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INEQUALITY IN MORTALITY: PORTUGAL VS. UNITED STATES, CANADA AND FRANCE

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ABSTRACT

This study assesses poverty's impact on mortality rates, employing an adapted Currie-Schwandt methodology to compare Portugal with the US, Canada, and France, accompanied by a regression analysis. Despite constitutional commitments to universal healthcare, stark disparities emerge for individuals aged 70 and above, with Portugal exhibiting higher mortality gradients (albeit for different reasons). The remaining Portuguese population shows no discernible mortality inequality linked to poverty. Among those over 70, healthcare spending disparities, particularly in medicines and pharmaceutical devices, and medical and hospital services, might be contributing to mortality inequality, emphasizing the urgency for targeted policies to rectify disparities in elderly mortality.

Keywords: Mortality, Inequality, Income, Healthcare, Health Economics, Regression analysis.

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1. INTRODUCTION

In the pursuit of the fleeting target of improving the well-being of a population, few topics resonate as profoundly as the unequal distribution of mortality rates. In a time where inequalities around the world rose, with the World Bank stating that the Covid-19 pandemic has disproportionally impacted the poor and vulnerable globally, leading to setbacks in poverty reduction and increased inequality, [1] this paper contributes to the understanding of how far the impact of income inequality on mortality rates faced by Portuguese individuals goes and understanding which are the more vulnerable segments of the population.

The Portuguese Constitution states that all citizens should have equal rights regarding the protection of health, promoted through the existence of a universal healthcare system. [2] Thus, for decision-makers, it is crucial that some metric of the relation between inequality in income and mortality exists as to better direct the public policies undertaken, better monitor their results and better compare them with the ones of other countries.

Taking this into account, this paper focuses on answering two questions: "Does a positive gradient in mortality inequality exist across all age groups, in Portugal?" and "Are these gradients equal to the ones observed for the United States, Canada and France?".[3]

Embarking on this study demands acknowledging the intellectual groundwork laid by previous research. This paper aims to fill a persistent gap, particularly regarding the Portuguese reality. Given the lack of a common global panorama (previous literature's results diverged significantly according to the studied countries), the need to close this gap is larger.

Therefore, to obtain a comprehensive view on this subject, i) an analysis of the evolution of Portuguese and American mortality was performed, ii) its mortality inequality gradients were computed and faired against those of the comparison countries and iii) an additional

[1] "2021 Year in Review in 11 Charts: The Inequality Pandemic"
[2] Article 64 of the Portuguese constitution, in "Diário da República".
[3] The choice of these countries is explained in the literature review.

investigation into what might be causing the differences found in Portugal was undertaken. Significant inequality in mortality was only found for the age groups 70-75+. In this case, Portugal faced much higher gradients than the aforementioned countries, though for different reasons, explained later. Moreover, disparities in expenditure in healthcare for rich and poor households were also found, offering a potential explanation for mortality inequalities.

This exploration started with a literature review to identify relevant gaps this paper aims at filling (Section 2), followed by the methodological approach and data presentation (Sections 3 and 4), concluding with the identification of the findings, implications, limitations of this paper and suggestions for further research (Sections 5 and 6).

2. LITERATURE REVIEW

Numerous authors endeavor to unravel the underlying factors contributing to mortality inequality. Pampel et al. (2017) explores the influence of risk factors, while Case et al. (2015), Cutler et al. (2011), Murray et al. (2006) and Olshansky et al. (2012) examine individual characteristics such as sex, race, or education, among various socioeconomic factors. Moreover, while many studies focus on the US, like Banks et al. (2006), Chetty et al. (2015) or Currie and Schwandt (2016), others extend their analysis to different countries, such as Brüning and Thuilliez (2019), Kravdal et al. (2017) or Zou et al. (2023). Moreover, Kord et al. (2023) studies how income impacts household out-of-pocket spending and Sultana et al. (2023) and Bunyaminu et al. (2022) the impact of expenditure in healthcare on health outcomes.

In their work, Currie and Schwandt (2016) propose a methodology for investigating the connection between income inequality and mortality, enabling the inclusion of all age groups. Historically, most studies focused exclusively on adults due to lower mortality rates observed in the youngest age groups and to an outdated perspective that assumed limited possibilities for improving the mortality of younger generations (often associated with automobile accidents).

Additionally, children's death certificates lacked socioeconomic indicators, whereas those of adults often provided some information on education and occupation, albeit imperfect.

Currie and Schwandt's approach involves allocating the US's population into 20 regional bins, of approximately equal size, which are then ranked from rich to poor. Extensive regional data was required to form such groups. Subsequently, for each age group, sex, and census year, mortality rates per capita are compared among the bins, creating a gradient based on the cumulative points.

While results for middle-aged individuals aligned with previous literature, showing increasing income inequality led to higher mortality inequality, the findings for children differed. For them, growing income inequality was accompanied by lower mortality inequality, as mortality fell less in richer areas compared to poorer ones. This flattening of the US gradient for the youngest was attributed to expansions of the Medicaid program, the creation of the Child Health Insurance Program, and similar policies, which increased the percentage of covered children and improved their access to healthcare, analyzed further in Currie and Duque (2019). Although initially applied to the US, this approach is adaptable for cross-country comparisons. Baker, Currie and Schwandt (2019) used it to compare the US with its northern neighbour. Results for Canada exhibited lower mortality per capita for each age group and sex, with greater equality between rich and poor. The difference in mortality between the US and Canada was largely explained by the higher mortality among the poor in the US, emphasizing the disparity in both mortality rates and equality. However, this pattern did not hold for children, whose gradient flattened, over the years, in the US, converging more towards the Canadian one, pointing to the effectiveness of the expanded safety net for the youngest in the US.

Baker, Schwandt, and Thuilliez (2020) extended this comparison with the US to France, showing that the latter exhibited significantly more equitable results than the former. The greater equality in the French mortality rates, before 2010, was driven by higher relative

mortality levels among the rich, but such explanation stopped being true afterwards, with France presenting lower levels of mortality for all groups. Once more, all segments of the American population faced worse mortality rates than the French and results were less equal.

Baker et al (2021) updated the previous estimates with the most recent available years of data at the time, consolidating findings into a comprehensive paper covering the US, Canada and France. This study confirmed that Canada and France have much lower gradients of mortality than the US, which the authors claim to be due to public policy impacting public health. Between 2010 and 2018, mortality and inequality in the US increased for most groups (except for the youngest and oldest), which will be further discussed in the results section of this paper, while Canada became even more equal and with even lower mortality rates, for most groups studied. France saw improvements in the mortality across all age groups. This way, the US lagged behind both countries in the studied period, according to the authors.

Building on the aforementioned research, the current study adds Portugal to the comparison made in the previously mentioned paper, although, in this case, the Currie-Schwandt approach was not fully implemented due to a lack of sufficiently disaggregated Portuguese reliable data on poverty, a limitation which will be further discussed later. This way, this paper aims at closing what, to the best of my knowledge, appears to be a gap in the literature concerning the analysis of mortality inequality in Portugal (in comparison to the other countries), using the previously described method adjusted to the available data for Portugal.

3. METHODOLOGY

In order to better understand the differences found in the Portuguese mortality, the analysis segment of this paper comprises three primary components. The initial one addresses the evolution of Portuguese mortality per capita and its comparison with that of the US. Subsequently, an examination is conducted to discern the impact of poverty on mortality probabilities across the different combinations of age group, sex, and year, approximately

following the previously described Currie-Schwandt approach, although adjusted to the available data. This method allows to discern if the differences found in the mortality of each region for a certain age group, sex, and year, are explained by the poverty rate of that region. The results of this analysis are then compared to those found in Baker et al. (2021) for the US, Canada and France. Thirdly, an exploration is undertaken to identify potential disparities in healthcare expenditure between poor and rich which could explain variations in mortality and generate conjectures for future work.

4. DATA

The initial two parts of the analysis required comprehensive data on population, mortality, and poverty, stratified by region, sex, age group and year. For the last one, additional granular data on healthcare expenditure, categorized by product and service, was essential.

Regarding age groups, the most finely segmented intervals for which it was possible to compute the population, mortality and poverty rate for all the years considered correspond to the brackets 0-14, 15-19, 20-24, 25-29, 30-34, 35-39, 40-44, 45-49, 50-54, 55-59, 60-64, 65-69, 70-74 and 75+. In certain sections of this paper, further disaggregation of these groups was possible because less information on the other variables was required. However, for the majority, this proved to be the most viable option.

Similar to the approach taken with age groups, occasions exist where data retrieval extended to additional years, driven by reduced necessity of disaggregation of the other variables. Nevertheless, for most of the analysis, data for 2005, 2010 and 2015 was the found solution.

The most disaggregated regional data available, for Portugal, is by NUTS2 regions.[4] The absence of more disaggregated data on Portuguese regions, such as NUTS3 (described in *Figure 11* of the appendices) or municipalities, hindered the creation of poverty percentiles

[4] NUTS is the "Nomenclatura das Unidades Territoriais para Fins Estatísticos", shown in *Figures 10 and 11* of the appendices. NUTS2 encompasses seven regions, five of which in the mainland (North, Algarve, Centre, Metropolitan Area of Lisbon and Alentejo) plus two which correspond to the Portuguese archipelagos (Autonomous Regions of Azores and Madeira).

required for the replication of the Currie-Schwandt approach. Consequently, instead of employing poverty percentiles, owing to insufficient observations, the seven available points (corresponding to the NUTS2 areas) for each combination of year, sex and age group were directly utilized to calculate the gradients. Data for the three years, both genders, all age groups and regions regarding poverty and mortality rates was regressed in order to produce results comparable to the ones obtained through the Currie-Schwandt approach used for the comparison countries.

The variable "sex" is binary (male and female), as obtained from the data retrieved from the national statistics institute in Portugal, INE.

Subsequently, data on the population, poverty, mortality and expenditures in healthcare products and services will be further explained.

4.1. POPULATION

To collect data on the population by sex, age group and region, for each year, two distinct sources were used. For the opening component of the results section, focusing on the evolution of mortality, data was directly obtained from "Pordata" (whose source for this information is INE). For the computation of the Portuguese mortality gradients, comparison with those of the US, Canada and France, and analysis of the expenditures in healthcare, information was extracted from the "Inquérito às despesas das Famílias" survey database. [5] Each family in the survey is representative of a different number of Portuguese families, depending on the number of children, age of each household member, amongst other factors. To account for this variability, in this paper, a different weight (estimated by INE) was given to each household, according to how representative it is of the Portuguese households.

[5] Quinquennial survey conducted by INE, wherein participants provided information on their family's characteristics, expenditures, and income.

For a thorough analysis of the survey data, three databases were merged for 2005, and two for 2010 and 2015. These encompassed i) an individual information database (on the sex and age group of each individual), ii) a household database (household consumption values for each category of expense, its monetary income and the NUTS2 it belongs to) and iii) for 2005, an additional database with information on poverty. Based on the merged data files, and after organizing all information and considering the representativeness of each household on the overall population, data on the Portuguese population for the 3 different years was extracted. These survey results' databases underwent separate treatment and curation processes due to disparities in organizational structures found within the data files for each of the three years.

4.2. POVERTY

To compute poverty rates, the "Inquérito às despesas das famílias" merged databases were also used. Consistent with the methodology employed for retrieving population data, weights assigned by INE to each household in the population were chosen according to how representative it is of the overall population.

The poverty threshold was derived from Pordata, [6] corresponding to 60% of the national median income of an equivalent adult after social transfers, in the respective year. Households which have a monetary net income (by equivalent adult) below the threshold are classified as poor. Following this methodology, either all members of a household are deemed poor, or none are. The equivalent income was the measure found to tackle the difficulty of comparing different households due to there being family economies of scale (i.e. the needs of a household grow with each additional member in a less than proportional way). For instance, a family of two with a monetary net income twice that of a single-member household can afford more goods per capita than the latter. This way, a scale suggested by the OECD was utilized[7] to transform

[6] Having questioned Pordata regarding the source of this series, it stated that, until 2000, it was Eurostat and, from then onwards, it was INE.

[7] The modified OCED equivalence scale was utilized, shown in the appendix, in *Figure 12*.

the income of different aggregates into comparable values, proportional to the needs of each family type (controlling for the size of the household and age of its members). Poverty risk, interpreted as the *ex ante* probability of being poor in that group, was computed as the percentage of poor people (people in households classified as poor), in that year, in that group, employing population data to determine the number of individuals in said group.

4.3. MORTALITY

Mortality data was gathered from Pordata (whose source, in this case, is INE) and directly from INE's online database. Subsequently, the mortality per capita for each analyzed group was computed, leveraging the previously acquired population data.

4.4. EXPENSES IN HEALTHCARE PRODUCTS AND SERVICES

Data on healthcare expenditure, extracted from the "Inquérito às despesas das Famílias" previously merged databases, was disaggregated into seven expenditure variables: medicines and pharmaceutical specialties, other medical and pharmaceutical products, therapeutical devices and material, medical services, dental health services, paramedical services and hospital services. Detailed data allowed for the determination of the average expenditure for the different age groups, distinguishing between poor and rich households. This analysis also considered the representativeness of each family in the overall Portuguese population.

5. RESULTS AND DISCUSSION

As previously stated, the results of this paper are organized into three main sections. The first explores the evolution of mortality in Portugal, comparing it to the US. The second delves into factors influencing mortality, specifically age, gender, and poverty, with results for Portugal compared to the US, Canada and France. The last section investigates healthcare expenditure as a potential determinant of income-based differences in per capita mortality.

5.1. COMPARISON OF THE EVOLUTION OF MORTALITY IN PORTUGAL AND US

Figure 1 illustrates the evolution of Portuguese mortality and its breakdown by age group.

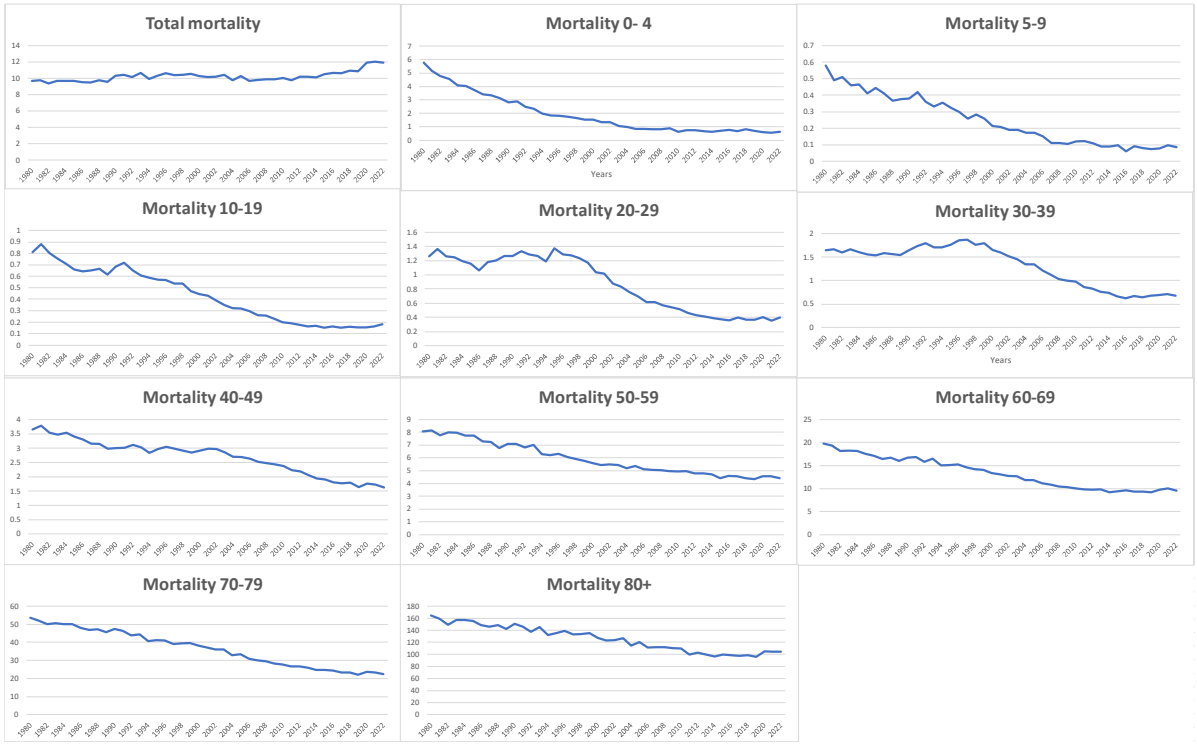


*Figure 1 - Evolution of mortality by age groups, in Portugal. The y-axis represents "Mortality/Population*1000". The x-axis represents "Years". Data on the mortality and population from Pordata.*

Although the scale of the y axis is not constant across graphics, the evolution in recent years appears to indicate diminishing marginal gains in mortality for all age groups, having reached a plateau with little improvement being observed.

For those aged 0-4, mortality diminished at a decreasing rate, stabilizing in values between 0 and 1 per 1000. This decrease was very influenced by the mortality of newborns, aged 0-1, which always represented between 75% and 85% of the overall mortality of this age group, and declined from 3839 deaths, in 1980, to 217, in 2022. Despite starting at a much lower level, infant mortality (ages 5-9) showed a similar trend. For ages 10-39, mortality only started to decrease unequivocally beyond a certain year between 1990 and 2000 (different for the 3 age groups), coinciding with the systematic promotion of road safety (a relevant cause of death for people in this age group), in Portugal.[8] Until that year, mortality oscillated considerably. For ages 40+, mortality decreased smoothly in this period, with only minor upward oscillations.

[8] According to information from the Portuguese Road Safety National Authority (Autoridade Nacional de Segurança Rodoviária), the systematic promotion of road safety in Portugal only started in 1990.

With the Covid-19 pandemic, mortality spiked for almost all age groups, except for the youngest and for those aged 10-19 years old. Overall mortality per capita increased 10.01%,[9] and the elderly were the most affected by it, especially those over 80 years old, showing a larger percentual increase from 2019 to 2020.

Throughout the analyzed period, total mortality remained relatively stable, although its upward trend was strengthened in recent years. Contrastingly, mortality was lower in 2022 than in 1980 for all age groups considered, which can be explained by the aging of the population. In other words, there are two opposite effects at play. On the one hand, mortality is lower for 2020 than for 1980, for all age groups, which, *ceteris paribus*, would lead to a decrease in overall mortality On the other hand, the percentage of elderly people has increased (see *Figure 2*), leading the weighted average of mortality per capita to become more influenced by the mortality of the elderly, which is higher than that of younger populations (see *Figure 3*). The latter would cause overall mortality to increase, prevailing over the former. Thus, despite the reduction in mortality per capita for all age groups when comparing 1980's levels with 2020's, overall mortality per capita increased in this period.

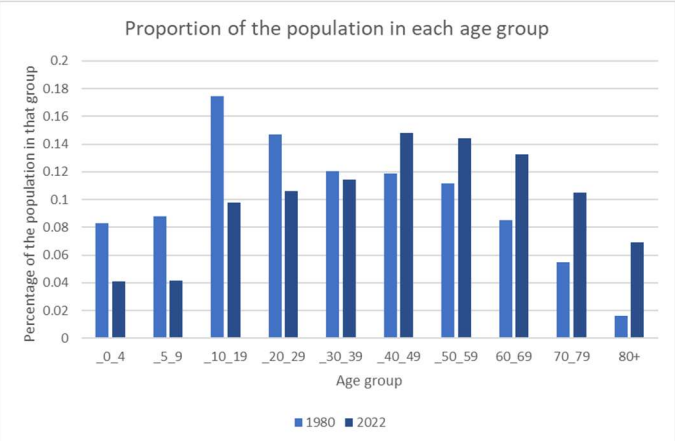


Figure 2 - Aging of the population, in Portugal (Data from Pordata).

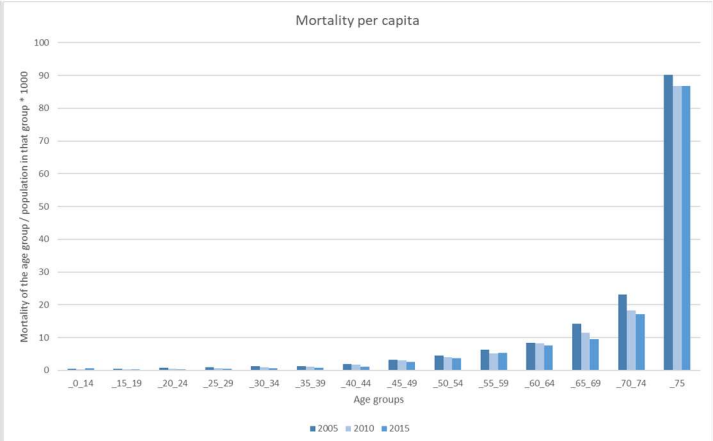
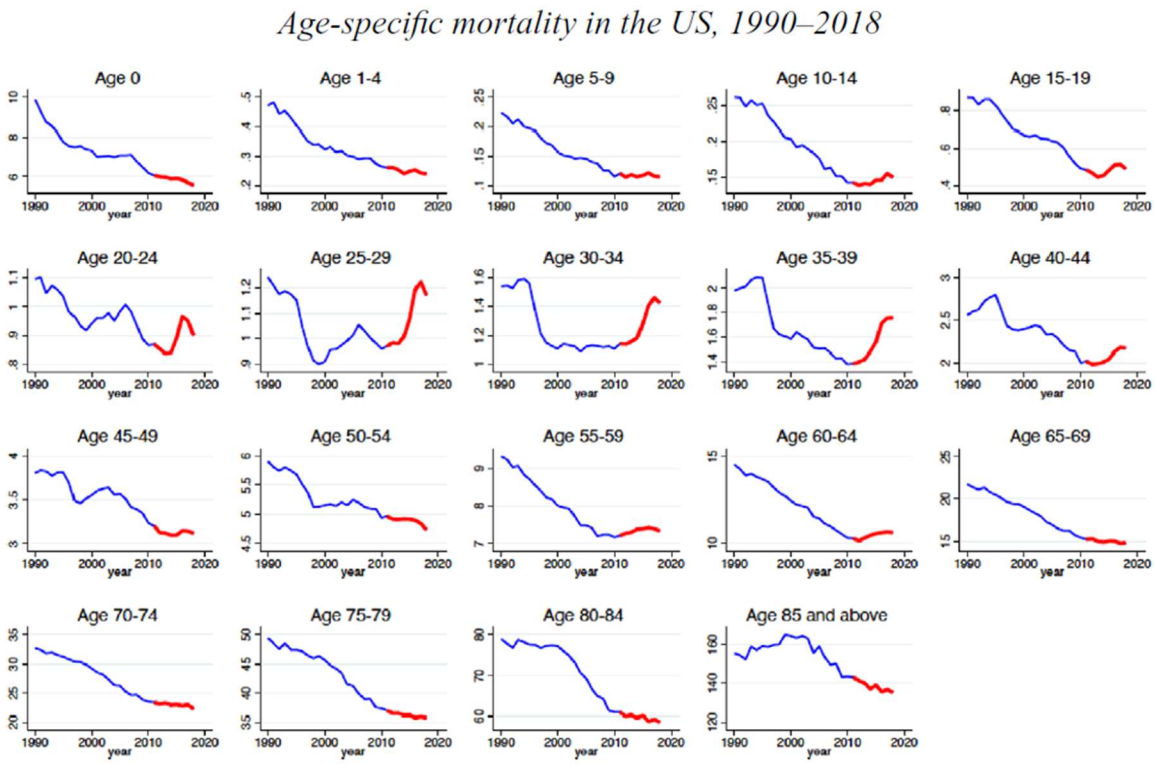


Figure 3 – Mortality per capita by age groups, in Portugal (Data on mortality from Pordata and on the population from "Inquérito às despesas das famílias").

[9] Calculated as: (Per capita mortality in 2020 - Per capita mortality in 2019) / Per capita mortality in 2019.



Note: The *y*-axis shows deaths per 1,000. The thinner blue line shows data up to 2010, while data from 2010 to 2018 are shown by the thicker red line.

Figure 4 - Age specific mortality in the US, 1990-2018. Graphic imported directly from Baker et al. (2021).

When comparing the evolution of per capita mortality in Portugal and in the US (*Figure 4*), the biggest difference lies in the fact that, in the US, since 1990, i) per capita mortality rose for age groups 5-19, ii) there were abrupt and dramatic increases in per capita mortality among prime-aged people (20-49) and iii) it increased slightly for the 55-64 group. None of those tendencies can be seen in Portugal, which shows signs of decreasing mortality for all age groups and most years considered. For the age groups 5-60, even for the cases where Portugal was lagging behind, in 1990, (for instance, for those aged 5-9), Portugal managed to surpass the US, achieving lower (or, at least, similar) levels of mortality, in 2020.

Baker et al. (2021) argues the increases in mortality in the US can be largely explained by the boom of the opioid crisis.[10] According to Currie and Schwandt (2021), the unregulated prescription of opioids was one of the main sources of this problem, leading to the creation of

[10] Since the synthetic prescription of OxyContin and other similar opioids in the late 1990s, the opioid crisis became even more worrisome, leading to an increased number of overdoses. Since 2010, the number of addicts who used illegal drugs like fentanyl increased and life expectancy decreased even further.

addictions that would boost the illegal market for these products. Additionally, the lack of adequate treatment led to the creation of the needed conditions for the opioid crisis to thrive. None of this can be seen in Portugal, whose evolution in mortality differs significantly from the one of the US, showing decreasing trends where, in the US, one can see worrisome increases in mortality of prime-aged people.

5.2. INFLUENCE OF PORVERTY ON PORTUGUESE MORTALITY

Following the approach of Baker et al. (2021), when trying to understand the impact of being poor on per capita mortality, in Portugal, regressions as described in Equation (1) for every combination of age group, year and sex, were computed, allowing for a great flexibility of the coefficients calculated. Despite this, their approach proved to be insufficient in the Portuguese context, which has a much more limited sample size, returning a high percentage of non-significant and inconclusive results.

$$Mortality\ per\ capita_i = \beta_0 + \beta_1 Poverty_i + u \qquad (1)$$

Where *i* corresponds to a certain region.

The results found following this approach were mixed, the statistical power of each regression was small, and most of the coefficients were not significant at a 95% confidence level. This was expected as each regression only had seven observations (the most disaggregated variable by region was by NUTS2, as previously explained). Additionally, the large number of slopes originated by the vast number of equations and graphs (concerning each combination of sex, age group and year) was not easily interpretable. *Figure 13*, in the appendix, illustrates the difficulty in understanding the large amount of contradicting information. One would expect all slopes to be positive, correlating higher mortality with higher poverty rates. However, some series present a negatively slopped line, there are cases where a reversal in the sign of the gradient occurs with no other clear interpretation other than the fact that the statistical power of the regressions was low as expected due to the low number of observations. Nonetheless,

one can glimpse a positive relation between poverty and mortality in most cases. Aiming to obtain higher statistical power, data on the 3 years (2005, 2010 and 2015) was used in each regression (to be able to use 21 observations, instead of only 7, per regression). The percentage of statistically significant coefficients remained small, also not allowing to conduct a further analysis on what explained each coefficient.

This way, a third route was taken. In Stata, an excel with mortality per capita (*1000) and the poverty rate for each age group, sex, year, and region was imported with the previously computed results for each variable. Data was retrieved at the NUTS2 level. To select the model used in this analysis, the stepwise prefix[11] was used to ensure all variables and interactions included are statistically significant at a 5% significance level. Not being statistically significant implies the effect associated with these cells to be similar to the one of the baseline levels. Thus, the following model was computed:

$$Mortality\ per\ capita_{itas} = \beta_0 + \sum_a \sum_s \beta_{1_{a,s}} + \sum_a \sum_s \beta_{2_{a,s}} * Poverty_{itas} + \beta_{3_t} * \delta_t + u \quad (2)$$

Where *itas* corresponds to a certain sex, *s*, and age group, *a*, of a certain region, *i*, in a certain year, *t*. The age variable corresponds to the age of the group considered, sex corresponds to 0 for a male subgroup and 1 for females, and the product of the summation of age with the summation of sex corresponds to all the combinations of the different values for these variables. To increase the flexibility in the model, interactions between sex and age group were created, allowing for the age variable to have a different effect on mortality depending on the sex considered. Likewise, interactions between sex, age group and poverty were created, allowing for the poverty variable to have a different effect for all combinations of sex and age groups. Poverty corresponds to the percentage of poor people in each group. β_3 captures the year fixed

[11] This is a procedure which combines forward selection and backward elimination, iterating the addition and removal of variables and updating and refining the model based on the specified criteria (which, in this case, was the p-value being below the 5% threshold). This process was complete when no more variables met the chosen criteria for inclusion nor removal. Further explanation of this command in Stata User's Guide (2018).

effects, accounting for systematic differences in a specific year and absorbing them. Following the stepwise procedure, the final model and respective output table can be seen in Table 1.

Table 1 - Regression of mortality per capita (output results exported from Stata)

VARIABLES	(1) Mortality
Men*(45-49)	3.649***
	(1.058)
Men*(50-54)	5.584***
	(1.058)
Men*(55-59)	8.729***
	(1.058)
Women*(55-59)	2.577**
	(1.058)
Men*(60-64)	12.51***
	(1.058)
Women*(60-64)	4.669***
	(1.058)
Men*(65-69)	19.67***
	(1.058)
Women*(65-69)	7.128***
	(1.058)
Men*(70-74)	19.85***
	(2.294)
Women*(70-74)	9.361***
	(3.095)
Men*(75+)	97.93***
	(2.307)
Women*(75+)	78.89***
	(2.785)
Poverty*Men*(70-74)	54.64***
	(9.277)
Poverty*Women*(70-74)	20.25**
	(10.31)
Poverty*Men*(75+)	20.84***
	(7.724)
Poverty*Women*(75+)	20.59***
	(7.737)
Constant	1.026***
	(0.257)
Observations	588
R-squared	0.966

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

The variables included in the model are all for age groups above 45 years old, as would be expected (mortality rates in older groups are much higher than in younger age groups, allowing for more precision in the calculations, and to lower p-values for the coefficients regarding these variables). Conversely, younger age groups sometimes have very few observations of mortality

for certain areas, being victims of high variability in mortality, more uncertain results and, consequently, higher p-values (being omitted from this model).

The possibility that poverty has no effect on the mortality of the age groups younger than 70 years old cannot, by this token, be excluded, leading to the conclusion that, to the best of our knowledge, in Portugal, access to care and living conditions might have neutralized existing income-based differences that would lead to different mortality rates. In fact, in the past 50 years, as previously analyzed, there has been a significant reduction in infant mortality and in that of the younger generations, leading to the conclusion that Portugal is doing well within these age groups, contrarily to what is seen in the case of the older generations.

The variables connected to the male population start being included from an earlier age group onwards, which also makes sense according to the previous reasoning. As females, *ceteris paribus*, live longer on average, their mortality is less pronounced than for males, for most ages, making the variables connected to women less prone to having p-values below the threshold. This way, male variables start having a relevant number of deaths sooner than women, having significant coefficients for more age groups.

The values of the poverty related coefficients can be interpreted as the increase in mortality per capita (*1000) associated to a hypothetical region with a 100 percentage points higher poverty rate, for each age group and sex. The higher value of poverty in our sample of population subgroups is 65% of the said population being below the poverty line, and the lowest is close to 0%. This way, in *Figure 5*, the sum of all coefficients related to a given group for three levels of poverty are represented. The poverty levels of 0, 0.65 and 1 were chosen to capture the effect on mortality of an area without poverty, of an area with everyone being poor (which does not exist in reality) and of areas with the minimum and maximum levels observed in our subgroups (as the minimum was close to 0, it was considered that there would be no need to add yet another point and that the proxy of 0 would serve for the intended purpose).

For instance, the value for males belonging to the 70-74 age group with a 65% poverty ratio is the sum of the constant plus the coefficient Men*(70-74) plus 0.65*Poverty*Men*(70-74), giving an overall result of 56.4 deaths per 1000. The coefficient for males with 0% probability of poverty is equal to the former without the addition of the poverty related coefficient.

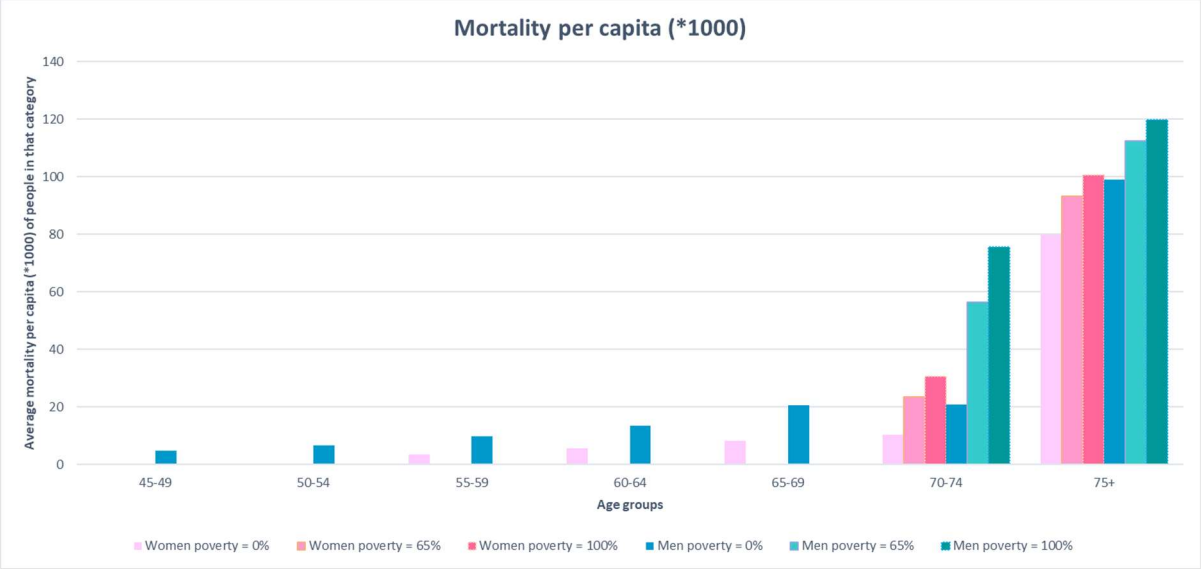


*Figure 5 - Average of the mortality per capita (*1000) of each group (calculated from the slopes of the previous regression).*

In *Figure 5*, one can see mortality of men is always higher than that of women. Additionally, belonging to an area with a higher poverty rate is connected to a higher mortality per capita for both genders, although the impact is not constant (being lower for the oldest population than for the ones between 70-74 years). This can possibly be explained by the inevitability of death (at some point, it starts being irrelevant if one is rich or poor). In other words, one would expect, if the 75+ age group was broken down into 75-80, 80-85, 85-90 and 90+, to find relevant inequalities in mortality of some of these age groups, until a certain threshold was reached when that difference would no longer be relevant. Following this reasoning, more disaggregated age groups should exist after 75 years as life expectancy has increased in recent years[12] and the 75+ age group is, most likely, capturing heterogeneous effects.

[12] According to the World Bank, life expectancy at birth went from 78, in 2005, to 81, in 2015.

For those aged 70-74, mortality in areas with the highest poverty rates found (65%) is, on average, ceteris paribus, connected to mortality probabilities more than two times as high as that of areas with the lowest poverty rates found (0%), for both genders. For men, the likelihood of dying in areas with 0% and 65% poverty rates is, respectively, 2.1% and 5.6%. For women, the scenario is not as dramatic, although far from equal, with mortality rates of 1% and 2.4%. For the oldest age group, the male mortality rate is of 9.9% for men who belong to a 0% poverty rate area and 11.3% for men who belong to an area with 65% of poor people. For women, those numbers correspond to 8% for the poorest areas and 9.3% for the richest areas.

5.3. COMPARISON BETWEEN PORTUGAL, THE US, FRANCE AND CANADA

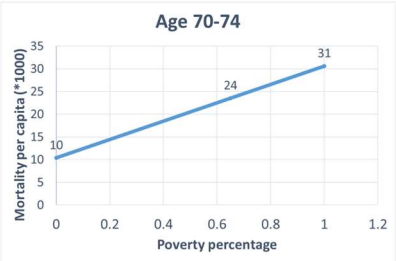
When comparing the mortality values for rich and poor areas in Portugal with those of the US, Canada, and France, an approximation had to be made for the values of the three countries from Baker et al. (2021), as the authors did not disclose the exact numbers and gradients they obtained. With access limited to the graphics in their paper, a replica incorporating Portuguese data was generated specifically for the ones over 70, as they demonstrated a significant impact of poverty on mortality. The replica graphics for Portuguese data include exact values.

One limitation of the comparison made is that the age groups are not exactly the same, with the 70-74 for Portugal being compared to the 65-79 of the other countries, and the 75+ age group for Portugal being compared to the 80+ of the remaining countries. Furthermore, the mortality rate in Portugal is an average of the values of 2005, 2010 and 2015, while, for the US, Canada and France, mortality values are computed by year. This way, the values for Portugal will be compared with the 2010 values for the US and France and with the 2018 values for Canada.

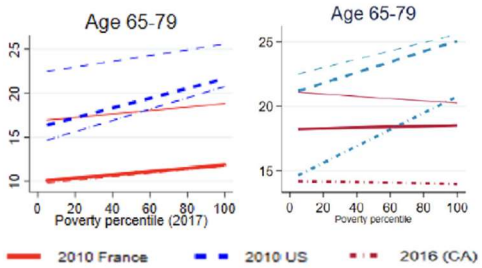
Additionally, mortality levels of regions in the different poverty percentiles, which were computed in Baker et al. (2021) and used to form the graphs of these countries, were not possible to compute for Portugal due to previously mentioned limitations (related to insufficient granular data). This way, the estimated values of mortality for the areas with the

lowest (0%) and highest (65%) found poverty rates are used for Portugal, based on the extracted values from Table 1. These values are compared to the extremes of the x-axis for the French, Canadian and American graphs (the mortality levels for the lowest and highest poverty percentiles). In *Figure 6*, values for a hypothetical region with 100% poverty rate are also included, although not corresponding to the 100% poverty percentile seen in the comparison countries.

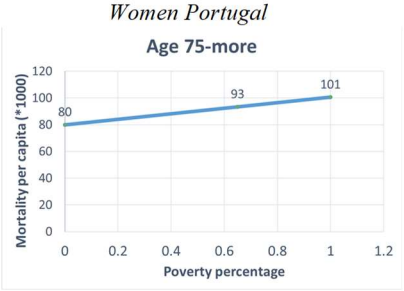
Women Portugal



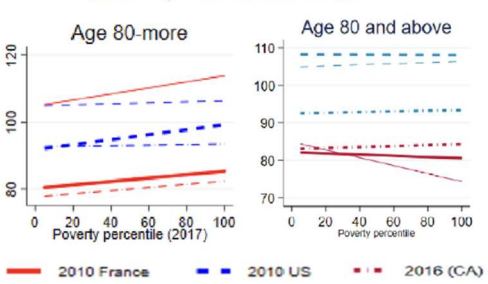
Women US, Canada and France



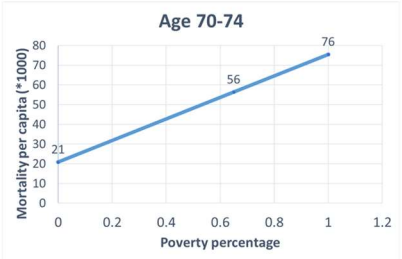
Women Portugal



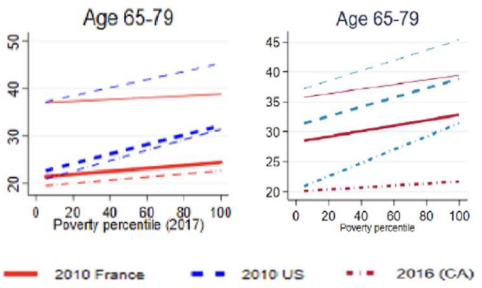
Women US, Canada and France



Men Portugal



Men US, Canada and France



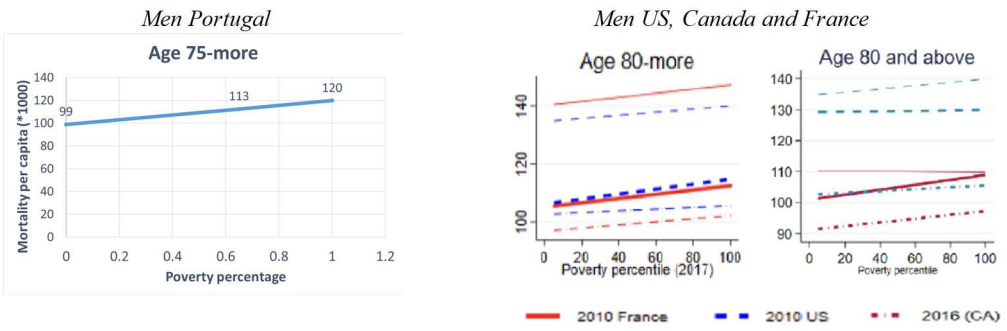


Figure 6 - Mortality gradients for Men and Women in Portugal (computed in this paper) and for the US, Canada and France (graphs imported from Baker et al. (2021)).

One would expect the mortality gradient for Portugal to be similar to the one of the other countries due to the existence of some form of social protection for these age groups in the four countries. In the US, there is a federal health insurance program called "Medicare"[13], which covers people aged 65 and older. In Canada, the "Medicare" program[14] covers all residents, being a responsibility of the provinces and territories but following the principles of the common "Canada Health Act".[15] The French program is perhaps the closest to the Portuguese, with both countries having a universal protection system which covers healthcare expenses, the "Assurance Maladie",[16] which follows "La protection universelle maladie" principle and the "Serviço Nacional de Saúde",[17] whose aim is the same.

In fact, considering mortality levels of rich areas, the most similar to the Portuguese are the French values, as one would expect due to the similarities between both countries' approach to healthcare. Conversely, mortality in poor regions is considerably higher in Portugal than in France, for most groups. By the same token, mortality gradients are steeper for Portugal than for France, for both genders and age groups.

[13] US's "Medicare" program official website: www.medicare.gov
[14] Canada's "Medicare" program official website: www.canada.ca/en/health-canada/services/canada-health-care-system.html
[15] Canada Health Act: https://chat.openai.com/c/033e9eee-3b0f-4df9-9fd1-50fa81d2ea32
[16] France's "Assurance Maladie" program official website: https://www.ameli.fr/
[17] Portugal's "SNS" program official website: www.sns.gov.pt

The same results are found in the comparison between Portuguese and Canadian gradients. Mortality in rich areas does not diverge significantly, although the difference in poor areas is striking, with Canada presenting even lower levels than France, for all groups considered. This way, Canadian gradients are flatter than the French ones (already flatter than the Portuguese). Regarding the US, Portugal has lower mortality levels in rich areas (total mortality by age and sex having been analyzed in *Figures 1 and 4*), although mortality in poor areas is similar (lower for some groups, higher for others). Portuguese gradients are also steeper, although this time it is due to lower mortality levels among the rich areas, and not to higher mortality levels among the poor areas, as happened with France and Canada.

These findings suggest that, despite Portugal's national health system aiming for universal access to care, the elderly appear to have very different mortality levels according to the poverty rate of the region they inhabit, with the ones who live in poorer areas exhibiting much higher levels of mortality than their counterparts in Canada and France.

In the following sub-chapter, an analysis was conducted to investigate differences in healthcare spending which might explain the considerable differences between Portuguese gradients and the ones of the comparison countries, which also have public health insurance for the elderly. By the same token, the following subchapter is dedicated to understanding if Portugal is failing their poor elderly and, if so, in what way.

5.4. IMPACT OF BEING POOR IN THE EXPENDITURE IN HEALTHCARE PRODUCTS AND SERVICES IN PORTUGAL, IN 2015

To further understand the impact of poverty on mortality, expenditures in healthcare products and services were analyzed for both poor and non-poor households (*Figure 14* in the appendix). Households that are not poor tend on average to spend more on healthcare, *ceteris paribus*, regardless of their age or the area of healthcare considered, compared to their poor counterparts.

Expenditure in medicines and pharmaceutical specialties, the highest spending category, remains relatively stable until age 45, starting to increase from then onwards for both rich and poor households. The poverty related difference in this expenditure, although positive for all age groups, is not indifferent to them. In childhood, this difference is relatively constant, while, for young adults, it is almost null (probably explained by a lack of need for medicines and pharmaceutical specialties due to most of the population being healthy in these age groups and due to a change in household composition). Conversely, for the 60-80 age group, the difference increases meaningfully with age, indicating that, in face of growing needs, *ceteris paribus,* the poor struggle on average to increase expenditures accordingly.

Differences in expenditure on other medical and pharmaceutical products correlated to poverty are minimal for all ages after 5 years old, increasing the 75 years old threshold onwards, indicating that, regarding inequality in expenditure, households with poor elderly individuals struggle most to meet their growing needs for healthcare.

For medical and hospital expenditures, differences between rich and poor households are striking in percentual terms, possibly explained by a greater use of the national health system (SNS) by the poor, and of private services with or without insurance protection by the rich, be it, for instance, related to doctor appointments, going to hospital emergency units, or performing surgical interventions.

Expenditures in dental health services, for instance, show a clear income effect on healthcare utilization, with poor households consuming it less than the rich ones.

Due to the combination of two factors (relevance to mortality in most clinical cases and weight of the expenditure in total consumption of healthcare) three categories of expenditures in healthcare were chosen to be further investigated in the following pages: medicines and other pharmaceutical specialties, medical services and hospital services.

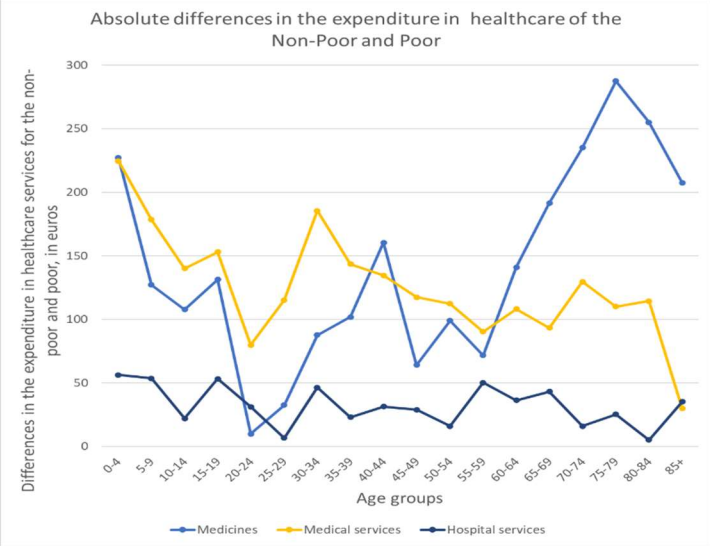


Figure 7 - Differences in the expenditure in healthcare related to poverty.

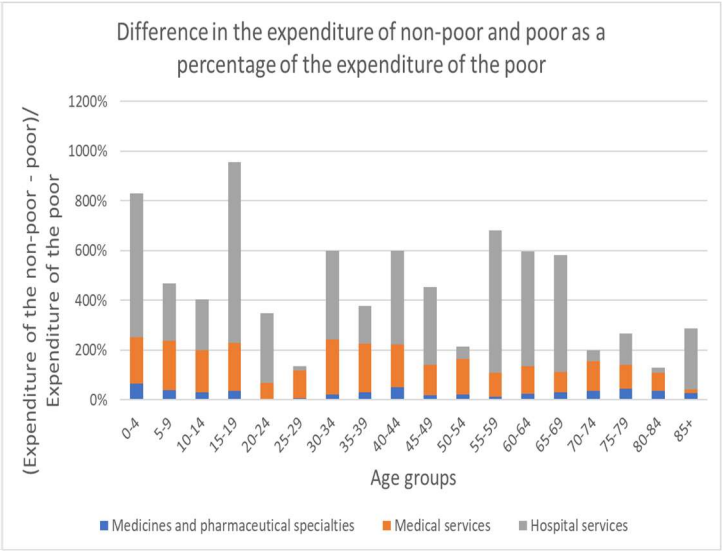


Figure 8 - Differences in the expenditure in healthcare related to poverty as a percentage of the expenditure of the poor.

Figures 7 and 8, regarding absolute and percentual differences in expenditure, show that differences in expenditure in medicines and pharmaceutical specialties by rich and poor households, although not being the most striking in percentual terms, are very large in absolute values, especially for the elderly. On the other hand, percentual differences in expenditure in hospital services are percentual much larger, albeit not as significant in absolute value.

To validate these findings, in the appendices, additional analyses explored the relation between regional poverty (*Figure 16*) or age-disaggregated regional poverty (*Figure 17*) and average healthcare expenditure. In both cases, significant coefficients appeared only in regressions of poverty on hospital services expenditure. The negative slope suggests higher poverty is*, ceteris paribus*, associated with lower hospital expenditure, aligning with household data.

For the elderly (70+), all three healthcare expense categories might contribute to mortality inequality, though the spending difference may not always reflect variations in provided care quality. Thus, in order to direct public policies that effectively decrease inequality in Portuguese elderly mortality, further research is needed to determine the impact of each category of healthcare spending on mortality, preferably relying on individual level data as to better connect both phenomena (this is, however, currently not available).

6. CONCLUSION

While Portugal, the US, Canada, and France exhibit notable differences across various dimensions, one might still anticipate similar inequality in the 70+ mortality due to the presence of protection systems or universal healthcare programs in these countries for this age group. Contrary to this expectation, significantly larger inequalities are found in mortality for Portugal within the elderly. In the case of the U.S., the steeper Portuguese gradient is attributed to lower mortality rates in rich areas in the latter, whereas the flatter Canadian and French gradients result from considerably higher mortality rate in the poorest regions of Portugal.

Higher US mortality in rich areas is partially attributed to increased exposure to the opioid crisis, while highest Portuguese mortality in poor regions in comparison to Canada and France might be explained by large differences in expenditure in healthcare spending in medicines and pharmaceutical specialties and hospital and medical services.

Nonetheless, even though the scenario for the elderly is worse in Portugal than in France or Canada, the age groups 0-70 show no sign of significant inequalities in mortality in Portugal.

To further understand what explains the higher mortality gradients found in Portugal, future research should delve into the relationship between healthcare spending and mortality (preferably with individual data), regional variations in healthcare service quality, and hospital density across regions. In fact, as for the service quality provided across regions, Londral et al. (2023) found considerable variance in multiple indicators related to hospitalizations and hospital procedures across regions, indicating inequality in the healthcare provided by the SNS.

The present study acknowledges certain limitations, some shared with Baker et al. (2021), amongst which is the use of only one metric to rank areas (the poverty rate). Nonetheless, other measures of social welfare (like education or life expectancy) are usually related and yield

similar results, in most cases. Moreover, while in Portugal and France the monetary poverty is calculated in a relative manner, in the US and Canda, it is done using an absolute approach.[18] Additionally, data for Portugal is incomplete and further disaggregation of the 75+ age group (due to increased life expectancy) and the existence of poverty and healthcare spending metrics for each individual death, as well as updated data, would improve this type of analysis. Regional heterogeneity (for instance, the North includes Oporto and Trás-os-Montes, two regions with very different demographic characteristics and, presumably, very different poverty and mortality rates), and the fact that NUTS2 regions do not share the same size, highlight the need for further regional disaggregation to enhance the results' accuracy and compute poverty percentiles. Furthermore, health statistical regions are not exactly equal to poverty statistical regions, although the difference is very small and should not impact the results found. The absence of age adjustment in the data, overlooking differences in age structure within each age group across countries, is another limitation, as well as the fact that Portuguese age groups often do not coincide fully with the ones computed for other countries. In conclusion, while the goal of universal healthcare in the Portuguese constitution may be falling short for the elderly, it is crucial to understand the underlying reasons. Additionally, although addressing this issue might not yield the same increase in life expectancy as targeting younger generations, having reached a plateau in the improvement of mortality (as seen in *Figure 1*), targeting the poor elderly (aiming for outcomes comparable to Canada and France) might be the most efficient option, having much to improve and representing a large share of overall mortality. Nonetheless, further research and more refined analyses are recommended to uncover additional factors underlying health inequalities, contributing to better inform targeted policy interventions.

[18] US: https://www.census.gov/topics/income-poverty/poverty/guidance/poverty-measures.html
Canada: https://www150.statcan.gc.ca/t1/tbl1/en/tv.action?pid=1110024101
France: https://www.insee.fr/en/metadonnees/definition/c1653

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APPENDICES

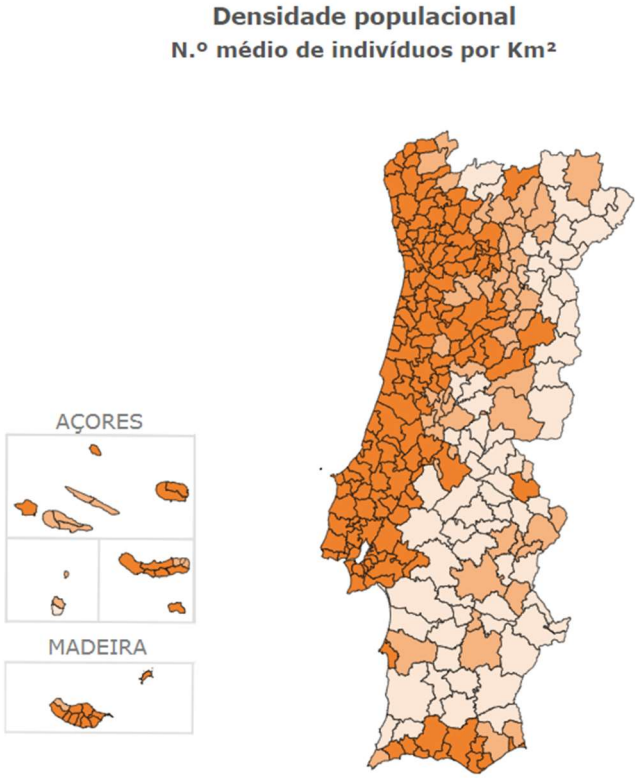

Figure 9 - Populational density in 2015 (average of individuals by squared km). Figure imported from Pordata's website : https://www.pordata.pt/Municipios/Densidade+populacional-452.

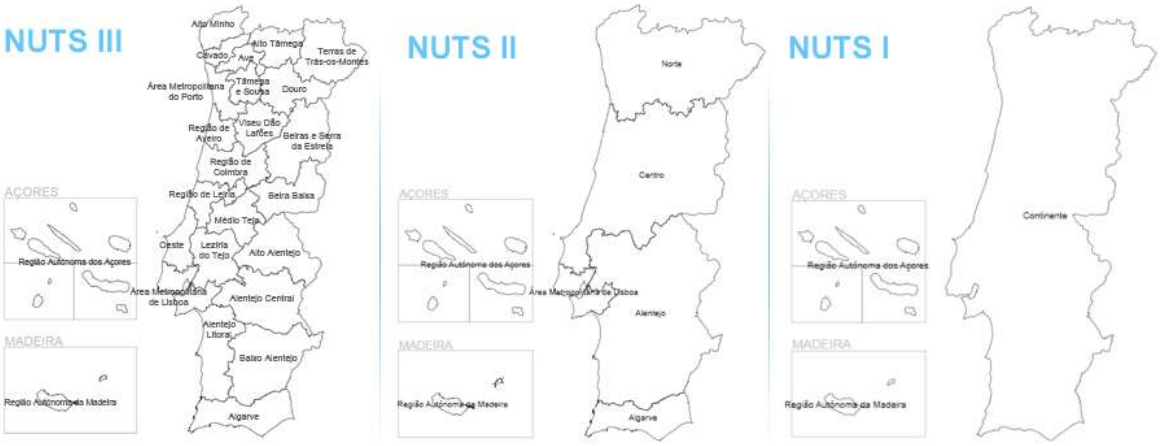

Figure 10 – Map of the NUTS regions according to the 2013 version. Figure imported from Pordata's website: https://www.pordata.pt/O+que+sao+NUTS.

NUTS III	NUTS II	NUTS I
Alto Minho	Norte	Continente
Cávado		
Ave		
Área Metropolitana do Porto		
Alto Tâmega		
Tâmega e Sousa		
Douro		
Terras de Trás-os-Montes		
Oeste	Centro	
Região de Aveiro		
Região de Coimbra		
Região de Leiria		
Viseu Dão Lafões		
Beira Baixa		
Médio Tejo		
Beiras e Serra da Estrela		
Área Metropolitana de Lisboa	Área Metropolitana de Lisboa	
Alentejo Litoral	Alentejo	
Baixo Alentejo		
Lezíria do Tejo		
Alto Alentejo		
Alentejo Central		
Algarve	Algarve	
Região Autónoma dos Açores	Região Autónoma dos Açores	Região Autónoma dos Açores
Região Autónoma da Madeira	Região Autónoma da Madeira	Região Autónoma dos Madeira

Figure 11 - NUTS regions according to the 2013 version. Figure imported from Pordata's website: https://www.pordata.pt/O+que+sao+NUTS.

Type of Household Member	Equivalence value
First adult	1.0
Additional adult	0.5
Child aged: 14 and over	0.5
Child aged: 0-13	0.3

Figure 12 - OECD-modified equivalence scale as applied by household composition. Table retrieved from the Office for National Statistics of the UK official website: https://www.ons.gov.uk/peoplepopulationandcommunity/personalandhouseholdfinances/incomeandwealth/compendium/familyspending/2015/chapter3equivalisedincome . This scale is also used in Eurostat and other statistics institutions.

Table 2 - Regression of mortality per capita without the stepwise procedure (output results exported from Stata).

VARIABLES	(1) Mortality
Men*(0-14)	0
	(0)
Women*(0-14)	-0.0835
	(3.878)
Men*(15-19)	0.534
	(3.642)
Women*(15-19)	-0.0854
	(3.726)
Men*(20-24)	0.919
	(3.440)
Women*(20-24)	0.184
	(3.621)
Men*(25-29)	1.114
	(3.396)
Women*(25-29)	0.361
	(4.017)
Men*(30-34)	1.632
	(3.474)
Women*(30-34)	0.432
	(3.708)
Men*(35-39)	1.946
	(3.784)
Women*(35-39)	0.342
	(3.870)
Men*(40-44)	2.843
	(3.648)
Women*(40-44)	0.708
	(3.981)
Men*(45-49)	5.419
	(3.957)
Women*(45-49)	1.758
	(3.975)
Men*(50-54)	6.335
	(3.858)
Women*(50-54)	3.020
	(4.512)
Men*(55-59)	11.18***
	(4.018)
Women*(55-59)	3.908
	(4.664)
Men*(60-64)	12.10**
	(4.831)
Women*(60-64)	5.131
	(4.965)
Men*(65-69)	17.59***
	(4.182)
Women*(65-69)	6.300
	(4.076)
Men*(70-74)	22.06***
	(3.737)
Women*(70-74)	11.91***
	(4.340)
Men*(75+)	100.4***
	(3.769)
Women*(75+)	81.40***
	(4.110)
Poverty*Men*(0-14)	5.016
	(14.47)
Poverty*Women*(0-14)	5.312
	(14.05)
Poverty*Men*(15-19)	2.185
	(9.722)
Poverty*Women*(15-19)	3.812
	(10.45)
Poverty*Men*(20-24)	2.713
	(10.75)
Poverty*Women*(20-24)	4.015
	(12.29)
Poverty*Men*(25-29)	4.437
	(14.18)
Poverty*Women*(25-29)	4.916
	(24.20)
Poverty*Men*(30-34)	2.883
	(15.72)
Poverty*Women*(30-34)	5.491
	(17.96)
Poverty*Men*(35-39)	3.462
	(18.29)
Poverty*Women*(35-39)	6.139
	(17.13)
Poverty*Men*(40-44)	1.040
	(14.04)
Poverty*Women*(40-44)	4.992
	(17.78)
Poverty*Men*(45-49)	-1.426
	(18.10)
Poverty*Women*(45-49)	4.165
	(17.08)
Poverty*Men*(50-54)	5.581
	(16.88)
Poverty*Women*(50-54)	1.238
	(23.72)
Poverty*Men*(55-59)	-5.554
	(16.67)
Poverty*Women*(55-59)	1.315
	(20.13)
Poverty*Men*(60-64)	11.18
	(21.34)
Poverty*Women*(60-64)	4.855
	(17.07)
Poverty*Men*(65-69)	18.68
	(14.40)
Poverty*Women*(65-69)	10.28
	(11.35)
Poverty*Men*(70-74)	51.71***
	(9.598)
Poverty*Women*(70-74)	16.77
	(10.70)
Poverty*Men*(75+)	17.56**
	(8.060)
Poverty*Women*(75+)	17.76**
	(8.054)
2010	-0.790
	(0.566)
2015	-1.311**
	(0.637)
Constant	0.162
	(2.806)
Observations	588
R-squared	0.967

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

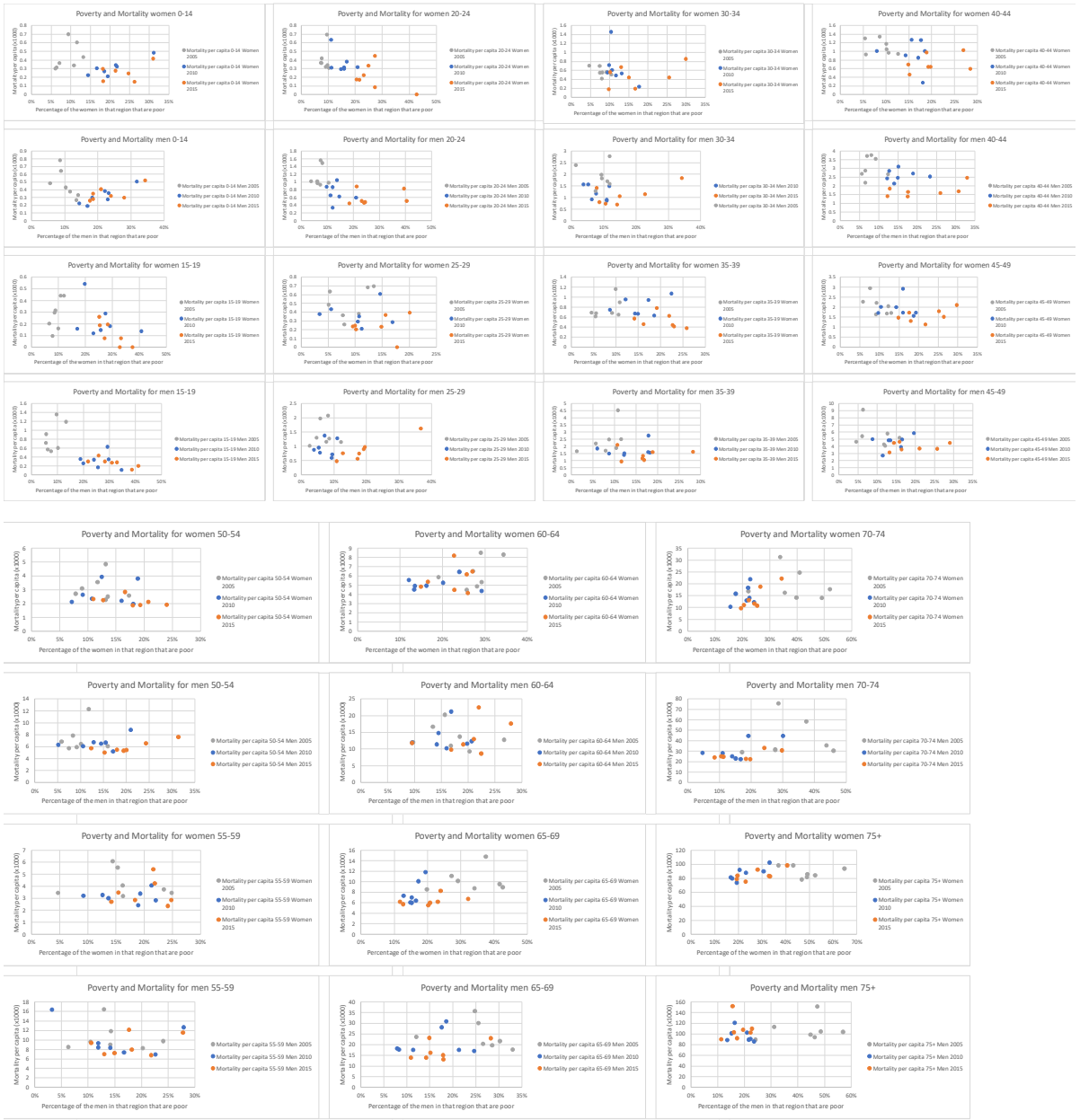

Figure 13 - Relation between mortality per capita and poverty, for all combinations of age groups and sex. Data from "Inquérito às despesas das famílias".

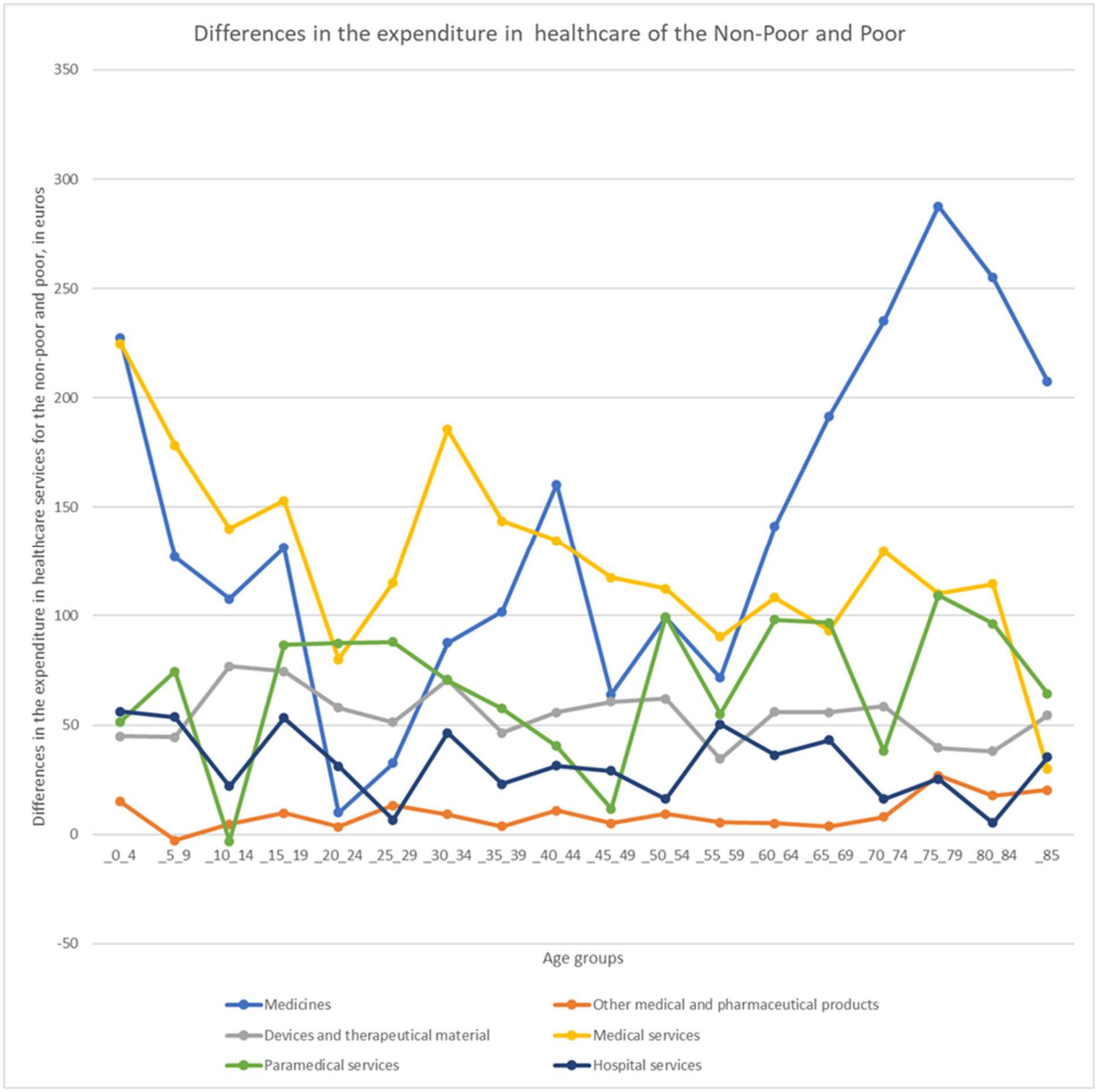

Figure 14 - Differences in the expenditure in healthcare related to poverty (all categories of healthcare expenditure).

Figure 15 - Impact on household expenditures in different areas of healthcare of a person who is and is not poor.

VARIABLES	(1) Average spending in healthcare	(2) Average spending in medicines and pharmaceutical specialties	(3) Average spending in medical services	(4) Average spending in hospital services
Poverty	-646.7	-350.4	275.2	-200.2**
	(792.7)	(354.5)	(240.6)	(66.01)
Constant	1,299***	631.4***	145.4**	77.93***
	(174.4)	(77.97)	(52.92)	(14.52)
Observations	7	7	7	7
R-squared	0.117	0.163	0.207	0.648

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

Figure 16 - Relation between the poverty of different regions and their spending in the different categories of healthcare.

VARIABLES	(1) Average spending in healthcare	(2) Average spending in medicines and pharmaceutical specialties	(3) Average spending in medical services	(4) Average spending in hospital services
Poverty	-179.2	122.6	60.27	-78.37**
	(267.8)	(245.2)	(73.35)	(33.11)
Constant	1,247***	579.5***	196.5***	54.37***
	(62.06)	(56.81)	(17.00)	(7.671)
Observations	119	119	119	119
R-squared	0.004	0.002	0.006	0.046

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

Figure 17 - Relation between the poverty of the different combinations of age groups and regions and the spending in the different categories of healthcare.