Ageing and disability-related chronic conditions in Puerto Rico: a comparative analysis with Developed Countries

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FIRST DRAFT
07/01/2008

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INTRODUCTION

Population ageing is a phenomenon affecting both developed and developing countries, albeit with sharp differences in speed, levels, determinants and social contexts. Currently the weigh of aging is heavier in developed countries than it is in developing ones. In 2005, the percentage of individuals aged 60 and older reach 25% in Germany and Italy, 23% in Greece, and 17% in the United States. Instead, these percentages are 8% in Mexico and close to 9% in Brazil. Uruguay, Puerto Rico, Argentina and Barbados are the most aged population in the Latin American and Caribbean (LAC) countries with percentages closing in or exceeding 18%, 17%, 14% and 13% respectively (United Nations 2007).

However, the momentum of aging in LAC countries has imparted an unprecedented speed to the process. What unraveled in more than 50 years in Europe and North America (except Mexico) may take only 15 years or less in LAC countries. Indeed, the rate of growth in the proportion of population over sixty is already at very high levels and its rate of change over time has not yet to peak (Palloni et al., 2006a).

There are also differences in the driving forces that account for the first phase of aging in LAC countries. The most important cause of aging among the countries of this region is the massive and fast mortality decline that took place between 1930 and 1970. The survivors of cohorts born during those years will be among the elderly of tomorrow, at least between 1990 and 2030. These cohorts are peculiar in that their mortality risks before attaining age 60 were profoundly altered by medical interventions that reduced infant and child mortality without a strong contribution of increases in standards of living (Preston 1976, Palloni and Wyrick 1981, Palloni et al 2007, Palloni et al. 2006a). As a result, a large amount of individuals among current cohorts of elderly in LAC countries survived despite of having experienced infectious and parasitic diseases, malnutrition and poverty during their childhood. According to new data available for the region (PREHCO, 2002-2003; SABE 2000), the proportion of elderly who self-reported having suffered bad socioeconomic conditions prior to age 15 exceeds one third in Puerto Rico, Bridgetown (Barbados) and La Havana (Cuba). The health conditions during the childhood among the Latin American elderly are also worrisome. In Puerto Rico, Mexico City, La Havana and Santiago de Chile, between 20% and 36% of the elderly reported having suffered from bad health or have experienced important infectious diseases (such as Tuberculosis, Rheumatic Fever, Hepatitis, or Typhus Fever, Malaria or Dengue among others) during their first 15 years of life.

We conjecture that this origin of current and future elderly cohorts may have deleterious implications for their health status and level of frailty (Palloni et al. 2006a, Monteverde et al 2007). There is a plenty of evidence that poor conditions experienced in the uterus, around the birth and during the infant and childhood increase the risks of suffering chronic diseases such as diabetes, hypertension, cardiovascular diseases among others (Barker 1989, Barker 1998, Elo and Preston 1992, Finch and Vaupel 2001, Kuh et al 2002, Palloni et al 2006a, Palloni et al 2007). In turn, chronic diseases are the main cause of disability and the risk of being disabled and the severity of disability increase with the number of illnesses (Verbrugge et al., 1989; Fried et al., 1999, Monteverde et al. 2007).

Furthermore, the ecological context in developing countries blends increased occurrence of modern chronic conditions and the persistence of parasitic and infectious diseases, an explosive combination that may not bode well for the health and well being of the elderly. Even though the mortality rates from communicable diseases are being replaced by the chronic diseases as the main cause of death among the LAC countries, they remain relatively high when compared to the more developed countries. In 2002, the age-standardized mortality rates from communicable diseases reached 73.3, 61.5 and 50.6 deaths per 100,000 inhabitants in Brazil, Argentina and Puerto Rico whereas in Canada and United States, they were about 16.8 and 29.9 (PAHO, 2007a). On the other hand, the mortality rates from chronic conditions in LAC are as high as or surpass those observed in developed countries. The age-standardized mortality rate from circulatory system diseases in 2002 is equal to 231.6 and 205.6 deaths per 100,000 inhabitants in Brazil and Argentina against 196.2 and 142.2 in the United States and Canada, respectively. In Puerto Rico this rate is around 142 (PAHO, 2007a).

The corollary that falls out of this demographic history and current socioeconomic characteristics is that we should find a larger proportion of frail individuals among current elderly cohorts in LAC countries than in the United States and Europe.

Social, Political and Economic Context in Puerto Rico

Puerto Rico provides an especially intriguing comparison with United States and Europe due to its political, social and economic context. On one hand, the aging process in Puerto Rico has many similarities with most of Latin American Countries. First, it occurs in a social context characterized by abundant poverty and sharp income inequalities. Despite of having the highest Gross Domestic Product (GDP) per capita in the region, Puerto Rico shares most of the Latin American socioeconomic indicators. In 1999, the Gini coefficient (which measures the level of income inequality of a society) was about 0.574 in the Island. This value is only 5% lower than the income inequality in Brazil and 35% and 20% higher than that one estimated for Uruguay and United States respectively (CEPAL 2004). The proportion of poverty in Puerto Rico is also high, around 48.2%, whereas in the United States it is 12.4% (CEPAL 2004). The comparison with LAC countries is not immediate, but there is evidence that the proportion of poverty in Puerto Rico is around the average level of the LAC countries and it is higher than the levels observed in Argentina, Chile, Costa Rica and Uruguay (CEPAL 2004).

However, the aging process observed in Puerto Rico has some particularities that distinguish it from the others countries of the region. Despite of gains in Life Expectancy in Puerto Rico being also due to improvements in medical interventions, the momentum by which the aging process took place in the Island differs from the LAC countries. Since Puerto Rico is a commonwealth associated with the United States, the Island is highly integrated with the US economy. Such condition allowed Puerto Rican citizens to benefit from important health policies promoted by the US government such as the program carried out early on the 20th century which aimed to eradicate vector-borne diseases (Palloni et al 2007). As a result, the onset of decreases in infant mortality rates experienced by Puerto Rico was earlier than in any typical LAC country. Those reductions contributed to increase the Life Expectancy (LE) in Puerto Rico from 30 years in 1900 to 77 years in 2000 (Palloni et al. 2007). This level is comparable to that of the United States and it places the Island amongst highest life expectancy observed in the Latin America. Among the elderly population, the LE at age 60 in Puerto Rico is around 22.3 years in 2000-05. This level is similar or in some cases higher than in several developed countries such as Denmark (21), Greece (21.5), Belgium (21.6), Netherlands (21.8), United States (21.9), Austria (22.2) and Sweden (22.6) to cite some examples (United Nations, 2007).

It is important to notice that the aging process observed in Puerto Rico did not come together with improvements in standards of living for an important proportion of the population especially compared to improvements in standard of living in the United States and in most of the western European countries. Therefore, the high level of life expectancy may not provide us with a good picture of the quality of life in Puerto Rico. As shown before, the proportion of elderly who experienced poor early conditions in Puerto Rico is really high. Therefore, if conjectures about the effects of early conditions on health later in life are true, it is expected that current cohorts of elderly are experienced more chronic illnesses. In this sense, gains in life expectancy could be followed by an (relative or absolute) expansion of morbidity.

To make the things worse, many developing countries have changed their lifestyles with the adoption of adult sedentary lifestyles and excessive consumption of fat (Popkins, 1999). Those changes, known as the Westernization' of lifestyles, has important implications to the morbidity profile of the elderly. In particular, in Puerto Rico, it is more likely that this process has occurred earlier than in others LAC countries due to its proximity with the United States. Therefore, it is expected that the longer the exposition to this new lifestyle the stronger the adverse effects on health status. In fact, there is evidence showing that the prevalence of chronic conditions among the elderly in Puerto Rico is remarkably higher than in some LAC countries, in especial the prevalence of obesity and type 2 diabetes (Palloni et al, 2005).

Another particularity of Puerto Rico has to do with the organization of the health care system which makes the comparison with United States and European countries more relevant. The United States and Europe, despite of being more developed economies, present structures of the health care system very distinct. In Europe, the organization of the health care system is predominantly public where the provision of the health services is very generous (Börsch-Supan et al 2005). In contrast, in Puerto Rico and United States, the provision of the health services is based on the market oriented system with a significant proportion of people without health insurance coverage (which means poor access to health care and/or poor quality of health care services) in especial in the United States. In 2003, 18% of the US individuals (considering all age groups) did not have any health insurance. In Puerto Rico this percentage is equal to 7% (PAHO 2007).

Since the reform of the Puerto Rican health care system in 1993, the government has provided public health insurance for the poorest individuals allowing free access to the private health care facilities in order to improve the access to the health care services among the poorest population (Ho et al 2006, Chirikos et al 2007, Alegría et al 2001, PAHO 2007b). In 2001, around 47% of individuals across the Island were covered by the reform-insurance (Chirikos et al 2007, Alegría et al 2006). Among the individuals above 60 years old, the proportion of beneficiaries is about 50% (PREHCO 2002-2003).

Objective

The objective of this paper is to test if the level of frailty of current cohorts in Latin American Countries, more specifically in Puerto Rico, is higher than in the United States and Europe. To achieve this objective we proceed in three steps: First, we estimate age-adjusted prevalence of some important chronic conditions for Puerto Rico and as a benchmark, for United States and selected Western European Countries. Second, we identify the main factors that explain the prevalence of chronic diseases. We focus on the role of demographic characteristics, socio-economic status, behavior factors (including obesity and smoke status) and also the role of having experienced poor early conditions among elderly Puerto Ricans. Finally, we perform counterfactual analysis in order to understand the differences in the prevalence of chronic diseases between Puerto Rico and the others countries analyzed. We will try to answer the following question: Are the differences between countries due to differences in the effects of risk-factors on the probability of suffering from chronic diseases or due to differences in the prevalence of the risk-factors by themselves? We restrict our analysis to risk-factors that are potentially modifiable by changes in lifestyle or policy public interventions such as obesity, smoking status, level of education and early socio-economic and health conditions.

To our knowledge, there are no studies of the prevalence of chronic diseases that compares a Latin American population with the United States and Europe.

METHODOLOGY

Description of datasets

The study relies on three sources of information: the Puerto Rican Elderly: Health Conditions survey (PREHCO, 2003), the Health and Retirement Study for the United States (HRS, 2004) and the Survey of Health, Ageing and Retirement in the Europe (SHARE, 2004). These studies are nationally representative samples of the elderly population (above 60 years old in PREHCO and above 50 years old in the HRS and SHARE).

The PREHCO study is a two-wave panel carried out between 2002-2003 and 2006-2007 in Puerto Rico. We use the first wave of the PREHCO study with a sample size of 4,293 individuals. The HRS consists of a total of seven waves with interviews conducted every two years since 1992 in the United States. We consider the sixth wave of the survey (carried out in 2004) in order to have a more comparable period of analysis for all countries. For this wave, the sample size of the US individuals above 60 years old is 14,241. The SHARE was carried out in 2004 for eleven countries: Denmark, Sweden, Austria, France, Germany, Switzerland, Belgium, the Netherlands, Spain, Italy and Greece. The sample size for individuals above 60 years old is 17,486 for the pooled European sample and it ranges from 609 in Switzerland to 2,285 in Belgium.

All the studies encompass detailed information on demographics and socioeconomic characteristics, self-report of height, weight and current health conditions such as chronic diseases, general health status and functional disability. For the purposes of this paper, the main advantage of these datasets is that the protocols used are similar and explicitly modeled after HRS.

Prevalence of chronic conditions

We considered the chronic conditions which are available in the three surveys such as obesity, diabetes, vascular diseases (stroke, hypertension and heart diseases), respiratory diseases (asthma and lung diseases), arthritis and rheumatism, osteoporosis, cancer and impairments (vision problems including blindness and hearing problems including deafness). All these conditions are self-reported (obesity and impairment) or self-reports of medical diagnosis (diabetes, stroke, hypertension, heart diseases, respiratory diseases, arthritis and rheumatism, osteoporosis and cancer). Osteoporosis is the only selected condition which is not strictly comparable among countries since in the HRS this disease is considered jointly with others musculoskeletal problems. Consequently the comparison of this condition among countries must be cautious.

Only few diseases were not included: cholesterol (available only in SHARE) and Parkinson (it is not available for Puerto Rico and it is not strictly comparable between the United States and Europe).

In order to estimate the average predicted probabilities of suffering from each chronic condition by age and sex we used Logistic regression models estimated by country and for male and female separately.

Effect of risk factors

We estimate Logistic regression models for the probability of suffering from the chronic diseases for each country. In order to identify their main risk factors, we control for demographics characteristics, behavior factors and socioeconomic conditions. In the models estimated for vascular diseases, arthritis or rheumatism and osteoporosis, we also include diabetes as independent variable.

We estimate a model controlling for the presence of health insurance and we compare the results to those when this variable is not taking into account. This analysis is performed for Puerto Rico and United States due to the characteristics of their health care system. Since this adjustment did not change substantially the effect of risk-factors, we opt to present only the model without controlling for health insurance.

For Puerto Rico we also test the effect of conditions experienced during the first 15 years of life. This analysis is important since poor early conditions have been associated with higher risk of chronic conditions later in life (Barker 1989, Barker 1998, Elo and Preston 1992, Finch and Vaupel 2001, Kuh et al 2002, Palloni et al 2006a, Palloni et al 2007). For this paper, we construct a general indicator that combines poor *early childhood health and poor early childhood SES.* These measures are not available in the HRS and SHARE datasets.

The table 1 describes all the independent variables included in the analysis.

TABLE 1 ABOUT HERE

Counterfactual analysis

Armed with the estimations of the logistic models we perform a set of counterfactual analysis in an attempt to understand the higher prevalence of chronic conditions in Puerto Rico compared to the others countries analyzed. First, we evaluate in which extent the prevalence of chronic diseases in Puerto Rico would decrease by changing the *prevalence* *of risk-factors*. We define three scenarios. In the first scenario we assume that the prevalence of obesity or overweight in Puerto Rico would decrease at levels observed in European countries. Since diabetes is one of the predictors for vascular diseases and arthritis or rheumatism, when performing the counterfactual analysis for both conditions we also use the counterfactual prevalence of diabetes estimated for Puerto Rico when the levels of obesity and overweight are assumed to be the same as in Europe.[1]

In the second scenario we analyze what would be the prevalence of chronic diseases in Puerto Rico if we observed increases in the years of schooling among the elderly. It is assumed that the proportion of individuals in each level of education in Puerto Rico would be the same as in the United States. In this case the proportion of elderly in the primary, secondary and tertiary levels of education would vary from 43%, 38% and 19% to 5%, 56% and 39% respectively. The comparison with United States is relevant since Puerto Rico is a commonwealth associated with this country. Also, the proportion of elderly in the secondary and tertiary level of education in United States is higher compared to the average of the SHARE European countries.

Finally, the third scenario is defined by changes in the proportion of individuals who experienced poor early conditions in Puerto Rico. As this information is not available in the dataset used for the United States and Europe, we consider an extreme situation where the proportion of individuals who experienced poor early conditions is equal to zero.[2]

[1] We also test the effect of diabetes on the probability of suffering from osteoporosis. As we will see later in this paper, this effect is not significant for Puerto Rico.
[2] We do not perform a counterfactual analysis by changing the proportion of individuals who ever smoked because in Puerto Rico this proportion is lower compared to the United States and Europe.

The second set of counterfactual analysis evaluates what would happen with the prevalence of chronic diseases in Puerto Rico if the *effect of the risk factors* on the probability of suffering from these illnesses were assumed to be as low as in the Europe or in the United States. For this analysis, we select the country with the lowest estimated effect (it varies according to the chronic disease and to the risk-factor itself). This analysis is carried out separately for risk factors that are significant in explaining the probability of suffering from chronic condition in Puerto Rico and at the same time potentially modifiable by changes in lifestyles or public policies interventions such as excess weight, level of education and smoke status.

For all counterfactual analysis, the hypothetical and observed predicted probabilities are evaluated at the mean value of the independent variables in Puerto Rico.

RESULTS

Comparisons of Prevalence of Chronic Diseases

Table 2 shows prevalence of obesity and selected chronic diseases for 11 European countries, the United States and Puerto Rico during 2002-2004 among individuals 60 years and older. We observe that Puerto Rico and the United States have much higher prevalence of chronic conditions than European populations among both women and men (except for impairment and cancer). Both countries show the highest prevalence of obesity (people with BMI≥30) and obesity-related chronic conditions such as diabetes and cardiovascular diseases (hypertension, heart diseases and stroke), arthritis and rheumatism. In addition, Puerto Rico shows much higher prevalence in osteoporosis and respiratory diseases than the United States and all the European countries analyzed.

TABLE 2 ABOUT HERE

Age and Gender-Composition and Chronic Diseases

In order to eliminate differences among countries that are due to differences in age and gender composition we estimate age-adjusted prevalence of each chronic condition separately by males and females. For this analysis, we classify the European countries into two groups. The first group we called "South of Europe" which includes Spain, Italy, Greece and France. This group shows in general higher prevalence of the chronic conditions than the rest of Europe (Germany, Austria, Netherlands, Sweden, Denmark and Switzerland). Belgium is in the middle of the two groups (South of Europe and the Rest of Europe). Because Belgium and Greece have similar levels of obesity we decided to include Belgium into the South of Europe group.

Figures 1, 2, 3 and 4 show the predicted probabilities of suffering from each chronic condition by age and gender.

FIGURE 1 ABOUT HERE

FIGURE 2 ABOUT HERE

FIGURE 3 ABOUT HERE

FIGURE 4 ABOUT HERE

We can observe gradients quite similar by age. The differences among countries are mainly due to differences in the levels of the probabilities of suffering from each condition. Puerto Rico and the United States show the highest levels of prevalence for most of the conditions than the European populations.

Obesity: Puerto Rico shows the highest probability of being obese among women at all single ages (60 years and older). The United States is the second country with the highest probability among women until 80 years old. Among elderly men, the United States shows the highest probability of being obese until 78 years old (even higher than among Puerto Ricans). Among men over this age, the differences among countries reduce significantly.

***Diabetes*:** Puerto Rico shows the highest probabilities of suffering from Diabetes type 2 among both men and women at all single ages (among 60 years and older individuals). European elderly show levels of diabetes significantly lower. For instance, among women 60 years old the probability of suffering from Diabetes is around 0.3 in Puerto Rico, 0.2 in the United States and about 0.1 in Europe.

Cardiovascular Diseases: The US and Puerto Ricans elderly have the highest probabilities of suffering from hypertension, heart diseases and stroke among both men and women compared to the European countries.

Arthritis and Rheumatism: The US and Puerto Ricans individuals (both men and women) also show much higher probabilities of suffering from Arthritis and Rheumatism than European populations. It is remarkably the similarity in the gradient over age among all countries for this condition.

Osteoporosis: The probability of suffering from osteoporosis is remarkable higher among Puerto Ricans women, even when compared to the United States (that includes a wider spectrum of diseases in this category).

Cancer: Probabilities of suffering from cancer are much higher in the United States than in Europe and Puerto Rico. Individuals from Puerto Rico and the South of Europe show the lowest probabilities of suffering from this condition among elderly women. Among men, the probabilities of suffering from cancer in Puerto Rico are similar to the Rest of Europe (with levels being higher than those observed in the South of Europe).

Impairment: Puerto Rico and the United States show the lowest probabilities of suffering from impairments. It is remarkably the extreme similitude in the gradients by age and levels between Puerto Rico and the United States and between South-Europe and Rest-Europe.

The role of the risk-factors

As shown before, Puerto Rico stands out for the highest prevalence of chronic diseases mainly compared to the European countries, except for cancer and impairment. Those differences could be associated to differences in the prevalence of risk factors as well as their effects on the probability of suffering from these illnesses. Therefore, we estimate logistic models for the probability of suffering from each chronic disease which prevalence is higher in Puerto Rico. Table 3 displays the odds ratio estimates for Puerto Rico, United States, South-Europe and the Rest-Europe. As it is shown, all variables are significant in explaining the probability of suffering from chronic diseases and their effects are as expected.

TABLE 3 ABOUT HERE

The effect of excess weight is positive and significant for almost all of the chronic diseases (table 3). In Puerto Rico, overweight elderly are 1.83 and 1.51 times more likely to suffer from diabetes and vascular diseases than those who are normal or low weight. Among obese elderly, this chance is even higher: 2.06 (for diabetes) and 2.26 (for vascular diseases). Being obese also increases the probability of suffering from arthritis or rheumatism even though the effect of being overweight on this condition is not significant.

The results in table 3 also show that diabetes increases the probability of suffering from vascular diseases and arthritis or rheumatism. For instance, having diabetes increases the chance of suffering from vascular diseases by 2.36 times in Puerto Rico, 2.67 in United States, 1.92 in South-Europe and 1.80 in Rest-Europe.

Smoking status is an important determinant for respiratory diseases in all countries analyzed. For the others chronic diseases the effect of smoke status is significant only for the United States (table 3).

According to the table 3, individuals who are more educated are less prone to suffer from respiratory diseases (in all countries), diabetes and arthritis or rheumatism (in Puerto Rico, United States and South-Europe) and vascular diseases (in United States and South-Europe). The exception is the effect estimated on the probability of suffering from osteoporosis in which case the highest educated individuals are more likely to have this illness in Puerto Rico, United States and Rest-Europe.

Table 4 presents the odds ratio estimates of suffering from chronic diseases for Puerto Rico controlling for early conditions.

TABLE 4 ABOUT HERE

In the Island, having experienced poor socioeconomic conditions or poor health status during the first 15 years of life increases the chances of suffering from all chronic diseases at older ages even controlling for educational level (proxy for current socioeconomic status). The exception is diabetes in which case the effect is not significant.

Counter-factual analysis

Is the prevalence of chronic conditions in Puerto Rico higher due to the *higher prevalence* of the risk factors or due to the *higher effect* of these same risk factors? In order to answer this question we perform two sets of counterfactual analysis.

Table 5 displays the results for the first group of counterfactual analysis for Puerto Rico that assumes the ***prevalence of the risk factors*** is equal to the lowest prevalence observed in the United States and Europe. Table 6 displays the results of the second group of counterfactual analysis that assumes the ***effect of each risk factor*** in Puerto Rico is equal to the lowest effect estimated for United States and Europe.

TABLE 5 ABOUT HERE

TABLE 6 ABOUT HERE

Counterfactual I: changes in the prevalence of risk-factors

The first panel of table 5 shows the observed and hypothetical predicted probabilities of suffering from each chronic disease, the second panel shows the percentage difference between them (hypothetical and observed) and in the last panel, for comparative purposes, we present the observed predicted probabilities for the United States and Europe. Three hypothetical scenarios were defined according to changes in the prevalence of 1) excess weight and diabetes, 2) level of education and 3) poor early conditions. We also show the results when all those scenarios are simultaneously considered.

What would be the prevalence of chronic diseases if the prevalence of obese and overweight elderly in Puerto Rico decreased at similar levels of the Rest-Europe (from 68.8% to 59.7%)?[3] As it can be noticed from table 5, the prevalence of respiratory diseases and diabetes would decrease by 5% and the prevalence of vascular diseases and arthritis by 4% and 3% respectively.

Assuming that the level of education in Puerto Rico increased at similar level of the United States (in which case the proportion of elderly in each level of education would vary from 43%, 38% and 19% to 5%, 56% and 39%), we would observe decreases in the prevalence of respiratory diseases, arthritis or rheumatism and diabetes around 8%, 5% and 4% respectively. An opposite result is observed for osteoporosis as long as the chance of suffer from this condition is higher amongst the more educated elderly. In this case, the prevalence would increase 6% (table 5).

In the third scenario, we define an extreme situation where the proportion of individuals who experienced poor early conditions is equal to zero. Under this

[3] To estimating the counterfactual for both vascular diseases and arthritis or rheumatism, we also use the counterfactual prevalence of diabetes defined for Puerto Rico by assuming the levels of obesity and overweight are equal in Rest-Europe.

assumption, the prevalence of suffering from respiratory diseases would decrease 35%. The prevalence of arthritis or rheumatism and vascular diseases would decrease 11% and 8% respectively.

Considering simultaneously decreases in the prevalence of obesity, improvements in the level of education and assuming that the proportion of individuals who experienced poor early conditions in Puerto Rico is equal to zero, the prevalence of respiratory diseases, arthritis or rheumatism, diabetes and vascular diseases would reduce significantly (44%, 19%, 13% and 11% respectively). In the case of arthritis or rheumatism, vascular diseases and respiratory diseases, the prevalence would reach levels comparable to those of South-Europe (0.41, 0.55 and 0.09 in Puerto Rico against 0.43, 0.55 and 0.08 in the South-Europe).

Counterfactual II: changes in the effect of risk-factors

Table 6 displays the results of the second group of counterfactual analysis (***changes in the effect of risk-factors)***. In the first panel of the table we present the observed and hypothetical predicted probabilities of suffering from chronic diseases for the Puerto Rico; the second panel shows the percentage difference between them (hypothetical and observed) and in the last panel, for comparative purposes, we present the actual predicted probabilities for the United States and Europe.

According to the results in table 6, the highest decreases in the prevalence of chronic diseases are observed by changing the effect of education (on the probability of suffering from diabetes and osteoporosis) and the effect of excess weight (on the probability of suffering from diabetes and respiratory diseases). For instance, if the effect of obesity and overweight were as low as it is estimated for the Rest-Europe, the prevalence of diabetes and respiratory diseases in Puerto Rico would decrease around 9%.

Assuming that the effect of education in Puerto Rico is equal to that estimated for South-Europe, the prevalence of diabetes and osteoporosis would be 16% and 17% lower respectively (table 6).

For the prevalence of vascular diseases and arthritis or rheumatism, the highest variation would be observed if the effect of diabetes on both conditions decreased at the same level estimated for the Rest-Europe. Under this scenario, the prevalence of vascular diseases would decrease 3% and arthritis or rheumatism, 6%.

Considering simultaneously decreases in the effect of all the relevant risk-factors on the probability of suffering diabetes, osteoporosis, respiratory diseases, arthritis and vascular diseases, the prevalence of these chronic diseases would reduce 23%, 17%, 16%, 7% and 4% respectively.

DISCUSSION

According to our results, Puerto Rican elderly are more likely to suffer from chronic conditions compared to the developed countries and in particular to the Europe. Since the analysis relies on self-reported measures of all chronic diseases, our findings could be subject to errors of reporting. However, some studies show high reliability of self-reported chronic diseases mainly among the elderly population. PREHCO's investigators (Garcia and Palloni, 2007) show that, for most self-reported chronic diseases, responses in the second wave are highly consistent with responses obtained in the first wave. Thus, among elderly who report hypertension in the first wave (PREHCO I) about 96%

reported it also in the second wave. The consistency is about 95% for diabetes, 93% for heart disease, 97 % for stroke, 94% for arthritis and rheumatism and 96% for osteoporosis. Inconsistencies are higher for pulmonary diseases and cancer: 23% of those who reported some form of pulmonary disease in the first wave did not identify it in the second wave, whereas 13% among those who reported some form of cancer in the first wave did not report it in the second. Of course, the latter discrepancies may be associated with true changes of status as well as with misreporting. In principle, however, the reliability of responses in Puerto Rico seems to be quite high.

From ongoing work (Palloni, Wong and Riosmena, 2007) using Encuesta Nacional de Salud (ENSA) and Mexican Health and Aging Study (MHAS), self-reported prevalence of diabetes and hypertension among elderly Mexicans has been shown very close to prevalence estimates derived from biomarkers. Similarly, Palloni, Soldo and Wong (2003) compared self-reported height and weight with anthropometric measures in MHAS and find that "self-reported weight and height provide an accurate gauge to baseline measure and neither estimates of prevalence of obesity nor prediction of individual obesity are influenced by errors in self-report height and weight." Another study, carried out of the United States (using HRS) and England (using ELSA) also finds high comparability of results that use self-reported chronic diseases and their respective biomarkers (Banks et al., 2006).

The lesson from these limited studies is that self-reports should not be dismissed off hand without a more careful scrutiny. Conversely, although these studies should boost our confidence on self reported chronic conditions, we must acknowledge evidence that undiagnosed rates of conditions such as diabetes mellitus are not trivial especially in

LAC countries (Aguilar-Salinas et al. 2002; Hernandez et al. 1987; Malerbi and Franco 1992; Sakata et al., 2002). Some studies also show that undiagnosed diabetes is much lower among the elderly (Baechler et al. 2002) and among those with more severe forms of the disease (Franse et al. 2001).

Our results show that the prevalence of obesity (people with BMI≥30) and obesity-related chronic diseases such as diabetes, cardiovascular diseases, arthritis or rheumatism are higher in Puerto Rico and United States than in Europe. Also, Puerto Rican elderly stands out for having the highest prevalence of respiratory illness and osteoporosis among all the countries analyzed. These results are observed among male and female and for almost all of age groups (over 60). The exceptions are cancer and impairments in which cases the prevalence is higher in Europe and in the United States.

The similarities of the results between Puerto Rico and United States and the contrast with European countries could be associated with the status of Puerto Rico in respect to the US economy. As shown before, Puerto Rico is a commonwealth associated to the United States. On one hand, such status allowed Puerto Rico to take advantage of many health policies promoted by the US government that contributed to increase the Life Expectancy to levels compared to many developed countries. On the other hand, the structure of the health care system in Puerto Rico largely differs from most European countries. This structure (marked oriented) could define poor access to the health care services among the Puerto Rican elderly especially because of the socioeconomic characteristics of its population. Using information present in SHARE (2004) and PREHCO (2002-2003) datasets, we found that despite of almost all of elderly in Puerto Rico are covered by health insurance (97.22%), the probability of consulting a doctor in the last 12 months in Puerto Rico is significantly lower than in the European countries even after controlling for sex, age and chronic diseases (SHARE, 2004, PREHCO, 2002-2003). These preliminary results could be suggesting the presence of barriers in the utilization of the health care services among the elderly in Puerto Rico compared to Europe. The comparison with the United States is not possible because the reference period of this variable in the HRS is different.

The estimation of logistic models allowed us to identify the main determinants of the chronic diseases in each country. According to our results, modifiable risk-factors have strong effects on the prevalence of diabetes, vascular diseases, arthritis or rheumatism, osteoporosis and respiratory diseases. Excess of weight and low level of education (as a proxy of lower socioeconomic status) increase the chance of suffering all of those illnesses in Puerto Rico, United States and Europe. Diabetes has an important role as a predictor of vascular diseases and arthritis or rheumatism. For Puerto Rico, we also found strong effects of conditions experienced early in life on almost all chronic diseases.

Is the higher prevalence of chronic diseases in Puerto Rico due to the higher *prevalence of risk-factors* or it is due to the higher *effects of risk-factors*? Our results suggest that the *prevalence of modifiable risk-factors* perform an important role. Decreases in the prevalence of obesity and overweight at to levels observed in the European countries would reduce the prevalence of chronic conditions among the Puerto Rican elderly.

The highest variation is observed by decreasing the proportion of elderly who experienced poor early conditions. If this proportion were equal to zero, the prevalence of chronic diseases would reduce significantly. In the case of respiratory diseases, arthritis or rheumatism and vascular diseases, the prevalence would reach levels compared to the Europe. This scenario is an extreme situation and it less likely to be observed. However, it reveals the important role of conditions experienced early in life on the probability of suffering chronic diseases among current cohorts of elderly in Puerto Rico.

Analyzing the results obtained by varying the *effects of risk-factors* the highest decreases are observed by changing the effects of educational level (on diabetes and osteoporosis) and the effect of excess weight (on respiratory diseases).

The results found in this paper shed some light on what would be the future prevalence of chronic diseases in LAC countries. Given the characteristics of the aging process observed in the region (which includes Puerto Rico), it is very likely that the effects of early conditions will last among the next generations of elderly contributing to increase the prevalence of chronic diseases. Moreover, since empirical research has found that chronic diseases are the main cause of disability (Verbrugge et al., 1989; Fried et al., 1999, Monteverde et al. 2007), it is expected that the higher prevalence of chronic diseases in Puerto Rico will be translated into a higher prevalence of disability. Therefore, future works should compare the prevalence of disability among developing and developed countries trying to seek associations between disability profiles and self-reported chronic conditions. Also, it would be important to project the distribution of disability profiles and the prevalence of chronic conditions taking into account the relationship between conditions experienced early in life and adult health status.

The main issue in performing such analysis is to find reliable measures of disability that allow the comparison among countries. In general, the variables present in household surveys are self-reported measures of disability (e.g. difficult to perform activities of daily life and instrumental activities of daily life). Therefore, when used in comparative analysis with different populations or subpopulations, observed differences may reflect not only differences in true latent traits (health) but also heterogeneity in the way individuals perceive and report their conditions (Sadana et al 2000, d'Uva et al 2006).

However, efforts to understand the future trajectory of disability in developing and developed countries would be crucial. Currently, there is significant uncertainty about the future trajectory of rates of disability and morbidity, as it is confirmed by the controversy between compression versus expansion of morbidity and mortality (Manton and Singer, 1994; Fries, 1980, 1989; Gruenberg, 1977). The uncertainty is even larger in developing regions. Indeed, the conjectures regarding the composition of future cohorts of elderly in LAC and about the ecology of diseases aforementioned plainly suggest that that is more reasonable to expect morbidity and disability to grow rather than decrease. A bad omen is sounded by the work of Davis, Heathcote and O'Neill (2002) in Australia where they find that "roughly two thirds or more of the increase in life expectancy over the decade 1988-1998 is taken in a state of disability." What can we expect in regions where, by all accounts, conditions will not be as favorable as those experienced today by Australia?

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Table 1

Description of the risk-factors included in the logistic regression model

Demographics Characteristics	
Sex	Reference category: male
Age	
Socioeconomic Characteristic	
Levels of education:	Primary (average 6 yrs of schooling) Secondary (average 7-12 yrs of schooling) Tertiary (average 13+ yrs of schooling)
Weight Status	
Groups of BMI defined by the World Health Organization:	Low weight: BMI<18.5 Normal weight: 18.5≤BMI<25 Overweight: 25≤BMI<30 Obese: BMI≥30
Smoke Status	
It is defined 3 groups:	Never smoke Ever smoked but not currently Still Smoke
Suffer from diabetes	
Poor Early Condition during the first 15 years of life	Individuals who self-report experienced poor economic situation of the household, poor general health, was sick or had activities restrictions very often, **OR** experienced at least one disease (hepatitis, tuberculosis, rheumatic fever, chronic bronchitis, typhus fever, polio, malaria, dengue, pneumonia and asthma).

Table 2

Prevalence of Chronic Conditions

Puerto Rico (2002-2003), United States (2004) and European Countries (2004)

Country	Obesity	Diabetes	Vascular Diseases	Arthritis and Rheumatism	Osteoporosis	Respiratory Diseases	Cancer	Impairment
Puerto Rico	0.28	0.28	0.63	0.48	0.19	0.18	0.06	0.11
USA	0.24	0.19	0.67	0.65	0.05	0.12	0.17	0.14
Spain	0.23	0.18	0.48	0.35	0.11	0.10	0.05	0.49
Greece	0.19	0.11	0.54	0.24	0.14	0.07	0.03	0.50
Belgium	0.19	0.10	0.47	0.27	0.11	0.09	0.08	0.51
Germany	0.18	0.15	0.52	0.14	0.10	0.09	0.07	0.49
Italy	0.17	0.15	0.51	0.38	0.14	0.12	0.06	0.53
Austria	0.17	0.09	0.45	0.13	0.10	0.08	0.04	0.50
France	0.15	0.11	0.47	0.37	0.09	0.10	0.07	0.60
Netherlands	0.15	0.11	0.41	0.12	0.10	0.11	0.07	0.53
Sweden	0.13	0.11	0.50	0.13	0.05	0.10	0.10	0.56
Denmark	0.13	0.09	0.43	0.31	0.05	0.15	0.10	0.55
Switzerland	0.12	0.07	0.38	0.16	0.09	0.06	0.07	0.46

Vascular: Hypertension, heart diseases and stroke.
Respiratory: Asthma and lung diseases

Table 3

Odds ratio estimates of suffering chronic diseases among elderly individuals: Puerto Rico, United States and Europe (1)

Diabetes	**Puerto Rico**	**United States**	**South-Europe**	**Rest-Europe**
Sex	0.97 ns	0.83 ***	0.83 **	1.15 ns
Age	1.00 ns	1.01 ***	1.01 ns	1.03 ***
Secondary	0.88 ns	0.66 ***	0.61 ***	1.06 ns
Tertiary	0.72 ***	0.52 ***	0.47 ***	0.75 ns
Overweight	1.83 ***	1.80 ***	1.74 ***	1.37 **
Obese	2.06 ***	4.06 ***	2.95 ***	3.16 ***
Vascular diseases	**Puerto Rico**	**United States**	**South-Europe**	**Rest-Europe**
Sex	1.30 ***	0.99 ns	1.15 **	0.95 ns
Age	1.02 ***	1.06 ***	1.04 ***	1.03 ***
Secondary	0.93 ns	1.01 ns	0.92 ns	1.05 ns
Tertiary	0.94 ns	0.86 **	0.81 **	1.19 ns
Overweight	1.51 ***	1.51 ***	1.47 ***	1.79 ***
Obese	2.26 ***	2.51 ***	2.16 ***	2.68 ***
Diabetes	2.36 ***	2.67 ***	1.92 ***	1.80 ***
smoked	1.10 ns	1.17 ***	1.37 ***	1.17 *
still smoke	0.50 ***	1.00 ns	1.02 ns	0.91 ns
Arthritis or Rheumatism	**Puerto Rico**	**United States**	**South-Europe**	**Rest-Europe**
Sex	2.54 ***	1.99 ***	1.99 ***	1.54 ***
Age	1.04 ***	1.04 ***	1.03 ***	1.02 ***
Secondary	0.91 ns	0.90 ns	0.89 ns	1.12 ns
Tertiary	0.59 ***	0.76 ***	0.65 ***	1.27 ns
Overweight	1.19 ns	1.34 ***	1.18 **	1.19 ns
Obese	1.66 ***	2.23 ***	1.69 ***	1.46 **
Diabetes	1.44 ***	1.32 ***	1.20 **	0.90 ns
smoked	1.17 ns	1.25 ***	1.02 ns	0.86 ns
still smoke	1.13 ns	1.19 **	0.81 *	0.83 ns
Osteoporosis	**Puerto Rico**	**United States**	**South-Europe**	**Rest-Europe**
Sex	9.83 ***	1.74 ***	12.10 ***	5.17 ***
Age	1.01 *	1.00 ns	1.01 **	1.04 ***
Secondary	1.36 **	0.95 ns	0.97 ns	1.38 **
Tertiary	1.24 ns	1.31 *	0.83 ns	1.81 ***
Low weight	1.39 ns	1.16 ns	1.45 ns	1.16 ns
Diabetes	1.05 ns	0.92 ns	1.39 **	0.88 ns
smoked	1.30 *	1.24 **	1.03 ns	1.02 ns
still smoke	1.20 ns	1.30 *	1.01 ns	0.90 ns
Respiratory	**Puerto Rico**	**United States**	**South-Europe**	**Rest-Europe**
Sex	1.89 ***	1.30 ***	0.92 ns	1.07 ns
Age	1.00 ns	1.01 ***	1.02 ***	1.02 **
Secondary	0.83 ns	0.89 ns	0.79 *	0.81 ns
Tertiary	0.64 ***	0.62 ***	0.87 ns	0.65 **
Obese	1.87 ***	1.34 ***	1.68 ***	1.29 *
smoked	1.94 ***	2.92 ***	2.12 ***	1.42 **
still smoke	1.83 ***	5.04 ***	2.03 ***	1.53 **

ns not-significant * p-value<.10 ** p-value<.05 *** p-value<.001

(1) Weight sample were used for this analysis

Table 4

Odds ratio estimates of suffering chronic diseases among elderly individuals for Puerto Rico (controlling for poor early conditions) (1), (2)

Independent Variables	Diabetes		Vascular		Arthritis		Osteoporosis		Respiratory	
sex	1.01	ns	1.44	***	2.69	***	11.27	***	1.97	***
age	1.00	ns	1.02	***	1.03	***	1.01	ns	0.99	ns
Secondary level	0.95	ns	1.01	ns	0.94	ns	1.32	**	0.86	ns
Tertiary level	0.79	*	1.04	ns	0.61	***	1.14	ns	0.69	**
Low weight							1.27	ns		
Overweight	1.83	***	1.43	***	1.18	ns				
Obese	1.98	***	2.26	***	1.58	***			1.69	***
diabetes			2.24	***	1.32	***	1.08	ns		
Ever smoked			1.17	ns	1.15	ns	1.31	*	1.88	***
Still Smoke			0.54	***	1.09	ns	1.09	ns	1.40	ns
Poor Early Conditions	1.10	ns	1.44	***	1.49	***	1.25	**	2.45	***

(1) Weight sample were used for this analysis.
(2) This analysis excludes individuals whose questionnaire was answered by a proxy since they did not answer the questions about conditions experienced early in life.

Table 5

Counterfactual analysis I:

Predicted probability of suffering from chronic diseases in Puerto Rico assuming changes in the prevalence of risk factors [(a)]

Counter-factual I: Prevalence of risk-factors Scenarios	Predicted Probability Model controlling for Poor early conditions				
	Diabetes	**Vascular**	**Arthritis**	**Osteoporosis**	**Respiratory**
observed	***0.26***	***0.62***	***0.50***	***0.16***	***0.16***
% obese and overweight = rest Europe	0.24	0.60	0.49	na	0.16
% educational level = USA	0.25	ns	0.47	0.17	0.15
% PEC = 0	ns	0.57	0.44	0.15	0.11
All assumptions	***0.22***	***0.55***	***0.41***	***0.16***	***0.09***
Scenarios	**% Δ in respect to the observed predicted probability**				
	Diabetes	**Vascular**	**Arthritis**	**Osteoporosis**	**Respiratory**
% obese and overweight = rest Europe	-4.7%	-3.7%	-2.6%	na	-5.0%
% educational level = USA	-4.3%	ns	-5.4%	6.5%	-8.1%
% PEC = 0	ns	-7.7%	-10.9%	-10.1%	-34.8%
All assumptions	-12.6%	-11.2%	-18.9%	-4.2%	-43.6%
Observed Predicted probability in developed countries	**Diabetes**	**Vascular**	**Arthritis**	**Osteoporosis**	**Respiratory**
USA	***0.16***	***0.76***	***0.73***	***0.04***	***0.08***
South of Europe	***0.14***	***0.55***	***0.43***	***0.06***	***0.08***
Others SHARE Countries	***0.15***	***0.43***	***0.12***	***0.07***	***0.08***

ns not significant (Counterfactual analysis performed only when the effect of the risk-factor is significant).
na not used as control variable
(a) Predicted Probabilities evaluated at the mean value of all variables in Puerto Rico.

Table 6

Counterfactual analysis II:

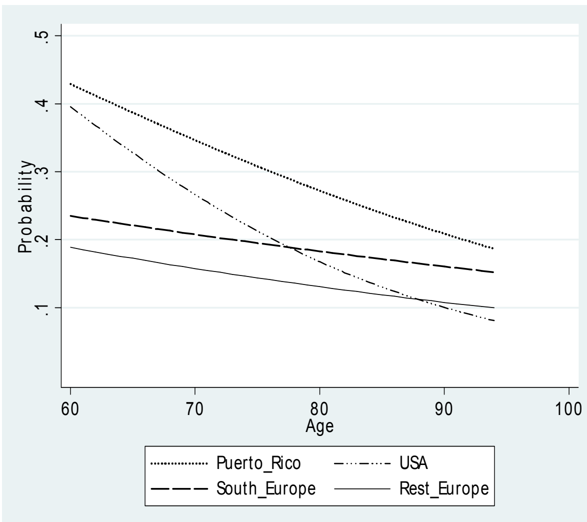
Predicted probability of suffering from chronic diseases in Puerto Rico assuming changes in the effects of the risk factors [(a)]

Counter-factual II: Effects of risk-factors	**Predicted Probability Model without controlling for Poor early conditions**				
Scenarios	**Diabetes**	**Vascular**	**Arthritis**	**Osteoporosis**	**Respiratory**
observed	***0.27***	***0.63***	***0.57***	***0.12***	***0.19***
lowest effect of obesity and overweight (1)	0.25	0.62	0.56	ns	0.17
lowest effect of diabetes (2)	na	0.61	0.54	ns	na
lowest effect of education (3)	0.23	ns	lpr	0.10	lpr
lowest effect of smoke (4)	na	lpr	ns	ns	0.17
All assumptions	***0.21***	***0.61***	***0.53***	***0.10***	***0.16***
Scenarios	**% Δ in respect to the observed predicted probability**				
	Diabetes	**Vascular**	**Arthritis**	**Osteoporosis**	**Respiratory**
lowest effect of obesity and overweight	-8.6%	-1.0%	-1.6%	ns	-8.5%
lowest effect of diabetes	na	-2.8%	-5.6%	ns	na
lowest effect of education	-15.7%	ns	lpr	-16.8%	lpr
lowest effect of smoke	na	lpr	ns	ns	-7.6%
All assumptions	-23.3%	-3.7%	-7.2%	-16.8%	-15.5%
Observed Predicted probability in developed countries	**Diabetes**	**Vascular**	**Arthritis**	**Osteoporosis**	**Respiratory**
USA	***0.16***	***0.76***	***0.73***	***0.04***	***0.08***
South of Europe	***0.14***	***0.55***	***0.43***	***0.06***	***0.08***
Others SHARE Countries	***0.15***	***0.43***	***0.12***	***0.07***	***0.08***

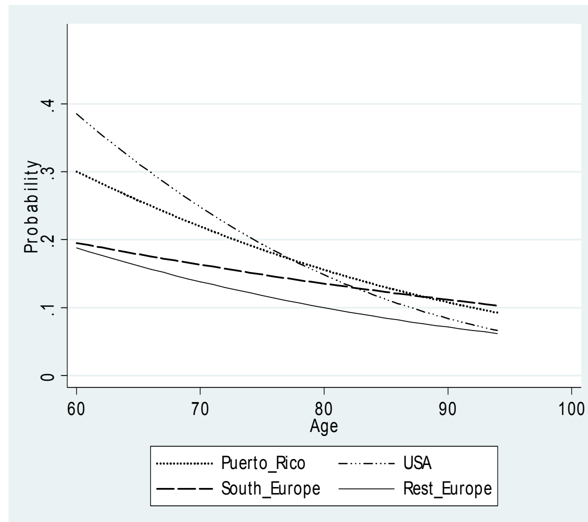
ns not significant (Counterfactual analysis performed only when the effect of the risk-factor is significant).
na not used as control variable
lpr The estimated effect is lower for Puerto Rico
(a) Predicted Probabilities evaluated at the mean value of all variables in Puerto Rico.
(1) For diabetes, arthritis or rheumatism and respiratory diseases, it is assumed the effect of obesity and overweight estimated for the Rest-Europe. For vascular diseases, it is assumed the effect estimated for the South-Europe.
(2) It is assumed the effect of diabetes estimated for the Rest-Europe.
(3) It is assumed the effect of level of education estimated for the South-Europe.
(4) It is assumed the effect of level of smoking status estimated for the Rest-Europe.

Figure 1: Probability of Suffering from Obesity and Diabetes among Women and Men 60 years and older in Puerto Rico, the US, South of Europe and Rest of Europe.

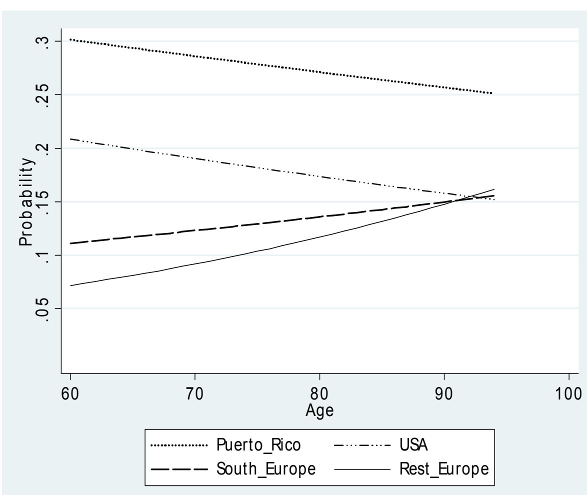
Probability Obesity Women



Probability Obesity Men



Probability Diabetes Women



Probability Diabetes Men

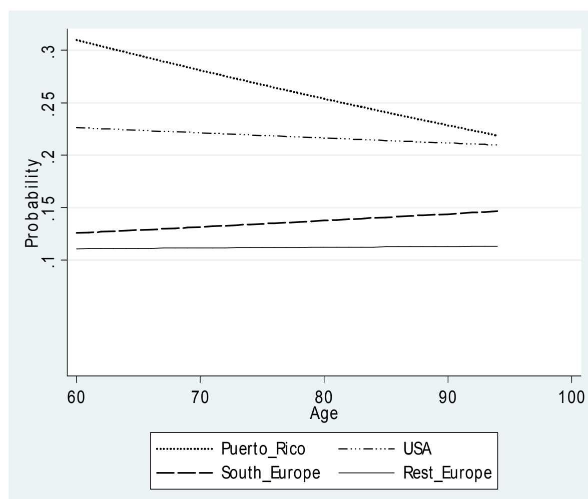
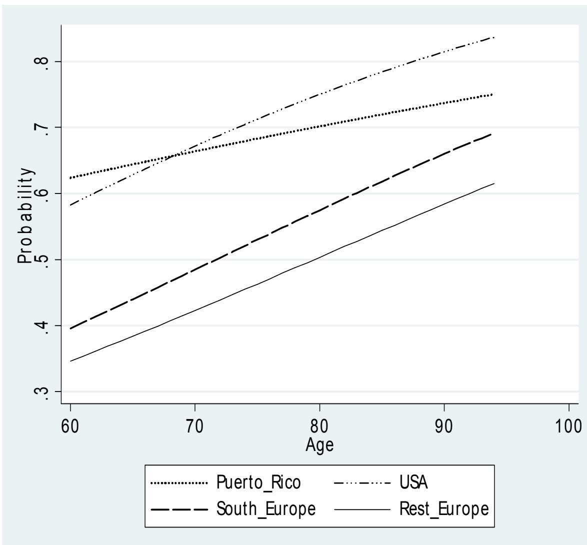
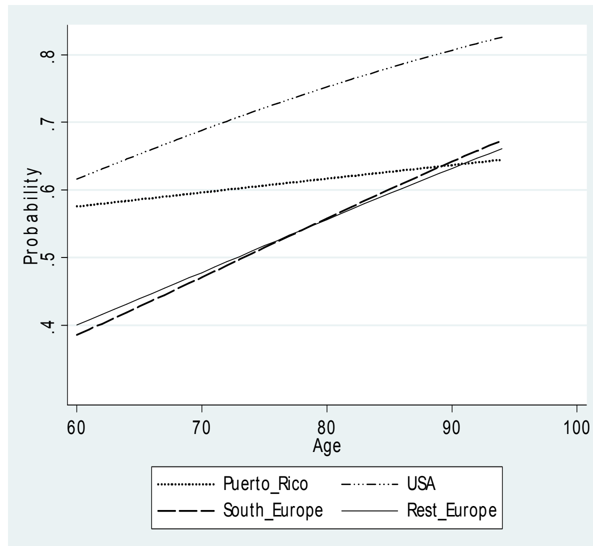


Figure 2: Probability of Suffering from Vascular Diseases and Arthritis or Rheumatism among Women and Men 60 years and older in Puerto Rico, the US, South of Europe and Rest of Europe.

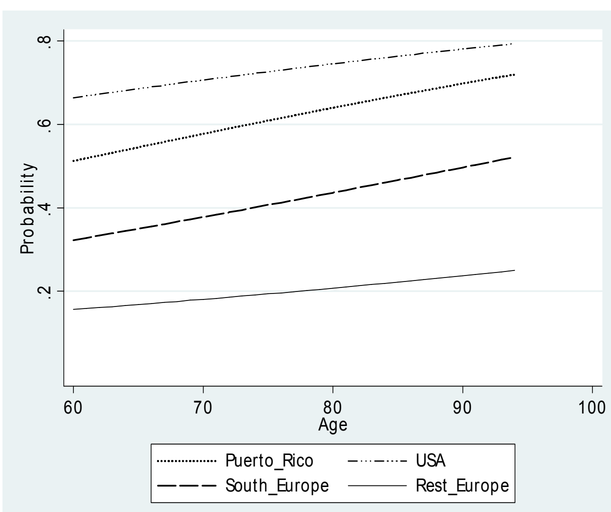
Probability Vascular Diseases Women



Probability Vascular Diseases Men



Probability Arthritis or Rheumatism Women



Probability Arthritis or Rheumatism Men

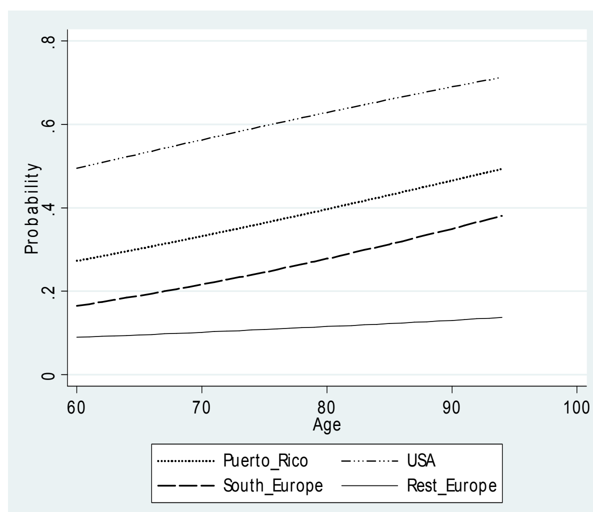
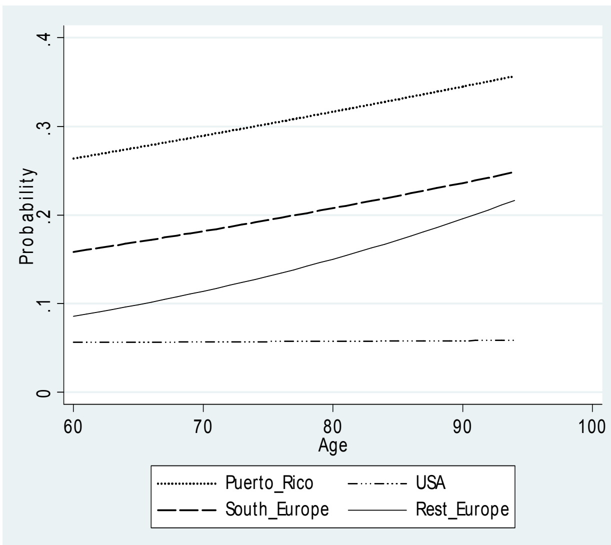
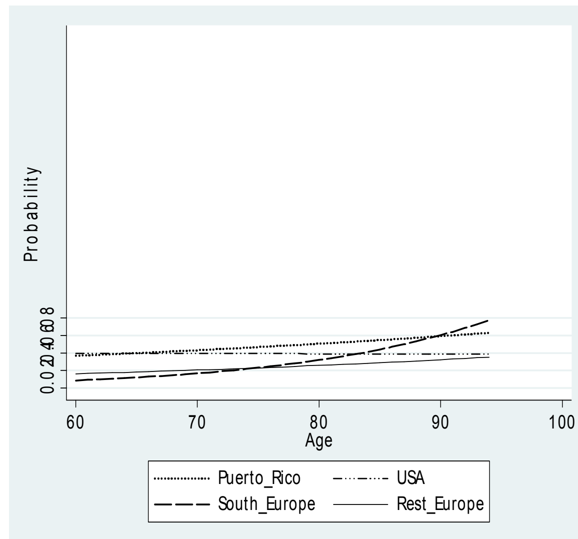


Figure 3: Probability of Suffering from Osteoporosis and Cancer among Women and Men 60 years and older in Puerto Rico, the US, South of Europe and Rest of Europe.

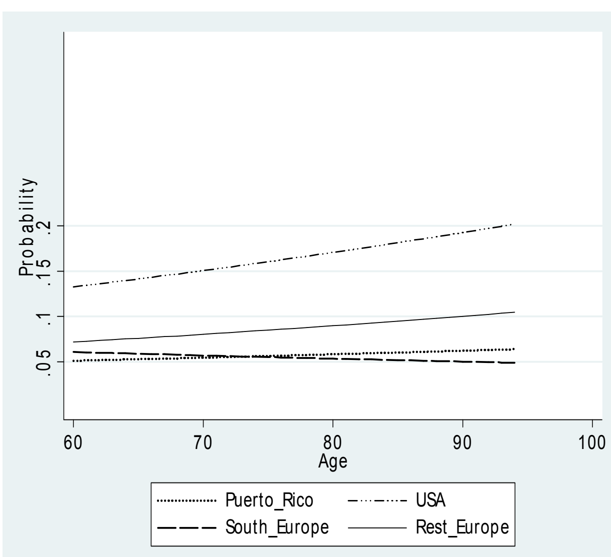
Probability Osteoporosis Women



Probability Osteoporosis Men



Probability Cancer Women



Probability Cancer Men

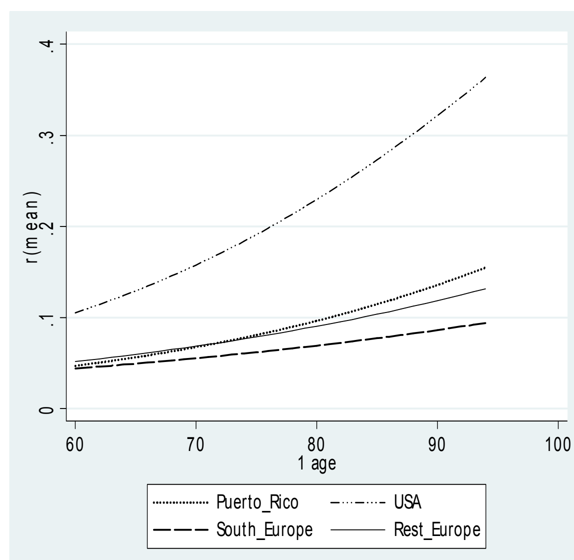


Figure 4: Probability of Suffering from Impairments among Women and Men 60 years and older in Puerto Rico, the US, South of Europe and Rest of Europe.

Probability Impairment Women **Probability Impairment Men**