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Nutrition information, Mediterranean diet, and weight: A structural equation approach

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Abstract: This paper studies the relationships between adherence to the Mediterranean diet, food-related information, and possible effects they could jointly exert on weight status. The empirical analysis was conducted *via* a consumer survey using face-to-face interviews, and a structural equation model was implemented to the data analysis. This model choice was led by its ability to simultaneously evaluate multiple constructs. The results outline the central role played by adherence to the Mediterranean diet and food-related information, both in terms of nutritional knowledge and expert recommendations, which seem to be the key drivers affecting healthy weight. Moreover, food label use increases the nutritional knowledge of consumers, which in turn favours a healthy diet.

Keywords: consumer behaviour; food choices; Mediterranean diet; nutrition information; structural equation model

Over-nutrition represents a major concern in many countries and, despite several policies implemented to face it, obesity prevalence has not globally decreased, since only some countries have stabilised this trend (Wiggins 2014; WHO 2017). Understanding the reasons behind consumers' unhealthy conditions is crucial, not only from an individual perspective in terms of private utility but also from a public perspective in terms of healthcare costs and losses of productivity for the economic system (Dorte and Trine 2015). Moreover, perceiving the reasons for excess weight problems is important in order to assist policymakers in finding more adequate ways to promote healthier food consumption and improve public health (Cavaliere et al. 2017).

Many economic studies have pointed out the main factors that contributed to the rise in overweight and obesity in the last decades, such as reduction of prices of energy dense food, greater availability of junk-food, increase in sedentary lifestyle and in out-from-home food consumption, scarce time dedicated to the preparation of meals at home, and higher intake of fats, sugar, and salt. Moreover, advances in medicine led to a significant reduction of consumers' perceived risk related to excess weight problems, which indeed are often underestimated (Cutler et al. 2003; Rashad et al. 2006; Currie et al. 2010; Dunn 2010; Drichoutis et al. 2012; Cawley 2015).

Our theoretical framework focuses on two specific behaviours: eating habits and food-related information. Moreover, these two factors could be strictly related to each other and exert a conjoint effect on consumers' healthy/unhealthy weight. We refer to the normal weight range of Body Mass Index (BMI between 18.5 and 25) as 'healthy weight condition', and refer to BMI values above the normal weight threshold as 'unhealthy weight' (BMI above 25).

Up to the present, structural equation modelling (SEM) has been employed in a wide range of studies, especially in the field of public health, and this paper may constitute an important attempt in the obesity analysis studies, providing a system of simultaneous cause-effect relationships (Sarmugam and Worsley 2015; Tanja

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et al. 2015). Specifically, the aim of this paper is twofold: firstly, to analyse the role of the Mediterranean diet in maintaining a good health status avoiding excess weight problems, and secondly, to assess the role played by food-related information in favouring healthy weight. Therefore, the possible effects that these factors (i.e. adherence to the Mediterranean diet and food information) could jointly exert on body weight are explored. The analysis is based on a survey carried out *via* face-to-face interviews on a sample of 300 Italian consumers.

METHODS

Definition of hypotheses. The Body Mass Index (BMI) measure was used to assess weight status. Especially, values of BMI between 18.5 and 25 were considered as 'healthy weight' and values above or below the normal weight thresholds (> 25 and < 18.5) as 'unhealthy weight'[1]. Among the factors that could contribute to maintaining a healthy weight status, an important role is played by a healthy diet. The Mediterranean diet is a nutritional model based on the consumption of low-processed food, mainly cereals and fresh or dried fruit and vegetables, with moderate consumption of fish, meat, dairy products, and the use of olive oil as the main condiment (Schröder et al. 2016). In the past years, this dietary pattern has been widely recognised to have a preventive effect against weight gain, cardiovascular diseases, diabetes, and even some types of cancer (Katz and Meller 2014).

The concept of the Mediterranean diet was introduced in the late 1950s by Keys[2], but several studies continue to explore this diet as a disease-preventing model (Keys 1980; Tektonidis et al. 2015; Schwingshackl and Hoffmann 2016). In this context, the first hypothesis concerned the relationship between diet and weight status. Some scholars outline that self-assessed health status could help predict mortality and morbidity. Are people who believe to be healthy actually healthy? The analysis tested both the direct link between diet and weight and also the mediating role of the self-perceived health status. The hypotheses tested were:

H_{1a}: People observing a high adherence to the Mediterranean diet have normal weight.

H_{1b}: People with a positive perception of their health have normal weight.

Another dimension considered in the framework of this study regards the knowledge. Many studies have investigated the association between BMI and nutritional knowledge, showing mixed results. Some research has shown a lack of association, while other studies have reported a positive relationship between BMI and the level of knowledge of consumers (Dallongeville et al. 2001; O'Brien and Davies 2007; Tineke et al. 2009; Banterle and Cavaliere 2014; Tabassum et al. 2015). In this sense, people with a good level of nutritional knowledge are potentially more likely to make healthy food choices and, thus, to have a healthy weight. Education, for example, could increase knowledge on health risks and reduce the probability to be affected by obesity (Devaux and Sassi 2013). Thus:

H_2: An increase in knowledge may promote a healthy diet (in terms of higher adherence to the Mediterranean diet).

Food labels could represent a tool that can increase the level of consumer knowledge (Banterle and Cavaliere 2014). Nonetheless, it is difficult to establish a specific causal relationship between nutritional knowledge and label use. Indeed, it is also true that nutritional knowledge could support the use of food labels in terms of comprehension and increase the ability to understand the benefits (De Magistris et al. 2010; Miller and Cassady 2015). In line with this second stream of literature the hypothesis was:

H_3: Higher knowledge may facilitate the use of food labels.

Other information sources (different from labels), that is media and friends/parents (by word-of-mouth), could also influence the acquisition of nutrition information and guide consumers' choices in terms of diet (Drichoutis et al. 2008). Nevertheless, it is difficult to establish if this kind of sources could lead to healthier/unhealthier choices. The assumption was:

[1]It is largely recognised that other measures could be used to measure this condition, from body circumferences to skinfold thicknesses or bio impedance, but in behavioral studies the BMI could be considered an appropriate measure.

[2]The first definition of Mediterranean diet provided by Keys was focused on the low content of saturated fats and high content of vegetable oil. After this, different definitions have been done, all with similar key components. According to the Mediterranean diet pyramid, the main characteristics are: high consumption of plant foods (fruit, vegetables, legumes, nuts and seeds and cereals, preferably wholegrain); consumption of seasonal and local food; presence of fruit as main daily dessert and olive oil as main source of dietary lipids; moderate consumption of dairy products, fish, poultry and eggs; limited consumption of red meat; and moderate intake of wine during meals (Katz and Meller 2014; Schröder et al. 2016).

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H$_4$: The use of other sources of information (different from labels) can lead to lower adherence to the Mediterranean diet.

Moreover, income and education have been used as indicators of social status, as disadvantaged social classes have been found to be more likely to experience unhealthy weight problems (Banterle and Cavaliere 2014).

Recruitment criteria. The study was conducted on the Italian population, which, even while reporting a quite low obesity rate compared to other European countries, presents a substantial difference between the northern and the southern regions. For this reason, to avoid any issue linked to cultural-geographical specificities and to guarantee a higher level of representativeness, two different regions were taken into account. Thus, the final sample was made up of 300 Italian consumers, 150 living in Lombardy (a northern region of Italy) and 150 in Apulia (a southern region of Italy). The sample size was selected taking into account the estimated relative error in the relation to the population size, choosing a level of error around 6%, and the constraints related to face-to-face interviews (Mazzocchi 2008). The multiple-choice questionnaire had been pre-tested on a small sample of 40 consumers. The interviews were conducted in small shops, supermarkets, and hypermarkets. The selection of the retails was based on stratified random sampling according to the size and the geographical distribution of the stores. Only individuals younger than 18 years of age were excluded from the survey. Participants were approached during their grocery shopping and the survey was carried out over 8 weeks, in the morning and afternoon, considering both weekdays and weekends, in order to try diverse segments of consumers. The survey was conducted in the springtime, with a total duration of two months. The interview was about 10 minutes long. A description of the sample characteristics is provided in Table S1 [Table S1 in electronic supplementary material (ESM); for the supplementary material see the electronic version].

Description of variables. Sets of manifest indicators were used to better explain the unmeasured latent variables. As shown in Table S2 [Table S2 in electronic supplementary material (ESM); for the supplementary material see the electronic version], the latent variables are represented by: weight status (*WEIGHT*), self-assessed health status (*H-STATUS*), diet (*DIET*), knowledge (*KNOW*), food label use (*LABEL*), and information sources (different from the label) (*SOURCES*). Moreover, income (*INC*) and education (*EDU*) were introduced as control variables to take into account their effect.

The central variable of the model is represented by *WEIGHT*. This latent variable was explained through two indicators. The first indicator is expressed by the measure of the BMI stated by consumers and the second is represented by an evaluation of BMI assessed by the interviewer through a graphic in which different body images correspond to different BMI levels. This indicator was used to verify the correspondence between the stated BMI and real BMI.

H-STATUS has been measured using two items: first, respondents self-evaluated their health condition; second, limitations in movements due to compromised health condition were verified. The item about self-perceived health is frequently used in medical and social studies and has been found to be a good way to predict morbidity and mortality (Johansson et al. 2008; Lyyra et al. 2009).

Concerning *DIET*, the measure of the adherence to the Mediterranean diet as defined by Trichopoulou et al. (2003) was used. This definition includes the consumption frequency of 10 food items that represent the major food groups in the Mediterranean diet pyramid (fruit, cereal, vegetables, fish, pulses, olive oil, meat, cheese, eggs, sweets). The frequency of consumption is expressed by a scale which aims to measure low and high consumption of such foods, ranging from never to more than once a day. With regard to the healthy components of the pyramid (fruit, cereals, vegetables, fish, pulses, olive oil) and according to the nutritional recommendation, value 0 was assigned to individuals with below-average consumption, and value 1 to those with consumption at or above average. On the other hand, as for foods presumed to be harmful (meat, cheese, eggs, sweets), individuals with a below-average consumption were assigned a value of 1, and those whose consumption was at or above average were assigned value 0. Thus, the total *DIET* score ranged from 0 (minimal adherence) to 10 (maximal adherence)[3].

In order to measure *KNOW*, a set of items were used to investigate consumers' knowledge about food products, as in the validated nutritional knowledge

[3]This kind of measure aims to give a general idea of diet, particularly about the adherence to Mediterranean diet. Some important nutritional aspects of the diet have been overlooked as the portion size or calories, the food preparation and cooking methods. Future studies could be developed also taking into account these aspects.

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questionnaire provided by Parmenter and Wardle (1999) and in other previous economic studies (Drichoutis et al. 2008). This measure included different forms of knowledge: (i) a specific knowledge regarding the nutrient content of some food products, i.e. nutritional knowledge (fibre content, protein content, vitamin content); (ii) forms of knowledge which refer to consumers' awareness concerning recommendations about food, i.e. food knowledge (fat to reduce, comparison fat content); (iii) knowledge about the link between food consumption and health problems or diseases, i.e. health knowledge (link fat-health disease, link salt-health disease, link F&V-health disease).

For the latent variable *LABEL*, three different indicators were used: (i) if consumers compare the labels of different food products; (ii) if nutritional labels affect consumers' purchase decision; (iii) how often consumers use nutritional labels.

The *SOURCES* considered other sources of information different from labels. Indeed, the consumer was asked if he/she refers to media and friends or parents (by word-of-mouth) as a source to collect information about food properties.

Only one indicator was used for *EDU* and a set of indicators for *INC*, one direct question on the income level and two variables about the consumers' self-perceived economic condition. Specifically, consumers' perception of their economic condition with respect to the average population, and if and how family income would meet the monthly expenses. A description of the variables is provided in Table S2 [Table S2 in electronic supplementary material (ESM); for the supplementary material see the electronic version].

Model specification and measurement model. In order to analyse the research model, a structural equation model with Partial Least Squares (PLS) approach was chosen. The PLS algorithm (Wold 1982) is adopted in the SEM framework as an alternative method to the covariance structure estimation procedures (Bollen 1989). PLS-SEM models, also called path analysis models, refer to the analysis of the existing relationships between latent variables that are not directly observable. Unlike the covariance-based methods, they do not require distributional assumptions and work with small samples (Fornell and Bookstein 1982). In this study, the relationships between latent variables and indicators were defined by using the reflective measure specification where the latent construct exists independently of the measure.

The loadings can be interpreted as factor loadings, while the path coefficients are similar to standardised regression coefficients. The explanatory power of the model is tested by examining the sign, size, and statistical significance of the path coefficients between constructs (Staples et al. 1998). Moreover, using a bootstrap technique is possible to test the significance of the paths, while the predictive capacity of a PLS model can be assessed by examining the variance explained (e.g. R^2) in the dependent or endogenous constructs.

The analysis was conducted by Smart PLS 2.0 software. To assess the indicator reliability, the loadings of all the PLS analysis reflective indicators were examined. As a first step, Cronbach's alpha statistics to test the 'internal consistency' of the measurement scales were used. Because Cronbach's alpha tends to provide a severe underestimation of the internal consistency reliability of latent variables in PLS path models, composite reliability ρ_c was used in conjunction. These

Table 1. Measurement model results: correlations ($AVE^{0.5}$– average variance extracted – on the diagonal)

	DIET	*EDU*	*WEIGHT*	*INC*	*KNOW*	*LABEL*	*H-STATUS*	*SOURCES*
DIET	1	–	–	–	–	–	–	–
EDU	0.093	1	–	–	–	–	–	–
WEIGHT	–0.239	–0.160	0.632	–	–	–	–	–
INC	0.195	0.428	–0.157	0.456	–	–	–	–
KNOW	0.302	0.434	–0.195	0.374	0.323	–	–	–
LABEL	0.059	0.255	–0.061	0.162	0.229	0.326	–	–
H-STATUS	0.253	0.363	–0.432	0.302	0.311	0.093	0.461	–
SOURCES	–0.155	–0.033	0.060	–0.157	–0.159	0.000	–0.076	0.455

DIET − diet; *EDU* – education; *WEIGHT* − weight status; *INC* − income; *KNOW* − knowledge; *LABEL* − food label use; *H-STATUS* − self-assessed health status; *SOURCES* − information sources (different from the label)

Source: Own calculation based on data survey

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Table 2. Measurement model results

	AVE	Composite reliability	R^2	Cronbach's alpha	Communality	Redundancy
DIET	1	1	0.103	1	1	0.091
EDU	1	1	0.184	1	1	0.184
WEIGHT	0.795	0.885	0.204	0.748	0.795	0.038
INC	0.675	0.862	0.000	0.759	0.676	0.000
KNOW	0.568	0.797	0.244	0.616	0.568	0.098
LABEL	0.571	0.797	0.065	0.644	0.571	0.035
H-STATUS	0.679	0.805	0.064	0.564	0.679	0.039
SOURCES	0.674	0.802	0.025	0.563	0.674	0.014

DIET – diet; *EDU* – education; *WEIGHT* – weight status; *INC* – income; *KNOW* – knowledge; *LABEL* – food label use; *H-STATUS* – self-assessed health status; *SOURCES* – information sources (different from the label)

Source: Own calculation based on data survey

indices are easily interpreted in the same way as Cronbach's alpha: a value below 0.6 indicates a lack of reliability (Henseler et al. 2009), but they take into account the fact that indicators have different loadings.

Establishing discriminant and convergent validity in PLS requires an appropriate *AVE* (Average Variance Extracted) analysis. For discriminant validity, the square root of the *AVE* and the correlations are compared. *AVE* indices, which are used to measure the percentage of variance explained by each factor and which are applied within each latent construct, must be greater than 0.5 to confirm the convergent validity and the goodness of the model (Henseler et al. 2009).

Tables 1–2 report all the measurement results, including reliabilities (alpha, ρ_c), *AVE*, correlations between latent variables and the square root of the *AVE*. They show that discriminant validity is satisfied with the square root of the *AVE* of each construct larger than the correlation of the specific construct with any of the other constructs in the model. Considering the values of alpha and ρ_c, all the measures have a good 'internal consistency'. Moreover, confirming the convergent validity and the goodness of the model (Henseler et al. 2009), all the values of *AVE* indices are greater than 0.5.

RESULTS

Model testing. The results supported H_{1a} and H_{1b} hypotheses (i.e. consumers that show high adherence to the Mediterranean diet are less likely to have an excess

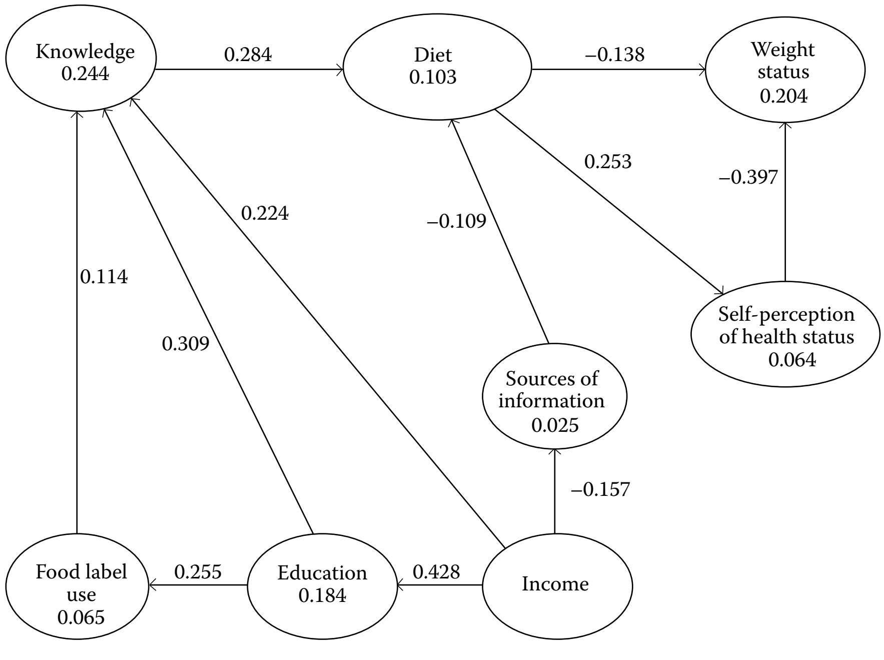

Figure 1. Structural model

Source: Own calculation based on data survey

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Table 3. Model results: total effects (with α = 0.10, t = 1.65)

Direction path	Total effect	t	Effect
Diet –> weight status	–0.239	4.057	–
Diet –> self-perception of health status	0.253	3.848	–
Education –> diet	0.096	3.697	only indirect
Education –> weight status	–0.023	2.490	only indirect
Education –> knowledge	0.338	5.631	–
Education –> food label use	0.255	5.098	–
Education –> self-perception of health status	0.024	2.440	only indirect
Income –> diet	0.122	4.273	only indirect
Income –> education	0.428	8.892	–
Income –> weight status	–0.029	2.657	only indirect
Income –> knowledge	0.368	6.346	–
Income –> food label use	0.109	4.094	only indirect
Income –> self-perception of health status	0.031	2.605	only indirect
Income –> sources of information	–0.157	2.074	–
Knowledge –> diet	0.284	4.933	–
Knowledge –> weight status	–0.068	2.876	only indirect
Knowledge –> self-perception of health status	0.072	2.686	only indirect
Food label use –> diet	0.032	1.986	only indirect
Food label use –> weight status	–0.008	1.677	only indirect
Food label use –> knowledge	0.114	2.167	–
Food label use –> self-perception of health status	0.008	1.625*	only indirect
Self-perception of health status –> weight status	–0.397	7.323	–
Sources of information –> diet	–0.110	1.822	–
Sources of information –> weight status	0.026	1.581*	only indirect
Sources of information –> self-perception of health status	–0.028	1.710	only indirect

*Effects are not significant

Source: Own calculation based on data survey

weight problem and consumers with a positive perception of their health status are more likely to be of normal weight). Indeed, as shown in Table 3, people that positively perceived their health status have low BMI (direct path = –0.397, t = 7.323). At the same time, higher adherence to the Mediterranean diet helps consumers to have a better perception of their health status (direct path = 0.253, t = 3.848) and to reduce their risk of becoming overweight or obese (direct path = –0.138, t = 2.54; total effect = –0.239, t = 4.057). Moreover, the results of the model highlighted complex relationships between income, education, food label use, knowledge, and diet. The final model shows that people with higher income are those with higher education (direct path = 0.428, t = 8.892), and the same consumers are more prone to use food labels (direct path = 0.255, t = 5.098). Increased attitude to use food labels leads to an increase in consumers' knowledge (direct path = 0.114, t = 2.167) which in turn favours better diet (direct path = 0.284, t = 4.933). Income also directly affects consumers' knowledge (direct path = 0.224), which in turn leads to healthy diet (total effect = 1.222, t = 4.273). Therefore, hypothesis H_2 is confirmed, as a direct and positive path between knowledge and diet was found (direct path = 0.284, t = 4.933). H_3 is rejected, as an opposite direction from food label use and nutritional knowledge was found (direct path = 0.114, t = 2.167), meaning that using labels could contribute to an increase in consumers' knowledge (Figure 1).

Furthermore, the model shows that people with higher income are less likely to use other information sources than food labels, in particular media or friends, to collect information on food properties (direct path = –0.157, t = 2.074). These consumers, in turn, have higher adher-

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ence to the Mediterranean diet (direct path = –0.110, t = 1.822) and lower BMI levels. This result confirms hypothesis H_4, as the use of different sources of information like friends or word-of-mouth can induce consumers to follow the alternative diet (for example vegetarian, macrobiotic, organic, diets that emphasise or restrict certain nutrients or foods) that are considered more unbalanced than the Mediterranean one.

Even though the latent variables are explained by a low R^2, following the Wetzels et al. (2009) classification, all the R^2 are largely acceptable. Indeed, Tenenhaus et al. (2004, 2005) proposed an index of overall Goodness-of-Fit (GoF), which considers both measure and structure sides. GoF of the proposed model is equal to 0.277. According to the guidelines published by Wetzels et al. (2009), this value is valid for medium-size effects (small = 0.1; medium = 0.25; large = 0.36).

DISCUSSION

The results outline the central role played by the adherence to the Mediterranean diet in preventing excess weight, stressing the link between diet and weight outcome. This result is in line with the existing literature and with studies that demonstrated that this dietary pattern is associated with a reduced risk of cardiovascular disease, cancer, diabetes, overweight and obesity, neurodegenerative diseases and, more generally, all-cause mortality (Bonaccio et al. 2012; Tektonidis et al. 2015; Schwingshackl and Hoffmann 2016).

Another result concerns the knowledge variable, which seems to be a key driver affecting diet. Indeed, knowledge is directly connected to diet, highlighting that greater knowledge can contribute to adherence to a more balanced diet and, thus, to maintaining a healthy weight. This implies that awareness about nutritional and food recommendations is crucial for healthy diet choices. In line with this, recent studies have shown that the higher the level of education (the higher the number of years of education), the higher the knowledge and individual awareness concerning food-related issues which may lead individuals to better complying with intake recommendations (Bonaccio et al. 2014; Cavaliere et al. 2018).

An important tool to increase the level of knowledge is represented by the food label. The food labels do not have a direct effect on weight status, but the effect is mediated by the Mediterranean diet. Therefore, the results of the analysis are in line with previous studies that highlighted the contribution of food labels to increasing nutritional knowledge (Miller and Cassady 2015).

Finally, the social variables also play a role: income appears as the origin of most of the relationships. Indeed, people with low levels of education, low use of labels and lower knowledge are more widespread among the lower-income classes of the population. In line with these results, other studies have shown that high education and income seem to exert an effect on mean consumption frequencies, in particular, increased consumption of fruit and vegetables as well as water (Bonaccio et al 2012; Bonaccio et al. 2014; Cavaliere et al. 2018).

Our findings, however, need to be considered also in light of the limitations of the analysis.

The main issues are related to the small sample size, the stated preferences, and the number of indicators for each latent variable. In particular, the limited number of observations does not allow us to compute any kind of moderation, neither for geographical distribution nor for other socio-demographic variables as gender or age. In this direction, other tests and extension need to be considered. Moreover, the results refer to the case of Italy, where the rate of obesity is quite low compared to other countries, and where the Mediterranean diet is quite widespread. Given these limitations, further research is needed to verify our outcome in other countries with different characteristics.

CONCLUSIONS AND POLICY IMPLICATIONS

This paper represents an exploratory study on Italian consumers about the relationships between diet (in terms of adherence to the Mediterranean diet), food information, and their outcomes on health in terms of weight. These relationships were analysed using a structural equation approach, aiming at filling the gap existing in the economic and nutritional literature on this issue, as this model provides simultaneous cause-effect relationships. All considered, the results confirm previous studies that provided evidence of the link between diet and health. Thus, a policy aimed at promoting the Mediterranean diet, recently recognised by UNESCO, would help to address the increasing rates of overweight and obesity. This should not suggest the Mediterranean dietary pattern is the only consumption model capable of favouring healthy weight, but it can be one of the good practices recommended to support public health. With this implication, the diet can be seen as a direct investment in health that can help consumers to maintain good health status.

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The contribution of knowledge in following a healthy diet is fundamental and highlights the need for policies aimed at disseminating recommendations on healthy food choices, targeted on the specific needs of disadvantaged population segments. At the same time, an intervention to increase consumer nutritional knowledge should be mainly based on educational programs in the schools and public nutritional campaigns (Cavaliere et al. 2017). In general, information-based policies are by far the most common healthy eating policies in the EU, probably because these policies are relatively cheap, do not impose direct restrictions or direct costs upon industry, and may be seen as being less intrusive by consumers.

On the other hand, a policy to improve general education can contribute to improving knowledge about food issues with a positive effect on public health. The analysis did not show a direct effect of labelling on healthy/unhealthy weight. Instead, this effect is mediated by knowledge. This leads to the idea that food labelling might be a tool to reduce information asymmetry in the market, but its effect in terms of public health is quite weak. Moreover, as the main issue of the food labelling is understanding, the provision of simple information in a consistent format and positioning should be encouraged. In other words, this tool only represents a single step in a set of practices to avoid excess weight, as it contributes to improving consumers' nutritional knowledge and increasing transparency on the market.

To sum up, the policies that emerge from this study are various: on the one hand, it is possible to think of a 'food policy' in order to promote healthy dietary patterns, on the other hand, of a 'social policy' to reduce the social gradient among different social classes of the population.

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