A Work Project, presented as part of the requirements for the Award of a Master's degree in Economics from the Nova School of Business and Economics.

POPULATION AGEING AND THE GROWTH IN HEALTH CARE EXPENDITURES

A STEEPENING STUDY FOR THE PORTUGUESE CASE

JOANA NUNES MANSINHO

Student Number 29009

Work project carried out under the supervision of:
Pedro Pita Barros

January 2021

POPULATION AGEING AND THE GROWTH IN HEALTH CARE EXPENDITURES
A STEEPENING STUDY FOR THE PORTUGUESE CASE

Abstract

With general population ageing, the impact of age on health care expenditures has largely been discussed as predictions represent a threat to national health services. The term *steepening* refers to the fastest growth of per capita health care expenditures of the elderly, a phenomenon that if confirmed can cause unprecedented increases in public spending. The goal of this work is to test for the existence of *steepening* on Portuguese NHS hospital inpatient care episodes between 2009 and 2018. Initial results suggest a non-rejection of the stated hypothesis. With the inclusion of mortality, results on *steepening* are reduced indicating part of the increase in health care expenditures for older individuals is due to death-related costs.

Keywords

Health Care Expenditures ; Ageing ; Steepening Study ; Diagnosis Related Groups (DRG)

I. INTRODUCTION

Over the last decades there has been a remarkable change in population structures for most countries. The increase in life expectancy and the reduction in both birth and mortality rates have contributed for the overall ageing of societies. By the beginning of 2019, individuals over 65 years-old were 20.3% of the total population from European Union countries (EU-27). Under this context, Portugal stood as the 3rd country with the highest share of elderly population, around 21.8%, that in comparison with a decade before represents 3.8 percentual points increase. Amongst other indicators, EU projections establish an even higher relative growth in the number of individuals aged above 65 years-old, causing the old-age dependency ratio to reach twice the value registered today, meaning there will be on average less than 1 active person per each individual with more than 65 years-old, by 2100. (Eurostat 2020)

Such prospects carry along consequences to countries' public health care services and spending, not solely with the rise of expenditures but also on structural issues as the type of care provided or the financing scheme used so far. In Portugal, the National Health Service (NHS) is mostly financed by general taxation revenue and its spending has consistently been growing, apart from the financial crisis cut back, accounting for 9-10% of GDP. (INE 2020) (INE 2012) It is now a concern that demographic trends as the population ageing alongside with the constant demand for larger technological advances on medicines and treatments will push for an even faster growth of national health care expenditures, particularly in the public sector.

The goal of the present work is to assess the impact of the Portuguese population ageing on the growth of health expenditures with NHS hospital inpatient care. This study will use the concept of *steepening*, firstly introduced by Buchner and Wasem (2006) as the fastest growth on health care expenditures for older groups of the population than for the remaining individuals, and test for its presence in the Portuguese NHS inpatient hospital records from 2009 to 2018. The dataset follows the Diagnosis Related Groups (DRG) framework to classify the patient hospitalization cause and expenditures will be computed using the reference weights set by the DRG coding system. As for the methodology chosen to test *steepening*, it is based on previous case-studies made in Switzerland, Germany and Norway that included three different approaches to the concept, resulting in three distinct models that allow not only for general results on the growth rate of care expenditures for the elderly but also for age-specific conclusions.

The application of this methodology to the Portuguese case represents a new contribution for the topic discussion. As costs on health care are expected to continue to increase, it is of most interest to understand if in the past there were any age-patterns on expenditures or if particular morbidities were the cost-drivers. Knowing this, it is possible to anticipate what will happen in the next decades and develop a strategy to guarantee the NHS viability, for instance by redirecting investment to cost improvement actions or emphasize the importance of morbidity prevention to avoid higher expenditures later on.

The paper is organized as follows: section II will be devoted to a review on the relevant literature and empirical work in this topic; next, on section III there will be a description of the data selected for the work, followed by a detailed revision and introduction of the methodology chosen to address the research question on section IV. Section V will firstly cover some descriptive results on the variables of interest and then present the *steepening* results for the three models. Finally, there will be a discussion upon the results obtained and what conclusions are possible to retrieve given the study limitations in section VI.

II. LITERATURE REVIEW

The discussion upon the consequences of an ageing population for general health care expenditures has been marked by two opposite stands. On one hand, some predict ageing of the population to lead to an increase of per capita health expenditures in the future due to the strong correlation between age and time – *steepening* hypothesis. Others believe health care expenditures are independent of age and by excluding the impact of ageing, health care spending should decrease because of the mortality compression and increase in length of life observed in the last decades – *red herring* hypothesis. Although the two are contradictory at first, it is important to unveil the underlying assumptions behind these terms and eventually find a common ground in both.

From a conceptual perspective, health care expenditures are considered to be influenced by individual and societal determinants. As one of the individual factors, *age* is classified as a predisposing element meaning it may not be the essential reason for the health care demand, but different age groups have distinct amounts of the need factor for it - illness or poor health status. These patterns generate consumption profiles for each age or age group, usually named as age-profiles of health care expenditures. (de Meijer, et al. 2013) Even though these can be affected by a variety of factors, over the last few years, empirical studies drew two possible scenarios for the prevalence of morbidity in future societies. On one side, as living conditions improve and people endorse healthier lifestyles, health care expenditures will probably decrease as they approach older stages in life and eventually their last years – *morbidity compression*. (Fries 1983) Nonetheless, it is also true, access to health care is expanding so people from all age groups will tend to seek for more care services shifting their consumption profile up and resulting in general higher expenditures in health – *morbidity expansion*. (Olshansky, et al. 1991)

The *steepening* hypothesis introduced by (Buchner and Wasem 2006) suggested an underestimation of future health spending as changes in those expenditure profiles were not being acknowledged. In their work, authors argued for a faster growth in per capita health care expenditures in elder groups of population compared with younger and middle-aged individuals that led to a *steepening* of the age-profiles. The causes behind were poorly described but relied essentially over the argument of the prevalence of chronic diseases being expanding amongst older groups and technological improvements associated with these morbidities driving higher per capita costs.

Later, (Felder and Werblow 2008) argued for the importance of including both effects of the increased length of life and morbidity compression in the *steepening* analysis as evidence predicted relatively lower per capita health care costs associated with death at later stages in life which would flatten the age-profile of the elderly. These impacts were captured by including mortality rates to the testing models and although authors did not find evidence for *steepening* in Swiss cantons data, they continued to recognize the ageing process as a threat to the reliability and functioning of the national health systems that are publicly financed, just as Buchner and Wasem did.

With a different perspective on the correlation between health care expenditures and *age,* the *red herring* hypothesis, formulated by (Zweifel, Felder and Meiers 1999), predicts a more optimistic scenario for the next years. Under this framework, population ageing is described rather as a "distractive" determinant for future health expenditures and focus should rely on the impact of the final years of a person's life on these, also referred as the "time-to-death". In fact, authors believed *age* would only influence as a predisposing element whereas this "time-to-death" would largely be the responsible for the rise in care expenditures, especially at younger individuals once death-related expenses are expected to be significantly higher, in comparison with older patients. In this sense, *red herring*'s view over the future comes acknowledging the ongoing expansion of the average lifetime which typically postpones the moment of death to older stages and results in relatively lower health care expenditures.

Despite the clear contrast between these two definitions, (Gregersen 2014) claimed for an independent relationship between them as each frame health care expenditures differently assuming conditions that are not mutually exclusive. However, proving the existence of both phenomena requires different sets of data, as the "time-to-death" indicator is only achievable on a longitudinal panel.

Due to this data constraint, the present work will only address the first concept – *steepening* – elaborating a cross-sectional study for the Portuguese case, following similar approaches as previous case-studies. Section IV provides additional revision on the methodology developed.

III. DATA

To perform the analysis of the Portuguese case, two data sources will be used. The first consists in a cross-sectional data with public hospital annual admissions from 2009 to 2018. Provided by the ACSS,[1] each observation contains information on a hospitalization episode, displaying details on the year, number of days the patient received inpatient care and respective unit, gender, age, residential area of the individual, and the DRG code associated with the patient admission. From here, only observations with one or more days of hospitalization will be considered. As no personal identification number is provided, patients are not identifiable on the records which makes it impossible to track them over the period. In addition, hospital registration is mandatory for public

[1] Administração Central do Sistema de Saúde

units so the only self-selection concern in this dataset is the patient's decision upon receiving care in a public or private hospital.

To this data, it will be added, from PORDATA, statistics on the number of residents and the number of decedents in Portugal from 2009 to 2018, by each NUTS level III and age group. (PORDATA 2020) (PORDATA 2020)

The Diagnosis Related Groups coding system is a hospital classification for patients with similar clinical conditions from a resource consumption point of view. Each group has associated a relative cost of the full patient treatment given the expected resources needed for the specific pathology.

Originally created in the United States in the 70's, this system has been used in the Portuguese health system since 1990 as a record and public providers reference tool. Since then, a few reforms occurred to the DRG version in practice. (ACSS 2020) Relevant for the following study are the changes made in 2006 for AP-DRG 21, later in 2013 for AP-DRG 27 and the last one in 2015 for an APR-DRG 31. Prior to 2015, the modification involved merely an update on the relative weights of each diagnosis group in monetary terms. (ACSS 2013)

However, with the reform introduced in 2015, the coding system adopted switched from an All-Patient classification to All Patient Refined (APR) allowing for further discrimination on the relative cost weights based on four levels of severity and mortality risks. As a result, there was a significant change in the price level associated with each DRG relative cost weight when comparing to prior versions, as it is possible to confirm on Table 1 at Appendix section. (ACSS 2014) (Ministério da Saúde 2015)

Merging the datasets

As there was no original variable on the cost of each episode at the ACSS data, the first step in building the dataset was to generate a new variable indicating the correspondent expenditure. Information on the full inpatient care "price" for each clinical group was available to all DRG versions, allowing to index these references costs to every observation. To such, an algorithm indicating the Major Diagnostic Category (MDC) and the respective DRG group was created and labelled as **"Cod_Pay"**. This variable worked as an auxiliary variable and will not be used for any inference purpose. From here, the variable **"Pay_Int"** was generated to all observations, displaying the total relative cost of the hospitalization for each patient.

Recognising for the structural change on the coding system, a second dataset was generated making the conversion of newest versions to the baseline (AP-DRG 21) and using as reference its own price table for all the remaining years. The goal is to try and remove a possible price effect originated from these reforms and confront the two scenarios – with and without price correction-throughout the study. With this step, a number of observations were lost as some of the new codes in the latest reforms were classified as "invalid diagnostics" once there was not a direct link to the first version.

Moving on, for the years of 2009 and 2010, the variable **"age"** had to be created based on the **"Date of Birth"**. Whereas from 2014 onwards, information regarding the patient residency area had to be transformed into a string variable since it was in a numeric format.

The next stage was to merge the ACSS and the PORDATA datasets using the residency area. Here, there was a problem on the geographical difference between **"district"** and each NUTS level III described on both databases. Because it was being measured in two distinct units, a new variable **"nutsiii"** was generated on the ACSS files that returned the corresponding NUTS level

III to the residency area indicated. (Diário da República 2013) Undertaking this methodology, a significant number of observations had no information for the residence area, so in order to avoid eliminate these episodes, the patient residency was assumed to be in the same region as the hospital where the admission occurred. Although it was necessary not to lose observations, assigning the hospital NUTS level III to the patient residency can raise a possible bias on the sample given that for specific pathologies or hospitals there are a lot of displaced patients due to lack of treatment near home or treatment necessities.

Having the dataset all built, the total number of observations is 6.811.607 which can be grouped into ten years, 22 five-year-old gap age groups, two genders, 25 NUTS level III and 26 DRGs. Further along, episodes of births, pregnancy and neonatal care labelled in DRG 14 and 15 will be excluded to perform the *steepening* analysis as these are not entirely representative of a disease.

Additionally, it is important to highlight the uneven distribution of observations throughout the years as around 58% of the episodes were registered during the first five years of the period in analysis. One possible but most likely not exclusive explanation is the high investment and development made in outpatient surgery that reduced in large scale the need for the patient to stay in hospital overnight or even additional days. All remaining reasons are out of the scope of this work.

IV. METHODOLOGY

Following the relevant literature and previous case studies, the *steepening* analysis will be performed with three different models. The inclusion of more than one model allows for a wider range of interpretations on the impact of ageing on health care expenditures when concerning different age groups and the inclusion of other explanatory factors.

Any result on the impact of age in health care spending can obviously combine various effects. For instance, in case of reaching a conclusion that older people spend more than younger, the question remains if it is due to higher consumption of care services, higher percentage of older people in that society or if the most frequent morbidities for this age group are more costly to treat. To try and disentangle these three dimensions, a price analysis across DRG groups as well as the use of a per capita variable for the health care expenditures will be considered.

The first model – **Model A** - was developed by (Buchner and Wasem 2006) and it is mainly the mathematical translation of the *steepening* definition introduced in their work. Observations are split between two groups - *old* and *young* - at the age threshold of 65 years-old, for every region (NUTS III). Then an annual ratio between the per capita expenditures of the two groups – here denominated as Ratio A - is regressed on the variable **"year"**, as follows:

$$\textbf{(1)}\ \ Ratio\ A_{\ year,region} = \frac{\bar{Y}_{age\epsilon[65,118],year,region}}{\bar{Y}_{age\epsilon[5,64],year,region}} = \lambda_0 + \lambda_1 * \ year$$

This model allows for the elimination of any inflation effect present on the sample due to the three price adjustments that created a price-effect on the per capita expenditure variable. As this change was not constant to all diagnostic groups, **(1)** will be run twice – first with the actual expenditures and secondly with the price correction already mentioned.

A more interesting strategy is to have an age group specific analysis, instead of an age-cut between old/young. Suggested by the same authors, **Model B** is an adaptation of the prior model in which Ratio B gives the balance between each age group per capita expenditures and a benchmark group. Once again, the unit of observation is obtained by year, age group and region using as reference the Metropolitan Area of Lisbon. Here, the age reference group will be individuals aged between 5 to 9 years old.

$$\textbf{(2)}\ \ Ratio\ B_{ageg,year,region} = \frac{\bar{Y}_{ageg,year,region}}{\bar{Y}_{benchmark,year,region}} = \beta_{0,ageg} + \beta_{1,ageg} * year$$

This standardisation attributes a new interpretation to the respective coefficients – now each reflects the age group average annual growth rate of the per capita expenditure relative to the annual growth rate of the benchmark group. Another advantage of this approach concerns with the additional knowledge on the behaviour of other age classes other than older ones. (Buchner and Wasem 2006)

As seen in equations **(1)** and **(2)**, a linear relationship is assumed between health care expenditures and age. Nonetheless, as it will be shown in section V, data seems to suggest for a non-linear association between the two. On the same note, both (Buchner and Wasem 2006) and (Felder and Werblow 2008) modelled an exponential relationship between the per capita health care expenditures and age and recognized the *steepening* hypothesis could not be properly tested only by including one explanatory variable to care spending. Therefore, **Model C** contemplates the effect of time, gender, mortality rates and age on natural logarithm of health care expenditures. Once the unit of observation (*i*) is defined by age group, gender, year and region, a set of 24 dummy variables for region will also be added to the regression as follows:

$$\textbf{(3)}\ \ \ln(\bar{Y}_i) = \gamma + \delta * female_i + \sum_{a=0}^{10} \upsilon_a * agegroup_a + \sum_{a=0}^{9} \tau_a * agegroup_a * female_i + \sum_{r=0}^{24} \beta_r * region_r + \theta * year_i + \sum_{x=1}^{4} \kappa_x * (mrate_i)^x + \sum_{a=0}^{9} \rho_a * agegroup_a * year_i + \varepsilon_i$$

The variable **“female”** is a dummy for gender that takes value 1 if the patient is a female and zero if male so δ must be interpreted as the marginal increase on per capita expenditures of women compared to men. As for coefficients on variable **“agegroup”**, each indicates the relative effect of belonging to an age group when compared with the benchmark group of individuals aged between 5-9 years old. Additional to the original model, **(3)** also distinguishes the contribution of female individuals’ health care expenditures to the overall performance of the age cohort, captured by the ten cross terms between **“agegroup”** and **“female”** dummies. As for the impact of regional differences, coefficients β measure the marginal effect of living in a specific area in comparison with the Metropolitan Area of Lisbon.

More interesting are the interpretations for coefficients θ and ρ_a . The inclusion of the interaction term between variables **“agegroup”** and **“year”** allows the model to capture the yearly growth rates of each age group expenditures. Therefore, any coefficient ρ_a should be evaluated as the difference between the annual growth rate, measured by θ, and that age group rate. Finally, κ_x retributes the increase on care spending derived by the mortality rate registered for the patient’s age class in his/her area of residence.

The inclusion of mortality rates to the approach seems rather crucial as it has already been proved the significant increase in health care expenses on the year before death. Once these costs tend to be higher in relative younger individuals, the increase in the length of life in the past decades and the reduction in mortality rates will also likely “delay” and reduce expenditures on the last year-to death. (Zweifel, Felder and Meiers 1999). Therefore, it is possible that some of changes in health care expenditures of a specific age group are due to changes on its respective mortality level. For instance, if individuals aged between 60 and 70 have lower morbidity levels and consequently lower mortality rates, then it is expected that their care expenditures are also relatively lower as death-related costs are diminished. In very broad terms, these mortality-related variables try to capture a similar effect as the “time-to-death” dimension introduced in the *red herring* hypothesis. In addition, mortality levels can also be related to health care demand. Once the share of population seeking for hospital treatment increases, the number of deaths is expected to decrease, in particular at older stages in life. This will naturally imply an increase in per capita health care expenditures.

To better understand how the model in **(3)** can help on testing the *steepening* hypothesis, it might be useful to go back to the essence of what the term stands for– the fastest growth of health care expenditures for older groups in comparison with the rest of the population. With this concept in mind, (Felder and Werblow 2008) redefined the mathematical expression for *steepening* as the cross derivative of health care expenditures with respect to variables age (*a*) and year (*y*):

$$\textbf{(4)}\ \frac{\partial^2 ln(\overline{Y_\iota}(a,y))}{\partial a \partial y} > 0\ ,$$

meaning that if the change in growth rate of per capita expenditures is positively affected by the increase in age and as the years go by then there is evidence for *steepening* in the sample. Additionally, they also argue *steepening* to be affected by the changes in mortality levels caused by changes in age profile throughout years. (Felder and Werblow 2008) To know the magnitude of these age and time effects on mortality rates, the first step relies on running the following:

$$\textbf{(5)}\ mrate_i = \alpha_0 + \alpha_1 * year_i * age_i + \alpha_2 * age_i + \alpha_3 * year_i + \varepsilon_i$$

From here and going back to **(3)**, the *steepening* proposition would not be rejected if the difference between annual growth rates of two consecutive age groups and the sum of mortality effects is positive:

$$\textbf{(6)}\ \frac{\partial^2 ln(\overline{Y_\iota}(a,y))}{\partial a \partial y} = \rho_{a+1} - \rho_a + \sum_{x=1}^{4} \kappa_{\mathrm{x}}(\alpha_1)^x > 0\ ,$$

The use of a polynomial function of power four to address the mortality effect on health care expenditures is poorly described by the authors and ends up being dropped later on by (Gregersen 2014) that suggested including solely the effect of mortality rates to the power of 1 on **Model C** as well as other mortality-related variables to capture the real impact of it.

As such, cross terms between mortality rate and age and mortality rate and year were added to the model:

$$\textbf{(7)}\ \ln(\bar{Y}_i) = \gamma + \delta * female_i + \sum_{a=0}^{9} \upsilon_a * agegroup_a + \sum_{a=0}^{9} \tau_a * agegroup_a * female_i + \sum_{r=0}^{24} \beta_r * region_r + \theta * year_i + \kappa * mrate_i + \sum_{a=0}^{9} \rho_a * agegroup_a * year_i + \omega * year_i * mrate_i + \psi * agegroup_i * mrate_i + \varepsilon_i$$

The first, identified by coefficient (ψ), aims at capturing the downward pressure of age on the death-related costs as explained above. The second, measured in coefficient (ω), displays the behaviour of mortality rates over time and the correspondent impact on average expenditures. (Gregersen 2014)

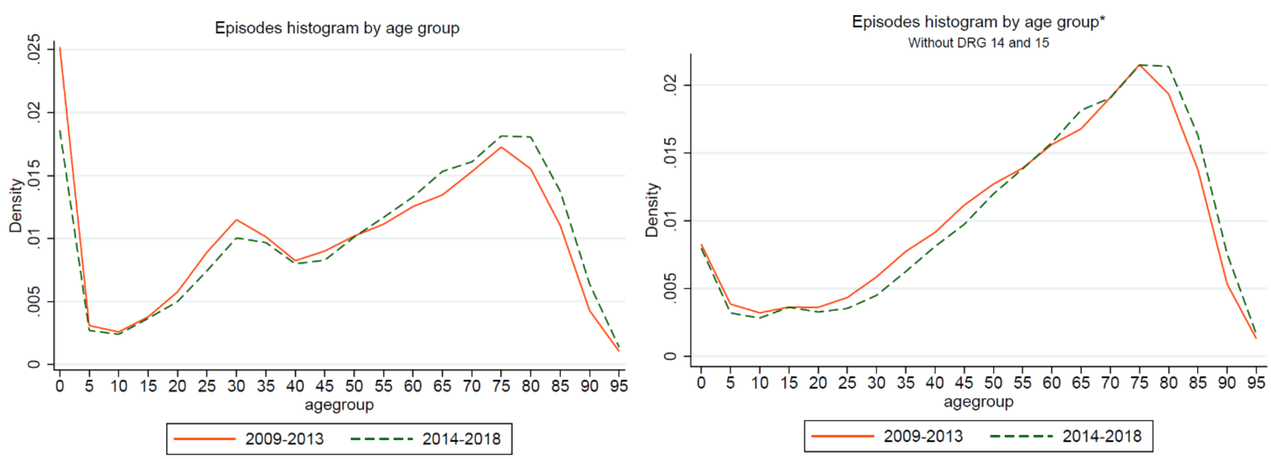
Finally, all equations of **Models A to C** will be run using robust stand errors to correct for the heteroskedasticity present in the data.

V. RESULTS

DESCRIPTIVE RESULTS

The most interesting variables to have a look at before performing the *steepening* analysis itself are **"age"** and **"pay_int"** that returns the expenditure dimension. Over the 10 years, there was an increase on the mean age of patients, ranging from 49 years-old in 2009 to 53 in 2018, without excluding the birth cases from the sample. Though these values are surely affected by the absolute decrease in the number of births, they can also be reflecting the presence of ageing on hospitalizations scenario. With a different perspective, the two histograms below demonstrate the episodes density distribution of variable **"agegroup"** over the sample but using as time unit two periods – from 2009 to 2013 and from 2014 to 2018.

Figure 1 : *Episodes histograms by* age groups



On the left, all observations were included, and it is clear the increase in the percentage of patients with more than 55 years-old on the second period, whereas the weight of relative younger cohorts decreased from the first period. On histogram plotted on the right, episodes belonging to DRG 14 and 15 were excluded from the sample. Both trends continued to be observed, however, with less prominence. In absolute terms, the number of observations for the years in the first period is always higher than in the second, so if one should look to the evolution of total episodes per each age group, it is not possible to confirm an increase from 2009 to 2018. (Table 2)

Focusing now on the expenditures dimension, its assessment must be done in two stages due to the reforms made in the DRG coding system explained in section III. Paying attention first to the original dataset that uses three different codes, in Table 3, the variable **"pay_int"** does not show an increase in the mean values for though the period, just as **“age”** did. The highest value for average was registered in 2011, whereas the lowest corresponds to 2014, with an average of 1944.4€. The opposite can be concluded if all episodes follow the same reference price table. For the year of 2009, the average inpatient expenditure was close to 2 590€ and by 2018 the value raised to 3029€.

Though there were two changes in “prices”, the revision undertaken in 2015 produced a much significant impact on the average price level. By looking to Table 1, the average price level of almost all MDC increased from 2009 to 2018, however, results on the original dataset showed the opposite trend. This discrepancy relies on the relatively higher cost associated with more severe levels of each DRG code that pushed the overall average price of the group up. As most inpatient care episodes can be classified as having minor or moderate levels of severity, the average patient expenditure displayed relative lower cost weights comparing with previous versions. Nonetheless, it seems clear results on *steepening* will largely be influenced by the control for this “price” effect or not.

Though these results are already important, examining the behaviour of per capita health care expenditures here named **“Totexp_pc”** should give a hint on the *steepening* hypothesis – if total expenditure per capita is proportionality higher for older age-groups in second period then it is quite possible that the *steepening* hypothesis is valid. **“Totexp_pc”** was generated by aggregating per year the total expenditures in **“pay_int”** for each age group and region and dividing it by the number of inhabitants in the same cohort and region.

Figure 2 - Total per capita expenditures by age groups (in €) (original)

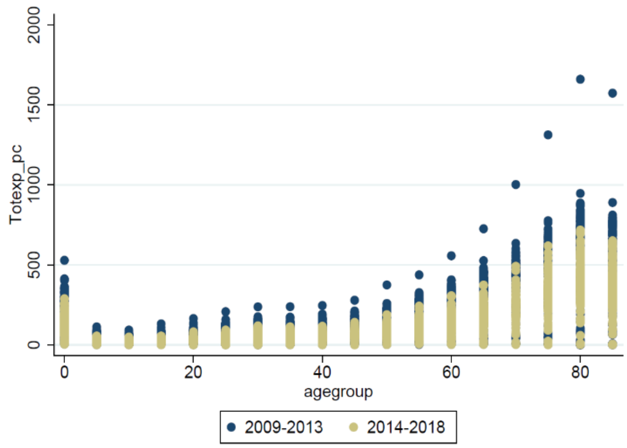
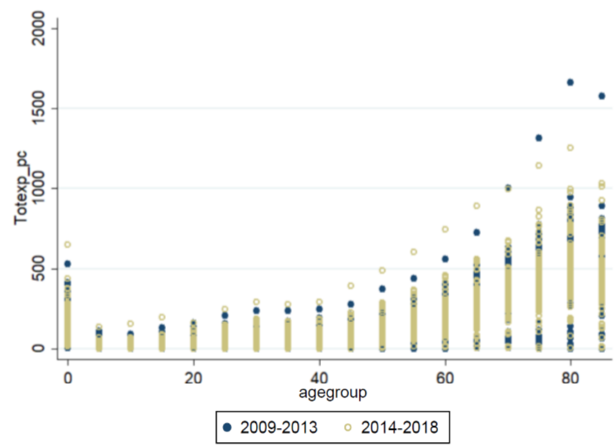


Figure 3 - Total per capita expenditures by age groups (in €) (with price correction)



The figures above show per capita expenditures by age groups in the two periods considered. Once again, the price effect has been taken into account and results demonstrate different scenarios. On the left, per capita expenditures for older people did not increased in the last five years as in comparison with the first period, something that would predict a rejection of the *steepening* hypothesis. On the second graph, the opposite is observed as per capita costs seem to have a slight increase on the second period for age groups above 65 years old.

Concerning the demographic variables for the number of inhabitants and the number of decedents that were retrieved from PORDATA, the comparison between the two periods is shown in Table 4. From the first to the second period, there was a general decrease of mortality levels for all age groups, excepting for children aged between 0 and 4 years old. However, in absolute terms, the total number of decedents increased on period 2, whereas total population was higher on the period 1. These results are consistent with the literature discussed above.

Additionally, preliminary results on the impact of age and time on mortality changes were obtained by running **(5)**. Following prior predictions, changes in mortality are negatively affected by changes occurred in age groups throughout the years considered, as the coefficient on **"AgegxYear"** is negative but statistically significant. This result reflects people living longer nowadays, showed by larger number of individuals in the older age cohorts, and although coefficients are quite small, they will be considered further along when testing for *steepening* under the rule in **(6)**. (Table 5)

STEEPENING RESULTS

Model A

The percentage of the per capita health care expenditures for older individuals aged above 65 years old has increased from 2009 to 2018. Based on the equation on **Model A**, the coefficient of interest is positive and statistically significant showing that, on average *ceteris paribus*, the ratio between elderly per capita expenses and the remaining population increased 15% from 2009 to 2018. On the other hand, acknowledging for the price effect, the ratio between per capita expenses for old and young, over the 10 years, has grew solely 4,8%, on average *c.p.*.

Despite the overall increase of this ratio, annual results on Ratio A show there is evidence for a continuous growth in the ratio between old and young health care expenditures, apart from years 2010, 2011 and 2014 that registered a lower value relative to the homologous. Correcting for the price effect does not change the conclusions for the first five years. However, for the remaining years, these ratios were relatively smaller indicating weaker effects of *steepening*, with the exception of 2015 that listed a decrease from the year before. (Table 7)

With results on **Model A** coefficient, it is not possible to reject the *steepening* hypothesis from 2009 to 2018, in both scenarios. Only when extending the analysis to a yearly basis, it possible to conclude the non-linear growth of Ratio A that leads to the hypothesis rejection in those exceptional years.

Model B

Within this framework each age group will have a coefficient associated since Ratio B was computed for all cohorts with the exception of the benchmark group 5-9 years old. For age groups above 50 years old, all **"year"** coefficients are statistically significant and display an increasing trend as age increases, apart from the >85 cohort. The highest value is registered for individuals aged between 80 and 84 years old, as their per capita expenditures grew, on average, *c.p.*, 1.1 times more than the reference group. (Table 8)

On a second scenario with the correction for the price effect, coefficients show smaller yearly growth rates for all age groups and the highest value is now registered for individuals aged between 75 and 79 years old, as the per capita expenditures for these individuals grew 0.6 times more than for per capita expenses for the reference age group, on average *c.p.*.

These results do not reject the *steepening* hypothesis once again, as per capita expenditures for older groups of the population grew faster than for younger groups, in relative terms over the 10 years, even after changes in prices are accounted for.

Model C

As described in section IV, this last model develops a more complex analysis of the *steepening* definition by suggesting a non-linear relationship between the variables of interest and the inclusion of the impact of mortality rates on health care expenditures behaviour. Just as before, regressions were run twice to account for the correction in the price level.

Common to **(3)** and **(7)**, there is evidence that support a marginal decrease in the level of health care expenditures for female individuals, in comparison to men. In addition, when considering gender discrepancies within each age cohort performance, for women with more than 50 years old, the marginal decrease in the level of care spending is even larger comparing with men in the same age group. These results hold even when the price effect is controlled for.

Regarding age alone, coefficient results suggest for positive and significant impact of the variable **"agegroup"** on expenditures. More importantly, this effect is relatively small for individuals aged below 50 years old, with the exception of children under 5, and starts to increase gradually as cohorts get older reaching maximum values in individuals aged above 80. Acknowledging the price effect seems to have almost no influence in the statistical inference of these coefficients.

Focusing now on the coefficient of interest for the *steepening* analysis (ρ_a), its interpretation changes from **(3)** to the remaining. On the first column of Table 9 and Table 10, the correspondent values represent the deviation in growth rates for the particular age group and younger groups (<50). Coefficients are small and in the vast majority not statistically significant, indicating that there is no evidence that health care expenditures increased faster for older cohorts. In the first scenario, for each 1€ increase on health care expenditures of younger individuals, per capita expenditures for people with 80 or more years old have increased, on average *c.p.*, 4.8€. When the price effect is accounted for, the marginal increase of per capita health care expenditures of the oldest cohort is reduced to 2.6€, for each 1€ increase in younger age groups, on average *c.p.*.

Given these results and following the rule defined in **(6)**, there is no statistical evidence that supports the existence of *steepening*.

On the second regression of **(3)**, the remaining annual growth rates were included to allow for a different interpretation of the coefficients and mortality rate variables were excluded. Now, instead of having comparisons between old and young, all expenditures growth rates are given as a deviation from the annual growth rate of health care expenditures of individuals between 5-9 years old. Once again, the larger relative increases have occurred in older cohorts for ages above 50 and in the youngest group. For instance, in comparison with a 1€ increase in the benchmark group per capita expenditures, for people with 80 and more years old, the marginal increase in per capita annual health care expenditure corresponded to, on average *c.p*, 8.2€. This value decreases to 5.6€ when correcting for changes in prices.

Coefficients on the yearly rates increased from the first to the second regression, suggesting that the omission of the mortality levels might overestimate the growth of health care expenditures, at least for older age groups.

Within this framework, there is statistical evidence to not reject the occurrence of *steepening* in the last two age cohorts as $(\rho_{80+} - \rho_{70} > 0)$ and $(\rho_{70} - \rho_{60} > 0)$, in the first scenario. However, once the price effect is accounted, the existence of *steepening* extends to the age group 60, as well.

Focusing on the model suggested by (Gregersen 2014) , results on the last four columns differ on the inclusion of the interaction term **"YearxMrate**" and in both cases mortality rate is only included to the power of 1, as the author did not find evidence to pursue with the polynomial form.

Results on annual growth rates (ρ_a) decreased from the previous regression as it should be expected by adding again the mortality effect. Besides, the coefficient on **"AgegxMrate"** displayed a significant and negative result suggesting that the initial suspicious on death-related costs being a decreasing function of age could be correct.

This time, the correction for changes in prices dictated different results for the presence of *steepening*. When excluding the interaction term between year and mortality, from Table 9, there is only significant evidence for the fastest growth of health care expenditures of individuals aged above 80, when in comparison with the reference group. However, from Table 10, the *steepening* hypothesis is not rejected for cohorts 60 and 70.

Once all variables of equation **(7)** are included, the yearly growth rates of expenditures declined even more, in particular for the older cohorts that showed negative deviations from the reference group rate. This might indicate that a significant share of the growth in health care expenditures for these individuals can highly be related to the decrease in the mortality levels registered throughout the years, as the coefficient on **"YearxMrate"** is positive.

Following the rule of thumb for the hypothesis testing, *steepening* is rejected as there is no evidence that health care expenditures grew faster for any two consecutive cohorts.

VI. DISCUSSION AND CONCLUSION

With the ongoing demographic transition occurring in most of the countries, concerns whether relatively older populations might impose additional pressure on health care systems worldwide have highlighted the long-term discussion on the impact of age, and consequently general population ageing, on health care expenditures. Under this context, Portugal is no exception as the country has now one of the largest shares of elderly population within the EU-27, estimated to increase in the years to come as well as a consistent increase in health care spending by the NHS over the last few decades. In this sense, the goal of the present work was to apply the concept of a *steepening* study to the Portuguese case and provide insights on what was the impact of ageing on NHS inpatient health care expenditures between 2009-2018 and derive conclusions for the next years.

Data on public hospital episodes showed an increase in the average age of patients over the period, as a larger percentage of individuals with more than 50 years old received inpatient care in the last five years in analysis. Contradictory to what was expected, average annual health care expenditures did not increase during the same period partially due to the changes made in the DRG coding system used as cost referencing to these hospitals. Once all records were standardized to the same price level, results on the average and per capita health care expenditures revealed a general increase from 2009 to 2018, reaching its maximum in 2017.

With respect to the existence of *steepening*, the three models chosen to perform the study had picked on different definitions of the term which also meant risking having ambiguous conclusions. The first approach applied a simple threshold between old and young and tested for the ratio on per capita health care expenditures between the two groups and how it evolved through the period. Within this framework, there was evidence to not reject the *steepening* hypothesis from

2009 to 2018. On the second model, the evaluation was made using age cohorts of five years each to allow for more flexibility in results. Taking as reference children aged between 5 and 9 years old, the relative expenditures growth rates for age groups above 50 years old except the last (>85), specified significant gradual increases suggesting once again the fastest growth of health care expenditures of elder groups in comparison with younger. In both models, the correction for the price effect derived the same conclusions on the original hypothesis though with less prominent annual growth rates.

For the third model, health care expenditures were defined not only as a function of age and time but also of mortality levels. Since 2009, Portuguese mortality rates decreased in great share due to expansion in the length of life. The addition of mortality-related coefficients led to a significant reduction on the yearly growth rates of per capita health care expenditures, in particular, for age groups above 50 years old, reflecting that part of the annual increases in health care expenditures could somehow be affected by the reductions in mortality levels.

With respect to the conclusions on the existence of *steepening*, the price effect played a distinguished role. On one hand, neglecting to correct for the changes occurred in the price level, led to the non-rejection of the hypothesis solely for the oldest age group (+80). On the other, when all episodes were standardized to the same price level, there was statistical evidence for the fastest growth of health care expenditures of individuals aged between 60 and 79 years old, not rejecting the presence of *steepening* though with lower results.

The repercussions of these inferences must be considered carefully when making any prediction on future health care expenditures for Portugal once two distinct scenarios are drawn depending on the cost-drivers contemplated. Furthermore, it is important to highlight this study only considered one type of health care service, so it is not possible to judge or predict how care expenditures will evolve for the remaining components of the total national expenditure. Extending to other sectors, such as long-term care or ambulatory care, could largely yield different results on the existence of *steepening*, especially in case there is a substitution and/or complementary effect between any of these services.

Another major limitation of this work is the use of DRG relative weights as a proxy for inpatient health care expenditures. By definition, these weights reflect the estimated cost for a specific treatment on an average patient, as such, attributing the same cost regardless of age can represent an underestimation of the actual expenditures for the elderly as typically these individuals develop worst health conditions and required extra care. (Gregersen 2014) Though the opposite can occur for younger groups, divergences between age groups could affect conclusions on the *steepening* premise.

In conclusion, evidence shows population ageing to have caused an acceleration on inpatient health care expenditures over time for individuals with more than 65 years old when *age* is the main explanatory variable. Once other determinants are included such as mortality levels, conclusions on the existence of *steepening* are reduced and only plausible for particular age cohorts, suggesting that a great share of the annual increases on per capita health care expenditures for these groups are related to the relatively higher costs with death. As these costs tend to decrease with age, the expansion in the length of life should gradually fade *steepening* in the next years.

References

ACSS. 2020. *ACSS.* Accessed 9 2020. http://www2.acss.min-saude.pt/.

ACSS. 2013. "Circular Normativa Nº1/2013." *ACSS.* 4 January. Accessed 10 16, 2020. http://www2.acss.min-saude.pt/.

ACSS. 2014. "Circular Normativa Nº22/2014." *ACSS.* 20 August. Accessed 10 16, 2020. http://www2.acss.min-saude.pt/.

Buchner, Florian, and Jurgen Wasem. 2006. "‘‘Steeping’’ of health expenditure profiles." *Geneva Papers Risk Insur. Issues Pract. 31* 581–599.

de Meijer, Claudine, Bram Wouterse, Johan Polder, and Marc Koopmanschap. 2013. "The effect of population aging on health expenditure growth: a critical review." *European Journal of Ageing* 353-361.

Diário da República . 2013. "Diário da República n.º 176/2013." *DRE.* 9 September. Accessed September 15, 2020. https://dre.pt/.

Eurostat. 2020. "Population structure and ageing." *Eurostat.* 8. Accessed 10 16, 2020. https://ec.europa.eu/eurostat/statisticsexplained/.

Felder, Stefan, and Andreas Werblow. 2008. "Does the age profile of health care expenditure really steepen over time? New evidence from Swiss Cantons." *The Geneva Papers on Risk and Insurance-Issues and Practice 33.4* 710-727.

Fries, James F. 1983. "The compression of morbidity ." *The Milbank Memorial Fund Quarterly. Health and Society* 397-419.

Gregersen, Fredrik Alexander. 2014. “The impact of ageing on health care expenditures: a study of steepening.” *The European Journal of Health Economics 15.9* 979-989.

INE. 2020. “Conta Satélite da Saúde.” *Instituto Nacional de Estatística.* 13 July. Accessed October 16, 2020. http://ine.pt/.

INE. 2012. “Conta Satélite da Saúde.” *Instituto Nacional de Estatística.* 27 June. Accessed 10 16, 2020. http://www.ine.pt/.

Ministério da Saúde. 2015. “Diário da República n.º 153/2015.” *Diário da República Electrónico*. 8 July. Accessed October 14, 2020. https://data.dre.pt/eli/port/234/2015/08/07/p/dre/pt/html.

Olshansky, S. J., M. A. Rudberg, B. A. Carnes, C. K. Cassel, and J. A. Brody. 1991. “Trading off longer life for worsening health: the expansion of morbidity hypothesis.” *Journal of aging and health* 194-216.

PORDATA. 2020. “Óbitos de residentes em Portugal: total e por grupo etário.” 28 April. Accessed October 1, 2020. https://www.pordata.pt.

PORDATA. 2020. “População residente, estimativas a 31 de Dezembro: total e por grupo etário.” *PORDATA.* 15 June. Accessed October 1, 2020. https://www.pordata.pt/.

Werblow, A., S. Felder, and P Zweifel. 2007. "Population ageing and health care expenditure: a school of ‘red herrings’?" *Health Economics* 1109-1126.

Zweifel, P, S Felder, and M Meiers. 1999. "Ageing of population and health care expenditure: a red herring?" *Health Economics* 485-496.

APPENDIX

Table 1 - Major Diagnostic Category average price evolution (2009-2018)

MDC*	AP 21	AP 27		APR 31		Overall
	Average Price	Average Price	Δ Average Price	Average Price	Δ Average Price	Δ Average Price
0. Pre-MDC	€ 50.035	€ 45.216	-9,6%	€ 37.421	-17,2%	-25,2%
1.Diseases and Disorders of the Nervous System	**€ 3.263**	**€ 4.724**	**44,8%**	**€ 6.433**	**36,2%**	**97,1%**
2.Diseases and Disorders of the Eye	€ 1.729	€ 2.042	18,1%	€ 3.718	82,1%	115,0%
3.Diseases and Disorders of the Ear, Nose, Mouth And Throat	€ 2.401	€ 1.510	-37,1%	€ 6.383	322,8%	165,8%
4.Diseases and Disorders of the Respiratory System	**€ 2.972**	**€ 3.196**	**7,5%**	**€ 4.483**	**40,3%**	**50,8%**
5.Diseases and Disorders of the Circulatory System	**€ 7.965**	**€ 5.221**	**-34,5%**	**€ 7.121**	**36,4%**	**-10,6%**
6.Diseases and Disorders of the Digestive System	**€ 3.481**	**€ 1.974**	**-43,3%**	**€ 4.549**	**130,4%**	**30,7%**
7.Diseases and Disorders of the Hepatobiliary System And Pancreas	€ 4.863	€ 3.813	-21,6%	€ 5.498	44,2%	13,1%
8.Diseases and Disorders of the Musculoskeletal System And Connective Tissue	**€ 4.336**	**€ 2.557**	**-41,0%**	**€ 7.777**	**204,2%**	**79,3%**
9.Diseases and Disorders of the Skin, Subcutaneous Tissue And Breast	€ 2.390	€ 1.918	-19,7%	€ 5.357	179,3%	124,1%
10.Diseases and Disorders of the Endocrine, Nutritional And Metabolic System	€ 3.677	€ 2.403	-34,6%	€ 5.513	129,4%	49,9%
11.Diseases and Disorders of the Kidney And Urinary Tract	€ 2.015	€ 1.729	-14,2%	€ 5.592	223,4%	177,5%
12.Diseases and Disorders of the Male Reproductive System	€ 1.921	€ 1.446	-24,7%	€ 6.870	374,9%	257,6%
13.Diseases and Disorders of the Female Reproductive System	€ 2.444	€ 1.412	-42,2%	€ 5.477	287,8%	124,1%
14.Pregnancy, Childbirth And Puerperium	€ 1.304	€ 597	-54,2%	€ 2.265	279,1%	73,7%
15.Newborn And Other Neonates (Perinatal Period)	€ 14.280	€ 20.698	44,9%	€ 16.786	-18,9%	17,5%
16.Diseases and Disorders of the Blood and Blood Forming Organs and Immunological Disorders	€ 2.593	€ 2.296	-11,5%	€ 5.096	122,0%	96,5%
17.Myeloproliferative DDs (Poorly Differentiated Neoplasms)	€ 7.809	€ 5.498	-29,6%	€ 8.687	58,0%	11,2%
18.Infectious and Parasitic DDs (Systemic or unspecified sites)	€ 2.668	€ 3.784	41,8%	€ 5.118	35,3%	91,8%
19.Mental Diseases and Disorders	€ 2.380	€ 2.239	-5,9%	€ 4.178	86,6%	75,6%
20.Alcohol/Drug Use or Induced Mental Disorders	€ 1.184	€ 1.294	9,3%	€ 3.061	136,6%	158,6%
21.Injuries, Poison And Toxic Effect of Drugs	€ 2.121	€ 2.102	-0,9%	€ 3.967	88,7%	87,1%
22.Burns	€ 14.486	€ 15.834	9,3%	€ 23.387	47,7%	61,4%
23.Factors Influencing Health Status and Other Contacts with Health Services	€ 2.016	€ 3.139	55,7%	€ 6.226	98,4%	208,9%
24.Multiple Significant Trauma	€ 8.554	€ 14.443	68,8%	€ 4.915	-66,0%	-42,5%
25.Human Immunodeficiency Virus Infection	€ 9.755	€ 14.828	52,0%	€ 12.698	-14,4%	30,2%

* Major Diagnostic Category

Table 2 – Inpatient health care episodes by age groups

Age	Absolute Frequency			
	2009	2012	2015	2018
0-4	101.758	104.592	62.135	57.425
5-9	13.885	12.205	6.838	5.414
10-14	10.201	11.000	5.987	4.747
15-19	14.373	16.649	9.121	7.906
20-24	23.254	24.186	12.958	12.302
25-29	36.239	37.042	19.860	19.115
30-34	46.175	47.452	27.410	25.466
35-39	37.973	43.646	25.458	24.228
40-44	30.694	35.620	20.488	19.249
45-49	32.632	39.873	21.347	19.585
50-54	36.196	46.141	25.876	23.097
55-59	38.131	50.467	29.233	27.457
60-64	43.718	57.977	32.809	32.145
65-69	45.903	62.946	37.591	37.075
70-74	56.673	68.181	39.321	39.939
75-79	62.518	78.483	46.795	41.755
80-84	56.001	70.481	45.796	44.553
85-89	39.274	50.926	34.774	35.525
90-94	14.450	19.766	16.277	17.107
95-99	3.975	4.668	3.294	4.239
>100	-	493	414	429
Total	744.023	882.794	523.782	498.758

Age	Absolute Frequency*			
	2009	2012	2015	2018
0-4	26.724	28.144	16.631	15.347
5-9	13.885	12.205	6.838	5.414
10-14	10.166	10.921	5.943	4.721
15-19	10.910	12.876	7.375	6.482
20-24	11.181	12.626	6.671	6.216
25-29	13.550	15.194	7.387	6.860
30-34	18.242	20.259	9.681	8.364
35-39	22.758	27.416	13.913	11.427
40-44	27.032	32.004	17.768	15.698
45-49	32.369	39.653	21.199	19.406
50-54	36.188	46.132	25.864	23.085
55-59	38.131	50.467	29.233	27.455
60-64	43.717	57.976	32.809	32.145
65-69	45.901	62.946	37.591	37.075
70-74	56.673	68.181	39.321	39.939
75-79	62.518	78.483	46.795	41.755
80-84	56.001	70.481	45.796	44.553
85-89	39.274	50.926	34.773	35.525
90-94	14.450	19.766	16.277	17.107
95-99	3.975	4.668	3.294	4.239
>100	-	493	414	429
Total	583.645	721.817	425.573	403.242

* excluding episodes on DRG 14 and 15

Table 3 - Average annual Health Care Expenditures on hospitalization episodes

Year	Pay_int			
	Original		With Price Correction	
	#Observations	mean	#Observations	mean
2009	744.023	2.590	744.023	2.590
2010	778.267	2.597	778.267	2.597
2011	891.142	2.803	891.142	2.803
2012	882.794	2.377	882.794	2.377
2013	626.913	2.350	662.746	2.338
2014	817.756	1.985	817.792	2.905
2015	523.782	1.944	523.762	2.822
2016	514.607	2.430	514.476	3.500
2017	499.286	2.470	498.779	3.521
2018	498.758	2.131	498.804	3.029
Total	6.777.328	23.678	6.812.585	28.483

Table 4 - Descriptive statistics: demographic variables

Age	Period 1 2009-2013			Period 2 2014-2018			Δ Mortality Rates
	#Decedents	Population	Mortality Rate 1	#Decedents	Population	Mortality Rate 2	
0-4	1.950	2.447.362	0,000637	1.643	2.170.431	0,000757	18,76%
5-9	310	2.626.046	0,000118	217	2.433.843	0,000089	-24,47%
10-19	1.157	5.583.681	0,000207	924	5.400.233	0,000171	-17,43%
20-29	3.134	6.079.054	0,000516	2.224	5.485.461	0,000405	-21,36%
30-39	7.436	7.857.099	0,000946	4.865	6.761.789	0,000719	-23,98%
40-49	18.613	7.780.072	0,002392	15.380	7.842.737	0,001961	-18,03%
50-59	36.383	7.055.051	0,005157	35.480	7.338.749	0,004835	-6,25%
60-69	61.380	5.900.010	0,010403	62.777	6.304.932	0,009957	-4,29%
70-79	130.413	4.589.503	0,028415	118.817	4.703.906	0,025259	-11,11%
+80	291.191	2.685.310	0,108439	329.144	3.151.288	0,104447	-3,68%
Total	551.967	52.603.188		571.471	51.593.369		

Table 5 - Results on equation (5)

Dependent Variable	Mortality Rate		(Mortality Rate)²		(Mortality Rate)³		(Mortality Rate)⁴	
Independent Variable	Coefficient	Std. er	Coefficient	Std. er	Coefficient	Std. er	Coefficient	Std. er
Year	0.000116***	(3.73e-05)	2.49e-05***	(8.13e-06)	3.88e-06***	(1.39e-06)	5.65e-07***	(2.14e-07)
Ageg x Year	-7.63e-06***	(8.25e-07)	-1.26e-06***	(1.80e-07)	-1.92e-07***	(3.08e-08)	-2.78e-08***	(4.74e-09)
Constant	-0.00117***	(0.000405)	-0.000358***	(8.83e-05)	-5.48e-05***	(1.51e-05)	-7.78e-06***	(2.33e-06)
N	2,469		2,469		2,469		2,469	
R-Squared	0.990		0.961		0.909		0.837	

Standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 6 - Results on equation (1)

Dependent Variable	**Ratio A**			
	Original		With Price Correction	
Independent Variables	Coeff.	Robust Std. er	Coeff.	Robust Std. er
year	0.149***	(0.0177)	0.048***	(0.0148)
Constant	294.728***	(35.5694)	-92.001***	(29.7180)
Observations	250		250	
R-Squared	0.611		0.522	

*** p<0.01, ** p<0.05, * p<0.1

Table 7 - Ratio between per capita health care expenditures of elderly and young population

Year	**RatioA**	**RatioA***
2009	4,39	4,39
2010	4,36	4,36
2011	3,83	3,83
2012	4,40	4,40
2013	4,55	4,62
2014	4,50	5,12
2015	4,77	4,23
2016	4,90	4,32
2017	5,35	4,63
2018	5,62	4,79

*corrected for changes in prices

Table 8 - Results on equation (2)

Original

Ratio B	(Agegroups)																	
Variables	**0-4**	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**> 85**
year	0.114***	-	0.0214**	0.0157	0.0184	0.0133	0.0265	0.0301	0.0372	0.0496	0.0869**	0.123**	0.192***	0.317***	0.524***	0.868***	1.123***	0.945***
	(0.0149)	-	(0.00924)	(0.0136)	(0.0156)	(0.0126)	(0.0168)	(0.0185)	(0.0242)	(0.0304)	(0.0347)	(0.0478)	(0.0610)	(0.0845)	(0.0877)	(0.121)	(0.147)	(0.142)
Constant	-227.1***	1	-41.90**	-30.00	-35.40	-24.89	-51.50	-58.22	-71.87	-95.67	-169.4**	-240.3**	-377.9***	-626.6***	-1,041***	-1,728***	-2,236***	-1,882***
	(30.06)	-	(18.61)	(27.36)	(31.35)	(25.30)	(33.84)	(37.23)	(48.65)	(61.26)	(69.89)	(96.25)	(122.9)	(170.1)	(176.5)	(244.6)	(296.2)	(285.0)
Observations	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
R-squared	0.332		0.168	0.157	0.187	0.336	0.189	0.356	0.304	0.227	0.413	0.348	0.365	0.433	0.537	0.566	0.613	0.598

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

With Price Correction

Ratio B	(Agegroups)																	
Variables	**0-4**	**5-9**	**10-14**	**15-19**	**20-24**	**25-29**	**30-34**	**35-39**	**40-44**	**45-49**	**50-54**	**55-59**	**60-64**	**65-69**	**70-74**	**75-79**	**80-84**	**> 85**
year	0.0270*	-	0.0218***	0.00987	0.0137	0.0184	0.0355**	0.0365**	0.0462	0.0607*	0.102***	0.151***	0.244***	0.343***	0.427***	0.626***	0.591***	0.423***
	(0.0140)	-	(0.00837)	(0.0127)	(0.0147)	(0.0119)	(0.0178)	(0.0177)	(0.0287)	(0.0349)	(0.0386)	(0.0512)	(0.0694)	(0.0924)	(0.105)	(0.126)	(0.155)	(0.148)
Constant	-52.07*	1	-42.87**	-18.39	-25.90	-35.18	-69.64*	-71.15**	-90.11	-118.2*	-199.7**	-296.6***	-483.3***	-680.0***	-846.3***	-1,242***	-1,169***	-832.8***
	(28.19)	-	(16.86)	(25.66)	(29.62)	(23.90)	(35.86)	(35.67)	(57.75)	(70.30)	(77.65)	(103.1)	(139.8)	(186.1)	(210.7)	(254.4)	(312.8)	(297.5)
Observations	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250	250
R-squared	0.160		0.142	0.182	0.147	0.257	0.154	0.289	0.206	0.152	0.221	0.233	0.210	0.215	0.224	0.262	0.249	0.232

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 9 - Results on regressions (3) and (7)

Dependent Variable	Per capita expenditures ln (Totexp_pc)							
Equation	(3)		(3) Excluding Mortality		(7) Excluding interaction between year and mortality		(7)	
Independent Variables	Coeff.	Std.Error	Coeff.	Std.Error	Coeff.	Std.Error	Coeff.	Std.Error
female (δ)	-0.277***	(0.0549)	-0.277***	(0.0552)	-0.277***	(0.0550)	-0.277***	(0.0551)
Agegroup (υ)								
0-4	0.806***	(0.0558)	0.633***	(0.0880)	0.589***	(0.0939)	0.606***	(0.0935)
5-9	-		-		-		-	
10-19	0.0357	(0.0513)	-0.0462	(0.0917)	-0.0494	(0.0909)	-0.0467	(0.0910)
20-29	0.142***	(0.0539)	0.158*	(0.0909)	0.143	(0.0924)	0.155*	(0.0925)
30-39	0.389***	(0.0565)	0.386***	(0.0896)	0.367***	(0.0935)	0.391***	(0.0933)
40-49	0.852***	(0.0749)	0.946***	(0.0881)	0.921***	(0.104)	0.988***	(0.104)
50-59	1.305***	(0.148)	1.487***	(0.0900)	1.491***	(0.126)	1.648***	(0.127)
60-69	1.704***	(0.242)	1.993***	(0.0885)	2.127***	(0.152)	2.481***	(0.163)
70-79	2.505***	(0.401)	2.317***	(0.0923)	3.043***	(0.211)	4.040***	(0.279)
80+	4.033***	(0.824)	2.539***	(0.111)	6.700***	(0.723)	10.76***	(1.039)
(τ)								
FemalexAgeg0	0.0819	(0.0745)	0.0819	(0.0748)	0.0819	(0.0743)	0.0819	(0.0744)
FemalexAgeg10	0.0987	(0.0738)	0.0987	(0.0746)	0.0987	(0.0740)	0.0987	(0.0740)
FemalexAgeg20	0.0209	(0.0756)	0.0209	(0.0758)	0.0209	(0.0755)	0.0209	(0.0756)
FemalexAgeg30	0.159**	(0.0749)	0.159**	(0.0748)	0.159**	(0.0748)	0.159**	(0.0748)
FemalexAgeg40	0.0680	(0.0735)	0.0680	(0.0739)	0.0680	(0.0736)	0.0680	(0.0736)
FemalexAgeg50	-0.144*	(0.0738)	-0.144*	(0.0743)	-0.144*	(0.0740)	-0.144*	(0.0738)
FemalexAgeg60	-0.237***	(0.0741)	-0.237***	(0.0744)	-0.237***	(0.0741)	-0.237***	(0.0737)
FemalexAgeg70	-0.181**	(0.0792)	-0.181**	(0.0801)	-0.181**	(0.0795)	-0.181**	(0.0782)
FemalexAgeg80	-0.0331	(0.0885)	-0.0269	(0.0985)	-0.0315	(0.0940)	-0.0353	(0.0923)
Year (θ)	-0.0748***	(0.00430)	-0.0911***	(0.0110)	-0.0907***	(0.0108)	-0.0914***	(0.0108)
(ρ)								
YearxAgeg0			0.0476***	(0.0152)	0.0482***	(0.0149)	0.0428***	(0.0150)
YearxAgeg10			0.0195	(0.0157)	0.0194	(0.0155)	0.0186	(0.0155)
YearxAgeg20			0.00195	(0.0156)	0.00252	(0.0154)	-0.000743	(0.0154)
YearxAgeg30			0.0114	(0.0152)	0.0122	(0.0150)	0.00600	(0.0151)
YearxAgeg40			0.00700	(0.0153)	0.00749	(0.0152)	-0.00993	(0.0155)
YearxAgeg50	0.00364	(0.0116)	0.0180	(0.0156)	0.0176	(0.0154)	-0.0230	(0.0173)
YearxAgeg60	0.0103	(0.0117)	0.0260*	(0.0154)	0.0242	(0.0154)	-0.0633***	(0.0228)
YearxAgeg70	0.0219	(0.0146)	0.0574***	(0.0158)	0.0458***	(0.0164)	-0.189***	(0.0474)
YearxAgeg80	0.0479***	(0.0151)	0.0823***	(0.0179)	0.0509***	(0.0190)	-0.885***	(0.178)
mrate (κ)	71.38**	(30.19)			65.42	(53.08)	39.38	(51.10)
mrate2	-3,897***	(936.9)						
mrate3	50,884***	(9,752)						
mrate4	-202,031***	(33,914)						
AgegxMrate (ψ)					-1.290*	(0.702)	-1.433**	(0.674)
YearxMrate (ω)							8.774***	(1.723)
Constant	3.710***	(0.0481)	3.814***	(0.0656)	3.756***	(0.0659)	3.762***	(0.0659)
Observations	4,998		4,998		4,998		4,998	
R-squared	0.794		0.780		0.788		0.792	

Robust standard errors in parentheses
*** p<0.01, ** p<0.05, * p<0.1

Table 10 - Results on regressions (3) and (7) with price correction

Dependent Variable	Per capita expenditures ln (Totexp_pc)							
Equation	(3)		(3) Excluding Mortality		(7) Excluding interaction between year and mortality		(7)	
Independent Variables	Coeff.	Std.Error	Coeff.	Std.Error	Coeff.	Std.Error	Coeff.	Std.Error
female (δ)	-0.270***	(0.0570)	-0.270***	(0.0574)	-0.270***	(0.0572)	-0.270***	(0.0572)
Agegroup (υ)								
0-4	0.685***	(0.0566)	0.667***	(0.0869)	0.615***	(0.0931)	0.634***	(0.0924)
5-9	-		-		-		-	
10-19	0.0284	(0.0525)	-0.0523	(0.0894)	-0.0563	(0.0889)	-0.0533	(0.0890)
20-29	0.140**	(0.0542)	0.134	(0.0883)	0.114	(0.0899)	0.128	(0.0899)
30-39	0.403***	(0.0574)	0.379***	(0.0875)	0.352***	(0.0917)	0.378***	(0.0914)
40-49	0.857***	(0.0753)	0.955***	(0.0858)	0.910***	(0.102)	0.985***	(0.101)
50-59	1.248***	(0.146)	1.492***	(0.0876)	1.460***	(0.125)	1.633***	(0.124)
60-69	1.599***	(0.241)	1.997***	(0.0863)	2.064***	(0.151)	2.452***	(0.160)
70-79	2.339***	(0.402)	2.354***	(0.0911)	2.923***	(0.210)	4.013***	(0.281)
80+	3.949***	(0.829)	2.615***	(0.111)	6.287***	(0.716)	10.72***	(1.075)
(τ)								
FemalexAgeg0	0.117	(0.0760)	0.117	(0.0768)	0.117	(0.0763)	0.117	(0.0763)
FemalexAgeg10	0.106	(0.0755)	0.106	(0.0760)	0.106	(0.0757)	0.106	(0.0757)
FemalexAgeg20	0.0639	(0.0761)	0.0639	(0.0763)	0.0639	(0.0761)	0.0639	(0.0761)
FemalexAgeg30	0.179**	(0.0759)	0.179**	(0.0759)	0.179**	(0.0759)	0.179**	(0.0759)
FemalexAgeg40	0.0637	(0.0746)	0.0637	(0.0749)	0.0637	(0.0747)	0.0637	(0.0746)
FemalexAgeg50	-0.141*	(0.0747)	-0.141*	(0.0751)	-0.141*	(0.0749)	-0.141*	(0.0747)
FemalexAgeg60	-0.220***	(0.0750)	-0.220***	(0.0752)	-0.220***	(0.0750)	-0.220***	(0.0745)
FemalexAgeg70	-0.160**	(0.0796)	-0.160**	(0.0804)	-0.160**	(0.0799)	-0.160**	(0.0784)
FemalexAgeg80	-0.00152	(0.0882)	0.00428	(0.0963)	0.00428	(0.0929)	0.00428	(0.0907)
Year (θ)	-0.0160***	(0.00419)	-0.0300***	(0.0108)	-0.0294***	(0.0106)	-0.0302***	(0.0106)
(ρ)								
YearxAgeg0			0.0148	(0.0150)	0.0154	(0.0148)	0.00944	(0.0148)
YearxAgeg10			0.0195	(0.0153)	0.0193	(0.0151)	0.0184	(0.0151)
YearxAgeg20			0.00780	(0.0150)	0.00855	(0.0149)	0.00494	(0.0149)
YearxAgeg30			0.0180	(0.0147)	0.0190	(0.0147)	0.0122	(0.0147)
YearxAgeg40			0.0111	(0.0148)	0.0121	(0.0148)	-0.00719	(0.0151)
YearxAgeg50	0.0134	(0.0112)	0.0248*	(0.0151)	0.0247*	(0.0149)	-0.0202	(0.0167)
YearxAgeg60	0.0210*	(0.0113)	0.0334**	(0.0150)	0.0322**	(0.0150)	-0.0645***	(0.0219)
YearxAgeg70	0.0160	(0.0141)	0.0480***	(0.0155)	0.0387**	(0.0160)	-0.221***	(0.0457)
YearxAgeg80	0.0261*	(0.0144)	0.0562***	(0.0177)	0.0281	(0.0181)	-1.007***	(0.171)
mrate (κ)	82.82***	(30.26)			78.19	(53.68)	49.07	(50.43)
mrate2	-4,084***	(930.6)						
mrate3	51,546***	(9,511)						
mrate4	-200,416***	(32,521)						
AgegxMrate (ψ)					-1.394**	(0.709)	-1.541**	(0.669)
YearxMrate (ω)							9.712***	(1.650)
Constant	3.652***	(0.0492)	3.741***	(0.0650)	3.689***	(0.0655)	3.696***	(0.0654)
Observations	4,936		4,936		4,936		4,936	
R-squared	0,789		0.776		0.782		0.788	

Robust standard errors in parentheses

*** p<0.01, ** p<0.05, * p<0.1