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Macro-level factors explaining inequalities in expected years lived free of and with chronic conditions across Spanish regions and over time (2006–2019)

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ABSTRACT

Life expectancy has long been associated with macro-level factors, including health expenditures, but little research has focused on the relationship with morbidity measures. This paper examines the relationship between the expected years lived free of and with chronic conditions (YLFCC and YLCC) at age 50 and macroeconomic and social factors including, for the first time, several indicators of public health expenditure. We calculate YLFCC and YLCC for Spanish regions using the Sullivan method over a long period of time (2006–2019). Spain is a good case study due to two reasons. First, its national health system is decentralized among regional administrations since 2002. Second, the financial crisis of 2008 led to public health cuts in 2010–2014 that each region handled differently. We use fixed-effects models to assess the relationship between changes in macro-level regional indicators (socioeconomic factors, healthcare resources, health behavior and public health expenditures) with YLFCC and YLCC across regions and over time. Results show that socioeconomic levels, public health expenditure, healthcare resources and health behaviors are associated with years lived free of and with chronic conditions when analyzing them independently. However, in the global model including all these dimensions only public health expenditure is associated with both YLFCC and YLCC for men and women, showing that a higher level of expenditures is correlated with more YLFCC and less YLCC. Therefore, regional authorities need to pay special attention to the level of investments on health services, as they are clearly associated with a better quality of living of the middle age and older population.

1. Introduction

Country and regional disparities in life expectancies (LE) have been long attached to income levels, and, more recently, to healthcare expenditure (Cremieux et al., 1999, 2005; Elola et al., 1995; Shaw et al., 2002; Nixon & Ulman, 2006; Jain & Yuan, 2020; Martín-Cervantes, Rueda López, & Cruz Rambaud, 2019). However, since LE are achieving very high levels, researchers have turn into looking at the macro determinants behind differences in morbidity measures, specifically on different indicators of healthy life expectancies (Gutierrez-Fisac et al., 2000; Groenewegen et al., 2003; Kondo et al., 2005; Jagger et al., 2008; Liu et al., 2010; Fourweather et al., 2015; Minagawa & Saito, 2018; Laborde et al., 2021). Here, the impact of socioeconomic variables on healthy life expectancies is extensively observed, but the correlation with healthcare supply indicators is not straightforward and results differ depending on the country under study (Groenewegen et al., 2003; Kondo et al., 2005; Laborde et al., 2021; Liu et al., 2010; Liu et al. 2010, 2010; Minagawa & Saito, 2018).

The case of Spain is of particular interest in the study of regional differences in health indicators because the country unfolded a decentralization of the national health system in favor of the regional administrations that finished in 2002 (Bernal-Delgado et al., 2018). Moreover, the 2008 financial crisis caused serious cuts on public provisions of health expenses which have been handled differently in each region (Gallo & Gené-Badia, 2013). Regional disparities in healthy life expectancies of Spain have been observed for a long time (Gutierrez--Fisac et al., 2000; Gispert et al., 2007; Zueras & Rentería, 2020), but the reasons behind these differences might have changed over time. In this vein, a recent study about trends in disease-free life expectancy at age 65 in Spain (Zueras & Rentería, 2020) found that regional differences

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decreased between 2006 and 2012 and widened again by 2017, suggesting that not all regions recovered equally from the government cuts to health services that occurred between 2009 and 2014. In addition, there were diverging trends by sex showing an expansion of morbidity among men in most regions while women experienced a compression in about half of them. Whether these results are related to regional inequalities of socioeconomic levels or to changes in the supply of public healthcare services and expenditure has not been explored yet.

This paper examines the factors explaining regional differences in health levels among the middle aged and older population, represented by two health indicators based on LE at age 50 over the period from 2006 until 2019 in Spain: the expected years lived free of chronic conditions (YLFCC) and expected years lived with chronic conditions (YLCC). All the health measures are based on the specific chronic conditions that are the main causes of death and disability in Spain (Zueras & Rentería, 2020) with the exception of high cholesterol -to avoid biases due to measurement changes over the period. We focus on the analysis of the prevalence of diseases over the LE because chronic conditions determine quality of life, they are a cause of multiple health impairments and define health care needs, the level of utilization of healthcare services as well as the demand of medical interventions. Using a healthy life expectancy measure is the best way to summarize both mortality and morbidity levels in one indicator (Robine et al., 1999). This type of indicators has been broadly used in public health because compared to life expectancy measures, they also provide information on the frailty level and quality of life of individuals and allow to monitor trends of compression and expansion of morbidity easily (Mathers et al., 2004; GBD, 2020). In addition, we use the threshold of age 50, instead of the more used age 65 for disability-free health expectancy, because chronic diseases appear earlier in life than disability impairments (Verbrugge & Jette, 1994). Among the factors explaining regional differences we include four groups of measures related to: (i) the socioeconomic level of the region, (ii) the level and type of health expenditure, (iii) health services infrastructures, and (iv) individual behaviors. The advantage of conducting regional analysis to examine these relationships is the higher comparability of variables across regions and over time (Crémieux et al., 1999; Crémieux et al., 2005; Gutierrez-Fisac et al., 2000; Groenewegen et al., 2003; Kondo et al., 2005; Liu et al., 2010; Minagawa & Saito, 2018; Laborde et al., 2021).

2. Macro-level factors and healthy life expectancy

Previous studies on the macro-level factors associated with healthy life expectancy have explored a broad range of indicators. Socioeconomic factors such as Gross Domestic Product (GDP) per capita, unemployment rates, material deprivation, several educational level indicators, as well as levels of urbanization show relevant associations with health indicators. Nevertheless, the same indicators are not significant for all studies. For example, Jagger et al. (2008) found that Healthy Life Years (HLY) at age 50 (using activity limitation) was associated with GDP per capita for both men and women, and long-term unemployment and educational level were also correlated with HLY for men, when comparing 25 European countries in 2005. However, in Fourweather et al. (2015), also with European countries, only material deprivation and long-term unemployment was correlated with variations in HLY from 2005 to 2010 (also using activity limitations). No association was found for GDP, poverty risk for older population, inequality of income, life-long learning or low education attainment. Results slightly differ in studies investigating within-country regional disparities. A study in the Netherlands showed that unemployment rates explained regional disparities in Healthy Life Expectancy (HLE) (using self-perceived health) in 1992–1997 for both men and women, and educational level was also significant for women (Groenewegen et al., 2003). In Spain, also unemployment was relevant to Disability Free Life Expectancy (DFLE) at age 65, as well as illiteracy rate in 1996 (Gutierrez-FIsac et al., 2000). Illiteracy and unemployment were again correlated with DFLE at age 60 in China, jointly with GDP per capita, the proportion of urban residents in the region and having fewer household utilities (Liu et al., 2010). In the case of Japan, Kondo et al. (2005) found that ordinary income was associated with DFLE at age 65 using data from 1995, but only in the univariate correlation. In the multivariate analysis no socioeconomic indicator coefficient was significant. However, in another study for Japan with data from 2010 Minagawa and Saito (2018) showed that income per capita, unemployment levels, the percentage of workers older than 65 years old and social welfare expenditure were strongly correlated to DFLE at age 65 for both men and women. Finally, a recent study examined the correlation of the taxation potential, the ratio of manual workers to higher-level occupations, the unemployment rate and the proportion of the population living in large urban areas with the indicators of LE, DFLE and share of DFLE over LE in France (Laborde et al., 2021). These indicators were associated independently with these health measures, however, the correlation of the local taxation potential disappeared in the multivariate model.

Studies that include healthcare supply measures are less common. The study in Japan from Kondo et al. (2005) showed a positive association between DFLE and the number of public health nurses and physicians, but no significant association with medical infrastructure such as hospitals, clinics, and beds. In Liu et al. (2010) with Chinese data they found the reversed results, with no correlation for the number of doctors and nurses, but a strong correlation with the number of hospital beds per 10,000 residents. In the study of Groenewegen et al. (2003) in the Netherlands, there were no significant correlations with any health resource indicator. Lastly, in France, in the study of Laborde et al. (2021), the density of nurses and physiotherapists were strongly associated with regional variations in health indicators but showed opposite directions. The density of physiotherapists had a positive association with DFLE while the number of nurses per 1000 population had a negative relationship. Authors proposed that physiotherapists help prevent functional deterioration of health problems whereas nurses respond to population needs.

Health behavior indicators are rarely included in these studies, and when considered, they refer mainly to the proportion of smokers or heavy drinkers. In the research conducted in the Netherlands (Groenewegen et al., 2003) and Spain (Gutierrez-Fisac et al., 2000), they showed the expected association with the number of estimated years lived in good health, that is to say, a higher proportion of smokers and heavy drinkers was correlated with less years spent in good health, although the association was only relevant for men.

Finally, health expenditure indicators are present in many studies that try to explain country variations in LE over time (Linden & Ray, 2017; Mackenbach et al., 2017; Obrizan & Wehby, 2018), although they are less used to understand healthy life expectancy differences. Minagawa and Saito (2018) explored welfare expenditures in the long-term care insurance program in Japan and found a strong relationship between these expenditures and DFLE at age 65 for both men and women. One of the reasons of not assessing health expenditure in health expectancy studies could be that in unique country studies it is difficult to capture regional differences in health expenditures if those are not decentralized as in the case of Spain. Another reason is that health expenditures are very much related to GDP, and therefore, it is difficult to disentangle them. Nevertheless, health expenditures have shown to be a very powerful intervention, at least to improve life expectancy (Obrizan & Wehby, 2018), and, therefore, it is worth analyzing if there would be similar effects on healthy life expectancies. This is even more important in a context of economic crisis, as in the case of 2008 in Spain, where it is crucial to assess the prioritization of health expenditure to ensure a higher quality of life of the population.

Despite life expectancy with and without disability or activity limitations are the prominent indicators used in cross-country or regional comparative studies examining the above mentioned factors, chronic conditions are more often used to explore the relationship with health expenditures. In an international study involving 17 European countries, Mackenbach et al. (2017) found that relative increases in healthcare expenditure was associated with lower mortality from amenable causes, mostly based in chronic diseases. These results were particularly significant regarding cerebrovascular and cardiovascular diseases. On the contrary, healthcare expenditure was not associated with a reduction of nonamenable mortality, except for low educated men. In the case of Spain, regional disparities in years spent with and without chronic conditions were increasing over time in recent years, showing the importance to explore the reasons behind these trends (Zueras & Rentería, 2020), knowing the special economic circumstances due to the financial crisis (2008–2014). Moreover, Spain is an ideal setting to study the association between regional disparities because it is a highly decentralized country. Large education and job outcomes divergences translate into one of the European countries with higher regional disparities in income and poverty (McGowan & San Millán, 2019). Spain is also one of the most decentralized countries regarding public spending, including health, where the provision of public services and the regulation of human resources or number of centers is transferred to regional governments (McGowan & San Millán, 2019). Regional differences have already been found for DFLE (Gutiérrez-Fisac et al., 2000; Gispert et al., 2007), but when looking at years lived with and without chronic conditions only one study has been done for Catalonia, a region of Spain (Sole-Auro & Alcaniz, 2015). Their findings refer to an increase between 1994 and 2011 in the percentage of LE lived with disease, as well as an increase in functional limitations, for both men and women, however, they did not compare with other regions in Spain. Also, only one of this three studies (Gutiérrez-Fisac et al., 2000) referred to regional characteristics to explain regional disparities. To our knowledge, this is the first longitudinal analysis to assess the effects of changes in a broad range of macro-level indicators on changes in YLFCC and YLCC with high comparable data across entities and over a long period of time.

3. Data and methods

To conduct the analysis, we used all the information disaggregated by Spanish regions. Life tables for Spanish regions are extracted from the National Institute of Statistics (INE, 2019). Macro level factors related to socioeconomic level, health expenditure and healthcare supplies at the regional level come from the National Institute of Statistics, the Labor Force Survey, and the Public Healthcare Expenditure Statistics, available from the Ministry of Health, Consumption and Social Welfare. Prevalence data on diseases and chronic conditions, as well as health-related behaviors come from six health surveys: The National Health Surveys (ENS as per its Spanish acronym) of 2006, 2012 and 2017; and the European Health Interview Surveys (EHIS) of 2009, 2014 and 2019 (the latest available). Data from health surveys correspond to a sample of the Spanish population that is representative for regions. We limited the study to 17 regions because we had to discard data from the two autonomous cities of Ceuta and Melilla due to small sample. We analyzed data for adults aged 50 and over.

The health conditions considered in this study are related to the leading causes of disability, death or their main risk factors (Soriano et al., 2018). These include asthma, back pain (including both low back and neck), chronic obstructive pulmonary disease (COPD), cancer, diabetes, heart disease, hypertension, myocardial infarction, and stroke. The following set of questions addresses the presence of these health conditions: (1) Have you ever suffered from ‘this specific health condition’? And, for those who have, (2) Have you had it in the last 12 months? (3) Has a doctor told you that you have it? We considered that individuals have the chronic condition when they answered all the questions in the affirmative. Therefore, the prevalence rate of having a chronic condition was estimated for each year and region as the weighted proportion of individuals in each age group and sex having at least one of the chronic conditions under study. Equity in access to healthcare is definitely an issue when investigating the relationship between health expenditure and population health (Joumard et al., 2008). Although uneven access to general practitioners could bias prevalence of diagnosed diseases, the Spanish public healthcare system is universal and Spain is among the European countries with lowest share of unmet needs for medical examination or treatment (OECD, 2017). Proportions of missing information for each question and health conditions included was very low among population aged 50 and over. Specifically, for all the health conditions included in each survey, less than 0.05% individuals in our sample did not respond or did not know if they had ever suffered the specific condition (question 1). Similarly, the numbers of those who had missing information on all health conditions here included were also below 0.05% in all years.

To estimate the expected years lived free of chronic conditions (YLFCC) and the expected years lived with chronic conditions (YLCC) we used the Sullivan method (Sullivan, 1971). This method estimates the number of expected years that a life table cohort would live at a certain age in a healthy or unhealthy state, given that they experience the same prevalence rates of disease as the population in that year. In this case, YLFCC (free of chronic condition) is estimated using the following formula:

$$YLFCC^{x}_{f\_c} = \frac{1}{l_x} \cdot \sum_{i=x}^{w} L_i(1 - C_i) \quad [1]$$

where L_i is the number of person-years lived in the age group (x, x + 5), l_x corresponds to the number of survivors at age x (in this case age 50) and C_i is the proportion of people living with any of the conditions considered in the age group (x, x+5) (prevalence rate of having a chronic condition). YLCC is estimated by subtracting to LE at age 50, the YLFCC estimated with formula 1.

Macro factors to explain the difference between regions were divided in four groups of variables. The first group measured socioeconomic characteristics and included: real GDP per capita in 2015 year constant prices, the level of inequality measured by the S80/S20 ratio, the percentage of rural population, the total unemployment rate, the older population (55+) unemployment rate, and the proportion of people over 50 with primary education or less. The S80/S20 ratio represents the relationship between the average income obtained by the 20% of the population with the highest income (highest quintile), and the average income obtained by the 20% of the population with the lowest income (lowest quintile). The percentage of rural population refers to the proportion of people living in municipalities smaller than 5000 inhabitants in the region. The second group related to healthcare expenditures and is represented by three measures: total expenditure on public healthcare, expenditure on public primary care and public hospital expenditure. These measures were included as real per capita measures over the whole population in 2015 euros. We focused only on public health expenditure due to their great importance in Spain. Public share of health expenditure represented 71% of total health expenditure in 2019, but they were even more important in the past, and private health expenditure are mainly devoted to co-payments for prescribed medicines, dental care and optical care (OECD, 2017). Besides, previous research has shown that public health expenditure is especially crucial to increase health levels, and private health expenditure increases are mainly driven by rises in public health expenditure as well (Linden & Ray, 2017).

In the third group of variables, we considered healthcare services and supplies and we used: number of hospital beds per 1000 population, the number of general practitioner doctors and nurses per 1000 population and the number of specialist doctors and nurses per 1000 population. Finally, in the last group we included measures that capture individual behaviors such as the percentage of overweight, the percentage of obese and the percentage of current and ever smokers. Given a moderate proportion of missing information on smoking, height and weight, we used multiple imputation by sex using chained equations with age, education and region as factors to impute these variables before deriving the proportion of smokers, overweight and obese. We created 20 imputations and used the random number seed 1234 for reproducibility. All these indicators were calculated among the 50+ population and separately for men and women.

In a first step, we explored the Pearson's correlation of each variable with each of the health measures (YLFCC and YLCC) for men and women separately. Secondly, we conducted fixed-effects multivariate models for each health outcome using all variables that turned out to be significant in the univariate analysis. We chose this model for panel data including regions because it allows to control for individual heterogeneity by controlling for unobserved time-invariant variables and variables that change over time but not across regions, such as national policies. Fixed-effect models were fit separately for each group of variables (socioeconomic factors, health expenditures, health resources and health behaviors) and then we also run a final model including all variables together. The equation for the fixed effects is:

$$Y_{it} = \alpha_i + \beta_1 X_{it} + \mu_{it} \quad [2]$$

where α_i (i = 1, …, n) is the unknown intercept for each entity (in this case 17 regions). Y_{it} is the dependent variable (YLFCC or YLCC estimated with formula 1) where i = entity and t = time. X_{it} represents an independent variable, β_1 is its coefficient, and μit is the error term. Fixed-effects models were done separately for men and women, but to test if sex-differences along the variables used were significant we also conducted a fixed-effects model for each health indicator with men and women outcomes together. In this model, each entity referred to each sex and region.

4. Results

4.1. Trends in health indicators and public health expenditure

Figs. 1 and 2 show the box plots of the regional YLFCC and YLCC in Spain between 2006 and 2019 for men and women. Therefore, these figures show the level of regional dispersion in each year, as well as the difference in levels over time. The maximum, minimum and median levels of YLFCC and YLCC can also be consulted in the supplementary materials (Table S1). YLFCC indicators have similar trends and levels for men and women, although women display a higher dispersion over regions. YLFCC was higher in 2009 and decreased in many regions in 2012 to continue a more stable trend until 2019, when YLFCC increased again. Also, since 2014, women experienced higher levels of YLFCC than men in more regions. Regarding YLCC, levels for women were higher than for men all over the period, but trends were similar between sexes and followed what was found in YLFCC but in the opposite direction, as expected. Hence, in 2009 YLCC had the lower levels that increased in 2012. After 2012, trends turned more stable, and only in 2019 the level of YLCC clearly diminished again.

Macro factor levels used here refer to a wide range of socioeconomic, health expenditure, health services and human resources, and health-behavior indicators. Table S2 in the supplementary materials shows the great range of disparities in each macro level factor. For more detailed examination, Fig. 3 displays three-year moving averages of yearly values of per capita public health expenditure in the different regions of Spain. Levels of expenditure per capita differ greatly by region, where highest values surpass by 50% the lowest values. Trends

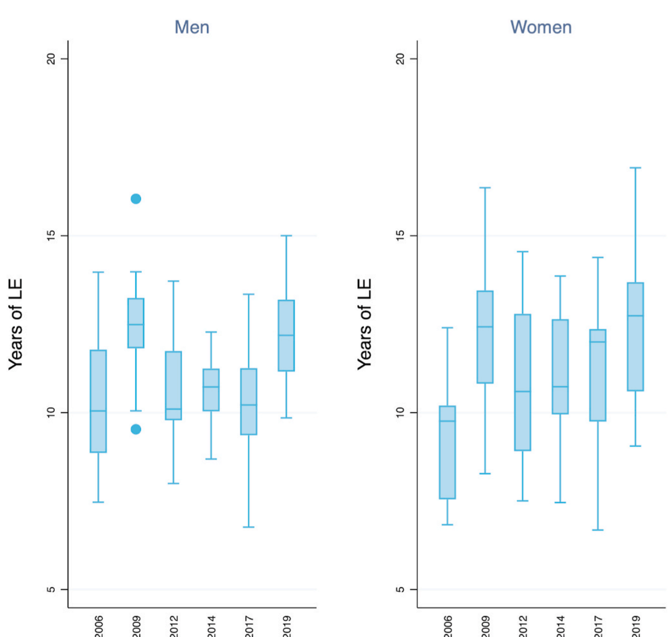

Fig. 1. Expected years lived free of chronic conditions (YLFCC) at age 50 in Spanish regions over 2006–2019 by sex.
Source: Author's calculations

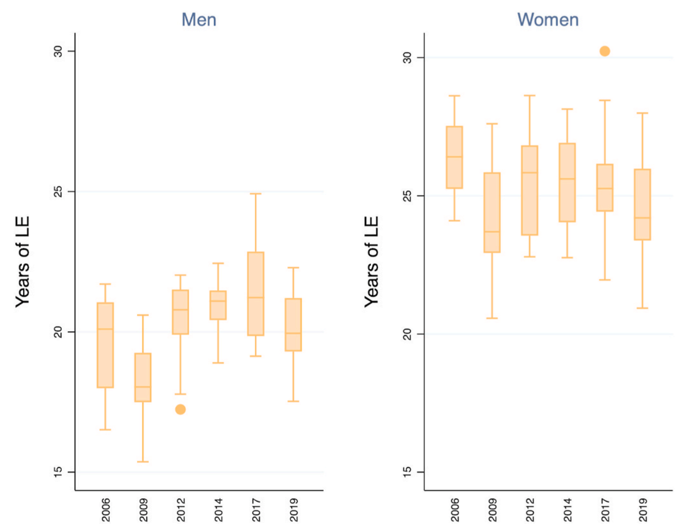

Fig. 2. Expected years lived with chronic conditions (YLCC) at age 50 in Spanish regions over 2006–2019 by sex.
Source: Author's calculations

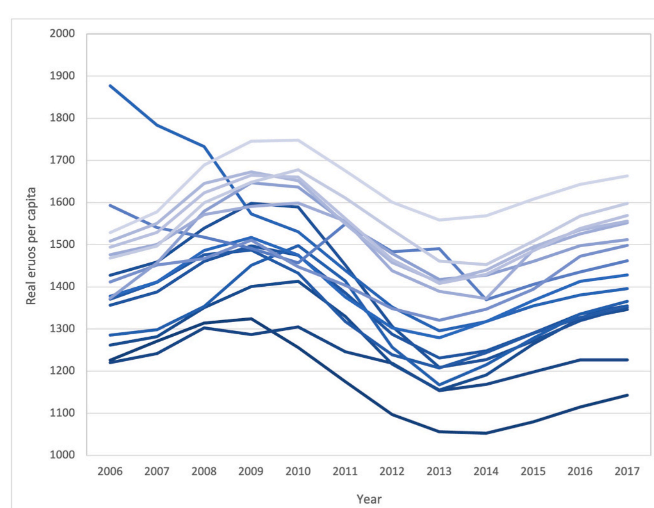

Fig. 3. Total public health expenditure per capita (moving averages) from 2006 to 2019 in the 17 regions of Spain.
Source: Author's calculations from the Ministry of Health, Consumption and Social Welfare. Real values in 2015 euros.

look similar, although the onset of changes differ in some years for each region. In any case, there are two clear inflexion points as expenditure increased until around years 2008–2010, and then decreased until 2013–2014, where it increased again until nowadays. This applies to all regions with two exceptions (La Rioja and Cantabria) that show a continuous decrease in health expenditure since 2006. In 2012–2014 the majority of regions experienced the lowest levels of the period, as a result of the public health cuts that started around 2008–2010. Since 2013–2014, health expenditure recovered, but in 2017-2019 the 2008–2010 real values were not achieved yet.

4.2. *Macro-level factors and regional health trends*

As explained in the methods, first of all we explored the univariate correlation between each variable and each health indicator, for men and women separately. The Pearson's correlation coefficients of each variable can be found in Table S3 of the supplementary materials. From this analysis, we selected only variables that were significant in the correlation with at least three of the health indicators, to be sure that they were significant for both men and women. Hence, only real GDP per capita and percentage of population with primary education or less were significant for all health indicators. GDP per capita was positively correlated with YLFCC and negatively with YLCC, in the expected direction. However, the percentage of population with primary education or less was negatively correlated with YLFCC, but also negatively correlated with YLCC for men (not for women). This means that regions with a higher proportion of men with lower education level are having a lower YLFCC and YLCC at the same time. However, it is not the case for women, and a higher proportion of women with lower education level in the region was correlated with a lower YLFCC and a higher YLCC. Those variables that were significant for three health indicators are the unemployment rate of older workers, public health expenditure per capita, hospital care expenditure per capita, the number of specialist doctors per 1000 population, the number of specialist nurses per 1000 population, the percentage of individuals aged 50 or more that are overweight, and the percentage of individuals aged 50 or more that are obese. From all these 9 indicators, we included 8 of them in the global fixed-effects model. We withdrew the variable of being overweight to avoid the intercorrelation effect with being obese.

Tables 1–4 display the results from the fixed-effects models for each health indicator and for men and women separately. All analyses examined first the role of macro-level factors separately by groups and then all groups of macro-level indicators together, following the same model specifications. Model 1 includes socioeconomic variables, model 2 health expenditure variables, model 3 health resources, model 4 health behaviors and finally, model 5 includes all variables together.

In models among men, GDP per capita was significant in both YLFCC and YLCC socioeconomic models, denoting that a higher GDP implied a higher YLFCC and a lower YLCC. Additionally, YLCC was also negatively correlated with the percentage of population with lower education, as we saw in the individual correlation. Among health expenditure variables, public health expenditure per capita was positively correlated with YLFCC and negatively with YLCC, and more hospital expenditure was also correlated with a higher YLFCC, but also with a higher YLCC. In the fixed-effects models of health resources and health behaviors, no variable turned significant for both YLFCC and YLCC. Finally, in the global model, only public health expenditure was significant for both health indicators, with a clear positive correlation with YLFCC and a negative correlation with YLCC. In the case of YLFCC also hospital expenditure continued to have a positive correlation in the global model, and for YLCC, a higher percentage of individuals with primary education also implied a lower YLCC, in the same direction that in the univariate correlation.

In models over women, some of the variables that were significant differed from those for men. In the socioeconomic variables models, only the proportion of women with primary or less educational level was negatively significant for YLFCC, but no correlation was found for YLCC. In the model of health expenditure variables, only hospital expenditure per capita was significant for both health indicators. As in the case of men, none of the health resources variables was significant, and contrary to them, the percentage of obese women was significant and negatively correlated with YLFCC, and positively with YLCC. In the global model, though, total public health expenditure per capita turned out to be significant for both health indicators, in the same direction than for men. Hospital expenditure per capita continued to be significant in the model of YLFCC but reduced the coefficient and the level of significance. When modelling YLCC, the number of specialist doctors per 1000 population was significant as well, although the coefficient was positive, meaning that a higher number of doctors was correlated with more years living with disease.

A final set of models (Tables 5 and 6) were applied to men and women jointly in order to know if differences by sex were significant. Therefore, we tested the interaction of each relevant variable with sex for YLFCC and YLCC. In the case of YLFCC, only the interaction of sex with GDP per capita, unemployment rate of older workers and the percentage of individuals with primary education was significant. In the case of GDP per capita and percentage of primary education, the interaction coefficient was negative, meaning that the lower correlation of GDP per capita and the more negative correlation of primary education for women than men, was, in fact, significant. In the case of the unemployment rate, the interaction coefficient was positive, therefore, the higher correlation between unemployment and YLFCC in the case of women compared to men, was also significant, even if the unemployment rate was not significant in the model of YLFCC for only women. The no significance in the interaction of the other variables indicates that differences by sex are not relevant. This is especially interesting in the case of the prevalence of obesity, as this variable turned significant in the joint model of men and women, although when the interaction is

Table 1
Fixed-effect models of expected years lived free of chronic conditions (YLFCC) at age 50 among men in 17 regions of Spain between 2006 and 2019.

	Socio-economic	Health expenditures	Health resources	Health Behaviour	Total
GDP per capita	0.000359*				0.0000571
Unemployment older workers (55+)	0.0628				0.0635
% of primary educ or less	−1.099				0.363
Public health expenditure x capita		0.00485***			0.00583**
Hospital expenditure x capita		0.00380*			0.00461+
Specialist doctors per 1000 pop.			1.25		−1.124
Specialist nurses per 1000 pop.			0.303		−0.296
% of obesity (50+)				−6.982	−6.162
Constant	2.24	0.942	7.708***	12.77***	1.147
Observations (N)	102	102	102	102	102

+ $p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 2
Fixed-effect models of expected years lived with chronic conditions (YLCC) at age 50 among men in 17 regions of Spain between 2006 and 2019.

	Socio-economic	Health expenditures	Health resources	Health Behaviour	Total
GDP per capita	−0.000371*				−0.0000975
Unemployment older workers (55+)	−0.044				−0.05
% of primary educ or less	−5.101**				−4.744*
Public health exp. per capita		−0.00804***			−0.00609**
Hospital expenditure per capita		0.00377+			−0.00373
Specialist doctors per 1000 pop.			1.343		1.694
Specialist nurses per 1000 pop.			0.507		0.698
% of obesity (50+)				4.12	5.949
Constant	31.76***	28.33***	15.89***	19.14***	30.05***
Observations	102	102	102	102	102

+ $p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 3
Fixed-effect models of years lived free of chronic conditions (YLFCC) at age 50 among women in 17 regions of Spain between 2006 and 2019.

	Socio-economic	Health expenditures	Health resources	Health Behaviour	Total
GDP per capita	0.000202				−0.00014
Unemployment older workers (55+)	0.103				0.092
% of primary educ or less	−4.380**				−3.465
Public health expenditure per capita		0.000547			0.00581**
Hospital expenditure per capita		0.00947***			0.00464+
Specialist doctors per 1000 pop.			1.45		−3.866+
Specialist nurses per 1000 pop.			1.366		0.856
% of obesity (50+)				−10.62*	−3.733
Constant	7.341	2.242	3.803+	13.93***	8.339
Observations (N)	102	102	102	102	102

+ $p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

Table 4
Fixed-effect models of years lived with chronic conditions (YLCC) at age 50 among women in 17 regions of Spain between 2006 and 2019.

	Socio-economic	Health expenditures	Health resources	Health Behaviour	Total
GDP per capita	−0.000156				0.000167
Unemployment older workers (55+)	−0.0563				−0.057
% of primary educ or less	0.822				0.962
Public health expenditure per capita		−0.00275+			−0.00627**
Hospital expenditure per capita		−0.00453*			−0.0041
Specialist doctors per 1000 pop.			0.332		4.075*
Specialist nurses per 1000 pop.			−0.867		−0.54
% of obesity (50+)				6.355+	1.593
Constant	29.22***	33.01***	27.51***	23.55***	27.56***
Observations (N)	102	102	102	102	102

+ $p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

included, this is not significant, and the coefficient of the variable loses its significance, as well.

In YLCC models, the interaction of sex with GDP per capita and population with primary education were also significant, in a similar way as in the YLFCC model. Also, the interaction with the number of specialist doctors per 1000 population was significant and negative, meaning that the higher negative correlation of specialist doctors with YLCC for women than men was statistically significant.

In both models (YLFCC and YLCC) for all sexes, public health expenditure per capita was significant and positively correlated with YLFCC and negatively with YLCC. Hospital expenditure per capita was also significant, although with a lower level, and with the same sign of correlation that public health expenditure. Specialist doctors per 1000 population were significant for both health indicators, but in the opposite direction than the previous variables. Hence, a higher density of specialist doctors was associated with less years of good health, and with more years of bad health, which could be representing a response of the public health sector to a higher prevalence of chronic problems among the older population.

5. Discussion

In this study we have assessed the macro factors explaining regional differences in YLFCC and YLCC at age 50 in Spain from 2006 to 2019. We have analyzed the relationship between these two morbidity measures and a battery of macro factors that relate to the socioeconomic level of the region, the distribution of health resources and different indicators of health-related behaviors of the population aged 50 and over, and for the first time we have examined the relationship with the level of public health expenditure at the regional level. This approach is

Table 5
Fixed-effect models of years lived free of chronic conditions (YLFCC) at age 50 among men and women in the 17 regions of Spain between 2006 and 2019.

YLFCC	No interactions	Interactions of Sex with … GDP per cap	Older unemployment	% primary education	Public health expenditure per cap	Hospital expendiutres per cap	Specialist doctors 1000 pop	% obesity 50+
GDP per capita	−0.0000384	0.0000982	−0.0000433	−0.0000361	−0.0000392	−0.0000384	−0.0000385	−0.0000386
Unemployment older workers (55+)	0.0754+	0.0748+	0.0204	0.0786*	0.0747+	0.0757+	0.0761+	0.0757+
% of primary educ or less	−1.366	−1.541	−1.663	0.797	−1.43	−1.358	−1.356	−1.333
Public health exp. enditure per capita	0.00566***	0.00574***	0.00580***	0.00570***	0.00671***	0.00567***	0.00569***	0.00567***
Hospital expenditure per capita	0.00474*	0.00467*	0.00462*	0.00471*	0.00471*	0.00392+	0.00474*	0.00474*
Specialist doctors per 1000 pop.	−2.390+	−2.447+	−2.485+	−2.483+	−2.419+	−2.384+	−3.327*	−2.371+
Specialist nurses per 1000 pop.	0.273	0.262	0.255	0.295	0.268	0.274	0.275	0.274
% of obesity (50+)	−4.773+	−4.570+	−4.355+	−4.823+	−5.180*	−4.563+	−4.229	−5.163
Women X GDP cap		−0.000279*						
Women X Unemployment 55+			0.108**					
Women X % primary educ.				−4.408*				
Women X Public health exp. x cap.					−0.00208			
Women X Hosp. Exp. x cap.						0.00164		
Women X Specialist doctors 1000 pop.							1.899	
Women X % obesitiy 50+								0.702
Constant	4.444	4.646	4.761	4.56	4.697	4.354	4.227	4.381
Observations	204	204	204	204	204	204	204	204

+ $p < 0.1$, *$p < 0.05$, **$p < 0.01$, ***$p < 0.001$.

especially important in a country like Spain where the public health system is decentralized and, therefore, the regional government has the power to decide, at some level, the amount of public health expenditure and its management. Moreover, the recent economic crisis of 2008 brought significant cuts in public transfers, including health provisions, which each region managed differently (Bernal-Delgado et al., 2018) and here we could preliminarily explore some of the health consequences of the different regional strategies.

The overall results showed that levels of public health expenditure per capita were strongly related to the number of years lived with and without disease and health problems, for both men and women. Therefore, a region with a higher level of public health expenditure per capita would also relate to a higher number of expected years lived without disease for individuals over 50 years of age, and a lower number of years lived with disease for both men and women. Most importantly, public health expenditure per capita was the only significant variable for all health measures and all sexes in all statistical models performed here, including the partial and global models, and the model with male and female outcomes together. Moreover, in the latter model the interaction between men and women was not significant, meaning that the relationship between public health expenditure and the health indicators across regions and years does not differ by sex. This result suggests the importance that health cuts have had on health measures in the immediate aftermath of the economic crisis. This is not always observed for mortality measures. As noted by Ruhm (2000) and Ruhm (2012), recessions can have a positive impact on mortality measures due to a reduction in road traffic accidents and work-related diseases and injuries.

Some of the other factors analyzed were also correlated with YLFCC and YLCC, but the relationship was not as persistent across models and, in some cases, differed by sex. For example, GDP per capita was correlated with YLFCC and YLCC for men, but not for women. The proportion of people aged 50 with primary education was significant for both men and women but in the case of men, it was negative for both YLFCC and YLCC, and for women it was negative only in the YLFCC model. A negative correlation with both the YLFCC and YLCC indicators implies that having a higher proportion of the population with primary education or less is associated with a lower LE, which could mean both less YLFCC and YLCC. This has already been detected in other international comparative studies, where countries with a lower LE would also show a lower life expectancy with functional limitations (Mathers et al., 2004).

Regarding health resources, only the number of specialist doctors and nurses was significant in the univariate models, and in the fixed-effects models, only specialist doctors was significant in the global model of YLCC for women, and with a positive coefficient. Specialist doctors were also significant in the model pooling male and female outcomes of YLFCC and YLCC. Here, again, the coefficient was negative for YLFCC and positive for YLCC, meaning that a higher number of doctors is attached to a worse YLCC and a higher number of years with diseases. This was a result already observed in Laborde et al. (2021) for the density level of nurses, and as proposed by these authors, this could be a response of the public health sector to a higher demand of doctors due to a higher prevalence of health problems in the population. This could suggest that, in the specific case of specialist doctors, there is a strategy of adjusting the services offered to the healthcare demand, but this should be further examined in the appropriate analytical model.

Health-related behaviors were only important for women and in the case of the proportion of overweight and obese individuals.

Table 6
Fixed-effect models of years lived with chronic conditions (YLCC) at age 50 among men and women in the 17 regions of Spain between 2006 and 2019.

YLCC	No interactions	Interactions of Sex with …					
		GDP per cap	% primary education	Public health expenditure per cap	Hospital expendiutres per cap	Specialist doctors 1000 pop	% obesity 50+
GDP per capita	0.0000321	−0.000118	0.0000287	0.0000327	0.0000321	0.0000324	0.0000327
Unemployment older workers (55+)	−0.0489	−0.0483	−0.0538	−0.0483	−0.0495	−0.0501	−0.0494
% of primary educ or less	−1.981	−1.789	−5.283**	−1.93	−1.997	−1.998	−2.05
Public health expenditure per capita	−0.00599***	−0.00607***	−0.00604***	−0.00682***	−0.00601***	−0.00604***	−0.00601***
Hospital expenditure per capita	−0.00402*	−0.00394*	−0.00397*	−0.00400*	−0.00224	−0.00403*	−0.00403*
Specialist doctors per 1000 pop.	2.804*	2.866*	2.946*	2.826*	2.790*	4.480**	2.763*
Specialist nurses per 1000 pop.	0.1	0.112	0.0665	0.104	0.0982	0.0971	0.0976
% of obesity (50+)	3.656	3.434	3.733	3.98	3.199	2.685	4.481
Women X GDP cap		0.000306**					
Women X % primary educ.			6.730***				
Women X Public health exp. x cap.				0.00165			
Women X Hosp. Exp. x cap.					−0.00358		
Women X Specialist doctors 1000 pop.						−3.396**	
Women X % obesitiy 50+							−1.481
Constant	28.88***	28.65***	28.70***	28.67***	29.07***	29.26***	29.01***
Observations	204	204	204	204	204	204	204

Nevertheless, in the models with results for men and women together, the proportion of obesity remained significant, revealing that YLFCC and YLCC also differed for men according to the level of obesity in the region, but this relationship might not be as strong as for women.

In the univariate models we tested a number of variables that were not significant, and we would have expected some of them to show some level of correlation with health indicators. It is particularly intriguing that smoking behaviors did not show any correlation for either men or women. It is true that in the case of women, for whom the smoking epidemic is more recent and linked to regions where female labor force participation is higher, there might be some confounding with other socioeconomic variables that have positive impacts on health. However, in the case of men, the non-existent correlation could be related to the fact that smoking levels after the age of 50 might be ascribed to more severe stages of diseases that have a large impact on mortality rates, but not on chronic diseases that persist over time (Reuser, Bonneux, & Willekens, 2009). Another variable that was not significant is public health spending on primary care, while total public healthcare expenditure and hospital expenditure were significant in the different models. This goes along with the fact that the density of general practitioner doctors and non-specialist nurses was also non-significant. One explanation could be that hospital expenditure increases sharply with age, while primary care expenditure is more stable over the life course and not so correlated with health problems at older ages (Kalseth & Halvorsen, 2020).

Another appealing result of the current study is the differences observed for men and women in the partial models. Socioeconomic variables are more correlated with YLFCC and YLCC in men, and health-related behavior measures are significant in women. The association of socioeconomic variables in men is a result previously observed in Spain (Gutierrez-Fisac et al., 2000), where unemployment levels were only relevant for men's morbidity measures. This is not new, and it is well known that socioeconomic status at the individual level is usually more influential on men's mortality than on women's (Permanyer et al., 2018). In contrast, the impact of socioeconomic status on women's health has also been reported when examining morbidity measures, although often using educational measures (Solé-Auró et al., 2020), which is the only socioeconomic measure we founded relevant for women in this study.

Conclusions drawn from an ecological study such as the one presented here are always subject to the possibility of ecological fallacies. However, this is a very effective way of analyzing whether macro factors, such as health expenditure and healthcare resources, are, in fact, linked to different performances among regional populations. Of course, results should always be taken with caution, especially with data that can be measured at the individual level such as socioeconomic factors and health-related behaviors. For example, the fact that a higher level of unemployment is correlated with a higher YLFCC in the univariate models, does not mean that an unemployed person is more likely to live more years in good health. Other limitations of the study refer to the information gathered. Health survey data does not include people living in long-term care institutions. This could bring bias to the study as institutionalized people are presumably in poorer health. However, in Spain, the proportion of older people living in institutions is very low, only 7% of individuals aged 85 to 89 in 2011 (Eurostat) and much lower for younger ages. Additionally, the measure used here refers to the existence of a chronic condition, but we don't know the level of severity in the disease. Therefore, although the presence of health problems might be increasing in specific periods, we don't know if they are affecting more or less the quality of life of the individual.

Finally, our results highlight the importance of such a study in Spain, where the correlation of health expenditure measures with healthy life expectancies of the older population had not yet been assessed. It is also the first time that measures of health expenditure are included in a model to understand differences in morbidity levels on different measures, and therefore underlines the recommendation to use them in further international comparisons of YLFCC and YLCC.

6. Conclusion

This study comes to acknowledge the importance of public health investments on the health status of the adult and older population. This is a prominent result because public health expenditure can be directly controlled by public policies, with a great benefit on the quality of life of the population. In the specific case of Spain, the paper also contributes to show that regional differences in YLFCC and YLCC are explained by different socioeconomic and behavioral factors, that might have a different impact on men and women's health, but more importantly by regional decisions on public health investments.

Ethical statement for SSM-population health

1) This material is the authors' own original work, which has not been previously published elsewhere.
2) The paper is not currently being considered for publication elsewhere.
3) The paper reflects the authors' own research and analysis in a truthful and complete manner.
4) The paper properly credits the meaningful contributions of co-authors and co-researchers.
5) The results are appropriately placed in the context of prior and existing research.
6) All sources used are properly disclosed (correct citation). Literally copying of text must be indicated as such by using quotation marks and giving proper reference.
7) All authors have been personally and actively involved in substantial work leading to the paper, and will take public responsibility for its content.

Contribution of authors

Elisenda Rentería: Conceptualization, Methodology, Data analysis, Writing-Original draft preparation. Pilar Zueras: Conceptualization, Methodology, Data preparation, Writing- Reviewing and Editing.

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Authorship statement

All persons who meet authorship criteria are listed as authors, and all authors certify that they have participated sufficiently in the work to take public responsibility for the content, including participation in the concept, design, analysis, writing, or revision of the manuscript. Furthermore, each author certifies that this material or similar material has not been and will not be submitted to or published in any other publication before its appearance in the SSM.

Authorship contributions

Please indicate the specific contributions made by each author (list the authors' initials followed by their surnames, e.g., Y.L. Cheung). The name of each author must appear at least once in each of the three categories below.

Category 1

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Category 2

Drafting the manuscript: E. Rentería, P.Zueras.

Revising the manuscript critically for important intellectual content: P. Zueras, E. Rentería.

Category 3

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Declarations of interests

None.

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Appendix A. Supplementary data

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