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Research Article

Environmental knowledge and Olive Cultivation in Andalusian Municipalities. Importance in Health Promotion, Type of Diet and Good Nutrition

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Abstract

Objective: Using records of mortality and sociodemographic statistics of the municipalities of Andalusia, this ecological study aims to analyse and identify the relationships between different variables such as the olive trees' surface and mortality rates from different causes. In the absence of municipal information on human food consumption, the analysis of cultivated land surfaces is a possible approach.

Methods: This ecological study analysed information about 408 Andalusian municipalities between two and fifty thousand inhabitants. Mortality rates adjusted for age were calculated between 2011 and 2015. The comparison was made and tested the differences in mortality rates and other sociodemographic variables among three groups of municipalities classified according to the amount of existing olive grove surface. Finally, a linear regression model was developed analysing mortality in relation to different variables (land uses, unemployment, declared income, altitude of the municipality, population evolution).

Results: When comparing municipalities according to "low" - "medium" - "high" olive grove surface, we observed significant differences as well as decreasing trend in mortality rates due to breast tumors, lung tumors, and ischemic heart diseases. The estimated regression model (R2 = 0.38), with the "summary" mortality (breast plus lung and heart disease) as dependent variable, included four predictors: altitude, unemployment rate, olive grove surface and declared income in each municipality.

Conclusions: We identified the four previous variables related to mortality in a significant way. It would be advisable to carry out more ecological studies. It would be also interesting to develop the comparative geographical study of food consumption.

Keywords: *Ecological Study; Olive Oil; Mediterranean Diet; Mortality Rates; Breast Cancer; Lung Cancer; Ischemic Heart Disease*

Introduction

Cultural patterns entail widespread nutritional habits in the population and are highly conditioned by the physical or geographical environment in which they are located and the availability of different foods. In our environment there is little comparable information on normalized food consumption that makes it possible to study the associations with values of basic health indicators in smaller geographical entities (population centers, municipalities, counties, provinces,...). Given this limitation, the analysis of land surfaces cultivated for different types of agricultural products, we think can be a good approach, firstly to the availability of food and secondly to the possible level of consumption that the inhabitants of these geographical environments make of certain nutrients.

The olive extension of the municipalities is related, in addition to the diet, to the general lifestyles of the people who live in the Andalusian municipalities. According to official data obtained through the Institute of Statistics and Cartography of Andalusia IECA (http://www.ieca.junta-andalucia.es/), Andalusia had around 1.5 million hectares of olive cultivation in 2013, to a total area of about 8.8 million hectares. This represents around 17% of the total area and between 40 - 45% of the cultivated area, well above the cultivation of other fruit trees. Andalusia remains prominent at the head of the Spanish production of olive oil, representing more than 80% of it. Spain produced in 2014, according to the International Olive Council, around 50% of the world production.

Based on the conclusions of many descriptive, observational and experimental scientific works and studies, the benefits of the "Mediterranean diet" are proclaimed [1-3]. This can be defined as rich in consumption of fruits, vegetables, legumes, bread, nuts, fish, olive oil, and with moderate amounts of wine. The monograph by Leonardis A, [4], summarizes and updates the basic knowledge on the production, composition, uses and benefits of virgin olive oil. The consumption of virgin olive oil has attracted great interest due to its protective relationship with respect to cardiovascular and metabolic diseases and tumors at different locations [1-3].

Various studies have assessed the impact of the Mediterranean diet and the consumption of olive oil on health. In this line, the international study of seven countries "The Seven Countries Study" [1] has already been followed for more than 50 years and shows differences in health indicators and their possible relationship with dietary factors and fat consumption. The MONICA project of the WHO [5], is also a study in 21 countries focused on cardiovascular diseases, risk factors and prevention, including dietary issues and geographic comparison of results. In Spain, multicenter projects have also been carried out, such as PREDIMED [6], which has shown a relationship between the use of the Mediterranean diet with olive oil supplements and a decrease in LDL-cholesterol levels. Different interventions have shown cardioprotective improvements by replacing saturated fats in the diet with mono- and polyunsaturated fatty acids [6-9].

In Mediterranean countries where there is a greater production and consumption of olive oil, the rates of coronary events seem to be lower than those of northern European countries [1,5,10,11], although in recent decades it is being observed a remarkable change in eating habits in different countries. This can be seen in studies on food availability [10,12] based on data from the "United Nations Organization for Food and Agriculture FAO", in 41 countries, observing the evolution since 1960. It is suggested that Mediterranean countries should develop policies to try to maintain traditional dietary patterns. In a review of changes in Greece and Cyprus, a great abandonment of traditional models among the youngest has been observed [13]. Dietary changes are also observed in northern European countries, where the body mass index has increased progressively with increases in the consumption of saturated fats [11].

In the bibliography of ecological studies in relation to food and other factors, there are exceptional works such as the study by municipalities [14] on factors related to greater longevity in mountainous areas of Sardinia, or another comparison between 94 Italian provinces, with evolutionary data and where mortality by cause is evaluated in relation to geographical, socio-economic, health care, environmental, cultural and nutritional variables [15]. Comparative studies between countries are somewhat more frequent [10,12], studying the evolution of the global availability and consumption of food, or analyzing relationships between food consumption and health indicators such as the frequency of obesity [16], tumors of different types [17,18] or cardiovascular diseases [1,5].

Due to all of the above and having different sources of information (mortality registers, sociodemographic statistics) with data at the level of each Andalusian municipality, the objective of the study was to analyze and identify the relationships between mortality rates due to different causes and the uses of the land along with some sociodemographic variables selected in the Andalusian municipalities. In particular, the relationship between the area rate of olive trees in each municipality (area/inhabitants) and age-adjusted mortality rates in both sexes was analysed. It is intended that this study provide a better knowledge of the municipalities that facilitates the development of work on lifestyle and nutritional habits, which in turn allow promoting differentiated preventive and promotional strategies at the local level.

Methods

The study was carried out with information from two main sources: 1. Interactive Mortality Atlas of Andalusia (AIMA) (https://www.demap.es/es/productos/aima), which provided the annual rates, specific by groups of age and sex, for the different causes of death in each municipality, and for the five-year period 2011 - 2015 (data prepared by the Andalusian School of Public Health and obtained from the Andalusian Mortality Registry) [19]. 2. Institute of Statistics and Cartography of Andalusia IECA (http://www.ieca.junta-andalucia.es/ using the application or Multiterritorial Information System of Andalusia-SIMA), which provided multiple information on the population and its demographic characteristics, as well as land uses or surfaces according to the type of crops in each municipality. Starting from quantitative frequency data in the municipalities, we designed and calculated the different indicators used. In addition, for this work we have carried out a bibliographic search ("ecological stuy and olive oil", period 2000 - 2019), in which we verified the low frequency of local ecological studies, which analyze the diversity of socioeconomic factors, food consumption and/or land uses.

The 408 Andalusian municipalities between 2 and 50 thousand inhabitants were chosen for the study, thinking that the smallest ones could have insignificant and fluctuating mortality rates (despite using 5 -year data). The largest municipalities have not been included in the study since they are few in number, and we also think that large food distribution companies play a greater role in consumption in them than the fact that they are produced and distributed locally. Using the records by municipalities included in the AIMA, this study started from the specific mortality rates for each year, by age group and gender. Next, annual average specific rates were calculated in the five-year period. Next, the adjusted annual rates of the global population between 45 - 84 years of age were calculated for each municipality (direct method, using Andalusia as reference population in 2013). The study was limited to this age range, considering that at younger or very old ages, the information on deaths from the causes analyzed may be scarce in terms of volume, statistical significance, and quality. Mortality due to cardiovascular diseases (ischemic heart disease and stroke) and tumors (of the lung, breast and colon-rectum) were studied, as these are the pathologies that the literature has shown to be more closely related to eating patterns such as the Mediterranean diet and fat intake, including olive oil [1,2,4].

Regarding the statistical analysis, first Pearson correlations between variables were calculated. Afterwards, the comparison of mortality rates and other sociodemographic variables was carried out between three groups of municipalities of the same size or number (n = 136 in each group) classified according to the amount of "high, intermediate and low" olive grove area, according to the area rate of olive groves in them ("high": between 511 - 3018 hectares/1000 inhabitants, "intermediate": between 510 - 67 and "low": < 67). The level of significance for all the tests used was $P < 0.05$ and the statistical analysis was performed using Stata/CI 14 for Windows.

The "summary" mortality variable was transformed (logarithmic) for its normalization and use as a dependent variable in the construction of multiple linear regression models. Finally, these models were developed, initially testing with the different causes of mortality as the dependent variable, although finally only one model was chosen that has as dependent variable a sum rate of causes of mortality in each municipality (ischemic heart disease and lung tumors in both men as women, more breast tumors in women), and this because these are the causes with which a statistical association was observed with the level or rate of olive grove area in the municipalities. To develop the model, the "backward" automatic selection method was first used, starting from the complete model with all the selected variables.

Results

Of the 778 Andalusian municipalities (year 2013), in 2 of them there was no information on mortality and in another 23 key statistical information was missing; 29 had more than 50 thousand inhabitants and 316 had less than 2 thousand (excluded from the study). Finally, 408 municipalities between 2 and 50 thousand inhabitants entered the study.

Significant correlations were observed between the rates of olive groves in the municipalities and all the mortality rates studied, with the highest correlation coefficients with mortality from breast tumors in women (r = 0.39), lung women (r = 0.37) and men (r = 0.29) and ischemic heart disease women (r = 0.29) and men (r = 0.25) (Table 1).

	Olive grove area rate	
	Coef. Pearson correlation	**P value**
Adjusted mortality rates between 45-84 years of age; annual averages per 10,000 inhabitants (period 2011-2015):		
Ischemic heart disease mortality (men)	-0,25	< 0,001
Ischemic heart disease mortality (women)	-0,29	< 0,001
Lung cancer mortality (men)	-0,29	< 0,001
Lung cancer mortality (women)	-0,38	< 0,001
Breast cancer mortality (women)	-0,39	< 0,001
Mortality due to cerebrovascular disease (men)	-0,22	< 0,001
Mortality due to cerebrovascular disease (women)	-0,21	< 0,001
Mortality due to cancer of the colon, rectum and anus (men)	-0,1	0,039
Mortality due to cancer of the colon, rectum and anus	-0,1	0,045
"Summary" mortality (due to ischemic heart disease plus lung cancer plus breast cancer)	-0,38	< 0,001
Indicators-demographic data and use of the territory of the municipalities:		
Population evolution between 1996 and 2014	-0,37	< 0,001
Rate of unemployed people	-0,48	< 0,001
Fruit area rate	-0,1	0,043

Table 1: *Correlation between the area of olive groves in the municipalities and other variables-indicators.*

When dividing the 408 municipalities into three groups by olive grove area (high, intermediate and low), we observe significant differences, along with a downward trend in the rates between the three groups, for mortality due to breast and lung tumors, as well as ischemic heart disease. These downward trends or differences were not clearly seen for cerebrovascular disease or colorectal cancer.

All distributions of municipal death rates are quite skewed. By calculating a new variable sum of the mortality rates due to tumors of the breast, lung and ischemic heart disease, we obtain a certain normality of the distribution that increases when performing the logarithmic transformation of this "summary" mortality variable (breast, lung and heart disease) (Figure 1).

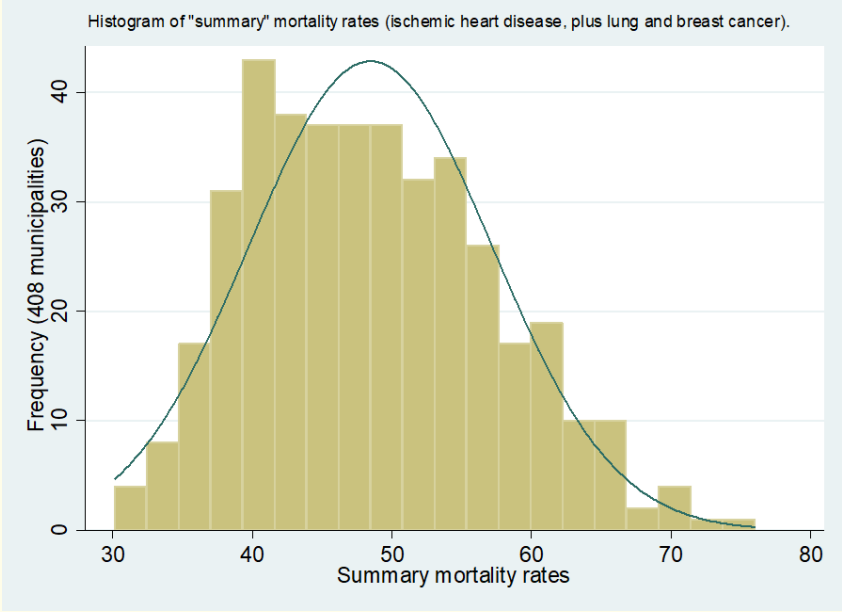

Figure 1

To develop the regression model, all the municipalities that had complete information for all the variables included were used (in 11 cases some information was missing). The estimated model with the "summary" mortality rate as dependent, finally included four predictor variables: altitude above sea level, the rate of unemployed people, the rate of olive grove area in the municipality and the declared net income per inhabitant (Table 2), in order of value of the standardized regression coefficients. A multiple correlation coefficient of the model (R2) of 0.38 was obtained. The "evolution of population size 1996 - 2014" and the "area rate of fruit trees excluding olive trees" were not finally included in the model because they did not meet the input conditions. The dispersion diagrams of the municipalities are presented as complementary information (Figure 2) relating each one of the predictor variables (X axis) with the "summary" mortality variable (Y axis).

Variables in the Model	Regression Coefficients (Standard Error)	P Value	Standardized Regression Coefficients
Altitude (m) above sea level	- 0,0002305 (0,0000259)	<0,001	-0,382
Rate of unemployed persons/1000 inhabitants (2013)	0,0014357 (0,0002285)	<0,001	0,288
Olive grove area rate (Hectares)/1000 inhabitants (2013)	- 0,0000448 (0,0000134)	0,001	-0,160
Declared net income /inhabitants (2013)	- 0,000015 (0,0000005)	0,007	-0,111

Table 2: *Regression coefficients of the association between "ln of the summary mortality rate (ischemic heart disease, plus lung and breast cancer)" and predictive characteristics in the linear regression model (*). Municipalities of Andalusia 2-50 thousand inhabitants (n = 397, R2 = 37,9%).*

(*) Variables that were analyzed but that were not finally included in the model: evolution of the population size, surface rate of fruit trees (not including olive trees).

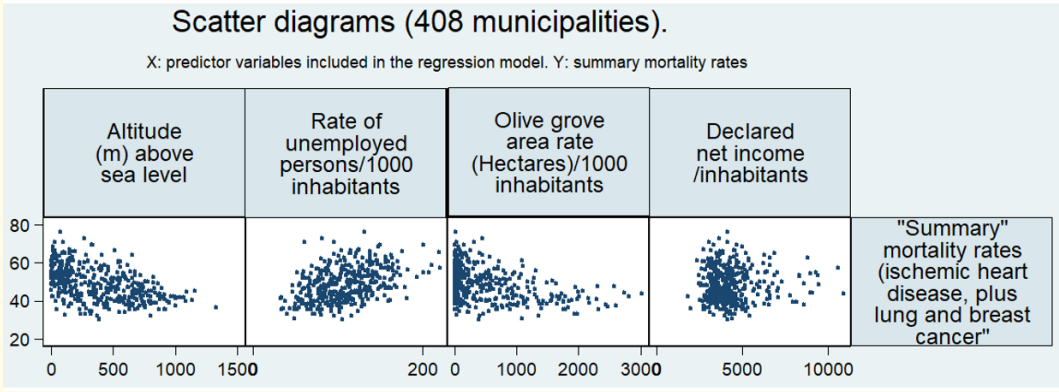

Figure 2

When interpreting the results, we must take into account the transformation in natural logarithm ("ln") made to mortality. The estimated model has been: ln ("summary" mortality estimated by the model) = 3.893 - (0.0002305 altitude) + (0.0014357 unemployment) - (0.0000448 olive grove area) - (0.000015 income).

To interpret the regression coefficients, we obtain their exponential values and we interpret them as proportions of increase (coefficients +) or decrease (coefficients -) that suppose a unitary change of each independent variable, keeping the other variables of the model constant. Thus, for example, we interpret for the "unemployment rate" of the municipalities that, according to the predictive model, for each unit of increase in this rate (/1,000 inhabitants) is to be expected or the model estimates an increase of 0.14% in the mortality rate (Exp(0.0014357) = 1.0014367). Similarly, we conclude that for every 100 m increase in altitude with respect to sea level, we estimate a 2.3% reduction in mortality; or for an increase of 100 hectares of olive groves (/1000 inhabitants), a 0.45% reduction in mortality (breast, lung and heart disease combined).

It was verified that the application conditions for the use of the multiple linear regression model were met (normality of the dependent variable, sufficient number of municipalities, few missing values of variables,...). The suitability of the final model elaborated was verified: linearity, homoscedasticity and normality of the residuals, as well as the degree of correlation between the independent variables.

Discussion

When studying the relationship between mortality and land use together with sociodemographic variables, it has been essential to have information sources with digital download and unified coding. Significant correlations are observed between the rates of olive groves in the municipalities and all the mortality rates studied. The estimated regression model finally included four predictor variables (Table 2), and would explain around 38% of the variability of the "summary" mortality rates, which represents a fairly acceptable level of prediction with a relatively simple model. The observed associations of the four variables with mortality would be significant, although it is not possible to define cause-effect relationships with this descriptive study. It would be the level of unemployment and income that could have a more direct or understandable theoretical impact, being in principle the altitude of the municipalities and their levels of olive cultivation intermediate indicators of other issues that are more difficult to measure or observe (air quality, habits nutritional and type of diet, cultural patterns and lifestyles,...).

Other variables, such as the mean age of the population, were not tested for inclusion in the predictive model, as the mortality indicators were already adjusted by this criterion.

Although they are not presented, in this study models were developed having mortality for each specific cause as dependent, observing that the rate of olive grove area of the municipalities seems to be a good predictor of mortality from breast tumors, ischemic heart disease and lung tumors. (in women), but not rates for colorectal tumors or stroke. We think that it would be interesting to take into account and contrast this information in future studies.

A very interesting conclusion is that, contrary to the olive grove surface, which is associated with the explanation of the inter-municipal variability of mortality rates, the same does not occur with the surface of other fruit trees and it is not observed to be related to any of the causes of death analyzed. This may support the interest in continuing to investigate the possible parallelism between the uses of the land, and the availability or consumption of food in the Andalusian municipalities.

As the main limitation of this work, mention that we use the study of cultivated area as an indirect indicator of the possible level of consumption (olive oil, fruits,...), but as long as real consumption data is not available in the municipalities, this is still a hypothesis to be tested. In the construction of indicators such as the level of unemployment or declared income, it could have been calculated with more common denominators (population of working age, number of people declaring income,...), but the search for a certain uniformity has led us to define these indicators in relation to global population.

Finally, we suggest the feasibility and importance of carrying out more ecological or geographical studies of this type, which relate public health indicators (mortality, morbidity,...) with other community or environmental variables. In other words, to promote the etiological study of health-disease with more and better population data, complementing the current overabundance of data obtained from individual people. Continuing to have at least annual information on deaths and other variables seems essential to us and can increase its value by carrying out evolution studies. We also want to emphasize the lack of information disaggregated by local entities (municipalities, counties, provinces) on food consumption. It is worth noting the regular information that the Ministry of Agriculture disseminates online, such as the Spanish "Household Consumption Surveys", very detailed by type of food, although they only have limited samples of local entities, which do not provide information significant at the regional level.

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