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Multistate projections by level of education for Portugal, 2011-2031

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Corresponding Author:	Maria Oliveira Martins, Ph. D. Universidade Nova de Lisboa Lisboa, PORTUGAL
Corresponding Author Secondary Information:	
Corresponding Author's Institution:	Universidade Nova de Lisboa
Corresponding Author's Secondary Institution:	
First Author:	Maria Oliveira Martins, Ph. D.
First Author Secondary Information:	
Order of Authors:	Maria Oliveira Martins, Ph. D.
	Ines Rodrigues, MD
	Teresa Rodrigues, PhD
Order of Authors Secondary Information:	
Abstract:	Educational attainment is an attribute that leads to a great distinction between the members of a population, including when considering their health and well-being, which are features to pursue within an aging society. The aim of this work was to produce demographic projections for the Portuguese population by sex, age group and level of educational attainment, for the period 2011-2031. Considering fertility, mortality and migration differentials by level of education, the population was projected using the multistate cohort-component method with a block Leslie matrix. Two scenarios were considered, one where educational attainment prior to 2011 remains constant and another in which educational attainment will follow the trend observed over the last decade, being the trend in the state proportion modeled using continuation ratio models. The results show an increase in the proportion of individuals who complete higher educational levels in almost all age groups of both sexes. Among women, only 13.6% had completed some level of higher education in 2011, a figure that will rise to approximately 23.4% in 2031, whereas among men this value was only 9.7% and will also rise by 2031, reaching 15.5%. We can expect the proportion of people with higher educational levels to continue to rise as the education of younger cohorts seems to evolve positively. This work will be particularly useful to study how the aging population and the rising levels of education can contribute to the planning and monitoring of public policies, although these findings can also be used in other research contexts.

Answer to Reviewers Comments

1. As suggested by the reviewer, we discuss in section 3.3.1 the medium scenario in terms of the evolution of the mortality differentials, and we present two additional tables on this subject. We expect that this new information will clarified our assumptions.
2. Similar to mortality, we discuss in section 3.3.2 what would be the medium scenario in terms of the evolution of the fertility differentials and we explain the ones that we think are most likely.
3. We also present, as suggested by the reviewer, more discussion on the education-demographic links in the context of Portugal, namely by including two additional graphs in section 2.1, related to age and education-specific fertility rates. These pictures shape the ASFR for each education group as well as for the overall, as suggested by the reviewer.
4. We explain more in detail the procedure of generating life tables using R package, in section 3.3.1.
5. We also explain in section 3.3.2 the procedure of arriving from UN projection and the fertility differentials to the final values presented in Table1 of the old version of the paper (Table 3 of this new version).
6. In what concerns migration it was not possible to go more in depth in the relationship between education and migration because of the inexistence of more detailed data on this subject.

As a whole, we provide more tables and details so that readers could get a clear picture and do not get the feeling of hovering around a "black-box" both in terms of data and assumptions, and procedures, as suggested by the reviewer. We also try to present more discussion on the education-demographic links in the context of Portugal. We also expect that this version of the paper explains more clearly the scenarios and the arguments on which the projections are used. Unfortunately, for several reasons, it was not possible to go further in the assumptions of mortality differentials for Portugal. We include a limitation section with this concern.

Finally, we would like to thank the reviewer for the very useful suggestions and comments.

Page Contaning Author's Details

Maria Oliveira Martins is Full Professora at Unidade de Saúde Pública Internacional e Bioestatística, Instituto de Higiene e Medicina Tropical, Universidade Nova de Lisboa, Rua da Junqueira, 100, 1349-008 Lisboa, Portugal, E-mail: mrfom@ihmt.unl.pt
Inês Rodrigues is researcher at CEPESE - Centro de Estudos da População, Economia e Sociedade, Universidade do Porto, Rua do Campo Alegre, 1021, 4169-004 Porto, Portugal, E-mail: rodrigues.inesc@gmail.com
Teresa Rodrigues is Associate Professor at Departamento de Estudos Políticos, Faculdade de Ciências Sociais e Humanas, Universidade Nova de Lisboa, Av. de Berna, 26 C, 1069-061 Lisboa, E-mail: trodrigues@fcsh.unl.pt

Multistate projections by level of education for Portugal, 2011-2031

Abstract Educational attainment is an attribute that leads to a great distinction between the members of a population, including when considering their health and well-being, which are features to pursue within an aging society. The aim of this work was to produce demographic projections for the Portuguese population by sex, age group and level of educational attainment, for the period 2011-2031. Considering fertility, mortality and migration differentials by level of education, the population was projected using the multistate cohort-component method with a block Leslie matrix. Two scenarios were considered, one where educational attainment prior to 2011 remains constant and another in which educational attainment will follow the trend observed over the last decade, being the trend in the state proportion modeled using continuation ratio models. The results show an increase in the proportion of individuals who complete higher educational levels in almost all age groups of both sexes. Among women, only 13.6% had completed some level of higher education in 2011, a figure that will rise to approximately 23.4% in 2031, whereas among men this value was only 9.7% and will also rise by 2031, reaching 15.5%. We can expect the proportion of people with higher educational levels to continue to rise as the education of younger cohorts seems to evolve positively. This work will be particularly useful to study how the aging population and the rising levels of education can contribute to the planning and monitoring of public policies, although these findings can also be used in other research contexts.

Keywords Population models · Demographic projections · Multistate 2demography · Education level · Portuguese population

1 Introduction

The knowledge on the demographic situation and dynamics of a given country or region is a crucial asset in the entire process of planning and monitoring of policies, whether at the strategic, economic, political, social or ecological level. Access to accurate information on the population structure at a given time, its evolution in recent years and how certain demographic variables may change in the future plays a key role in decision making in several sectors (Lutz and KC 2010; O'Neill et al. 2001).

Relevant technology improvements over the past decades, particularly those related to computers capacity, allow us to explore in a more efficient way the variability among individuals in the study population (O'Neill et al.2001; Wilson and Rees 2005). The main national and international projections usually deal with the population divided by age and gender (INE 2009; UN 2011b); nevertheless, in the presence of good quality data, it is possible to produce more elaborate projections, namely where attributes such as marital status, educational level, employment status, place of residence (urban/rural), household type or income level are considered (Alho and Keilman 2010; KC et al. 2010; Willekens 2006).

The multistate demographic methods are currently the standard methodology used to study a population divided according to multiple features, considering the interactions between these subgroups (Rogers 1975; Willekens 2006). When a given individual attribute changes, an event occurs, which leads to changes in the population structure. If the age change is inherent to the passage of time (as long as the individual remains alive), changes in other variables such as educational level, by contrast, can follow different patterns for different individuals. Consequently, it is essential to study the moment and the intensity at which these events occur, in order to achieve estimates for the future population structure (Willekens 1985). Also, in such models, it is adequate to consider the differences concerning the demographic behaviour between these multidimensional groups (Lutz and KC 2010).

The level of education is one of the most distinguishing features among the members of a human population. Widely recognized as an essential driving force of human development at individual and society levels, education influences the behaviour related to fertility, mortality and migration (Dustmann and Glitz 2011; Fernandes 2007; Goujon 2008; Gustavsson 2006; Jejeebhoy 1995; KC et al. 2010; Lutz and KC 2010; Oliveira 2009). Additionally, it is associated with other variables: for example, in Portugal, the data provided by the National Health Survey (2005/2006) pointed out that individuals with higher educational levels tend to assess their health status more positively, compared with the less educated (Henriques, Rodrigues and Martins 2009). The primary goal of this work was to produce, for the first time, country specific demographic projections for the Portuguese population by gender, age group and level of education, for the period 2011-2031. The multistate projection method, developed by IIASA, was used and two scenarios were set. After presenting an overview of the recent demographic and educational dynamics of the Portuguese population, we summarize the main concepts concerning the demographic multistate projection model and describe the data, methods and assumptions applied in order to reach our specific aims. We then present and discuss the obtained results, namely by comparing our exercise with figures obtained by KC et al. (2010). This work will be particularly useful to study how the aging population and the rising levels of education can contribute to the planning and monitoring of public policies, namely in the education and health sectors.

2. Background

2.1 Population Size and growth in Portugal

According to the 2011 population census (INE 2012), the number of people living in Portugal is 10.562.172 (47.8% of which are men), a figure that results from an increase of only 2% since 2001 Census. The population growth rate has been declining, currently approaching zero: it is estimated that the average annual growth rate has been of 0,33% between December 31, 2001 and the end of 2010 (The World Bank 2013). In the last decades, the fertility levels in Portugal have declined significantly, resulting in a clear decreasing trend of the average number of live births per woman of reproductive age: in 1980, the Total Fertility Rate (TFR) was 2.8 and, by 2012, it reached only 1.3 children per woman, placing Portugal among the ten world countries with the lowest TFRs (Population Reference Bureau 2012). As in other countries, the decline in fertility levels is part of a set of social and demographic changes, also characterized by the postponement of marriage and childbearing, the increase in divorce, cohabitation without formal marriage and childbearing outside marriage (Sleebos 2003; Sobotka 2004). Procreation in Portugal occurs at increasingly later ages: the average maternal age at first birth has gradually increased since the80s, currently reaching over 29 years (Statistics Portugal, Demographic indicators), and such delay is often associated with the completion of higher levels of education (Cleland 2002; Oliveira 2009; UN 1995) (see figure 1). Recent data for Portugal show that mothers with intermediate education attainment levels were those who had, on average, fewer children (Statistics Portugal, Labour force survey and Live-birth statistics, 1998-2010): in 2010, the TFR for mothers who completed Lower Secondary Education was 1.28 children per woman, which is clearly below the corresponding value for those with no formal education (1.68) and those who completed Higher Education (1.43). Furthermore, if around the year 2000 the women who completed Higher Education were those who had a greater number of children, today those with no formal education lead with respect to this indicator (in fact, it was only in the group of women with no education that the TFR was higher in 2010 compared to 1998).

Fig. 1: Age and education-specific fertility rates, 2000 (left) and 2010 (right)
Source: Statistics Portugal, Live births; Statistics Portugal, Labour Survey; Authors' calculations

Mortality levels in Portugal have been decreasing in all age groups, with particular emphasis on the mortality within the first year of life, leading to an increase in the average life expectancy at all ages (Carrilho and Craveiro 2013). Between 2000/01 and 2009/10 the life expectancy at birth increased 3.2 years for men and 2.6 years for women, reaching 76.6 and 82.6 years in the end of this period, respectively. The Infant Mortality Rate (IMR) decreased 7.5% per year, on average, between 1970 and 2010, and Portugal has currently a IMR which is one of the lowest among the OECD countries (2.5 deaths per 1 000 live births) (OECD 2012). The mortality pattern by educational level is not available for Portugal. Instead, we can analyse the IMR by mother's level of education and Portuguese data suggest that, in the last decade, there is a clear difference between such groups: during the period 1996-2010, the IMR for the group of mothers with no education was, on average, 2.8 times higher than the IMR for the group of mothers who had completed Higher Education, in the same year. In 2010, the IMR for children whose mothers didn't complete Lower Secondary Education were 3.4% whereas that for whose mothers had the highest educational attainment level was only 0.7%. Such data suggest that the higher the mother's educational level, the lower the level of associated child mortality, but this effect seems to be present especially after the completion of Upper Secondary education, since the rates corresponding to mothers with no education and those who have completed Lower Secondary education present similar behaviours over time.

Migration trends in recent years are characterized by the change in the contribution of net migration to population growth in Portugal. Particularly in the years following 1994, the difference between the number of immigrants and emigrants (net migration) exceeded considerably the balance between the number of births and deaths (natural change). Although the net migration has remained positive between 1993 and 2010, in 2011 the number of exits already exceeded the number of entries in 24,331 individuals (Statistics Portugal, Demographic Indicators). As such, the contribution of migration for population growth declined, ceasing to be sufficient to ensure an increase in the number of residents in Portugal, against the decrease in natural change. Data on migration flows by level of education are very scarce for Portugal. Although referring to short time periods, data provided by Statistics Portugal suggest that most emigrants and foreign individuals claiming resident status have an intermediate level of education (Lower or Upper Secondary education);

additionally, there seems to be an ever greater percentage of individuals with higher levels of education relatively to those who have no formal education among immigrants, while among the emigrants, this pattern has not been constant (Statistics Portugal, Demographic Statistics, 2000-2006).

As a consequence of these demographic changes, the population is increasingly aging: between 1992 and 2011, the number of people aged 65 years and more increased approximately 42% and, at the end of this period, accounted for 19.1% of the total population, a value that is clearly above the EU-27 average (17.5%) and which is only exceeded by Germany (20.6%), Italy (20.3%) and Greece (19.3%). Simultaneously, the decrease in fertility rates translates into a progressive reduction in the percentage of young people (those aged under 14 years), which since 2001 has been lower than the proportion of elderly. These changes are also reflected in the marked increase of aging index, which relates the number of elderly to the number of young people: in 1970, there were approximately 34 elderly persons for every 100 young persons and, in 2011 this value has amounted to 127.6 elderly per 100 youth. On the other hand, the weight of the oldest old (aged 75 years or more) in the overall elderly population has become higher: the longevity index reached 48.6% in 2011, when it was of 32.8% in 1970. The number of elderly per 100 persons of working age (old-age dependency ratio) increased from 15.64 in 1970 to 28.9 in 2011, when the EU-27 average was of 26.2 (Eurostat). These demographic trends have a significant and unavoidable impact for public policies, namely at the social support, health care and the labour market levels, representing an important challenge for the government.

2.2 Recent education dynamics in Portugal

Census information (1981, 1991, 2001 and 2011) shows that, in the last decades, the increase in educational levels of the Portuguese population occurs in all age groups and for both genders, the largest differences being noticed mainly after 1991. In 1981, 89.7% of people living in Portugal had not completed Lower Secondary education and, by 2011, this percentage had fallen to 57.1%. The completion of the Higher education level became more frequent and, in 2011, 11.7% of individuals had reached this maximum level, while in 1991 this figure was only of 2.9%. In the younger cohorts, schooling levels seem to be different between genders, with a higher proportion of women completing higher levels of education. Since the level of education of an individual can only remain constant or increase, we can expect that the older age groups become increasingly more educated as time progresses, even if the completion of education levels occur only in younger ages (in this sense, we must also take into account the differences in mortality patterns by education level, which may explain some of the variation in the representativeness of each level of education in distinct age groups).

Fig. 2: Portuguese population by age group, gender and level of education, Census 1981, 1991, 2001 and 2011 (left to right)
Source: Statistics Portugal, XII, XIII, XIV and XV Population Census

The United Nations (UN 2011b), Eurostat (Eurostat 2010) and Statistics Portugal (INE 2009) produce regular long-term demographic projections for Portugal, but none of these consider the population divided simultaneously by gender, age and educational level.

2.3 Education and demographic behaviour

To produce population projections by level of education, we need to consider the impact of education on demographic behaviour. The awareness that mortality rates differ substantially between different socio-economic groups is common among demographers (KC et al. 2010), even though the existence of a causal relationship between education and mortality is not yet completely known (Clark and Royer 2010; Lleras-Muney 2005). In Portugal, it has been found that socioeconomic inequalities are associated with inequalities in access to health care, in lifestyles and in the available resources (social, cultural, educational and economic capital), which translate into different forms of manage health and disease throughout life (Fernandes 2007).

According to Jejeebhoy (1995), the impact of female education on fertility can be highly determined by the context, varying according to the region of the world, the level of development or the period in study. Some recent studies indicate that there has been a transformation in the relationship between fertility and female participation in the labor market in developed countries (Billari and Philipov 2004; Brewster 2000; Sleebos 2003). Oliveira (2009) studied the Portuguese case and found that the general decline in fertility in Portugal might have been be due to the decrease in fertility among the less educated, having been partially offset by increased fecundity of more educated groups. Effectively, being the effects of education, occupation and income intrinsically associated, it is necessary to understand the effect of education in the context of the increasing prevalence of working women and of the wage differences that are a result of the level of education. To a certain degree of academic qualification, it is possible that increased education has a negative effect on fertility, by leading to increased likelihood of women entering the labor market, although for positions in which educational skills do not influence wage levels. Beyond that point, increases in the level of education result in higher wages, but the differences in the likelihood of working are not as significant; thus, higher wages may result in a reduction in the relative cost of having children. Consequently, differences in fertility appear to be a function of the level of education related to an 'education-work' effect among the least educated and with an 'education-income' effect among the most educated. Finally, Dustmann and Glitz (2011) discusses the relationship between education and deliberate migration1, concluding that decisions on migration and investment decisions in human capital are in fact closely related.

2.4 Previous Projections by level of education

In recent decades, several attempts were made to estimate and project the population composition by educational level, but many of these efforts faced constraints related to each country data or to the absence of appropriate methodologies .Psacharopoulos and Arriagada (1992) estimated the mean years of schooling for the active age population of 99 countries and Nehru, Swanson and Dubey (1995) obtained similar estimates for each education level -primary, secondary and tertiary -considering both sexes. Barro and Lee (1993; 2000) have produced data on educational attainment and mean years of schooling for a large number of countries; however, the estimates concerned only two broad age groups (15 and over and 25 and over), and the 1960-2000 period. Ahuja and Filmer (1995) used existing International Labour

[1] Dustmann and Glitz (2011) classifies as deliberate migrations those due to individual decisions, based on seeking better economic conditions in other regions.

Organization demographic projections by sex and age group, to which they overlapped an estimated educational distribution for two broad age groups (6-24 and 25 and over), obtained from data on projected enrolment ratios provided by UNESCO (United Nations Educational, Scientific and Cultural Organization). Like Nehru, Swanson and Dubey (1995), they used the Perpetual Inventory Method, under which the total number of enrolled students is summed throughout long time series, yielding estimates of the schooling level in the adult population. Since these long time series are rarely available, this method involves many projections into the past based on a set of assumptions. Furthermore, we can say that this methodology has, somehow, a static nature, by not allowing the composition of the population in terms of education to have influence on fertility or mortality (Lutz, Goujon and Wils 2005).

The use of the multistate model on the demographic projection by sex, age and educational attainment level has been conducted primarily at the Institute for Applied Systems Analysis (IIASA). Several members of this Institute have prepared projections by level of education for a number of countries, mainly with the intent to relate them to their development level (Goujon and Wils 1996; Goujon et al. 2007; KC et al. 2010; Lutz 1999; Lutz and Goujon 2001; Lutz, Goujon and Wils 2005). The nearest approach to that followed by IIASA is from Education Policy and Data Center (EPDC); in 2007, EPDC produced projections for 83 developing countries and three categories of education level up to 2025, based on the definition of country-specific trajectories (Wils 2007). In their very interesting and challenging work, KC et al. (2010) used demographic multistate, cohort-component methods to produce projections for 120 countries by five-year age groups, sex, and four levels of educational attainment for the years 2005-2050. One of the covered countries was Portugal. As suggested by the authors, several refinements are suitable to validate and improve the results obtained by this broad-based, global model. One recommendation was to compare their projections with those resulting from more in-depth, country-specific modelling exercises.

3 Methodology

3.1 Multistate demographic projection model

Multistate models can be perceived as an extension of the demographic models that describe the population dynamics by age and gender (see, for example, Sharpe and Lotka (1911), Bernardelli (1941), Lewis (1942), Leslie (1945), Keyfitz and Caswell (2005)), thus allowing for a demographic analysis that simultaneously accounts for additional attributes, such as marital status, education level or place of residence (urban or rural) (Keyfitz and Caswell 2005; Rogers 1995; Willekens 1999; 2006). It is a model for a stochastic process which, at any given time, occupies one of a set of discrete states defined by the group of characteristics considered. The state transitions, also referred to as events, lead to changes in the composition of the population, linking the individual life history with consequences at the population level (Imhof and Keilman 1991; Schoen 1988; Willekens 1999; 2005). A common approach is to assume that, with respect to the observed life trajectory, only the state occupied at time t contributes to explain the behaviour in a subsequent instant; we are thus dealing with a Markov process with finite state space (Imhof and Keilman 1991; Willekens 2006). The multistate demographic model is usually applied to cohorts, describing the life course of groups of individuals that were born in the same period (typically, a year or five-year period), which is usually referred to as the cohort biography (Rogers 2008; Willekens 2006).

A central feature of the multistate demographic model is that it may be based on the use of population projection matrices which refer, in its simplest version, to the occurrence of events in discrete time. The configuration of such matrices depend upon the population model to be considered, which, in turn, is conditioned by the nature of the population in study, the objectives of the projection and the available baseline data (Schoen 2006).

In practice, the projections are made separately for men and women, by age group. We need to estimate age-and state-specific fertility rates, for women, and age-and state-specific mortality rates and transition probabilities, for men and women, for all the future years of interest. Migrations are generally considered through the estimation of sex-, age-and state-specific net migration in absolute numbers, which is added to the population of each instant, particularly since it is usually difficult to determine the 'population at risk' of immigration (Alho and Keilman 2010).

3.2 Data

As an essential step in producing multistate demographic projections, we have to ascertain which type of data is available and analyse its quality. For estimating the base-year Portuguese population, we used the estimate of resident population in December 31, 2010 (Statistics Portugal), divided by gender and age group, which was then distributed by educational attainment based on the 2011 Census data (INE 2012). For the estimation of fertility differentials, the annual number of live births by mother's age group and educational level, obtained from the Demographic Indicators published by Statistics Portugal, were used. The age-specific fertility rates projected for Portugal by the United Nations (2010 Revision of the World Population Prospects) were then used to estimate age-and education-specific fertility rates. The annual number of deaths under 1 year by gender and mother's level of education and the annual number of live births by mother's age group and educational level (Statistics Portugal), were used together to estimate the mortality differentials. The sex-, age-and education-specific mortality rates were then estimated also using the sex-specific life expectancies at birth and infant mortality rates projected for Portugal by the United Nations (2010 Revision of the World Population Prospects)[2] . Data on net migration were based on the national demographic projections produced by Statistics Portugal and on the age structure of international migration for Portugal provided by the United Nations (UN 2011a). Annual estimates of the resident population (aged over 15 years) by gender, five-year age groups and level of education, for years 1998 to 2010, which are available from the annual Labour Force Survey (Statistics Portugal), were used to estimate the sex-, age-and education-specific transition probabilities between levels of education, together with data on actual schooling rate values provided by the Ministry of Education (GEPE -Gabinete de Estatística e Planeamento da Educação).

All data were adjusted to the same four levels of education:

1. No *education/Primary Education,* which includes those who haven't complete any formal education level and those who have only completed the first cycle of basic education (first four year of schooling) or the second cycle (six years),

[2] There are no published results from the projections produced by Statistics Portugal, concerning neither age-specific fertility rates nor infant mortality rates, which led to the need for using the results from the United Nations projections.

completing Primary Education[3];

2. *Lower Secondary Education*, which includes those who completed the nine years of schooling necessary to reach Lower Secondary Education;

3. *Upper Secondary Education*, for those who completed the 12th year of education;

4. *Higher Education*, which comprises those who completed some Higher degree course, achieving, at least, a degree of *Bacharel* or *Licenciado*.

3.3 Main assumptions and challenges

3.3.1 Sex, age and education-specific survival probabilities

The sex-specific life expectancy at birth and infant mortality rate for Portugal from the medium variant of the most recent revision of World Population Prospects (UN 2011b) (tables 1 and 2) were used to estimate sex-specific life tables for each five-year projection period. This procedure was based on the methodology presented by Clark and Sharrow (2011), who used clustering techniques to identify five age patterns of mortality in 844 life tables from the Human Mortality Database and, using each pattern as the basis for a "family" in a traditional system of model life tables, created a model that distinguishes the mortality levels in each family. As a

[3] In the two first age groups (0-4 and 5-9 years), this state only includes individuals that have no education or, for a reduced proportion of children between 5-9 years, those who completed the first four years of schooling: according to the structure of the Portuguese Education System, it is not possible to complete the second cycle (6 years) before age 10.

result, they obtained a two-parameter system of model life tables for the countries and time periods included in the Human Mortality Database4. The *Life Tables* package from R allowed us to identify, using discriminant analysis, the most appropriate family based on the projected measures of infant mortality and to obtain a model life table based on the selected family and level of life expectancy (Sharrow and Sevcikova 2011).

Starting from the resulting abbreviated life tables, the mortality differentials by level of education were established upon the probability of dying between exact ages x and x + n.

Table 1: Infant Mortality Rates (%), by gender, 2005-2030, medium variant (Portugal)
Source: World Population Prospects: The 2010 Revision (UN 2011b)

Table 2: Life expectancy at birth (years), by gender, 2005-2030, medium variant (Portugal)
Source: World Population Prospects: The 2010 Revision (UN 2011b)

[4] Considering the limitations associated with the use of more common model life tables systems, which were created several decades ago -for instance, the Coale-Demeny system (Coale 1966) doesn't allow us to consider extremely low infant mortality levels, since such kind of mortality pattern didn't exist in that moment -we chose to use a system based in contemporary data

For children aged up to 15 years old, we used, like Lutz, Goujon and Wils (2005), information on the infant mortality rate by mother's education, computed from the annual number of deaths under 1 year and the annual number of live births by mother's age group and educational level (Statistics Portugal), to introduce differentials in mortality by educational level. The relationship between infant mortality rates computed for each group of mother's education and the infant mortality rate for the entire population were used to estimate the sex-, age- and education-specific mortality rates. The average differential of infant mortality rates observed in 2006-2011 was used to introduce the differential mortality by educational level in all five-year periods subsequent to 2011. Using the resulting rates, four separate life tables for each sex were constructed, one for each group of education and already reflecting the differences in mortality by level of education5. We then computed the survival proportion for each age group, i.e., the proportion of people in the z-th age group at initial moment t that survive to belong to the age group z +1 at t + n, specific for each sex and education level. Following these steps, we do not get a real multistate life table; instead, the survival proportions computed correspond not only to the survival to the next age group, but also to the permanence in same state.

3.3.2 Age- and education-specific fertility rates

It was assumed that fertility differentials by education level observed for each age group, in the period 2006-2011, will remain constant until the projection period ends. According to these estimated values, fertility levels of women in the younger

[5] It was assumed that no transitions occurred between education levels; it is also admitted that the deaths within a given time range occurred in the mid-interval.

age groups (15-19 and 20-24 years old) will decrease significantly over the projection period. The same will happen with regard to older women (45-49 years old), who have, since the beginning of the period, the lower fertility levels. On the other hand, women between 25 and 39 years will present increasingly higher fertility rates, as we move forward to 2031. There will be a postponement of fertility, most obviously among women who did not complete Lower Secondary Education: in this group, the highest fertility levels occur between 20 and 24 years in 2011-2016 and thereafter, between 25 and 29 years. In all other education levels, the ages with higher levels of fertility will remain stable over time (between 25 and 29 years for women with Lower Secondary Education and between 30 and 34 years for those who completed at least Upper Secondary Education). It appears, therefore, that women with higher levels of education continue to be those who have their children at a later time in their lifes; still, considering all women of reproductive age, those who completed some level of Higher Education are the ones that have, throughout the period, higher fertility levels (table 3).

Table 3: Total Fertility Rate by mother's level of education, 2011-2031 (Portugal)
Source: Authors' calculations

3.3.3 Sex-, age- and education-specific net migration

The values of five-year net migration by sex, age group and educational level were calculated using the annual net migration of the central scenario of demographic projections prepared by Statistics Portugal for the period 2011-2031. The distribution of these annual values for total net migration by sex and age group was based on the structure of international migrations for Portugal (UN 2011a) for the year 2010. Next, the distribution by education attainment was based on the assumption that the educational structure of migrants does not substantially differ from that observed in the resident population. The average proportions of resident individuals at each educational level between 2006 and 2010 were used for this purpose (for the 10-14 age group we always used the structure observed in the 2011 Census, because this is the only year for which that kind of data is available).

3.3.4 Sex, age, and education-specific transition probabilities

Considering the expected age for completing the different educational levels, according to the structure of the Portuguese education system, it is admitted that transitions from state No schooling/Primary to Lower Secondary occur around age 15. Therefore, these transitions are estimated for age groups 10-14 and 15-19 years. On the other hand, transitions from Lower Secondary to Upper Secondary (which happen, theoretically, around age 18) may occur in the age groups 15-19 and 20-24, and finally, it is assumed that transitions from Upper Secondary to Higher Education happen in age groups 20-24 and 25-29. Still based on the organization of the education system and due to the fact that individuals cannot return to a lower level of education, it is assumed that no transitions occur after age 30. The estimation of fertility and mortality rates, as well as the transition probabilities, is a relatively straightforward process if we can observe the sequence of states that forms the life trajectory of each individual, and the entry and exit of elements through migration (Anderson and Goodman 1957; Crowder and Stephens 2011; Jones 2005; Mahlmann 2006). However, in this particular work, only the number of individuals occupying each state at different observation instants are available for estimating the relevant transition probabilities, namely from the Labour Force Survey developed by Statistics Portugal (see section 3.2). We then developed an estimation procedure similar to that used in other demographic projections by level of education based on administrative data, such as Lutz and Goujon (2001), Lutz, Goujon and Wils (2005), Goujon et al. (2007) and KC et al. (2010). Since we want to estimate transition probabilities in a five-year time interval, specifically for each age group in which they occur, we need to compare the proportions of individuals of a certain age group, in each level of education, at time t , with the proportions in the next age group, at time t +5 (both obtained from the annual estimates of the resident population (aged over 15 years) by gender, five-year age groups and level of education, provided by the Labour Force Survey). To estimate the transition probabilities, we made use of the existing hierarchy between levels of education and of the unidirectional passage through different states. Let $p_{it}(x, x + n)$ be the unconditional probability of individuals aged between x and x+n at time *t* to be in state *i*. The row vector containing the probability distribution among the various states for individuals aged between x and x+n at time *t* is given by $p_t(x, x + n)$. Let also $p_{ijt}(x, x + n)$ be the conditional probability of individuals in the state *i* aged between x and x + n at time *t* to be in state *j* exactly n years later. Then, we have (Willekens 2006):

$$p_{j,t+n}(x+n, x+2n) = \sum_i p_{it}(x, x+n) p_{ijt}(x, x+n) \qquad (1)$$

or,

$$\mathbf{p}_{t+n}(x+n, x+2n) = \mathbf{p}_t(x, x+n) \mathbf{P}_t(x, x+n) \qquad (2)$$

where $\mathbf{P}_t(x, x + n)$ is the matrix of transition probabilities p_{ijt} $(x, x + n)$. Considering only the transitions that are relevant in this work, based on the assumptions described above, we have:

$p_{2,t+5}(10, 15) = p_{1,t}(5, 10)\, p_{1,2,t}(5, 10)$

$p_{2,t+5}(15, 20) = p_{1,t}(10, 15)\, p_{1,2,t}(10, 15) + p_{2,t}(10, 15)\,(1 - p_{2,3,t}(10, 15))$

$p_{3,t+5}(15, 20) = p_{1,t}(10, 15)\, p_{1,3,t}(10, 15) + p_{2,t}(10, 15)\, p_{2,3,t}(10, 15)$

$p_{3,t+5}(20, 25) = p_{2,t}(15, 20)\, p_{2,3,t}(15, 20) + p_{3,t}(15, 20)\,(1 - p_{3,4,t}(15, 20))$

$p_{4,t+5}(20, 25) = p_{3,t}(15, 20)\, p_{3,4,t}(15, 20)$

$p_{4,t+5}(25, 30) = p_{3,t}(20, 25)\, p_{3,4,t}(20, 25) + p_{4,t}(20, 25)$

The proportion of people in state *i* between ages x and x + n at time *t*, which will be represented by $\tilde{p}_{it}(x, x + n)$, is an unbiased estimator of $p_{it}(x, x + n)$.

Therefore:

$$\tilde{p}_{1,2,t}(5,10) = \frac{\tilde{p}_{2,t+5}(10,15)}{\tilde{p}_{1,t}(5,10)} = \tilde{p}_{2,t+5}(10,15)$$

$$\tilde{p}_{3,4,t}(15,20) = \frac{\tilde{p}_{4,t+5}(20,25)}{\tilde{p}_{3,t}(15,20)}$$

$$\tilde{p}_{3,4,t}(20,25) = \frac{\tilde{p}_{4,t+5}(25,30) - \tilde{p}_{4,t}(20,25)}{\tilde{p}_{3,t}(20,25)}$$

$$\tilde{p}_{2,3,t}(15,20) = \frac{\tilde{p}_{3,t+5}(20,25) - \tilde{p}_{3,t}(15,20) + \tilde{p}_{4,t+5}(20,25)}{\tilde{p}_{2,t}(15,20)}$$

where $\tilde{p}_{ijt}(x, x+n)$ is the estimator of $p_{ijt}(x, x+n)$.This is the approach used in our work.

Because the number of unknown variables exceeds the number of equations, and since both estimates of $p_{1,2,t}(10, 15)$ and $p_{1,3,t}(10, 15)$ can be obtained from an estimate of $p_{2,3,t}(10, 15)$, we choose to assume that:

$$\tilde{p}_{2,3,t}(10,15) = ASR_{UpperSec}(t, t+5)\left(1 - RDR_{UpperSec}(t, t+5)\right) \quad (3)$$

where $ASR_{UpperSec}(t, t + 5)$ is the average actual schooling rate on Upper Secondary Education for the period (t, t + 5) and $RDR_{UpperSec}(t, t + 5)$ is the average retention and dropout rate on Upper Secondary for the same period. This expression results from the following assumptions: a) the achievement of an education level requires, first, the enrolment on that cycle, and the ratio between the number of students enrolled in each level, who are aged as expected for that study cycle, and the resident population for the same age groups, is given by the actual rate of schooling; b) the students who do not dropout or get retained are those who complete the corresponding level; c) the proportion of students enrolled in a study cycle and the proportion of retentions or dropouts are independent. The actual schooling rate values provided by the Ministry of Education (GEPE -Gabinete de Estatistica e Planeamento da Educação), relate to both sexes, resulting in equal estimates of $p_{2,3,t}(10, 15)$ for men and women. Under these assumptions, we can easily obtain the estimators for the remaining transition probabilities:

$$\tilde{p}_{1,2,t}(10,15) = \frac{\tilde{p}_{2,t+5}(15,20) - \tilde{p}_{2,t}(10,15)(1 - \tilde{p}_{2,3,t}(10,15))}{\tilde{p}_{1,t}(10,15)}$$

$$\tilde{p}_{1,3,t}(10{,}15) = \frac{\tilde{p}_{3,t+5}(15{,}20) - \tilde{p}_{2,t}(10{,}15)\tilde{p}_{2,3,t}(10{,}15)}{\tilde{p}_{1,t}(10{,}15)}$$

It is important to emphasize that these transition proportions take into account the possibility of an exit from the population by death or emigration, in each five-year interval, but ignore the possibility of entry by immigration. As such, the estimation of $p_{ijt}(x, x + n)$ when $i = j$ should take the survival proportions into consideration.

3.3.5 Estimation of effective population

The estimation of parameters relating to mortality, fertility and migrations demographic components and to transition probabilities, allows, starting from the initial population, to estimate the number of individuals of each sex in each age group and education level, by the end of each five-year projection period. To this end, we use a block Leslie matrix, **B**, that includes the survival ratios, fertility rates and transition probabilities, and a vector for net migration. We get the following expression, for each sex:

$$l_{t+5} = Bl_t + SM_t \qquad (4)$$

Taking the female population, represented by the f exponent, as example, we have:

$$\begin{bmatrix} l^f_{1,1,t+5} \\ l^f_{1,2,t+5} \\ l^f_{1,3,t+5} \\ l^f_{1,4,t+5} \\ l^f_{2,1,t+5} \\ l^f_{2,2,t+5} \\ \vdots \\ \vdots \\ \vdots \\ l^f_{m,4,t+5} \end{bmatrix} = \begin{bmatrix} r\cdot b_{11}\cdot p_{01} & r\cdot b_{12}\cdot p_{02} & r\cdot b_{13}\cdot p_{03} & r\cdot b_{14}\cdot p_{04} & r\cdot b_{21}\cdot p_{01} & r\cdot b_{22}\cdot p_{02} & r\cdot b_{23}\cdot p_{03} & r\cdot b_{24}\cdot p_{04} & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & 0 & 0 & 0 & 0 & 0 & \cdots \\ p_{111} & p_{121} & p_{131} & p_{141} & 0 & 0 & 0 & 0 & \cdots \\ p_{112} & p_{122} & p_{132} & p_{142} & 0 & 0 & 0 & 0 & \cdots \\ p_{113} & p_{123} & p_{133} & p_{143} & 0 & 0 & 0 & 0 & \cdots \\ p_{114} & p_{124} & p_{134} & p_{144} & 0 & 0 & 0 & 0 & \cdots \\ 0 & 0 & 0 & 0 & p_{211} & p_{221} & p_{231} & p_{241} & \cdots \\ 0 & 0 & 0 & 0 & p_{212} & p_{222} & p_{232} & p_{242} & \cdots \\ 0 & 0 & 0 & 0 & p_{213} & p_{223} & p_{233} & p_{243} & \cdots \\ 0 & 0 & 0 & 0 & p_{214} & p_{224} & p_{234} & p_{244} & \cdots \\ \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots & \vdots \end{bmatrix}$$

where l^f_{ijt} is the number of women in the age group *i* and state *j* at *t*; b_{ij} is the fertility rate for women in the age group *i* and state *j* (note that only the first row includes the female contribution to the first age group composition, since all births will belong to the first state); r is the probability of female births during the interval [6]; p_{ijk} is the probability that individuals who, at *t*, are in age group *i* and state *j*, survive, being in state *k* at t + 5, and $SM^f_{i,j,t}$ is the net migration for women in age group *i* and state *j*, during the period [t; t + 5[. By considering that women's reproductive age ranges between 15 and 49 years old and, as such, age-specific fertility rates are zero outside this interval, the only non-zero values in the first row of matrix **B** will be those corresponding to age groups *i* = 4,5,…..10. Furthermore, we know that, regardless of the age group, transitions to a lower educational level

[6] The estimated number of births was divided by the two sexes according to the births sex ratio (0.512 male births and 0.488 female)

are impossible and, therefore, p_{ijk} will be zero whenever j > k. Also the transitions from No education/Primary and Lower Secondary to Higher Education are considered to be impossible in the five-year time range. Depending on the age group, there will be other null transition probabilities (for example, we admit that individuals aged between 20 and 24 years at *t*, can only pass from Upper Secondary to Higher Education in the next five years, but won't make any of the previous transitions). Is such cases, the probabilities p_{ijk} become simple survival probabilities when there are no longer possible transitions from *j* to *k*: they become known as p_{ij} and represent the probability of people in the age group *i* and state *j* to survive for 5 years, passing to age group *i + 1*, but staying in state *j* (these probabilities are the survival ratios described above). The probabilities of individuals surviving and staying in a certain state, on the age groups where transitions occur, are given by p_{ijj} , and are computed as $p_{ijj} = p_{ij} - \sum_{k \neq j} p_{ijk}$. For elements of an age group *i* in education level *j*, at *t*, the death probability in the period [t; t+5[is given by $1\text{-}p_{ij}$, the probability of survival and transition to any other education level by $\sum_{k \neq j} p_{ijk}$ and the probability of survival and stay in the same level by p_{ijj}, Therefore, we will have that:

$$(1 - p_{ij}) + p_{ijj} + \sum_{k \neq j} p_{ijk} = 1 \Leftrightarrow p_{ijj} = p_{ij} - \sum_{k \neq j} p_{ijk} .$$

The projection of the male population (identified by the exponent m) is done in a similar way, but, in this case, the matrix **B** does not include fertility rates and the total number of births in [t, t + 5[is given by:

$$l^{m}_{1,1,t+5} = (1 - r) \sum_{i=1}^{4} \sum_{j=1}^{4} b_{ij} l^{f}_{ijt} \qquad (5)$$

The projected population for January 1, 2016 is based on the vector 2011, which corresponds to the starting population, and on the estimates for survival probabilities and transition probabilities, fertility rates and net migration, obtained based on the steps mentioned above. The projected population for the end of each five-year period is used as the initial population for the next five years.

3.3.6 Projection scenarios

Starting from the average transition probabilities estimated for the periods 2001-2006 and 2006-2011, a scenario of constant schooling may be assumed, where these figures remain unchanged throughout the entire projection period. This scenario leads to constant proportions of individuals in each education level for different cohorts and, therefore, only serves the purpose of showing the effect of extending the initial context to the future, without taking into account neither the recent trend nor the effect of possible changes in the starting circumstances. In the trend scenario, we assume that schooling levels will continue to follow, in the future, the trend observed over the last years. It was therefore decided to model the trend in state proportions using a continuous ratio model in order to derive estimates of the proportions of individuals in each level of education in future instants and, based on these, calculate the corresponding transition proportions[7] , an approach also followed by Goujon et al. (2007). To estimate $p_{2,3,t}$ (10, 15) we also needed to model the trend

[7] The trend modelling for state proportions is based on data from Labour Surveys (Statistics Portugal), regarding individuals aged above 15 years, by sex, age group and educational attainment level, for years 1998 to 2010. Since we intend to project such trend to 2031, we can expect the prediction error to be high, given the small number of observations used for modeling, in relation to the number of periods ahead for prediction.

concerning the actual schooling rate and the dropout and retention rate on Upper Secondary Education, on the basis of the available estimates (annual figures between 1998 and 2010). In the first case, the best fit (assessed through the coefficient of determination, R^2) was obtained for a logarithmic trend line (R^2 =0.176), and for the dropout and retention rate, the best fit was observed with a log-linear trend line (R2 =0.798). These models were constructed in order to analyse the evolution of transition proportions behavior over time, in order to project them into the future, even though they are subject to scarce baseline information.

4 Results and discussion

In both scenarios, we can expect a decrease in the total number of residents in Portugal, falling from 10.636.979 inhabitants in 2011, to 10.284.134 according to the constant scenario or to 10.265.109 in accordance with the trend scenario, by 2031. The distribution by gender is expected to remain stable over time: in 2011, 51.6% of inhabitants were female and, by 2031, this percentage is expected to be approximately 51.5%, for both the considered scenarios. Regarding the age structure of the total population, significant changes are expected relative to the baseline year: the proportion of individuals above 65 years is expected to increase to approximately 22%, by 2031, while the proportion of children and young people under 15 years is projected to be slightly above 14% for the same period. Consequently, the ageing index is expected to increase considerably. According to the trend scenario, by 2031, there will be 154.5 persons aged above 65 years for every 100 individuals aged below 15. The working-age population should also become increasingly aged and, by 2031, there will be only 70.9 people between 20 and 29 years for every 100 people aged between 55 and 64 years. As a result of the decrease in the number of births and the reduction on mortality levels, we can expect an increase of the elderly and the young, relatively to the population in the working ages (see table 4).

Table 4: Summary indexes, 2011 and 2031, by scenario
Source: Authors' calculations

The proportion of residents who complete at least Lower Secondary Education will continue to rise, being possible to expect that, by 2031, over half the population will have finished this level of education (table 5). Even with fixed transition proportions (constant scenario), the levels of education of the whole population will tend to increase over time, as younger and more educated cohorts replace older cohorts. The trend scenario leads to an acceleration of that effect, since it is based on transition proportions that follow the trend of the last decade and, as such, increase during the projection period.

Table 5: Population structure by gender, age group and level of education, 2011 and 2031, by scenario
Source: Authors' calculations

Given that the Lower Secondary Education accomplishment usually occurs around the age of 15, the group of people up to 14 years of age remains mostly in the first group, regardless of the period of time and the level of education. Thus, it is important to analyse the effects of schooling focusing on individuals aged 15 years onwards. Considering the residents in the age group 15 to 64 years (figure 3), there is a key improvement of the human capital, with the fall in the proportion of individuals who didn't complete Lower Secondary from 84.4% in 1981 to approximately 25% by 2031 (26.65% under the constant scenario and 22.03% in the trend scenario). The percentage of individuals with Higher educational level in the working age group is expected to reach values close to 25% by 2031, while, 50 years earlier, it was only of 2.3%. Even though the total number of individuals aged between 15 and 64 years projected for 2031 by the trend scenario is near the value projected by KC et al. (2010) for the year 2030 (approximately 6 597 thousands and 6 609 thousands, respectively), our trend scenario results in a slightly lower proportion of individuals with Higher educational level, compared with their Global Education Trend (GET) Scenario (26.0% and 29.9%, respectively)8 . Also in figure 3, we see an increase in the total number of people aged 65 or over, together with a clear change in its educational structure: by 2031, 40.3% of individuals in this group should have completed at least Lower Secondary Education, which represents an increase of 36.2 percentage points compared to 1981; on the other hand, the percentage of people with Higher Education, which stood at 1.1% in 1981, is expected to increase to 13.04% by 2031 in both scenarios. Here again, the obtained results are very close to those presented

[8] The remaining proportions are not comparable, since KC et al. (2010) presented a different state structure -1. *No education*; 2. *Primary*; 3. *Secondary* and 4. *Tertiary* -and only the last class of education is defined as our Higher Education state.

by KC et al. (2010), both with respect to the total number of individuals aged 65 years or more (2226 thousands according to our results and 2475 thousands under their GET scenario) as in relation to the proportion of individuals with Higher education (13.04% and 12.7%, respectively).

Fig. 3: Number of people aged 15-64 (left) and 65+ (right), by level of education, 1981-2031, Trend scenario
Source: Authors' calculations

The residents distribution by key variables -sex, age group and educational level -can be analysed through the construction of multistate population pyramids. The comparison between the observed population structure in 2011 and that estimated for 2031 (figures 4, 5 and 6) indicates that the proportion of individuals who complete higher levels of education should increase in all age groups of both sexes, according to any of the scenarios.

Regarding the pattern of educational attainment by sex, the existing differences remain over time. Although we can observe, in the older cohorts (above 70 years), a higher percentage of men with at least Lower Secondary Education by 2031, relative to women, in general, schooling among women tends to surpass the corresponding levels among men. Considering all age groups, the percentage of men who never completed Lower Secondary Education was, in 2011, slightly higher than for women (57.2% of men and

57% of women), a situation that remains throughout the projection period, with 42.4% of men without completed Lower Secondary Education, by 2031, against 39.95% of women (trend scenario); among women, 13.6% had completed some level of Higher education in 2011, a figure that will rise to approximately 23.4% by 2031, whereas among men, this number was only 9.7% in 2011 and should also rise by 2031, reaching 15.5%. Since the transition to a higher level of education is an irreversible event, we can expect the proportion of elderly people with higher levels of education to continue to increase, since the schooling of younger cohorts seem to continue to evolve positively.

Fig. 4: Portuguese population by gender, age group, and level of education, January 1st, 2011
Source: Statistics Portugal, annual Estinates of the Resident Population and authors' calculations

Fig. 5: Portuguese population by gender, age group, and level of education, January 1st, 2031,Constant Scenario
Source: Authors' calculations

Fig. 6: Portuguese population by gender, age group, and level of education, January 1st, 2031 ,Trend Scenario
Source: Authors' calculations

5 Conclusions

This work presents an useful and to some extent original overview of the concepts and challenges usually faced by researchers when dealing with multistate demographic models, with a practical application to Portugal. These models are an essential tool for the analysis of multidimensional populations, as they are able to model the demographic dynamics more closely to the real demographic behavior.

Demographic projections were produced for the Portuguese population by sex, age group and educational attainment level, for the period 2011-2031. The multistate projection model was used in order to cover the dynamics inherent to demographic behavior. The population were projected forward, at each five-year step, using sex-, age- and education-specific values for survival probabilities, fertility rates and net migration. Also, sex-, age- and education-specific transition probabilities were estimated to account for the conclusion of higher levels of education by the elements of each cohort. It was assumed that no education transitions occur after age 30. We established two scenarios of evolution of the schooling levels, a constant and a trend scenario. The estimated country-specific projections were compared with those obtained in a more general context by KC et al. (2010). We obtained a lower proportion of individuals with Higher education among those aged between 15 and 64 years, but a slightly greater proportion among the older population (aged 65 years or more). Also, the obtained values for the total number of individuals in each age group were very close to those presented by KC et al. (2010).

Our results show that the methodology proposed by IIASA is extremely useful and feasible at the country-specific level. The resulting projections from our work are, in a certain sense, more refined, and provide a framework for analysing the structure of Portuguese population that will be particularly useful for public policies in an aging society. The knowledge of population trends by sex, age and educational attainment is crucial namely to the strategic planning of educational and health care services. Furthermore, within the actual economic crisis faced by Portugal, our results will permit a more accurate estimation of health care and social security burdens. As future research, we will develop projections disaggregated also by health status and considering the NUTS II Portuguese Regions. This type of investigation will contribute to the debate surrounding the future sustainability of the Portuguese health system, by looking at the extent to which the burden associated with an ageing population can be counterbalanced by successive improvements in human capital.

As in similar studies, our work present some limitations related to the complexity of the multistate models and the scarcity of available data. The major limitations with regard to the projected distribution of older individuals by the four groups of education might be the one related to assumptions on mortality -namely, the use of differentials in infant mortality by mother's education to estimate the differences in mortality levels between groups of education in other age groups. Considering the lack of appropriate data to estimate mortality differentials by level of education in adult ages, we decided to use the results on infant mortality differentials, keeping in mind that these provide us an alternative way of quantitatively distinguish mortality levels between education groups, in the same direction that was observed in previous works (Huisman et al. 2004; Huisman et al. 2005): decreased mortality levels as educational level rises, a differential that persists in older ages. Regarding migration, the most important limitation might be the assumption of immigrants entering the country at the exact time t +5, thus resulting in the absence of events between their entry into Portugal and the end of that interval -since, as individuals aged 65 years or older in 2031 were at least 45 years old at the beginning of the projection period, no transitions between levels of education occurred in this group during the period 2011-2031. On the other hand, results concerning younger age groups should also be particularly determined by projected transition probabilities. The use of constant transitions for the group 10-14 years, for which the Census 2011 data were the only available baseline information, in addition to the limitations regarding the projection of state proportions in the trend scenario, might influence the projected distribution of individuals by education level. Even though those effects on the total number of people in the younger groups should be weak, because mortality levels of the various groups of education are very low and still very close at these ages, they might have a larger impact on the number of young people (aged under 14), given the differences in fertility levels between mothers with distinct educational attainment levels.

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Figure

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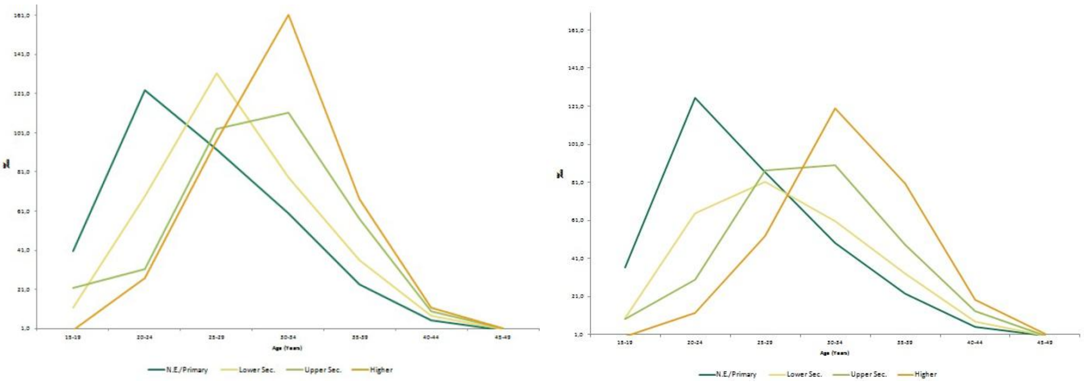

Fig. 1: Age and education-specific fertility rates, 2000 (left) and 2010 (right)

Source: Statistics Portugal, Live births; Statistics Portugal, Labour Survey; Authors' calculations

Figure
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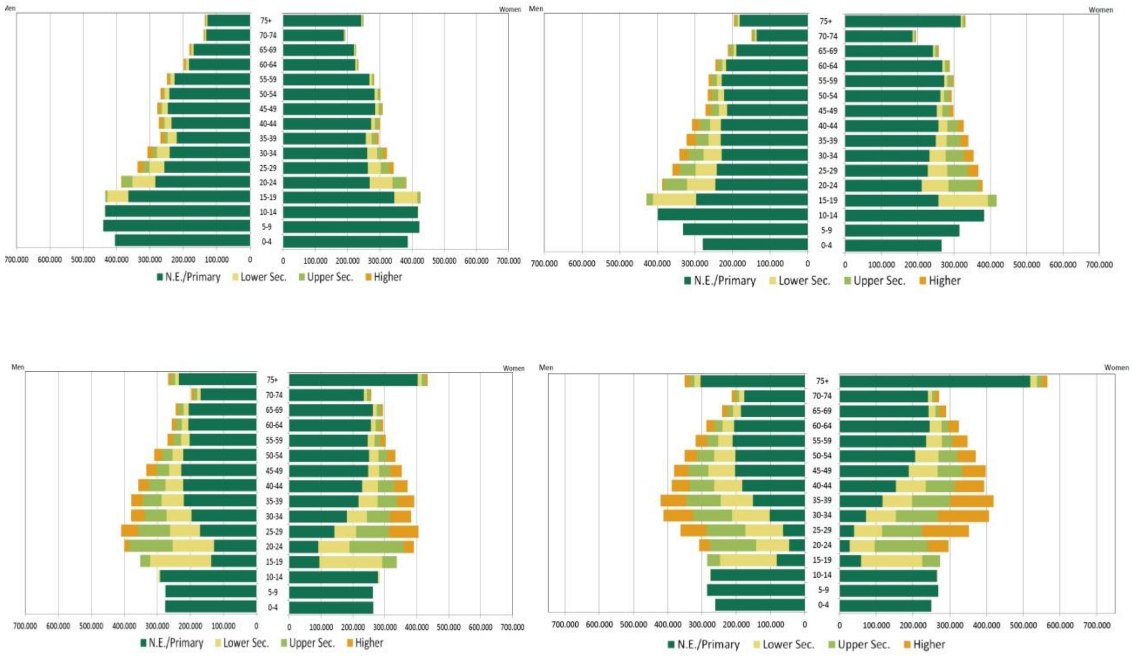

Fig. 2: Portuguese population by age group, gender and level of education, Census 1981, 1991, 2001 and 2011 (left to right)

Source: Statistics Portugal, XII, XIII, XIV and XV Population Census

Figure
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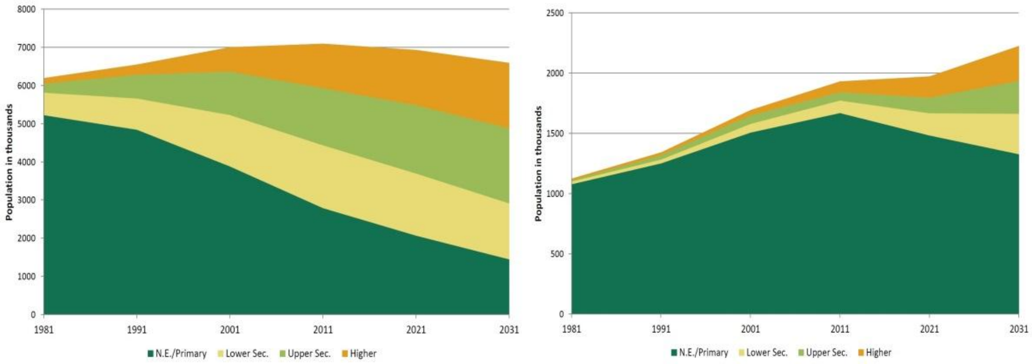

Fig. 3: Number of people aged 15-64 (left) and 65+ (right), by level of education, 1981-2031, Trend scenario

Source: Authors' calculations

Figure

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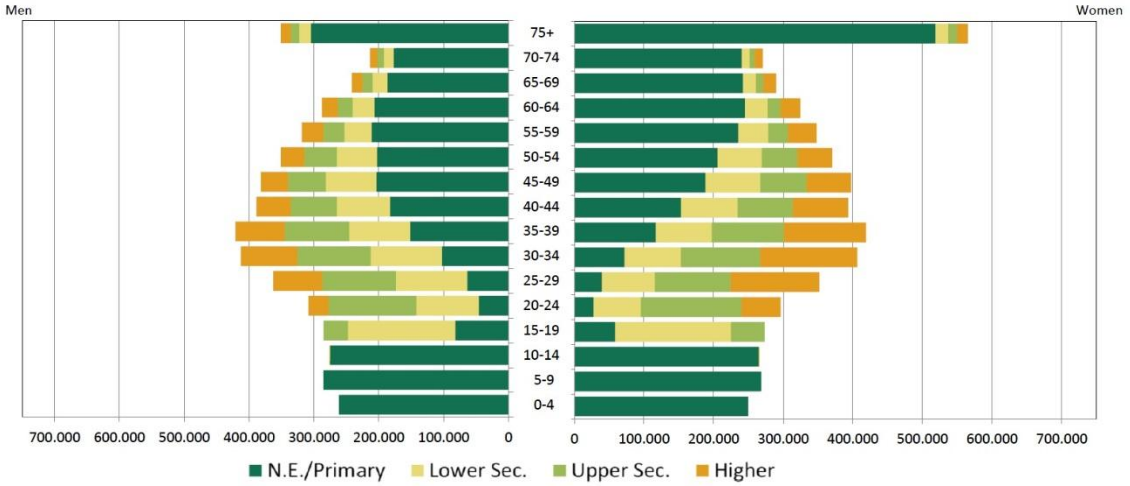

Fig. 4: Portuguese population by gender, age group, and level of education, January 1st, 2011

Source: Statistics Portugal, annual Estimates of the Resident Population and authors' calculations

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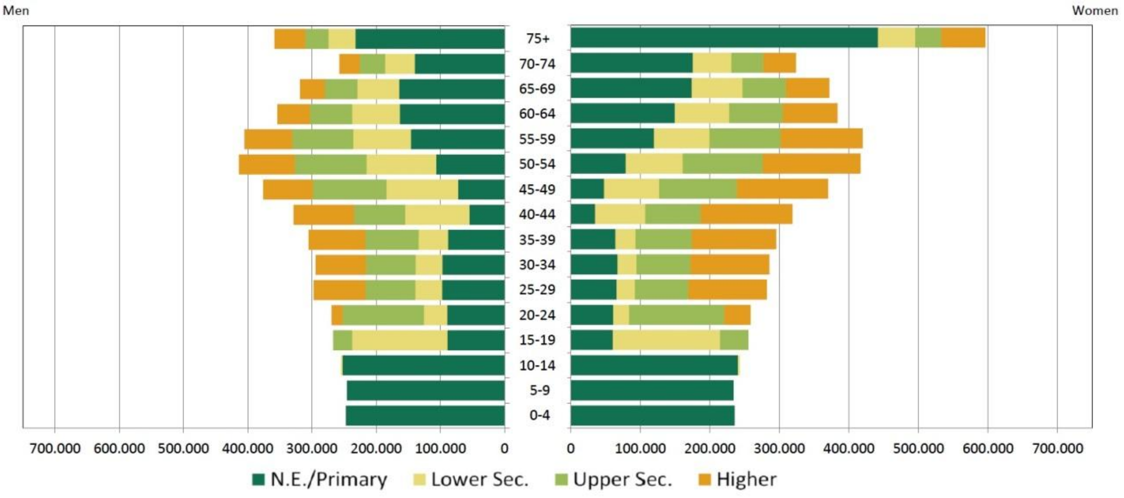

Fig. 5: Portuguese population by gender, age group, and level of education, January 1st, 2031,Constant Scenario

Source: Authors' calculations

Figure
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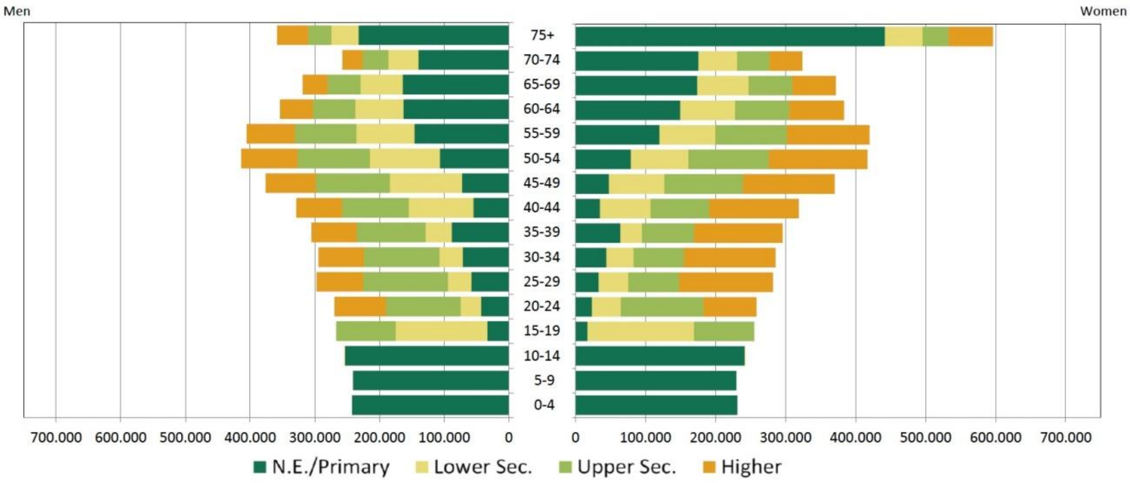

Fig. 6: Portuguese population by gender, age group, and level of education, January 1st, 2031 ,Trend Scenario

Source: Authors' calculations

Tables

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Table 1: Infant Mortality Rates (%), by gender, 2005-2030, medium variant (Portugal)

Source: World Population Prospects: The 2010 Revision (UN 2011b)

	Gender		
Period	**Total**	**Male**	**Female**
2005-2010	4,5	4,8	4,0
2010-2015	4,2	4,5	3,8
2015-2020	4,0	4,4	3,7
2020-2025	3,9	4,3	3,6
2025-2030	3,8	4,2	3,5

Table 2: Life expectancy at birth (years), by gender, 2005-2030, medium variant (Portugal)

Source: World Population Prospects: The 2010 Revision (UN 2011b)

	Gender		
Period	**Total**	**Male**	**Female**
2005-2010	78,6	75,3	81,8
2010-2015	79,8	76,8	82,8
2015-2020	80,4	77,4	83,3
2020-2025	80,9	78,0	83,8
2025-2030	81,4	78,5	84,3

Table 3: Total Fertility Rate by mother's level of education, 2011-2031 (Portugal)

Source: Authors' calculations

	Level of education			
Period	**No education/Primary**	**Lower Sec.**	**Upper Sec.**	**Higher**
2011-2016	1,37	1,25	1,41	1,51
2016-2021	1,29	1, 24	1,42	1,55
2021-2026	1,28	1,28	1,50	1,67
2026-2031	1,29	1,34	1,61	1,82

Table 4: Summary indexes, 2011 and 2031, by scenario
Source: Authors' calculations

	Portugal		
	2011	**2031 Constant**	**2031 Trend**
Youth Index	83.2	65.6	64.7
Ageing Index	120.1	152.4	154.5
Longevity Index	47.4	42.9	42.9
Working Age Population Renewal Ratio	103.2	70.9	70.9
Young-age Dependency Ratio	22.7	22.1	21.8
Old-age Dependency Ratio	27.2	33.8	33.7
Total Dependency Ratio	49.9	55.9	55.6

Table 5: Population Structure by gender, age group and level of education, 2011 and 2031, by scenario

Source: Authors' calculations

		Portugal		
	Year	**2011**	**2031 Constant**	**2031 Trend**
	Total (Nº)	10.636.979	10.284.134	10.265.109
Gender	**M**	48.4%	48.5%	48.5%
	F	51.6%	51.5%	51.5%
Age Group (years)	**0-14**	15.1%	14.2%	14.0%
	15-64	66.7%	64.1%	64.3%
	65 +	18.2%	21.6%	21.7%
Level of education	**N. E./ Primary**	57.1%	44.2%	41.1%
	Lower Sec.	16.4%	17.4%	17.6%
	Upper Sec.	14.7%	19.7%	21.8%
	Higher	11.7%	18.7%	19.5%
Population aged 65 +				
Level of education	**Total (Nº)**	1.931.457	2.226.497	2.226.497
	N. E./ Primary	86.5%	59.7%	59.7%
	Lower Sec.	5.4%	15.1%	15.1%
	Upper Sec.	3.6%	12.2%	12.2%
	Higher	4.6%	13.0%	13.0%