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EDUCATIONAL ATTAINMENT AND CARDIOVASCULAR DISEASE MORTALITY IN THE SLOVAK REPUBLIC

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ABSTRACT. This paper devotes to the development analysis of cardiovascular disease mortality rate by sex, age, education, and leading causes of deaths during the period of 1996-2014 in the Slovak Republic. Survival analysis and Cox proportional hazard model were conducted to estimate the impact of sex and education level on the probability of death due to cardiovascular diseases at different age. According to our results, standardised mortality rates decreased by an average of 31.5% for both sexes. The leading causes of death were hearth failure and cardiomyopathy for persons under 30 years of age. The myocardial infarction, chronic ischemic heart disease and atherosclerosis were the most common causes of death for adults, as well as seniors. Women represented a lower level of hazard rate than men and primary education group reported the lowest level of hazard rate in comparison to the other education groups.

JEL Classification: I10, I14

Keywords: cardiovascular disease mortality, socioeconomic status, education.

Introduction

Good health is a crucial resource for social and economic development in each country. The higher interest of a society in the protection and development of health, the people enjoy a larger number of healthy life years and contribute more to the social and economic welfare (Mladovsky *et al*., 2009).

Cardiovascular diseases (CVD), in other words diseases of the circulatory system, marked I00-I99 according to the International Classification of Diseases (WHO, 2010), are the leading causes of death and disability worldwide, as well as in the European countries including the Slovak Republic. They perform the biggest part of noncommunicable diseases, namely 46.2% worldwide, which are defined as “those diseases which are not transmissible or caused by injury” (WHO, 2014).

In 2013, recent data of CVD mortality account for 37.5% of all deaths in the European Union (28), while ischemic heart disease and cerebrovascular diseases are the leading causes of death among CVD (Eurostat, 2016; Gavurová & Vagašová, 2016). In the Slovak Republic, there were 51,346 deaths in 2014, of which the proportion of cardiovascular diseases accounted for 49% (NCZI, 2014).

CVD mortality rates are influenced by many determinants, therefore they are challenging to examine. Some behavioural factors are completely modifiable, like alcohol and tobacco consumption, obesity, physical activity; partly modifiable are socioeconomic characteristics, e.g. family income, education, occupational status, marital status; conversely, others are non-modifiable, such as age, sex, ethnicity (Pol & Thomas, 2013). One of the many factors that may play a role is educational level which used to be marked as an indicator of social and economic status. This can cause a certain level of psychosocial stress leading to the greater expected CVD mortality rate (Schmidt *et al*., 2012).

The main aim of this paper is to reveal the structure of mortality from cardiovascular diseases by educational level, age and sex in the Slovak Republic throughout the time period 1996-2014. We would like to know if there are some differences in CVD mortality among sexes, age categories of people, various types of cardiovascular diagnoses, and educational attainment of the Slovak population.

The paper consists of four parts. The first one contains brief overview of CVD mortality research with emphasis on educational attainment. In the second part, there is a description of data used and methodology. The next part is dedicated firstly to a development analysis of CVD mortality rate by sex, age and leading causes of deaths, and secondly a CVD mortality structure by education, age, sex is presented during the period of 2011-2014. Finally, we conclude and evaluate research findings.

1. Literature Review

Differences in socioeconomic status, mainly in income, education and occupation, are associated with disparities in health status of population. Education is the most commonly used measure of socioeconomic status in epidemiological studies (Berkman & Kawachi, 2000).

Many researchers provide the evidence that the educational attainment strongly and negatively correlates with the all-cause mortality (Kibele, 2012; Hoffmann, 2008; Muller, 2002; Kunst & Mackenbach, 1994). A variety of recent epidemiology studies devote to the cardiovascular disease mortality reporting the negative influence of risk factors, for example, alcohol and tobacco consumption, physical inactivity, unhealthy eating habits, high cholesterol, etc. (Nichols *et al*., 2014; Protulipac *et al*., 2015; GBD, 2013; Kamenský & Murín, 2009; Bowry *et al*., 2015; Psota *et al*., 2013; Odden *et al*., 2014).

There are some studies showing that men and women with low socio-economic status, defined also as low educational level, have an increased all-cause as well as CVD mortality risk (e.g. Stringhini *et al*., 2010; Albert *et al*., 2006; Strand & Kunst, 2007; Mackenbach *et al*., 2003). Winkelby *et al*. (1992) confirmed that within the income, education and occupation, the strongest relationship was showed between education and cardiovascular risk factors. Higher risk was associated with lower education level. Interestingly, according to WHO (2012), in Poland, differences in the risk of death related to educational attainment are greater for men than women for all causes of death except CVD. In Japan, Ito *et al*. (2008) found that less than 10 years of education was associated with significantly higher mortality from cardiovascular disease than 12 years of education and over.

Obviously, many educational activities devoting to the prevention programs for CVD risk factors are priorities of health policy in the Slovak Republic, namely Project MONIKA (Baráková *et al*., 1999), Project CINDI (Avdičová *et al*., 2000), National Program of Prevention Heart Conditions in Adults (Kamenský & Murín, 2009), The National Action Plan for the prevention of obesity for the years 2015-2025 (PHASR, 2015). Their aim is to ensure effective long-term education of the population on all social levels of society.

2. Data and Methodology

The data used was provided by the National Health Information Centre in Slovakia. They consist of data on the cause of death, age and sex and include years from 1996 to 2014. The data concerning education was only available from 2011.

Standardised mortality rate per 100,000 population was estimated by the method of direct standardisation using European standard population.

The data was processed using the R project for statistical computing. The standard Mann-Whitney U test was performed to identify differences among various groups of mortality.

Survival analysis methods were used to quantify the impact of sex and education level on the probability of death due to cardiovascular diseases at different age. The methodology was applied as follows:

- The dependent variable age was assumed to have a continuous probability distribution $f(t)$
- The probability that age would be less than t was

$$F(t) = Prob(T \leq t) = \int_0^t f(s)ds \qquad (1)$$

- Surival function was the probability that age would be at least t

$$S(t) = 1 - F(t) = Prob(T \geq t) \qquad (2)$$

- Hazard rate was the probability that death would occur after time t

$$\lambda(t) = f(t)/S(t) \qquad (3)$$

- The hazard rate was the probability that the individual would die of cardiovascular disease specifically at age t while the individual was at risk.

The next step was to calculate the Cox proportional hazard model (n = 174290; number of events = 91174) in order to quantify the differences between individual sex groups and education level groups.

coxph(formula=Surv(age, event)~1+sex+edu2+edu3+edu4,method=berslow) (4)

Dummy variables were created to represent sex (0 – male, 1 – female) and education level groups (edu2, edu3, edu4 representing incomplete secondary, secondary and university education respectively, with primary education as base).

3. Results

3.1. Development of CVD Mortality Rate by Sex, Age and Leading Causes of Deaths

As you can see on the *Figure 1*, between 1996 and 2014, the standardised mortality rates of CVD changed very rapidly. A high drop from 1,269 per 100,000 inhabitants in 1996 to 869 per 100,000 in 2014 (-31.5%) was recorded for men compared to the same decrease for women, from 923 per 100,000 persons to 628 per 100,000. Mortality rates for men are around one third higher than those for women.

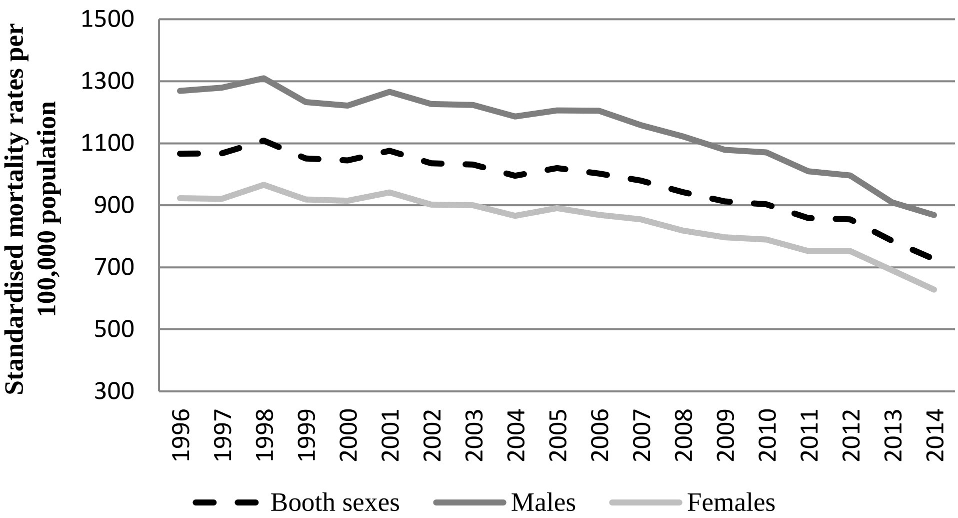

Figure 1. Development of mortality from cardiovascular diseases by sex, 1996 – 2014
Source: Authors' calculations based on mortality reports.

Table 1 presents the descriptive statistics concerning the age structure of the total population as well as separately for men and women concerning death due to cardiovascular diseases. As can be seen, a total of 53.8% of all deaths within the population was due to the selected category of diseases. The percentage was slightly lower for men (47.3%) and higher for women (60.9%). There was also a slight difference when it comes to the median age of death between the sexes (74 for men and 81 for women) as well as the 25th and 75th percentile, with men having a higher variability of the age of death.

Table 1. Descriptive statistics of deaths due to cardiovascular diseases

	Counts of deaths	Annual average deaths	Share on all-cause mortality	Median age	25th percentile of age	75th percentile of age
Total	536,465	28,235	0.538	78	70	85
Men	248,608	13,084.63	0.473	74	64	82
Women	287,857	15,150.37	0.609	81	74	86

Source: Authors' calculations using R project.

When discussing different age groups within the population, it is expected to observe different diagnoses within the group to present the most prevalent cause of death in different age groups.

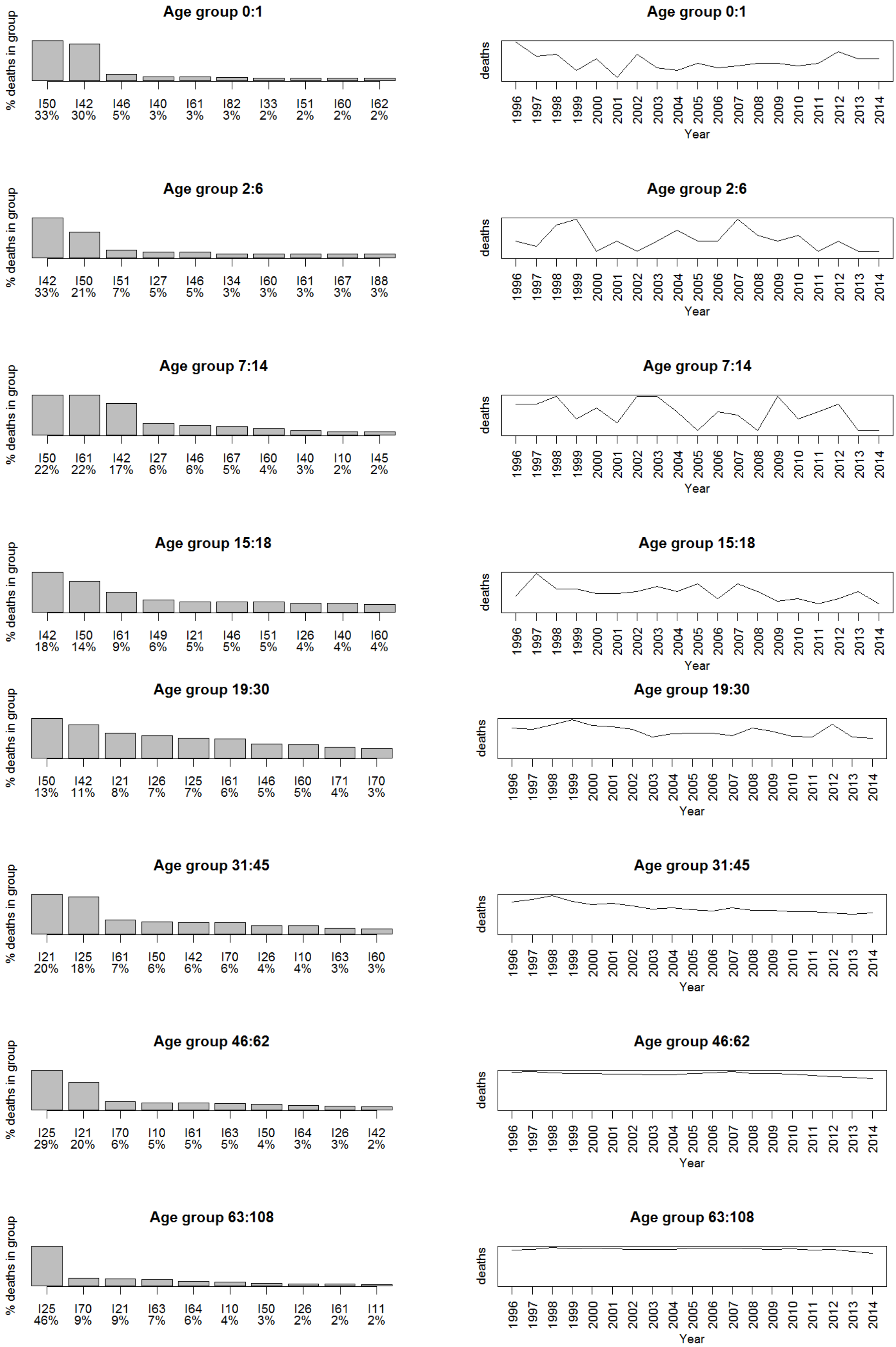

Figure 2. The leading causes and trend of cardiovascular disease deaths by age groups
Source: Authors' calculations using R Project.

Figure 2 depicts the distribution of major causes of deaths concerning diseases of the circulatory system for individual age groups. As can be seen, up to the age of 30 years the most dominant causes of death are the diagnoses I50 and I42 (Hearth failure and Cardiomyopathy respectively), accounting for up to 50% of all deaths in the given age groups, with their share decreasing with age. As for the age group of 31 to 62 years of age, the diagnoses I21 and I25 (ST elevation (STEMI) and non-ST elevation (NSTEMI) myocardial infarction and Chronic ischemic heart disease respectively) take over as the main causes of death, again accounting for up to 50% of all deaths within the specified age groups. The I70 diagnosis (Atherosclerosis) starts emerging in the age group of 19 to 30 years of age and slowly becomes one of the main causes of death with increasing age, holding second place in the highest age group of 63 and above. Other noteworthy diagnoses include the I61 (Nontraumatic intracerebral hemorrhage), representing a major cause of death for the age group of 7 to 14 and 15 to 18 years of age. As for the total number of deaths for given age groups, it is worth noting the in the observed period, the age group of 19 to 30 as well as 31 to 45 years of age has seen a significant drop in the number of deaths caused by diseases of the circulatory system.

3.2. CVD Mortality Structure by Education and Age

As education is an important socioeconomic factor affecting living conditions and lifestyle, we look at the differences between different education groups to see if there are any major differences in the age structure of deaths caused by diseases of the circulatory system. *Table 2* presents the age statistics for different education groups. As can be seen, the group with primary education only presents a much higher mortality rate (61.2% of all deaths) caused by diseases of the circulatory system, while the mortality rate seems consistent between the other groups (from 43.6% to 45% of all deaths). There also seems to be a difference in the age structure of deaths, with the median age of death being much higher for the primary education group, as well as the 25th and 75th percentile age of death. To better understand this difference, *Figure 3* presents the age distribution of deaths for individual education groups.

Table 2. Age structure of dead associated with educational level

	Share on all-cause mortality	Median age	25th percentile of age	75th percentile of age
primary	0.612	83	76	88
incomplete secondary	0.45	74	64	82
secondary	0.436	77	67	84
university	0.437	78	68	84

Source: Authors' calculations using R project.

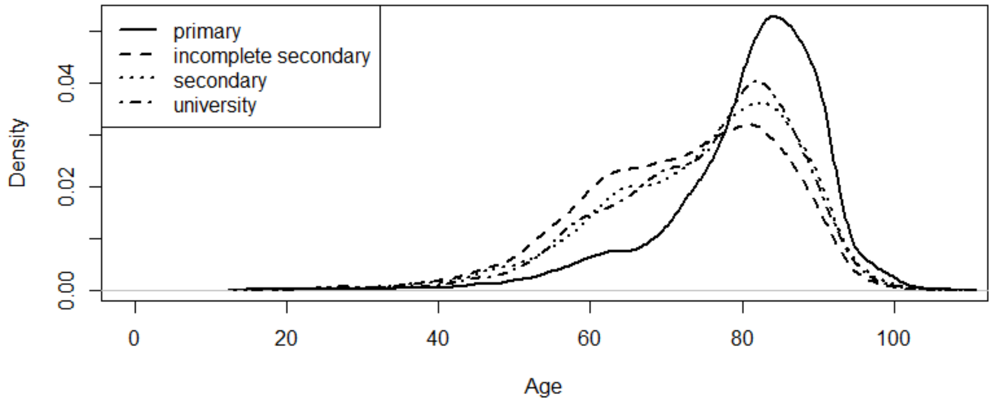

Figure 3. Age distribution by education
Source: Authors' calculations using R Project.

As was stated above, the mortality for the primary education group seems to become prevalent at a much later age, but sees a major increase come 70 years of age.

3.3. Survival analysis for Education and Sex

To account for sex and education differences, we performed a survival analysis, with the age at the time of death as the dependant variable and cardiovascular disease being the cause of death representing the failure event in the model. The first step was to calculate the Kaplan-Meier non-parametric analysis per sex group and per education level attained. Specific survival functions are presented in *Figure 4* and *Figure 5*.

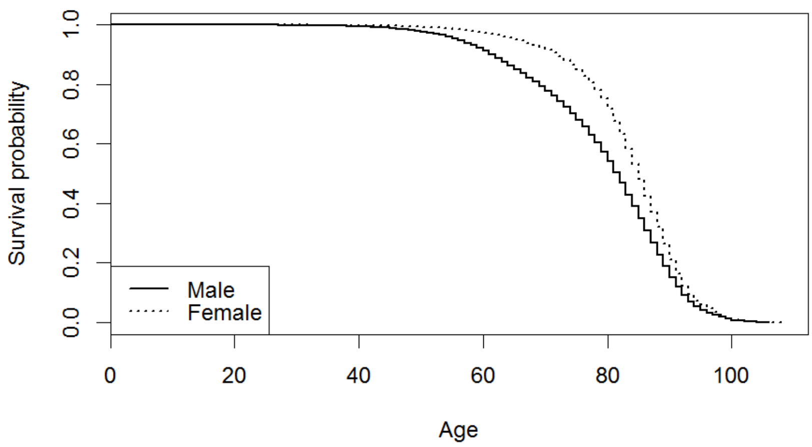

Figure 4. Survival function per sex group
Source: Authors' calculations using R Project

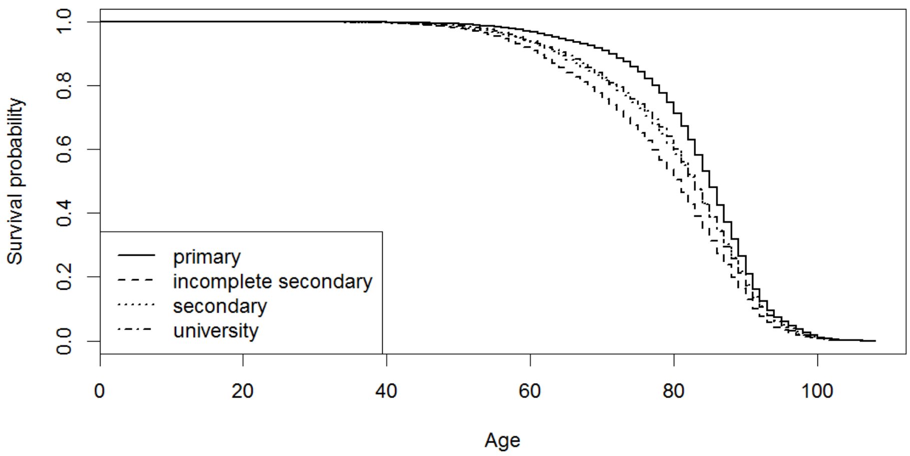

Figure 5. Survival function per education level
Source: Authors' calculations using R Project

We estimated the Cox proportional hazard model in order to quantify the differences between individual sex groups and education level groups. Results of the Cox proportional hazard model are presented in *Table 3*.

Table 3. Cox proportional hazard model results

	coef	exp(coef)	se(coef)	z	Pr(>|z|)	
sex	-0.32118	0.725294	0.007111	-45.168	0.000	***
edu2	0.39855	1.489664	0.008447	47.185	0.000	***
edu3	0.179631	1.196776	0.0098	18.33	0.000	***
edu4	0.083291	1.086858	0.015194	5.482	4.21E-08	***

Source: Authors' calculations using R Project.

As can be seen, both sex and education levels were statistically significant. In case of sex, females presented a lower level of hazard, corresponding to *Figure 4*, as females die on average at a higher age than males in the case of cardiovascular diseases. As for education levels, primary education group presents the lowest level of hazard in comparison to the other groups, again corresponding to *Figures 3* and *5*. The highest level of hazard is presented by the incomplete secondary education group.

3.4. Differences among sex groups within individual education groups

The next step was to see if there are differences between individual sexes within the given education groups, combining the two factors. Descriptive statistics for the education groups are presented in *Table 4*. An interesting observation is that while the diseases of the circulatory system are more prevalent causes of death for women (as was presented above), this only holds for the primary and incomplete secondary education groups. For the group with completed secondary education, the percentage of total deaths seems to be equivalent, however, for the university educated group, the percentage of total deaths for women seems to drop, accompanied by a shift in median age of death.

Table 4. Age and sex structure of deaths in relation to education

	% deaths men	% deaths women	Median age men	Median age women	25% men	25% women	75% men	75% women
primary	0.514	0.666	79	84	69	79	85	88
incomplete secondary	0.426	0.505	70	80	61	71	79	85
secondary	0.428	0.446	74	80	64	71	83	86
university	0.465	0.359	77	79	67	69	84	85

Source: Authors' calculations using R project.

To confirm this observation, a series of tests was performed to test for differences within the given education groups. The results are presented in *Table 5*.

Table 5. Results of the Mann-Whitney U test

	W statistic	p value
primary	1.79E+08	0
incomplete secondary	34464380	0
secondary	18276616	3.89E-117
university	1978817	7.80E-06

Source: Authors' calculations using R project.

As can be seen, statistically significant differences were detected in all the observed groups. To better illustrate these differences, a comparison of the distribution of deaths by age is presented in *Figure 6* for all the education groups. Confirming the prior observations, the age of death seems to be shifted for women towards higher age compared to men in all education groups as well as the total percentage of deaths being higher, with the exception of university education group.

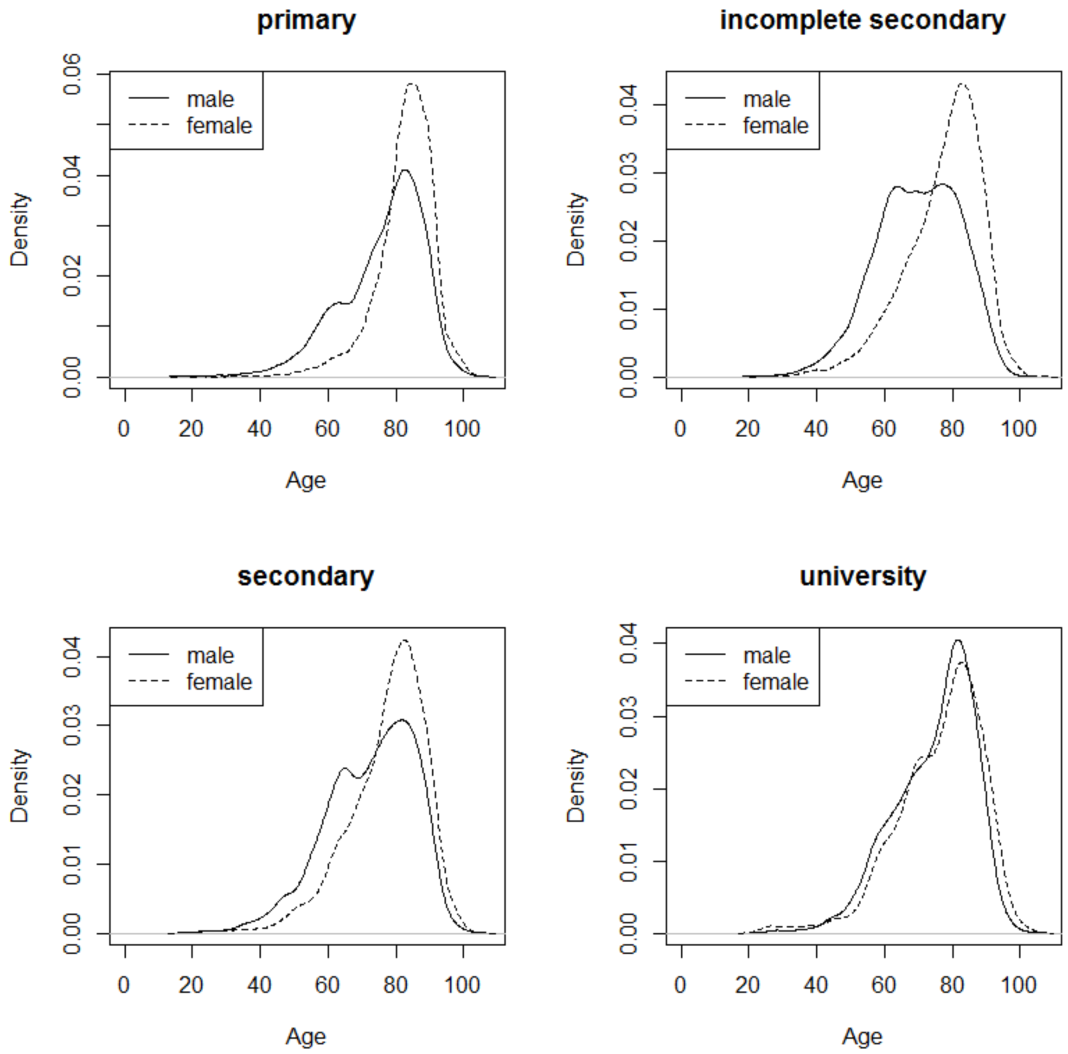

Figure 6. Age and sex distribution by education
Source: Authors' calculations using R Project.

Conclusions

In this paper we focused on the structure of cardiovascular disease mortality by educational level, age and sex in the Slovak Republic during the time period of 1996-2014.

Firstly, we evaluated development of mortality rate from cardiovascular diseases by sex. Our analysis revealed that standardised mortality rates from cardiovascular diseases decreased by an average of 31.5% for both sexes what can indicate improving life conditions concerning cardiovascular diseases in the Slovak Republic. However, men are more burdened than women likely relating to the men´ higher responsibilities for social status of their family.

Secondly, descriptive statistics of the age structure of the population was conducted, both for men and women. During the 1996-2014, the median age of death for men was 74 years of age compared to 70.5 years of life expectancy at birth. Women outlived men by about 8 years on 78.1 years and the median age was 81 years. The difference between median age and life expectancy at birth is narrowed for women than it is for men. This demonstrates that men are exposed to slightly higher risk of premature deaths compared to women.

Thirdly, we revealed the most serious causes of death within cardiovascular diseases separately in the age groups, namely for children, adolescents, young adults, adults and seniors. The leading causes of CVD death are Hearth failure (I50) and Cardiomyopathy (I42) accounting for up to the 50% of all deaths for persons under 30 years of age. Although, deaths of children (age group 7-14) at primary school or adolescents (age group 15-18) at the secondary school are also characterised by high occurrence of Nontraumatic intracerebral hemorrhage (I61). As for the adults, from 31 to 62 years of age, the myocardial infarction (I21) and chronic ischemic heart disease (I25) perform the main causes of death. Similarly, these two diseases and in addition Atherosclerosis (I70) are typical for seniors over 63 years of age. A professional medical assessment is required for a more detailed specification of deaths caused by these diseases.

Fourthly, we looked at the differences between people with different educational level to find out if there are some differences in their age structure of deaths. The primary education group accounted for the highest share on CVD mortality compared to the other education groups, however, primary educated people had died later than others.

Subsequently, we calculated Cox proportional hazard model to find out the highest level of hazard comparing education and sex. It provided information that women had a lower level of hazard compared to men. Additionally, primary education group represented the lowest level of hazard in comparison to the other education groups.

Finally, we detected if there are differences between individual sexes within the given education groups. We found that women died later than men in all education groups, however, the age of death is similar between both sexes in the university group. The highest difference in median age of death between men and women was found in incomplete secondary group.

Education plays an important role in different areas of life of the people. This is also reflected in mortality reports where mortality rate should decline faster for better educated people. Additionally, more educated people should die later than people with lower educational level. This is partly explained by healthier lifestyles and more appropriate use of the healthcare services (Soltes & Gavurova, 2014; Rogalewicz, 2015; Zavadil *et al*., 2015), what could be apparent in both prevalence of various diseases, mortality differences and effective hospital care delivery system (Pol & Thomas, 2013; Nováková & Šoltés, 2016; Bem *et al*., 2015; Siedlecki *et al*., 2015). However, our analyses did not confirm these assumptions. The possible reasons may be inactive prevention programs in Slovakia that could be reflected in the educational level of population. This requires the access to a deeper structured data what allows conducting a detailed analysis.

Public policy should aim at reducing health disparities and need to consider the possibility that education may have differential effects on incidence and mortality of CVD. It is desirable to extend our results in the further analyses, for example, relating to the cardiovascular risk factors influencing a targeted group of the Slovak population with the aim to eliminate economic, social and health inequality in a society.

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