Rev Esp Cardiol. 2011;64(10):876–882

Original article

Rationale and Methods of the Study on Nutrition and Cardiovascular Risk in Spain (ENRICA)

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Article history:
Received 24 March 2011
Accepted 17 May 2011
Available online 6 August 2011

Keywords:
Cardiovascular disease
Epidemiology
Spain

ABSTRACT

Introduction and objectives: The ENRICA study aims to assess the frequency and distribution of the main components of the natural history of cardiovascular disease in Spain, including food consumption and other behavioral risk factors, biological risk factors, early damage of target organs, and diagnosed morbidity.

Methods: A cross-sectional survey of 11 991 individuals representative of the non-institutionalized population aged 18 years and older in Spain was conducted from June 2008 to October 2010. Data collection comprised 3 sequential stages: *a)* computer-assisted telephone interview to obtain information on lifestyle, knowledge and attitudes about cardiovascular disease risk factors, and the signs and symptoms of heart attack and stroke, subjective health, and morbidity; *b)* first homevisit, to collect blood and urine samples for analysis by a central laboratory, and *c)* second home visit, to measure anthropometric variables and blood pressure and to administer a computer-assisted dietary history; data on functional limitations are also collected from participants aged 65 years and older.

Discussion: The ENRICA study has shown the feasibility of a large home-based health interview and examination survey in Spain. It will provide valuable information to support and evaluate national strategies against cardiovascular disease and other chronic diseases in Spain. Moreover, a 3-year prospective follow-up of the study participants, including a new physical exam, is planned to start in the second semester of 2011 and will update lifestyle information and biological variables. (ClinicalTrials.gov number, NCT01133093).

Justificación y métodos del estudio sobre nutrición y riesgo cardiovascular en España (ENRICA)

Palabras clave:
Epidemiología
Enfermedad cardiovascular
España

RESUMEN

Introducción y objetivos: El estudio ENRICA pretende medir la frecuencia y la distribución de los principales componentes de la historia natural de la enfermedad cardiovascular en España, incluyendo el consumo alimentario y otros factores de riesgo conductuales, factores de riesgo biológicos, daño precoz en órganos diana y morbilidad diagnosticada.

Métodos: Estudio transversal realizado de junio de 2008 a octubre de 2010 sobre 11.991 personas representativas de la población no institucionalizada de 18 y más años de edad en España. La recogida de datos se hizo en tres etapas secuenciales: *a)* entrevista telefónica asistida por ordenador sobre estilos de vida, conocimiento y actitudes sobre factores de riesgo de enfermedad cardiovascular y sobre signos y síntomas de alerta de ataque al corazón e ictus, salud subjetiva y morbilidad; *b)* primera visita al domicilio, para obtener muestras de sangre y orina que se envían a un laboratorio central para las determinaciones analíticas, y *c)* segunda visita al domicilio, para realizar antropometría, medir presión arterial y completar historia dietética electrónica. De las personas de 65 y más años, se obtuvo información sobre limitaciones funcionales.

Discusión: El estudio ENRICA ha mostrado en España la factibilidad de un gran estudio con entrevista y examen físico en los domicilios. Este estudio proporcionará información valiosa para orientar y evaluar las estrategias nacionales contra la enfermedad cardiovascular y otras enfermedades crónicas. Además,

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1885-5857/$ – see front matter
doi:10.1016/j.rec.2011.05.023

está previsto que en el segundo semestre de 2011 comience el seguimiento durante 3 años de los participantes en el estudio. Con ello se actualizará la información de estilos de vida y sobre variables biológicas obtenidas en un nuevo examen físico (ClinicalTrials.gov number, NCT01133093).

Abbreviations

CVD: cardiovascular disease
NHIES: National Health Interview and Examination Surveys

INTRODUCTION

Cardiovascular diseases (CVD) are the leading cause of disease burden in Spain,[1] and in most developed countries.[2,3] Control of CVD requires population-based strategies as well as clinical interventions that give priority to high-risk patients.[4] Rational implementation and evaluation of both types of intervention requires information on the natural history of CVD in the population.

The natural history of a disease is the set of progressive stages occurring from initial exposure to risk factors through disease onset, diagnosis of disease, and its subsequent resolution (cure, sequelae, death).[5] From a practical standpoint, the first component that must be known to control CVD is the frequency and distribution of the risk factors linked to lifestyle, such as smoking, diet, and physical activity. A very large percentage of the population has a high risk of CVD in the medium term due to smoking, inadequate diet, and inactivity. Controlling these factors illustrates the "public health challenge" in the prevention of CVD.[6] (Fig. 1).

Second, we need to know the distribution of biological risk factors that result from inadequate lifestyles. Notable among these factors are excess weight and the so-called metabolic syndrome. When these factors remain elevated long enough, they lead to hypertension, dyslipidemia, impaired glucose tolerance, and diabetes mellitus. Another important fraction of the population (though smaller than those with unhealthy lifestyles) has a short-term risk of CVD, precisely because of elevated biological risk factors. Their control illustrates the so-called "clinical challenge" in CVD prevention (Fig. 1). Meeting this challenge requires diagnosis of the elevated risk factor, appropriate treatment (lifestyle counseling, pharmacological treatment), and control of the risk factor itself, which is often difficult to achieve in clinical practice. One efficient strategy to face this clinical challenge is to modulate the intensity of preventive intervention according to the magnitude of absolute CVD risk, as recommended by most clinical guidelines. People with biological risk factors are relatively healthy for a long time, but after diagnosis they require clinical care and follow-up and become chronic patients. Care of these patients is one of the main challenges to health systems.

In the future, information is likely to be needed on emerging CVD risk factors like leptin, fibrinogen, and C-reactive protein. These factors illustrate important mechanisms (metabolic, thrombotic, inflammatory) that produce or aggravate CVD. They are not yet in routine clinical use, but this situation may soon change. For example, C-reactive protein could aid decisions on using lipid-lowering drugs.[7] Also, to interpret the level of these factors and make decisions about financing certain laboratory tests, population reference values are needed.

If biological cardiovascular risk factors remain elevated for a sufficient time, they might damage the target organs and subsequently lead to symptomatic diseases like acute coronary events or stroke. Thus, information should also be obtained on markers of early damage of target organs, like microalbuminuria, and of diseases which are often asymptomatic for long periods, like diabetes mellitus. Finally, data should be available on physician-diagnosed cardiovascular morbidity and its impact on perceived health and use of health services (Fig. 1).

Implementation and evaluation of national strategies to combat obesity and CVD also require data on people's response to these health problems, specifically data on knowledge of CVD risk factors and attitudes about their control, as well as knowledge of the warning signs and symptoms of a heart attack or stroke.[8–10]

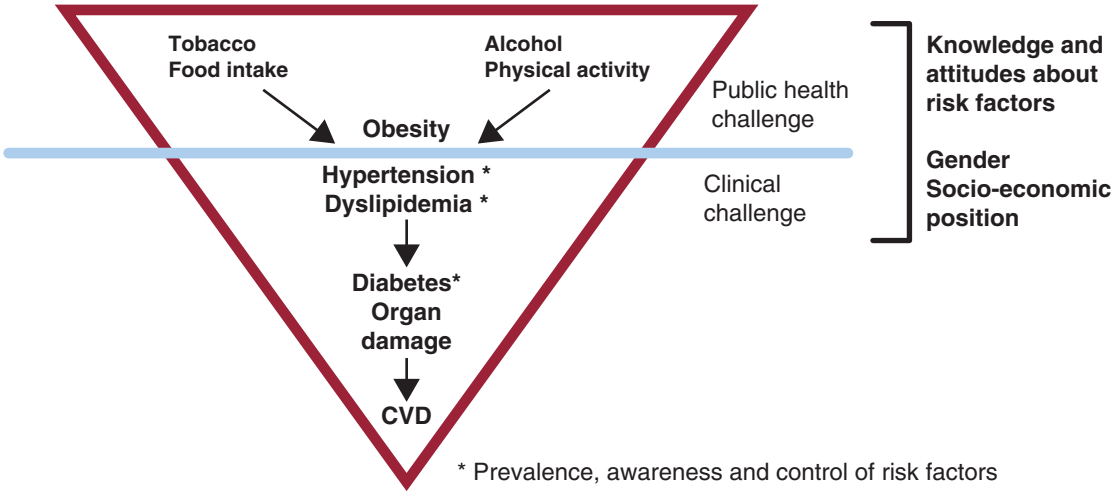

Figure 1. Principal components of the natural history of cardiovascular disease to be assessed in the ENRICA study (adapted from Yusuf et al.[6]). CVD: cardiovascular disease.

In general, the information on the natural history of CVD should be disaggregated by sex and indicators of socioeconomic position to show the social inequalities in CVD risk and control that should be the main focus of interventions.[11,12]

Obtaining the aforementioned information requires National Health Interview and Examination Surveys (NHIES) on representative samples of the whole population. This is because clinically based studies usually overestimate the frequency of the main risk factors for CVD and other health problems, and do not provide a good representation of population response to CVD. Only a few European countries and the United States of America conduct NHIES,[13,14] and Spain has no study of this type. Until now, information on biological risk factors for CVD in Spain proceeds mostly from local and regional examinations surveys records[15,16]. Moreover, detailed information on some lifestyles, like energy spent in physical activity, is available only at the regional level.[17,18] A European health examination survey is in preparation, with the participation of 14 European countries, including Spain. A pilot study on 200 persons per country should be finished in 2011; the definitive field work, which would include 4000 persons aged 20-54 years in each country, could begin afterwards.[19]

Study Objectives

The Study on Nutrition and Cardiovascular Risk in Spain (*Estudio de Nutrición y Riesgo cardiovascular en España*-ENRICA) is a NHIES conducted on a representative sample of the Spanish population. The ENRICA study aims to assess the frequency and distribution of the main components of the natural history of CVD in Spain, including diet and other behavioral risk factors, biological risk factors, early damage of target organs, and diagnosed morbidity. It will also examine knowledge and attitudes of Spaniards about CVD risk factors and their control. In addition, the study will document inequalities in management and control of the main risk factors by sex and socioeconomic status, as well as population attitudes about CVD risk. This information may guide national strategies against obesity,[8] ischemic heart disease,[9] and stroke[10] in Spain.

METHODS

Design

The ENRICA study is a cross-sectional survey of the noninstitutionalized population of Spain aged 18 years and older. The data were collected between June 2008 and October 2010. The information was collected in the participants' homes in 3 sequential stages:

1. Computer-assisted telephone interview, with a structured questionnaire on lifestyles, knowledge and attitudes about CVD risk factors, warning signs and symptoms of a heart attack or stroke, and health status, among other variables of interest. Mean duration of the telephone interview was 35 min.
2. First home visit, to obtain biological samples (blood and urine).
3. Second home visit, to measure anthropometric variables and blood pressure, and take a dietary history. In participants aged $\geq$ 60, information on functional limitations was also obtained. The average visit duration was 2 h. The average time between the first and the second home visit was 10 days.

All persons who collected information (nurses to obtain biological samples, and non-health personnel for the rest of the tasks) received specific training in the study procedures. Those who conducted the physical examination, took the dietary history, and assessed functional limitations (third phase of the study) received two and a half days of training, after which they passed a certification process including every aspect of the fieldwork.[20] Of 111 participants in the training, only 86 (77.4%) were certified. An additional 1-day reinforcement training was held 1 week after the main training. Finally, the data quality was audited for the first 10 persons visited in their homes by each examiner/interviewer.

The laboratory tests were performed centrally at the Center of Biological Diagnosis of the *Hospital Clínic* in Barcelona, according to standard procedures and appropriate quality controls.

Study participants have received the results of the blood and urine determinations and information on possible abnormal values. A telephone hotline was also available so that participants could consult with the research team if they had any questions about the study objectives and procedures or the results of the physical examination or laboratory tests.

The ENRICA participants provided informed consent by telephone and in writing. The study protocol was approved by the Clinical Research Ethics Committees of the *Hospital Universitario La Paz* in Madrid and of the *Hospital Clinic* in Barcelona. An insurance policy for civil liability was contracted to cover any risks to participants that derived from the study.

Study Participants

The study sample comprised noninstitutionalized persons aged 18 years and older residing in Spain. The study participants were selected by stratified cluster sampling. The sample was first stratified by province (the 50 provinces of Spain) and size of municipality (10 000; 10 000-100 000; 100 000-500 000; >500 000 population). Second, clusters were selected randomly in 2 stages: municipalities and census sections. Finally, the households within each section were selected by random telephone dialing using the directory of telephone land-lines as the sampling frame. Subjects in the households were selected proportionally to the distribution of the population of Spain by sex and age group (18-29, 30-44, 45-64, $\geq$ 65 years). Only 1 person was selected in each household; when there was more than one person in the required age and sex group, the invited individual was chosen randomly. During the telephone call, the overall objectives and procedures of the study were explained and invited individuals provided initial consent to participate; a formal letter of invitation and detailed written information on the study characteristics were then sent to the participant's home. Several days later, a second telephone call was made to confirm the consent to participate and to conduct the initial health interview. Information was obtained from a total of 248 municipalities and 1241 census sections in Spain.

Of the 22 387 subjects invited to participate in the study, 12 985 (58%) responded to the telephone interview. Among those not participating, the more frequent reasons were refusal to agree to a blood extraction (51.7%), no interest in the study (37.8%), and lack of time to participate (10.7%). Of those responding to the telephone interview, 12 880 (99.2%) provided a sample of blood and urine. Of these, 11 191 (86.9%) participated in the physical examination and provided dietary information. Accordingly, the final response rate in the study was 51%. Although the data are not directly comparable, the global response rate in ENRICA is among the highest of the NHIES conducted in Europe,[21,22] but is somewhat lower than the response rate in the NHANES III carried out in 2007-2008 in the United States of America.[23]

Table 1 presents the sociodemographic characteristics of the participants in the 3 stages of the ENRICA study (telephone interview, home visit with biological sample, and home visit with physical examination and dietary history) and of the Spanish population in 2009 according to the 2009 municipal register.[24] In

Table 1
Socioeconomic Characteristics of the Participants in the ENRICA Study and of the Spanish Population in 2009

	ENRICA n (%)			Population of Spain aged 18 and older n × 10 000 (%)		
	Total	Men	Women	Total	Men	Women
Total	11 991 (100)	5929 (49.4)	6062 (50.6)	3855 (100)	1890 (49.0)	1965 (51.0)
Age, years						
18-44	6007 (50.1)	3131 (52.8)	2876 (47.4)	1933 (50.1)	994 (52.6)	9391 (47.8)
45-64	3545 (29.6)	1757 (29.6)	1788 (29.5)	1144 (29.7)	566 (30.0)	5780 (29.4)
≥65	2439 (20.3)	1041 (17.6)	1398 (23.1)	778 (20.2)	330 (17.5)	4479 (22.8)
Level of education						
Primary or lower	3580 (30.2)	1446 (24.7)	2134 (35.6)	1414 (36.8)	659 (34.9)	755 (38.5)
Secondary	4953 (41.7)	2710 (46.2)	2243 (37.4)	1548 (40.3)	786 (41.8)	762 (38.9)
University	3331 (28.1)	1706 (29.1)	1625 (27.1)	880 (22.9)	437 (23.2)	442 (22.5)

Data for the age and sex distribution of the Spanish population were taken from the municipal register in 2009, while data for educational level were estimated from the European Health Interview Survey in Spain.

the ENRICA study there is a slight predominance of women (50.6%) over men (49.4%), and of younger individuals, both in women and men (47.4% and 52.8%, respectively, in the 18-44 years age stratum). This sex and age distribution is similar to that of the Spanish population. Given that there is no up-to-date national information on educational level, this variable was estimated from the European Health Interview Survey in Spain, conducted in over 20 000 persons in 2009.[25] As compared with participants in the European Health Interview Survey, those in the ENRICA study had a lower percentage of individuals with primary education or less (in men it was 10 percentage-points lower) and a slightly higher percentage of persons with university studies (Table 1). Phone surveys usually lead to overrepresentation of higher education levels as compared to face-to-face surveys.[26] Moreover, in most health surveys the response rate tends to be higher among those with higher education.[22] However, the Active Population Survey (*Encuesta de Población Activa*), conducted every 3 months on 200 000 people, reports that 31.4% of the population aged 16 years and older had primary or lower education in 2009.[27] Thus, the distribution of educational level in this large survey and in the ENRICA study is fairly similar.

The relatively high response rate in ENRICA and the similar sociodemographic distribution between the study participants and the Spanish population in 2009 suggest that the ENRICA study is representative of the population of Spain.

The sample size of ENRICA (11 991 individuals) allows estimation of the prevalence of a risk factor with a 95% confidence interval of ±1%, assuming a risk factor prevalence of 50% (worst case) and a sampling design effect of 1.3. The 95% confidence interval is wider for estimations in sex and age strata because of their smaller sample size. The sex-specific 95% confidence interval is ±2.5%, ±2.9%, and ±4% among those aged 18-44 years, 45-64 years, and 65 years or older, respectively.

Study Variables and Methods of Data Collection

Table 2 presents a complete description of the variables collected in each of the 3 stages of the study, and the instruments used. The telephone questionnaire included validated questions and scales from previous health surveys, and is available upon request to the authors.

During the first home visit each study participant provided 12-h fasting samples of blood and urine, which were then subject to numerous tests (Table 2). In addition, some aliquots have been stored in the *Hospital Clinic* in Barcelona to form a serum/plasma bank and a DNA bank. During the home visit the nurse also recorded each participant's medication use.

During the second home visit the physical examination was performed, which included anthropometry and measurement of blood pressure. Weight, height, and arm, waist, and hip circumferences were measured twice on each subject in standardized conditions.[28] These measurements were performed using electronic scales (model Seca 841, precision to 0.1 kg), portable extendable stadiometers (model Ka We 44 444Seca), and flexible, inelastic belt-type tapes.

Blood pressure was measured with validated automatic sphygmomanometers (model Omron M6), which have 3 cuff sizes according to arm circumference (<22, 22-32, or >32 cm). Blood pressure was measured using standardized procedures.[29] Two sets of readings were made, before and after the dietary interview. In each set, blood pressure was measured 3 times at 1- to 2-min intervals, after the individual had rested for at least 3 to 5 min in a seated position (or, if not possible, lying face up). Heart rate as measured by the sphygmomanometer was also recorded.

In addition, functional limitations in the instrumental activities of daily living were assessed in persons ≥ 65, using Lawton and Brody's test.[30]

Finally, in the second home visit, information on individuals' diet was collected using a computerized dietary history (DH-ENRICA), which collects the usual diet during the past year with questions related to all possible meals throughout the day. It begins by asking about the food eaten upon getting up in the morning ("Do you usually eat breakfast every day?" and "What foods do you usually eat for breakfast?"), and ends with food consumed before going to bed. Questions are asked about the food consumed in a typical week, and all foods consumed at least once every 15 days are recorded. Information on seasonal and weekend food consumption is also obtained with the DH-ENRICA.

The DH-ENRICA includes standardized information on 900 foods cooked in 30 different ways, using 122 household measures, and incorporates 127 sets of photographs to assess portion size. It also has 190 pre-established recipes for typical Spanish dishes, including regional dishes, which can be modified to capture the actual food consumed by those interviewed. Moreover, DH-ENRICA records the level of food processing, and applies fat absorption coefficients to food depending on the cooking method. Lastly DH-ENRICA estimates the intake of macronutrients, micronutrients, and minerals from food using composition tables for Spanish and foreign foods.[31–35]

To facilitate the dietary register, DH-ENRICA provides alerts about food groups not eaten, identifies participants who report inappropriate energy intake, and includes a dictionary of synonyms of foods from different regions. The final part of the dietary history also includes information on eating behaviors.

Table 2
Data Collection Methods and Main Study Variables in ENRICA

Collection method	Variables
Computer-assisted telephone interview	Health habits, in particular tobacco consumption, physical activity, and sedentariness Knowledge and attitudes about cardiovascular risk factors Knowledge and attitudes about signs and symptoms of heart attack and stroke Management of cardiovascular risk (frequency of risk factor assessment, lifestyle counseling, treatment adherence) Morbidity diagnosed by a physician Self-rated health and health-related quality of life Use of health care services Socioeconomic status
First home visit	
Blood and urine samples	Total cholesterol, LDL cholesterol, HDL cholesterol, nonHDL cholesterol, triglycerides, fibrinogen, high sensitivity C-reactive protein, glucose, insulin, hemoglobin-A1c, creatinine, uric acid, and leptin in blood samples. Microalbumin (ratio microalbumin/creatinine) in urine samples Serum and plasma bank DNA extraction and DNA bank
Face-to-face questionnaire verified against drug packaging	Use of drugs/medication
Second home visit	
Physical exam	Measurement of blood pressure, weight, height, and arm, waist and hip circumference, under standardized conditions
Face-to-face interview	Limitations in instrumental activities of daily living (only in individuals aged ≥65 years)
Computer-assisted face-to-face diet history	Consumption of foods and Spanish food dishes Nutrient intake Eating behaviors (recent diet change, dieting, snacking, eating away from home, eating while watching TV, drinking water before meals, eating alone, eating at the table, eating seated on an armchair/sofa).

HDL, high-density lypoprotein; LDL, low-density lipoprotein.

Statistical Analysis

The main analyses will be conducted according to a statistical plan drafted before completion of data collection, and will address the main study objectives. Thus, most analyses will take a descriptive approach.

The prevalence of the main CVD risk factors will be calculated by sex and age group (18-44, 45-64, ≥65 years). The cut-off points that define the risk factors (obesity, hypertension, dyslipidemia, etc.) and their control will be taken from the European Guidelines on CVD Prevention[36] and other reference publications.[1–3]

Spaniards' adherence to the principal dietary recommendations and indices of a healthy diet will also be examined. Specifically, we will assess the compliance with the nutritional goals set by the Spanish Society of Community Nutrition,[37] the conformity of nutrient intakes to the Recommended Dietary Intakes,[34] and adherence to the Spanish Society of Community Nutrition dietary recommendations for the Spanish population.[37] The Spanish Society of Community Nutrition makes recommendations on consumption of certain food groups, specifically potatoes, rice, bread and pasta, vegetables, fruit, olive oil, milk and other dairy products, fish, eggs, poultry, lean meats, legumes, and dried fruits and nuts. To determine whether food consumption in Spain adheres to the Spanish Society of Community Nutrition recommendations, the different food groups, number of recommended portions, and portion size will be taken into account (Table 3). In the case of rice, pasta and legumes, the portion size will be calculated according to the weight of the boiled food. The percentage of subjects whose intake is below the recommendation will be determined based on the lower limit of the number of recommended portions and of the weight of each portion. For the percentage of those who exceed the recommendation, we will use the upper limit of the number of recommended portions and of the weight of each portion. Finally, we will use standard scales[38,39] to assess whether the Spanish diet adheres to the Mediterranean pattern.

Table 3
Food Consumption Guidelines Developed by the Spanish Society of Community Nutrition[34]

Food group	Recommendation	Weight per serving
Rice, pasta, bread, potatoes	4-6 servings/day	Rice and pasta: 180 g Bread: 40 g Biscuits: 35 g Breakfast cereals: 30 g Potatoes: 150 g
Vegetables	≥2 servings/day	150 g
Fruit	≥3 servings/day	120 g
Olive oil	3-6 servings/day	9 g
Milk and milk products	2-4 servings/day	Milk: 200 g Yogurt: 200 g Cured cheese: 40 g Fresh cheese: 80 g
Fish	3-4 servings/week	125-150 g
Lean meat	2-4 servings/week	100-125 g
Poultry	2-4 servings/week	100-125 g
Eggs	2-4 servings/week	55 g
Legumes	2-4 servings/week	150-200 g
Nuts	3-7 servings/week	20-30 g

The statistical analyses will take into account the complex sampling design. Individual observations will be weighted to reconstruct the Spanish population, and the variances will be corrected. The main estimates will be presented with their 95% confidence intervals.

DISCUSSION

The ENRICA study has shown the feasibility of conducting a large NHIES in a representative sample of the Spanish population. Specifically, it has demonstrated that in a household survey it is possible to obtain biological samples safely and to conduct a

physical examination and a long (2-h) interview with good rates of participation.

A key factor facilitating the field work and the good participants' response is inter-institutional collaboration. The study was directed by an academic institution, analytic determinations were performed in a prestigious hospital, and the field work was conducted by a team with vast experience in regional door-to-door studies. In addition, the study has been financed by a private company, with additional contributions from public research agencies, and has received support from the Ministry of Health of Spain, and the regional governments of the Basque Country, Catalonia and Galicia. The invitations to participate in the study were issued by the Ministry of Health and in some cases by the regional governments as well. The latter also provided free telephone hotlines for potential participants to obtain additional information about the study. Moreover, regional governments informed physicians in the public health system about the study characteristics so that they could respond to inquiries from their patients. This close institutional collaboration will also lead to a better use of the ENRICA results, guiding and evaluating national strategies on CVD and other chronic diseases.

A further strength of the ENRICA study is the serum/plasma bank and DNA bank. This will make it possible to determine the reference population distributions of new serum markers and CVD risk genotypes as they emerge from the scientific literature.

Lastly, the ENRICA study sets the baseline for a prospective follow-up of a representative sample of the population of Spain. Funding has already been secured for a new telephone interview of the whole study sample, and for a home visit to the subsample comprising the individuals aged $\geq$ 60 years. The follow-up will allow us to update information on lifestyles (including diet), conduct a second physical exam, ask new questions on eating behaviors, and record new measures of body composition and strength in older adults. It will serve to test new hypotheses on the natural history of CVD in a Mediterranean country. Follow-up is planned to start in the second semester of 2011.

ACKNOWLEDGEMENT

We acknowledge the support from the Spanish Agency for Food Safety and Nutrition (*Ministerio de Sanidad, Política Social e Igualdad*), and the Health Departments of the Regional Governments of Catalonia (*Departament de Salut, Generalitat de Catalunya*), Galicia (*Consellería de Sanidade, Xunta de Galicia*) and Basque Country (*Osasun Eta Kontsumo Saila, Eusko Jaurlaritza*).

We thank Demometrica SL for conducting the field work, and study participants for their generous contribution to the ENRICA study.

FUNDING

The ENRICA study is funded by Sanofi-Aventis. Additional funding is obtained from FIS grants PI08-0166 and PI09-1626, and from PND 2010/006. The ENRICA study is being run by an independent academic steering committee.

CONFLICTS OF INTEREST

J.M. Taboada and M.T. Aguilera are employees of Sanofi-Aventis. The rest of authors declare that they have no conflicts of interest.

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