0)	40.9 (10.5)	39.8 (10.2)	0.13
SFAs	26.2 (8.6)	26.8 (8.8)	27.0 (8.9)	<.0001	8.9 (2.5)	8.8 (2.3)	8.7 (2.2)	0.040
Dietary vitamin D	2.47 (0.98)	2.61 (1.00)	2.64 (1.06)	<.0001	26.7 (8.7)	27.2 (8.8)	26.3 (8.9)	0.46
Dietary calcium	901 (290)	945 (311)	960 (317)	<.0001	2.51 (0.99)	2.61 (1.02)	2.61 (1.02)	0.25
Dietary fibre	24.3 (6.7)	24.8 (6.8)	25.1 (7.1)	0.12	924 (297)	954 (307)	953 (322)	0.38
Diet diversity fruits (score)	8.9 (2.4)	8.8 (2.4)	8.8 (2.4)	0.15	24.5 (7.1)	24.6 (6.7)	25.9 (7.1)	0.0008
Diet diversity vegetables (score)	7.1 (2.4)	7.2 (2.5)	7.2 (2.5)	0.0005	7.3 (2.4)	7.2 (2.5)	6.9 (2.5)	< 0.0001
Diet diversity vegetables subgroup (score)	4.20 (1.05)	4.20 (1.08)	4.23 (1.08)	0.016	4.2 (1.1)	4.2 (1.1)	4.2 (1.1)	0.34
Diet diversity fruit and veg (score)	16 (3.6)	15.9 (3.7)	15.9 (3.6)	0.15	16.2 (3.7)	16.1 (3.6)	15.7 (3.7)	0.0068
Organic vegetables consumers (%)	1.9	2.7	5.1	0.0047	2.2	2.3	4.7	0.08
Whole-grain bread consumers (%)	13.4	18.7	25.4	<.0001	13.8	19.0	21.8	0.018

Means and *P*-values adjusted for age, sex and energy intake. Continuous variables are presented as adjusted means ± SD. *P* for trend for continuous variables were calculated by linear regression and by logistic regression for categorical variables. *P*-values adjusted for age, sex, energy intake, income (for analyses with education) or educational level (for analyses with income), marital status, BMI, total physical activity, smoking, hypertension, hypercholesterolaemia, cancer and adherence to the Mediterranean diet.

whether, given apparently similar adherence to an MD, high-SES groups actually select foods higher in polyphenols or antioxidants compounds that would result in future health advantages. This hypothesis could be only tested by a direct measure of such natural compounds in biological samples.

On the basis of our results and by accounting for all the limitations inherent to our approach, we suggest that at comparable levels of adherence to the MD, higher SES groups actually select foods with increased nutritional value as those higher in antioxidant content or capacity, and are more keen on reporting a larger variety in fruit and vegetable consumption, thus obtaining more adequate intake of essential nutrients. Such nutritional gaps may partly explain the observed socioeconomic pattern of protection derived from apparently similar scores of adherence to the MD. Of note, the interaction between diet and SES on CVD health outcomes was found both for cultural (education) and financial resources (income), likely indicating that healthier choices are driven either by a good set of knowledge and skills or greater financial resources.

In light of our findings, we speculate that standard dietary scores, although useful and valid parameters to quantify the adherence to the Mediterranean diet, may not fully capture the complexity of this diet, leaving out a number of additional dietary details mainly related to the quality of the products. If so, we would be dealing with a methodological limitation which may be overcome by the use of other tools to better appraise the dietary behaviours of a given population.

Strengths and limitations of this study

Major strengths of the present study include the large sample size, prospective study design, large number of indices of diet quality and diet-related behaviours, and comprehensive information on covariates, thus minimizing sources of bias and confounding.

Some potential limitations include the relatively short follow-up (and the consequent low number of events) and the observational nature of the study, which cannot fully rule out residual confounding. In addition, dietary data were based on self-reported information and therefore may be susceptible to error and bias. Moreover, although we tested a large number of indices for assessing diet beyond the MD, we are aware that several nutritional details may remain unaddressed, i.e. organic foods other than vegetables, and food purchasing behaviours consistent with dietary guideline recommendations. Finally, subjects' information was collected at baseline only; thus, life course changes possibly occurring during follow-up may influence the strength of the findings.

Conclusions

To the best of our knowledge, this large epidemiological study in a population-based cohort is the first to shed light on SES inequities in the cardiovascular protection associated with a traditional Mediterranean diet. From a public health perspective, these results support the need to adopt more effective strategies aiming to reduce socioeconomic disparities in health, not only by promoting the adoption of healthy eating patterns but also by facilitating access to foods with higher nutritional values likely associated with improved health outcomes.

Supplementary Data

Supplementary data are available at *IJE* online.

Funding

The enrolment phase of the Moli-sani Study was supported by research grants from the Pfizer Foundation (Rome, Italy), the Italian Ministry of University and Research (MIUR, Rome, Italy)–Programma Triennale di Ricerca, Decreto no.1588 and Instrumentation Laboratory, Milan, Italy. M.B. was supported by a Fondazione Umberto Veronesi Fellowship. The present analyses were partially supported by the Italian Ministry of Health [Grant number GR-2013-02356060]. Funders had no role in study design; collection, analysis or interpretation of data; the writing of the manuscript; or the decision to submit the article for publication.

Acknowledgments

The Moli-sani research group thanks the Associazione Cuore Sano Onlus (Campobasso, Italy) for its financial and cultural support.

Author Contributions

M.B., L.I. and A.D.C. contributed to the concept and design of the work and interpretation of data; S.C., M.P. and G.P. managed data collection; M.B. and A.D.C. analysed the data; M.B. wrote the paper; M.B.D., C.C., G.d.G. and L.I. originally inspired the research and critically reviewed the manuscript.

Conflict of interest: None of the authors had a personal or financial conflict of interest. All authors were and are independent from funders.

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