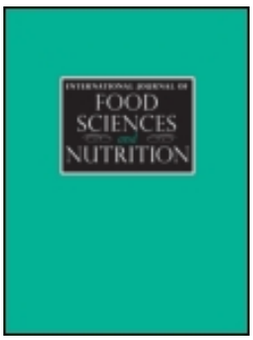

International Journal of Food Sciences and Nutrition

ISSN: 0963-7486 (Print) 1465-3478 (Online) Journal homepage: http://www.tandfonline.com/loi/iijf20

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To cite this article: Stefanos Tyrovolas, Yannis Tountas, Evangelos Polychronopoulos & Demosthenes Panagiotakos (2012) A classification and regression tree analysis for the evaluation of the role of nutritional services on cardiovascular disease risk status of older people living in Greek islands and Cyprus, International Journal of Food Sciences and Nutrition, 63:5, 522-529, DOI: 10.3109/09637486.2011.641941

To link to this article: http://dx.doi.org/10.3109/09637486.2011.641941

International Journal of Food Sciences and Nutrition,
August 2012; 63(5): 522–529

informa
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A classification and regression tree analysis for the evaluation of the role of nutritional services on cardiovascular disease risk status of older people living in Greek islands and Cyprus

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Abstract

Introduction: The purpose of this study was to evaluate, with classification–regression tree analysis, the structure of the associations between nutritional and health care services and the cumulative prevalence of the classical cardiovascular disease (CVD) risk factors of older individuals living in Greek islands and Cyprus.

Methods: During 2005–2009, 744 men and 742 women (>65 years) from nine Greek islands and Cyprus Republic were voluntarily enrolled in the Mediterranean Islands study; various socio-demographic, clinical and lifestyle characteristics were recorded. Moreover, information regarding practising dieticians ($n = 88$) and nutritional services provided in these islands was also recorded.

Results: Both medical and nutrition services act more effectively to elders' cardiovascular health. For example, older individuals living in areas with nutritional services' support for at least five years, with collaboration between dieticians and physicians, reduced the CVD risk factors (CVD RF) burden by 42%. Whereas, in areas with dietetic support less than five years, but more than two, the presence of advanced health care system seemed to control the CVD RF burden to the population average.

Conclusions: Despite the fact that the present work shares some limitations mainly because of its cross-sectional design, the classification and regression tree approach has clearly demonstrated the interrelation between nutritional services and the health care system towards achieving benefits among the elders' quality of life.

Keywords: *cardiovascular risk, risk modelling, elderly, health care, nutrition, public health*

Introduction

According to the World Health Organization (WHO), cardiovascular diseases (CVD) constitute a major cause of death, especially for older adults (Levi et al. 2002). Furthermore, the causal pathway of CVD is much more complicated than ever before, since various novel environmental risk factors (e.g., financial status, etc.), in addition to the classical modifiable factors, i.e., smoking, unhealthy diet, hypertension, etc., have arisen, making the prevention of the disease quite difficult. In Greece, according to recent studies (Panagiotakos et al. 2009; Tyrovolas et al. 2009), the burden of the major CVD RF, such as smoking, unhealthy dietary habits, hypertension, hypercholesterolemia, diabetes, obesity, has been increased (i.e., the five-year incidence of CVD was 11.0% in men and 6.1% in women, in ATTICA study). This increase of CVD RF, at alarming rates, leads the scientific community into examining ways to improve the well-being and to prevent disease at every stage of life (Stefanadis 2010). One of these novel approaches is to focus on the role and effectiveness of health care services for the prevention of the disease. Until now very few studies have assessed the role of primary care doctors and prevention strategies on CVD risk. Within the framework of health care system, the role of nutritional services seems to be

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ISSN 0963-7486 print/ISSN 1465-3478 online
DOI: 10.3109/09637486.2011.641941

underestimated in the majority of countries (Tyrovolas et al. 2011c). In the few studies that have evaluated the role of dieticians and nutritional support on populations' health, the results were very promising (Tyrovolas et al. 2011a, 2011b). However, the complicated inter-relationships between nutritional support, physicians' role and individuals' behaviour and clinical status, within the framework of health care system, need careful investigation, beyond the classical approach of an epidemiological analysis.

It is a fact that the evaluation of factors implicated in the development of CVD has been mainly based on the classical association models' approach (i.e., logistic regression and Cox PH models). The classification tree is a method usually applied in decision theory in order to make informative rules. The purpose of this method is to develop a sophisticated model that predicts a dependent variable based on several input variables and to create association rules between the implicated variables (Breiman et al. 1984; Rokach and Maimon 2005). During the past few years, decision trees have been used as exploratory tools in several clinical analyses (Herman et al. 1995; Selker et al. 1995), whereas their use in epidemiological analysis is very limited.

Thus, the aim of the present work was to evaluate, with classification–regression tree analysis, the structure of the associations between nutritional and health care services and the cumulative prevalence of the classical CVD RF (i.e., hypertension, hypercholesterolemia, diabetes and obesity) of older individuals living in Greek islands and Cyprus Republic and participated in the Mediterranean Islands (MEDIS) study.

Materials and methods

Participants

The MEDIS study is a health and nutrition survey, aimed at evaluating bio-clinical, lifestyle and behavioural characteristics of older adults living in the Mediterranean islands (Tyrovolas, Bountziouka et al. 2009; Tyrovolas, Polychronopoulos et al. 2009; Polychronopoulos et al. 2010). As it has already been presented, a population-based, multistage sampling (i.e., three age group levels (65–75, 75–85, 85 +) and two sex levels) was used to select a representative sample of both men and women, from the Cyprus Republic and nine Greek islands (i.e., Lesvos, Samothraki, Cephalonia, Crete, Corfu, Lemnos, Zakynthos, Syros and Naxos). The sampling was based on a volunteer and feasibility basis; individuals were approached in public areas or in their homes and were asked to participate in the study. People residing in assisted-living centres, as well as those with a clinical history of CVD or cancer, were not included in the sampling in order to reduce recall bias and residual confounding. The sample consisted of 744 men (75 ± 7 years) and 742 women (73 ± 7 years) ($n = 1486$) (Cyprus, $n = 300$; Lesvos, $n = 142$; Samothraki, $n = 100$; Cephalonia, $n = 115$; Crete, $n = 131$; Corfu, $n = 149$; Lemnos, $n = 150$; Zakinthos, $n = 103$; Syros, $n = 151$; Naxos, $n = 145$). Of them, 523 (36%) were living in rural areas of the islands. The participation rate varied from 75% to 89% among the islands (people who denied participating provided various reasons, mainly lack of time).

As an extension of the MEDIS study, further information about nutritional services was collected from dieticians practising in the studied islands. Based on information provided by the Hellenic and Cypriot Dietetic Associations, the relevant Departments of the Ministry of Health and local administration offices, 88 dieticians agreed to participate in the interviews [i.e., 2 dieticians from Naxos (100% participation rate), 2 from Syros (50%), 4 from Lesvos (100%), 1 from Zakynthos (100%), 12 from Crete (60%), 3 from Cephalonia (100%), 9 from Corfu (50%) and 55 from Cyprus Republic (39%)], whereas in Samothrace and Limnos islands no dieticians were practising.

All the information from the elders and the dieticians was collected by a group of experienced field investigators (i.e., physicians, dieticians and nurses), using a quantitative questionnaire and standard clinical and biochemical procedures.

Participants were informed of the aims and procedures of the study and asked for their consent. The collected data were confidential, and the study followed the ethical considerations set by the World Medical Association (52nd WMA General Assembly, Edinburgh, Scotland, October 2000). Moreover, the design, procedures and aims of this study are approved by the Institutional Review Board of Harokopio University.

Measurements

Basic demographic characteristics, such as age, gender, annual income and lifestyle factors (i.e., dietary habits, physical activity, depressive symptoms, etc.), were recorded using a standard protocol that has extensively been presented elsewhere (Tyrovolas, Bountziouka et al. 2009; Tyrovolas, Polychronopoulos et al. 2009; Polychronopoulos et al. 2010). Specifically, dietary habits were assessed through a semi-quantitative, validated and reproducible food-frequency questionnaire (Tyrovolas et al. 2010). Physical activity was evaluated using the shortened version of the self-reported International Physical Activity Questionnaire (IPAQ) (Craig et al. 2003), while depressive symptoms were assessed using the validated Greek translation of the shortened, self-report Geriatric Depression Scale (GDS) (Fountoulakis et al. 1999). Weight and height were measured to attain body mass index (BMI) scores (kg/m^2). Overweight was defined as BMI between 25 and

29.9 kg/m^2, while obesity was defined as BMI $>$ 29.9 kg/m^2 (WHO 1997). Moreover, diabetes mellitus (Type 2) was determined by fasting plasma glucose tests and was analysed in accordance with the American Diabetes Association diagnostic criteria (i.e., fasting blood glucose levels $>$125 mg/dL or use of special medication indicated the presence of diabetes). Participants who had blood pressure levels (140/90 mmHg or used antihypertensive medications were classified as hypertensive. Fasting blood lipids levels were also recorded and hypercholesterolemia was defined as total serum cholesterol levels $>$200 mg/dL or the use of lipid-lowering agents according to the National Cholesterol Education Program (NCEP) ATPIII guidelines (NCEP 2002).

Moreover, a cumulative score indicating the overall burden of CVD RF of the older participants was calculated (Score 1 was given for each additional risk factor: hypertension, hypercholesterolemia, diabetes and obesity, theoretical range 0–4).

Information about nutritional services and practices within the health care system

Information regarding the number of dieticians within the public sector (i.e., primary: health care centres or medical offices, and secondary: hospitals) was retrieved from the departments of the Hellenic Ministry of Health (i.e., Administration Sanitary Districts), the Cypriot Ministry of Health, as well as the Hellenic Association of Hospital Dieticians and the Cypriot Dietetic Association. The number of dieticians practising in the private sector was obtained by the Hellenic Dietetic Association, the Hellenic Technological Association of Dieticians – Nutritionists, the Cypriot Dietetic Association, as well as from local telephone directories. The information about the role of nutritional services within the public or private sector was retrieved from both dieticians and older adults, through a standard questionnaire which included both quantitative and semi-quantitative questions and was developed for the purposes of this project. The questions were formed and based on an extensive literature review regarding the role of nutritional and other health care services and practices, usually followed in westernized societies (Writing Group of the Nutrition Care Process/Standardized Language Committee et al. 2008; European Federation of the Associations of Dietitians 2010). In particular, the following questions were asked to both the older adults participating in the MEDIS study and the dieticians practising in the studied islands: 'What was the main reason that an elder/you stopped nutritional consultations: financial, personal reasons, fatigue from the continuant consultation, long distance from home?' 'Do older people/you change their/your dietary habits according to your/dieticians' consultations?' 'Who urged older people/you to visit your/dieticians' office (i.e., physician, family, friend, other patient)?' 'What was the most frequent clinical reason that the older adults visited their dietician (i.e., obesity, malnutrition, hypercholesterolemia, diabetes, hypertension, menopause, osteoporosis, autoimmune diseases, depression, metabolic syndrome, kinetic problems, gastrointestinal problems or just for prevention/healthy eating)?'. Additionally, the following questions were asked only to the dieticians practising in the islands: 'How many years have you been practising at this island?' 'Do you have a masters or Ph.D. degree?' 'Are you working privately or in public services?' 'How often (i.e., rarely, every one year, every six months) are you updated on the progress in nutrition research through scientific journals and congresses' 'How often (i.e., rarely, every one year, every six months) do you modify your nutrition recommendations when something new is reported in the literature' 'Do you have older adults as patients ($>$65 years old) and how many?' 'How many elder clients visited your office at least once during last year?' 'How many elder clients completed their sessions of nutritional interventions last year?' 'Do you evaluate whether older adults have any information on healthy nutrition?'

Statistical analysis

The classification and regression tree (CART) method was used to evaluate the research hypothesis (Kass 1980; Breiman et al. 1984). The CART is a classification and regression method that splits the data into segments that are as homogeneous as possible with respect to the dependent variable. A terminal node in which all cases have the same value for the dependent variable is a homogeneous (pure) node; $n = 50$ cases was set here as the lower limit of each node. The algorithms that are usually used for constructing trees work top-down by choosing a variable at each step that is the next best variable to use in splitting the set of items. By the term best is meant by how well the independent variable splits the data into homogeneous subsets that have the same value of the dependent variable. The chi-squared automatic interaction detection (CHAID) growing method was applied here. The CHAID chooses the independent (predictor) variable that has the most significant association with the dependent outcome. Misclassification costs were taken into account in order to select the best tree model. In the present analysis, the CVD RF score was the dependent variable, while the nutritional and health care services (i.e., primary or secondary), dietician's presence or not, mean years of practicing, completion of dietetic consultations, postgraduate dietician's education, change to healthier food patterns after nutritional consultation, doctor's recommendation to visit an elder a dietician), were the input variables. Furthermore, ordinal logistic regression models were estimated in order to confirm the association between the overall CVD RF score

(dependent outcome) and the provided nutrition services (independent variables) by CART analysis. All reported *p*-values were based on two-sided tests and compared to a significance level of 5%. SPSS 18 software (SPSS Inc., Chicago, IL, USA) was used for all the statistical calculations.

Results

Basic demographic and clinical characteristics of the sample are presented in Table I. Although the participants had no chronic diseases, such as CVD or cancer, the prevalence of risk factors was quite high.

Results from the CART analysis of the nutritional and health care services, in terms of the overall burden of CVD RF measured using the cumulative score (range 0 to 4), are presented in Figures 1 and 2. Specifically in Figure 1, it can be seen that the parent node suggests that the mean number of CVD RF score of the studied sample was 1.4. Based on CART analysis, the most important classification factor was the mean years of the dietician's practice on an Island (Figure 1). In particular, when the dieticians were practising for more than five years, the sample had a decreased burden of CVD RF score (i.e., 0.4 mean number of CVD RF score) as compared with the islands that dieticians were practising up to five years (i.e., 3.2 mean number of CVD RF score). In addition, in the islands where the nutritional health care support was less than five years, the presence of only primary health care increased CVD RF burden, whereas CVD RF score decreased when both primary and secondary health care units existed, and further reduced when dieticians were practising for at least two years (see Figure 1, left branch). In the islands where dieticians were practising for at least five years, the CVD RF score was considerably reduced as compared with Islands having dieticians practising for equal or less than five years. Further reduction was observed in the cases where physicians recommended to the participants consulting a dietician (see Figure 1, right branch). Specifically, older individuals living in areas with nutritional services' support for at least five years, with collaboration between dieticians and physicians, reduced the CVD RF burden by 42%. Thus, according to the aforementioned analysis, a rule of having lower than the average (i.e., expected) CVD RF burden is to have dieticians practising for at least five years, as well as physicians who recommend their patients to consult a dietician. When dieticians were practising for less than five years, a combination of both primary and secondary health care services and the presence of dietician for at least two years were the most important factors affecting the mean of CVD RF score.

Table I. Characteristics of the study's participants ($n = 1486$).

	%
Age	
65–80 years old	74.4
80–90 years old	22.6
Over 90 years old	3
Male gender	50.1
History of diabetes mellitus	22.9
History of hypertension	65.1
Obesity (BMI $> 29.9\,kg/m^2$)	32.7
History of hypercholesterolemia	50.7

To further evaluate the association between nutritional and health care services and the burden of CVD RF, an ordinal regression model was applied (data not shown in tables). According to this model, mean years of dietician's practice (-4.4 ± 0.95, $p < 0.001$), completion of nutritional consultations from the elders (-13.7 ± 6.5, $p = 0.04$) and improvement of dietary habits after nutritional consultations (-24.5 ± 6.2, $p < 0.001$) were associated with a lower burden of CVD RF. These findings confirmed the results previously illustrated by CART analysis.

In Figure 2, another CART analysis is presented in which the independent variable of mean years of dieticians practising on an island was replaced by the number dieticians' practising in the studied islands. The interactions between the investigated variables were much more complex. In particular, the most important classification factor was the presence of primary and secondary health care units which decreased the burden of CVD RF by 36% (i.e., from 1.4 to 0.9), followed by the successful dietary consultations by dieticians in either the public or the private health care sector (Figure 2, right branch). Under this branch of the CART, it can be seen that at the bottom end of the tree participants who were under all these conditions had none of the studied CVD RF. However, in islands with only primary health care, presence of dieticians with graduate education seems to provide protection of CVD RF burden (i.e., as it can be seen at the end of the left branch of the CART, the CVD RF score was 1.0 as compared with the initial population average score which was 1.4). An ordinal regression model also confirmed the aforementioned results of Figure 2 (data not shown here).

In both CART analyses, no differences were observed when they were stratified by gender. Furthermore, it seems to be a common clue that the active cooperation between health care and nutrition services could be more functional to elders' cardiovascular health.

Discussion

In this work the association of nutritional services within the health care system was evaluated in relation to the prevalence of cardiometabolic risk factors among older individuals living in Greek islands and Cyprus. Strengths of this study are the initial concept that has never been studied in such populations and, to the best of our knowledge, has very rarely been studied

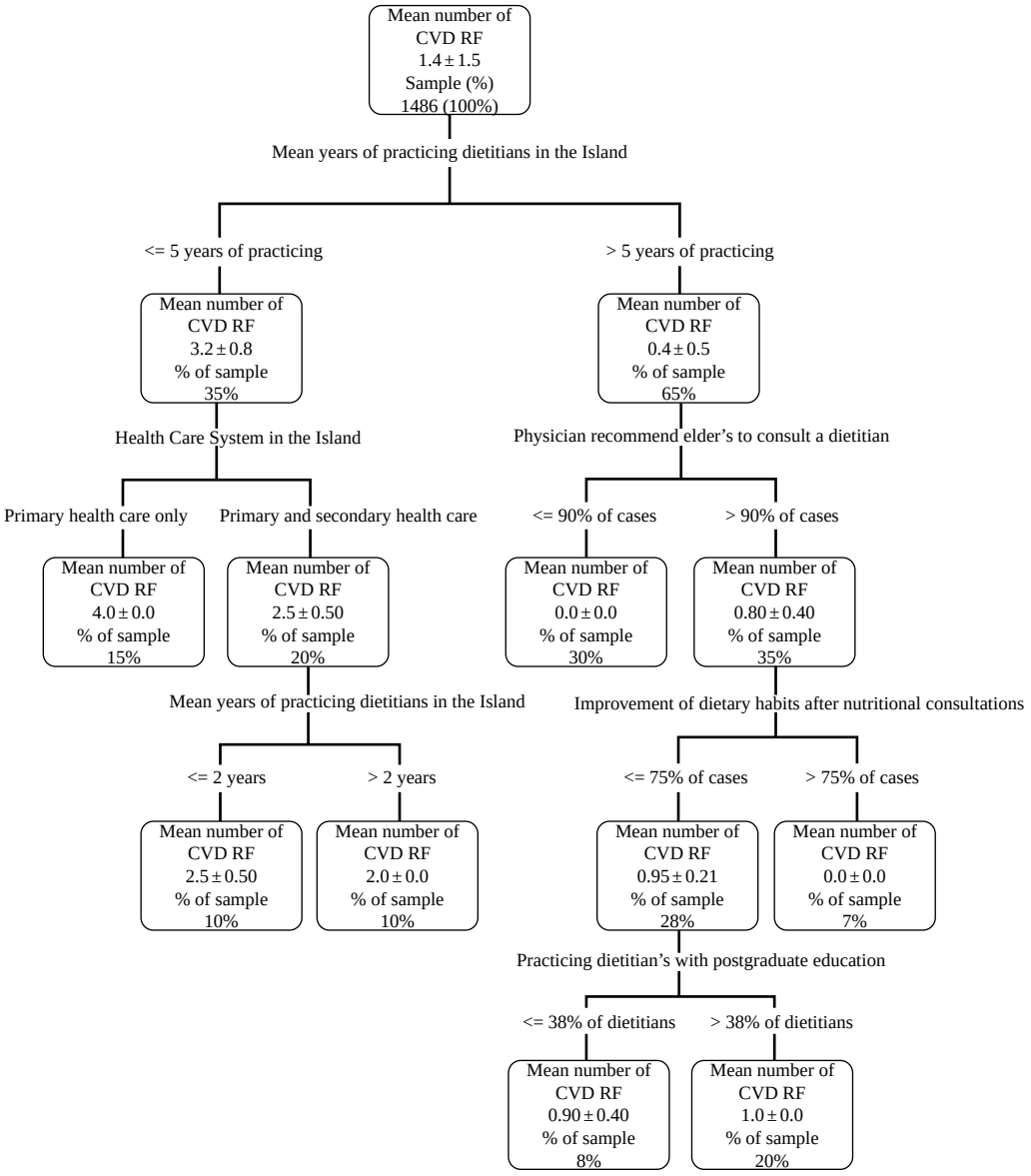

Figure 1. Classification and regression tree for cumulative CVD risk factors score (0: none to 4 risk factors), nutritional and health care services, including mean years of dietician's practice in the Islands of the study.

worldwide, and the sophisticated approach in analysing epidemiological data, i.e., the CART analysis. However, the cross-sectional design, the healthy volunteer effect (since cases with chronic disease were excluded) and the residual confounding (i.e., smoking habits, socio-economic status, physical activity, adherence to medication, etc.) may limit the findings of this work. Based on the presented analysis, a pathway was revealed suggesting that older individuals living in areas with nutritional services' support for at least two years (and favourably five years) and higher organization level of health care (primary and secondary) had lower burden of CVD RF. The latter finding is of major importance for public health, in order to plan the priorities for health better, by emphasizing on nutritional support and, consequently, nutrition education of the population. Additionally, the fact that the survey took place in Greece, a country with increasing CVD risk (Panagiotakos et al. 2009), enrolled only elders, living in islands with several transportation and other related problems during the year, and in many cases, with problematic or inadequate health care support, increases the public health implications of the presented results.

The CART is a useful classification method that assists to identify hierarchy, and, as a consequence, to understand the inter-correlation of the collected information better. The first node of each tree denotes the most important classification factor, followed by the less important factors; this way the reader may visualize the priorities hidden in the collected information. Furthermore, according to some studies, tree analysis classification seems to have minor differences with the classical logistic regression methods (Long et al. 1993). The presented analyses

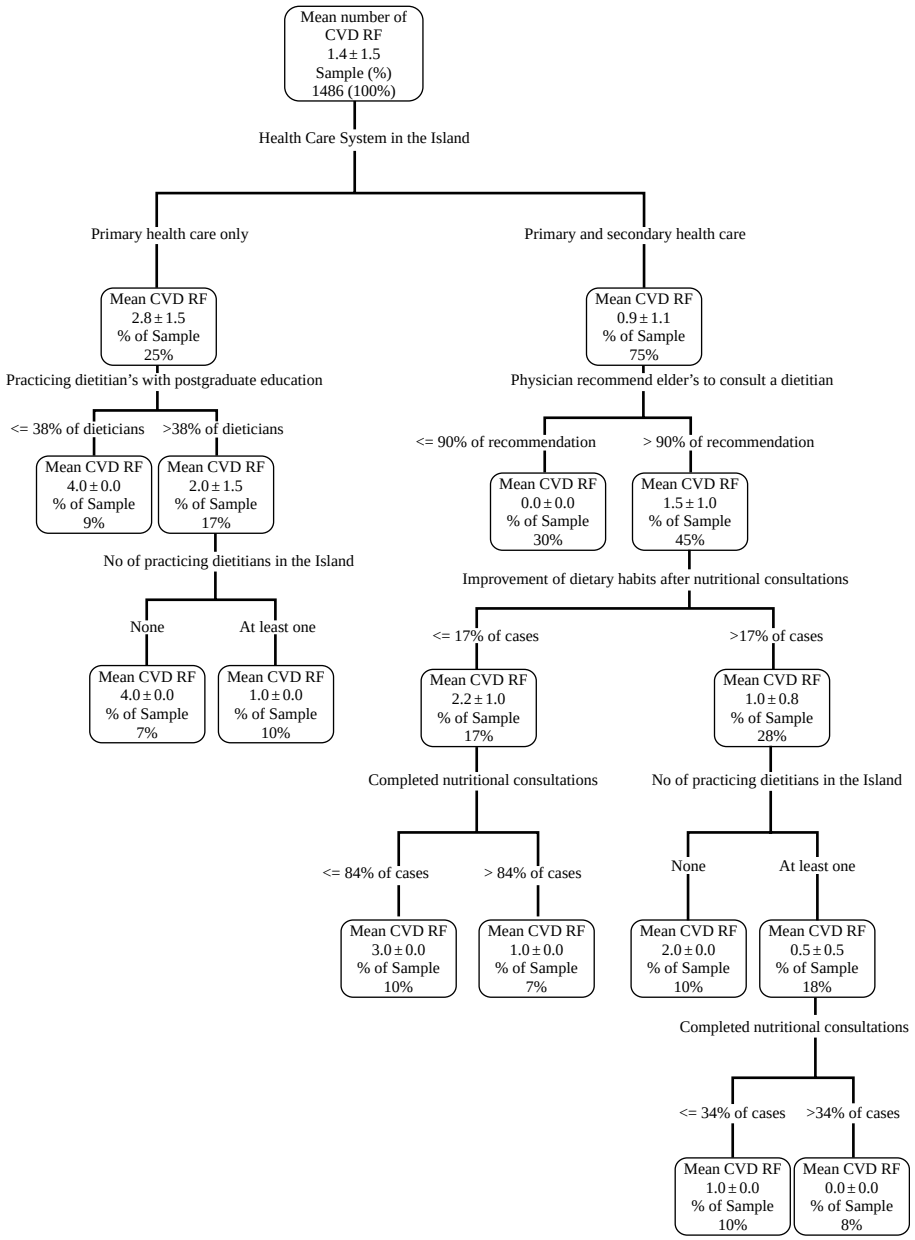

Figure 2. Classification and regression tree for cumulative CVD risk factors score (0: none to 4 risk factors), nutritional and health care services, including dietician's presence in the islands of the study.

confirmed the latter finding by showing that the direction of the association between the investigated factors and the CVD RF profile of the participants was similar in CART and the ordinal logistic regression models that were applied. Thus, under the concept that CART may provide more interpretable results than a classical regression model, in terms of visualizing the pathways between the investigated parameters and the outcome, the used classification method may be applied, alone or in combination with other methods, to better explore the relationships between the investigated variables in epidemiological analyses.

Healthy dietary habits have long been associated with reduced risk of CVD, as well as all components of the cardio-metabolic syndrome (Kastorini et al. 2011). Thus, the promotion of a healthy dietary pattern is, or more accurately, should be, of major priority for the health care system. The first classification tree of the present analysis revealed that the most important factor in the reduction of the burden of the four investigated CVD RF by almost 3.5 times was the presence of dieticians for at least five years within the health care system (public or private) of the island (Figure 1). Then, the cooperation between physicians and dieticians, and the effective changes in the elders' dietary habits after nutritional consultancy, contributed to further reduction of the overall burden of CVD RF (Figure 1). This model's structure indicates the necessity for active dietetic support within the health

care system and a strong cooperation between dieticians and physicians. Recent studies suggest that dietetic support is considered to be an important parameter in the prevention of CVD and diet together with healthier lifestyle recommendations, which may assist people in living better and longer (Haveman-Nies et al. 2003). An effective dietetic support should be focused on nutritional consultancy through the steps of assessment, education, goal setting and monitoring of outcomes (Writing Group of the Nutrition Care Process/Standardized Language Committee et al. 2008). However, this approach needs time to develop and be understood by the population; the latter was confirmed by the present analysis where a threshold of five years for dietetic support was observed in order to be effective in reducing CVD risk. And in the case that the dietetic support on an island was less than five years, a minimum of two years was found essential to have the burden of the investigated CVD RF around the population average (i.e., 1.4 out of four risk factors).

Another classification analysis revealed that another important factor for reducing CVD RF burden among the elders was the level of organization in the available health care services. In particular, islands that provided both primary and secondary health care units (health care centres, hospitals) had almost 1.5 times lower burden of the investigated cardiometabolic risk factors (Figure 2). However, islands with only primary health care services did not have the same positive effects in CVD RF score. This may be, partially, explained from the impact of the adherence to medication or on the fact that the majority of older people with one or more CVD RF are unaware of their condition, as it has been already reported by the MEDIS study (Panagiotakos et al. 2007b). Some other studies before have also revealed the benefits of structured health care services on populations' health (Shi et al. 2003). This could be partially explained by the better organization of the health care system in the region, the completeness of the medical services provided and the educative role of the health care providers to the community. Furthermore, the offer of secondary health services together with structured nutritional services seems to further reduce the accumulation of the classical CVD RF. The presented results seem to be in accordance with very recent studies in the field of nutritional services and population health (Tyrovolas et al. 2011a, 2011b). According to these studies, active nutritional policy and enhancement of nutritional services may contribute to improve health and quality of life among older populations. Furthermore, these findings deserve further attention by public health policy-makers, since Greece is a country with aged population and increasing incidence of CVD (Panagiotakos et al. 2009), and thus the collaboration between physicians and dieticians may lead to a significant reduction of CVD.

Strengths and limitations

The present study has several strengths, since it is the first that evaluated the current status of nutritional services offered in Greek islands and Cyprus, in relation to the burden of CVD RF among older adults, free of cardiovascular or any other chronic disease (i.e., cancer). Although the aforementioned findings cannot indiscriminately apply to other older populations, this study could be a model for a methodological framework for future studies throughout the world. As previously mentioned, strength of the present work is the application of a more sophisticated and visualized data analysis method, the CART, in order to explore the inter-relation between the collected data. However, the present work has some additional limitations to the ones presented above. The estimation of total CVD risk among elders is a difficult task, since the common risk models (i.e., Framingham Heart Sheet, ESC SCORE, HellenicSCORE) are mainly for middle-aged and younger individuals (Panagiotakos et al. 2007a). The cumulative risk score that was developed here by simply adding the presence of the common metabolic CVD RF of the individuals may not accurately estimate the CVD risk of these individuals. The exception of other, classical and novel modifiable CVD RF, like smoking and sedentary lifestyle, socio-economic and education level in the CVD RF score may consider as a limitation, but nutrition support has limited influence on these factors as the classical cardiometabolic risk factors. Moreover, lack of data from other non-insular regions of the country may also limit the generalization of the findings.

Conclusion

The application of the CART analysis illustrated the interrelation between nutritional services and the health care system towards achieving better health status and quality-of-life among the elders'. Health care together with nutrition services may act more effectively to the burden of CVD RF in older population. The presented findings also raised some concerns about the measures need to be taken for the promotion of nutritional services within the health care system, in Greece. Nutrition support by physicians should be further enhanced. Moreover, actions like nutritional continuous education, by the organization of nutritional programmes within the community, may assist elders to improve their quality of life.

Acknowledgements

They are particularly grateful to the elders and dieticians from the islands of Cyprus, Lesvos, Samothrace, Crete, Corfu, Limnos, Zakynthos, Cephalonia, Syros and Naxos, who participated in this survey. They also wish to express their gratitude to C. Lazarou, C. Lionis, A. Zeimbekis, F. Anastasiou,

P. Stravopodis, A. Skamagathis, E. Gotsis, V. Bountziouka, D. Antoniadis, as well as the Hellenic Dietetic Association, the Hellenic Association of Hospital Dieticians, the Cypriot Dietetic Association and the Hellenic Technological Association of Dieticians – Nutritionists, for their substantial assistance in retrieving information about health care system and nutritional data. The study is under the auspices of the Hellenic Dietetic Association. Stefano Tyrovolas received a scholarship from the Hellenic Atherosclerosis Society and Foundation for Education and European Culture (IPEP) to undertake his Ph.D. thesis, of which this work is part.

Declaration of interest: The authors declare that they have no conflict of interest. The authors alone are responsible for the content and writing of the paper.

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