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Educational differences in all-cause mortality Evidence from Bulgaria, Finland and the United States

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Keywords
all-cause mortality, Bulgaria, educational differentials, Finland, marital status, USA

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research article

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Using life table measures, we compare educational differentials in all-cause mortality at ages 40 to 70 in Bulgaria to those in Finland and the United States. Specifically, we assess whether the relationship between education and mortality is modified by marital status. Although high education and being married are associated with lower mortality in all three countries, absolute educational differences tend to be smaller among married than unmarried individuals. Absolute differentials by education are largest for Bulgarian men, but in relative terms educational differences are smaller among Bulgarian men than in Finland and the U.S. Among women, Americans experience the largest education-mortality gradients in both relative and absolute terms. Our results indicate a particular need to tackle health hazards among poorly educated men in countries in transition.

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1. Introduction

A well established pattern in the demographic, sociological, and epidemiological literature is that people with high education, high income, and high status occupations experience lower risks of death than do individuals from lower socioeconomic strata. This inverse relationship has been extensively documented for many industrialized countries (Adler et al. 1994; Antonovsky 1967; Drever et al. 1996; Elo and Preston 1996; Valkonen 1987, 1989; Valkonen and Martelin 1988, Mackenbach et al. 1997, 2000). A growing body of literature has also examined whether inequalities by socioeconomic status (SES) are uniform and to what extent they vary among countries (e.g., Valkonen 1989; Kunst and Mackenbach 1994; Sihvonen et al. 1998; Kunst et al. 1998; Mackenbach et al. 1997, 1999, 2000, 2003; Huisman et al. 2005; Shkolnikov et al. 2006). Several studies have revealed considerable variation in the magnitude of socioeconomic inequalities in mortality among developed countries, with inverse gradients typically larger for men than for women (Valkonen 1989; Mackenbach et al. 2004; Borell et al. 2005). Despite the considerable theoretical and health-policy relevance of comparative research, the evidence thus far has been based mostly on Western European countries and the United States. Eastern European countries have had limited representation in this comparative work with the exception of Estonia, Hungary, the Czech Republic, Russia, and recently, Lithuania (Carlson 1989; Hajdu et al. 1995; Carlson 2000; Mackenbach et al. 1999; Shkolnikov et al. 1998, 2004, 2007). Nonetheless, evidence suggests that socioeconomic differentials in mortality in both relative and absolute terms also exist in the former socialist countries of Central and Eastern Europe, and these differentials appear to be even larger than are those observed in Western Europe and other industrialized countries (Hajdu et al. 1995; Watson 1995).

In this paper, we contribute to the comparative research on educational inequalities in mortality in several ways. We focus our analysis on post-transition mortality in Bulgaria, an Eastern European country whose SES mortality and morbidity disparities have not previously been investigated in comparative studies. We set the Bulgarian experience in an international perspective by comparing it to that of Finland and the United States, countries included in previous international comparisons (e.g., Kunst and Mackenbach 1994; Mackenbach et al. 1999, 2000, 2003; Elo et al. 2006; Fawcett et al. 2005; Lorant et al. 2005). The three countries differ on many salient dimensions relevant to health and mortality. Finland represents a northern European country with a large sex difference in both overall mortality and the education-mortality gradient. High male mortality in Finland has been attributed in part to high levels of alcohol abuse, a pattern also common in Eastern Europe (Martelin et al. 2004; Watson 1995; Cockerham 1997; Cockerham et al. 2004). At the same time, Finland has universal health insurance coverage and a low level of income inequality, which sets it apart from post-transition countries such

as Bulgaria. The United States in turn is characterized by large income inequality. In addition, the country lacks a uniform national health insurance policy, with the result that many working-age adults have no or only limited health insurance coverage, while the elderly are covered by the national Medicare program (DeNavas-Walt et al. 2004). This large income inequality and unequal health-care coverage is also found in eastern European countries in transition, including Bulgaria. Given these contextual differences and similarities, a comparison of the three countries provides insights regarding the extent to which national differences in social, economic and health care policies may contribute to SES inequalities in mortality.

A specific aim of the present study is to quantify educational differentials in Bulgarian mortality in the 1990s and to place them in an international perspective. We further add an additional - much less often studied - perspective by including marital status and examining whether marital status and educational attainment interact in their association with mortality. Numerous studies have shown marital status to be closely associated with mortality, with the association typically stronger for men than for women (e.g., Hu and Goldman 1990; Valkonen et al. 2004). Evidence also suggests that mortality differentials by marital status are large in comparison with other socioeconomic characteristics (e.g., Martikainen et al. 2005). We hypothesize that the association between education and mortality also depends on the marital status of individuals. For instance, Smith and Waitzman (1994) found that individual-level poverty status interacted with marital status in the United States in the early 1980s such that poor, unmarried men between ages 25 and 64 were at highest risk of death. We examine whether a similar pattern also holds true in the 1990s in different social and economic contexts. We expect that education-marital status interactions will be most pronounced in Bulgaria, which was undergoing rapid economic and social transformations during the period under investigation. During this transition individuals with low levels of schooling were particularly disadvantaged. We hypothesize that the economic and psychosocial support from a spouse may have helped mitigate the negative consequences of severe economic hardship for underprivileged individuals.

We translate educational and marital status differentials in mortality into life-table measures that facilitate a straightforward comparison of the association of education and marital status with survival. We examine both *relative* differentials, which demonstrate how unequally the risk of death is distributed among social groups (Kunst et al. 2004), and *absolute* differences in survival, which reflect "more directly the public health significance of excess mortality of high risk groups" (Valkonen et al. 2004: 307).

We utilize individual-level data sets obtained from linkages between vital statistics records and censuses in Finland and Bulgaria and nationally representative survey data in the United States. Consequently, our data are not subject to the numerator/denominator bias present in some comparative studies that use dual data sources to estimate mortality

(for a discussion of this type of bias see for example Kunst et al. 2004; Shkolnikov et al. 2007).

The remainder of this paper is organized as follows. In the next section, we discuss relevant differences among the three countries and our choice of education and marital status as explanatory variables. Next, we describe our data and analytic strategy. We then report our findings, and we end with a discussion of our main findings.

2. Background

2.1 Choice of countries

Our discussion of educational and marital status inequalities in Bulgarian mortality during the 1990s is set in the context of Finland and the United States, two Western countries included in previous comparative studies (e.g. Mackenbach et al. 1999, 2000, 2003; Valkonen 1989; Leclerc et al. 1990; Lorant et al. 2005; Sihvonen et al. 1998; Elo et al. 2006). The three countries are characterized by considerable divergence in historical mortality trends, especially since the 1950s, as well as substantial socioeconomic and political differences during the 20th century. During the first half of the 20th century, the three countries underwent very similar demographic developments, namely large improvements in life expectancy for both sexes resulting primarily from steep declines in infectious diseases and infant mortality. By the beginning of the 1960s, life expectancy at birth was highest among Bulgarian men (67.47 years), followed by U.S. men (66.63 years) and Finnish men (65.40 years). In contrast, a lower life expectancy was recorded for Bulgarian women (70.94 years) than for Finnish women (72.39 years) or U.S. women (73.31) (Human Mortality Database 2008).

Beginning in the late 1960s, Bulgarian mortality trends diverged from those in the other countries when mortality improvements at adult working ages started to decelerate. In particular, between 1965 and 1989, male death rates at working ages rose and the progress in reducing female mortality stagnated. This reversal did not reflect short-term periodic fluctuations, but rather a continuous and steady trend that became particularly acute after the onset of the transition towards a market economy in 1989 (Kohler 2007). This development was not unique to Bulgaria, as the pattern was characteristic of many Eastern European counties, where life expectancies fell even below those observed in some developing countries (Feachem 1994). In the 1990s, Bulgaria continued to undergo considerable economic and political upheaval that led to substantial impoverishment of large segments of the population, a trend that further distinguished it from the other two countries. By the mid-1990s, male life expectancy at birth in Bulgaria was below what it had been in the mid-1960s, and female life expectancy continued to be below the levels observed in the other two countries (Human Mortality Database 2008). During this more

recent period, Bulgaria also remained an outlier in terms of other demographic patterns, including substantial out-migration and a decline in fertility to unprecedentedly low levels (Council of Europe 2003; Kohler et al. 2002).

Consistent with trends in other Western European countries, life expectancy in Finland improved substantially after the early 1960s, and by the mid-1990s male life expectancy was 72.8 years, and female life expectancy was 80.2 years. Although male and female mortality fell in all age groups, a large sex difference in life expectancy was still evident in the mid-1990s. A severe economic recession in the early 1990s was not associated with negative changes in life expectancy trends in Finland, in sharp contrast to the pattern observed in Bulgaria.

In the United States, following a period of stagnation in mortality improvements during the 1950s and early 1960s (Crimmins 1981), death rates began to fall in the late 1960s, and life expectancy increased in subsequent years. By the mid-1990s, U.S. life expectancy at birth had increased to 72.7 years for men and 79.2 years for women (Human Mortality Database 2008). Because of enduring racial disparities in health, life expectancy for whites exceeded that for the nation as a whole. In 1995, life expectancy was 73.4 years for white men and 79.6 years for white women (National Center for Health Statistics 1998).

Other important country-specific differences relevant to health are also notable. In Bulgaria prior to 1989, health care was free and accessible to everybody. However, similar to other former socialist countries, the health sector was a low priority during the Cold War and was subject to tight resource constraints (Davis 2000; Field 2000). In the 1990s, despite the introduction of various reforms in the health sector, the Bulgarian health-care system faced increasing budgetary constraints (Delcheva et al. 1997) and continued to be beset by inadequate resources and lack of medical equipment. The emerging private health care system in turn was expensive and unaffordable for a large segment of the population, resulting in stratified access and provision of health care. In contrast, Finland has the most egalitarian health care system of the three countries, with universal health insurance coverage that would be expected to provide uniform access to health care and to thus reduce SES differences in mortality. At the other end of the spectrum, in the United States publicly supported health insurance is limited to the elderly and to low-income children and adults, mainly women. In 1995, for example, approximately 15.4% of the US population had no health insurance coverage, and despite some public coverage for low income individuals, the percentage was even higher (24.3%) for those without high school education. Moreover, the quality and extent of coverage varied by insurance type (U.S. Census Bureau 2001).

2.2 Educational attainment and marital status

For substantive and methodological reasons, we focus our analyses on educational differentials in mortality at ages 40 to 70. Although the socioeconomic status of a population or of individuals can be assessed using several social and economic indices, education is preferable for this study for a number of reasons. First, education is a composite socioeconomic measure that is related to many other social and economic factors, such as social class, earnings and income, cognitive abilities, and health behaviors (Elo and Preston 1996). Level of schooling also indexes the socioeconomic position of individuals early in adulthood, as well as the stock of human capital available to them during their life course (see also Feldman et al. 1989; McDonough et al. 1999; Preston and Taubman 1994). In addition, other indices of SES, such as occupation or income, are problematic in the context of a transition economy such as Bulgaria's or when we are interested in measuring health and mortality differentials among women, some of whom have never worked or do not have independent sources of income.

Compared to other individual-level characteristics besides education, marriage has been found to have a particularly large impact on health outcomes, with married men and women showing a clear survival advantage over the unmarried. Moreover, several studies have demonstrated that the health benefits of marriage tend to be larger for men than for women (Hu and Goldman 1990; Murphy et al. 1997; Murray 2000; Lillard and Waite 1995; Rogers 1991; Waite and Lehrer 2003). Previous research further suggests that marital status accounts for at least some of the variation in educational differentials in mortality. In the Finnish context, for example, although the relative magnitude of unadjusted educational inequalities in mortality is larger for men than for women, these differences partly diminish once marital status is taken into account (Koskinen and Martelin 1994). By introducing marital status into the analysis, we further explore whether the educational gradient is different for the married and the unmarried, thus adding a new dimension to comparative research on educational inequalities in mortality.

3. Data

The analyses for Bulgaria and Finland are based on population census data linked to death records. For the United States, the data come from a nationally representative survey of the non-institutionalized civilian population linked to death records. The U.S. and Bulgarian populations are more heterogeneous in terms of their racial and ethnic composition than is the Finnish population. Thus, race/ethnicity is a potential confounder in the relationship between educational attainment and mortality in the United States and Bulgaria. In both countries race/ethnic minorities, e.g., non-Hispanic blacks and Hispanics in the

United States, and the Roma and Turkish ethnic groups in Bulgaria, have lower levels of education than do non-Hispanic Whites or ethnic Bulgarians, respectively. Furthermore, these groups face racial/ethnic discrimination that can affect both access to health-care services and other health-related resources. In addition, linkages to national death records are likely to be more complete for non-Hispanic whites than for non-whites in the United States (National Center for Health Statistics 2000). For these reasons, we have restricted our data for the United States to non-Hispanic whites and for Bulgaria to ethnic Bulgarians who report Bulgarian ethnicity and Bulgarian mother tongue in the census. We also restrict the Bulgarian and the Finnish data to the non-institutionalized civilian population to make them comparable to the data for the United States.

3.1 The Bulgarian data

The data for Bulgaria are individual-level and come from a linkage between the 1992 population census taken on December 4th and death certificates for the period December 5, 1992 to December 31, 1998. The link between the census and death records was performed by the National Statistical Institute of Bulgaria on the basis of a personal identification number that is uniquely assigned to each Bulgarian citizen and is included on death and census records. Approximately 93% of all death certificates for the study period were linked to the 1992 census records. Non-linkage of death records stems from incorrectly coded information on either the death or the census record and from internal and international migration during the 1990s that made it difficult or impossible to locate a deceased individual. As evidence of the latter, linkage rates are lower (about 89%) in regions that experienced high international migration during the 1990s. It is worth noting that these data are unique among Eastern European countries and represent an innovation for countries of Central and Eastern Europe.

Our mortality estimates for Bulgaria pertain to the period January 1, 1993 to December 31, 1997. Information on exact date of death comes from death records, and information on age at baseline, education, and marital status are obtained from the census records. The Bulgarian dataset is the largest of the three datasets used in this paper and comprises 3,339,817 men and women ages 40 to 70 during the period of observation (see Table 1). The mean length of follow-up for men is 4.17 (s.d. 1.4) years and for women is 4.23 (s.d. 1.4) years. During the study period, 6.9% of Bulgarian men and 3.2% of women at ages 40 to 70 died.

3.2 The Finnish Data

For Finland, we use an 11% random sample of the Finnish Longitudinal Census Data File (Statistics Finland, permission TK-53-1783-96) that is similar in its construction to the

Table 1: Descriptive Statistics, Bulgaria, Finland, and the United States

	Bulgaria		Finland		United States	
	Men	**Women**	**Men**	**Women**	**Men**	**Women**
Characteristic Age (%)[1]						
40-44	31.4	30.0	37.2	34.6	40.9	39.6
45-49	15.1	14.6	18.2	17.3	15.5	15.1
50-54	12.9	12.7	12.8	12.6	12.5	12.1
55-59	14.2	14.3	11.7	11.9	10.8	10.8
60-64	13.9	14.5	10.7	11.9	10.5	11.0
65-69	12.5	13.9	9.4	11.8	9.9	11.4
Educational attainment (%)[2]						
Low	42.2	44.7	47.0	48.5	15.4	14.5
Medium	40.7	37.8	39.5	39.3	35.4	43.3
High	17.2	17.3	13.5	12.2	49.1	42.2
Marital status (%)						
Married	86.0	77.1	69.5	65.6	82.7	74.7
Not married	14.0	22.9	30.5	34.4	17.3	25.3
Dead (%)	6.9	3.2	4.1	1.8	3.7	2.3
Mean years of follow-up	4.17	4.23	4.23	4.26	4.5	4.5
(s.d.)	(1.4)	(1.4)	(1.4)	(1.4)	(2.0)	(2.0)
Mean age at death	59.8	61.4	59.1	60.0	59.7	59.9
(s.d.)	(7.8)	(7.4)	(8.4)	(8.2)	(8.2)	(8.0)
Number of deaths	111,124	54,557	4,976	2,169	2,963	1,980
Number of observations	1,619,026	1,720,791	120,175	124,047	80,585	86,977

[1] The age group 40-44 years comprises almost twice as many people compared to the age group 45-49 years due to the fact that we allow individuals to enter our analysis if they reach age 40 during the period of observation.
[2] Education is coded to represent low, medium and high educational attainment in each country. Because of differences in educational systems, the levels of schooling correspond to slightly different years of completed education (see text for further details).

Bulgarian data. The individual-level dataset includes 244,222 men and women ages 40 to 70. The different Finnish data sources - census, population registration and death records - have been linked by Statistics Finland using a unique personal identification code. Non-linkage of death records to census records is less than 0.5%. Socio-demographic characteristics of respondents – age at baseline, educational attainment, and marital status – come from census records, and the date of death is based on the linked death record. These data have been used in previous studies to analyze mortality differentials by education (Martikainen and Valkonen, 1998), occupation (Valkonen et al. 2000), and family income (Martikainen et al., 2001), and to compare SES differentials in mortality in Finland to those in the United States (Elo et al. 2006).

For Finland, our mortality estimates pertain to the period January 1, 1994 to December 31, 1998. The mean years of follow-up are 4.23 (s.d. 1.4) for men and 4.26 (s.d. 1.4) for women. During the study period, 4.1% of men and 1.8% of women died.

3.3 The U.S. Data

The main difference between the US data and the Bulgarian and Finnish data is that the US data come from a nationally representative survey rather than a full census. We use the 1990-1994 waves of the National Health Interview Survey (NHIS) that have been linked to the National Death Index (NDI) through 1997 (Massey et al. 1989; National Center for Health Statistics 2000). The NHIS is an annual health survey of the civilian, non-institutionalized population of the United States dating back to 1957 and is the primary source of annual data on the health status of the US population. The survey's health and demographic core questionnaire collects information on socio-demographic characteristics of individuals residing in surveyed households, including information on age, race/ethnicity, marital status, and education. The National Center for Health Statistics has estimated that about 6% of female and 3% of male deaths are missed in the linkage to the NDI, with higher percentages estimated for non-whites (National Center for Health Statistics 2000).The NHIS-MCD linked data are considered the most reliable, large, nationally representative data source for the study of SES differentials in mortality in the United States in the 1990s (Rogers et al. 2000).

The mortality estimates for the United States pertain to the period 1990-1997, with 4.5 (s.d. 2.0) mean years of follow-up for men and women. Information on age, marital status, education, and race/ethnicity comes from the NHIS, and the date of death is obtained through the linkage to the NDI. The analysis of the U.S. data is based on 167,562 individual records. During the study period, 3.7% of the men and 2.3% of the women died (see Table 1).

3.4 Coding of educational attainment and marital status

Education was classified into three categories. Our low education category corresponds to 0-8 completed years of education in Bulgaria, 0-9 completed years of education in Finland, and to 0-11 completed years of schooling in the United States. Our medium education category corresponds to 9-12 completed years of education in Bulgaria, 10-12 completed years of schooling in Finland, and 12 completed years or a high school education in the United States. In all three countries, the highest educational category refers to 13+ completed years of education.

We use this coding of educational attainment to reflect substantive differences in educational systems across the three countries. We use two marital status categories: currently married and currently unmarried. The latter category includes those who were never married, divorced, separated, or widowed at the time of the census or the baseline NHIS interview. Due to sample size considerations, we were unable to make finer distinctions in the currently unmarried group.

4. Methods

We focus our analyses on ages 40 to 70. Mortality differentials by education and marital status are large at these ages, and deaths in this age range are considered premature (e.g. Elo and Preston 1996; Koskinen and Martelin 1994). To facilitate a comparison of educational inequalities in mortality, we calculate several life table measures using estimated age-specific death rates obtained from a parametric specification of the mortality hazard based on the following Gompertz model:

$$m(x) = a(z)\, e^{b(z)\, x}$$

The model assumes that the death rate $m(x)$ is an exponential function of age and a vector of covariates $z = (z_1, ..., z_n)$, i.e., in our case education and marital status. The parameter $a(z) = \exp(\alpha_0 + \alpha_1 z_1 + ... + \alpha_n z_n)$ determines the overall level of mortality for a given set of socioeconomic characteristics. The parameter $b(z) = \beta_0 + \beta_1 z_1 + ... + \beta_n z_n$ indicates how the risk of death changes with age for a given socioeconomic group.

The Gompertz model is appealing in the present analyses for several reasons. It is well documented that it aptly describes the age-specific mortality patterns at adult ages, where the logarithm of the risk of death increases linearly with age. In addition, we can calculate age-specific death rates by sex, educational attainment, and marital status using the parameter estimates obtained from the model.

In estimating the model, we allow individuals to age into the sample. That is, if an individual celebrates his/her 40th birthday during the period of observation, s/he enters our

analysis and is observed until either death or the end of the observation period, whichever comes first. In addition, we censor individuals at age 70. This strategy ensures that our mortality estimates pertain to ages 40 to 70 during the observation period. We estimate separate models by sex and country.

An illustrative example of the fit of the Gompertz model to our data is shown in Appendix 1A, which plots the observed and the fitted sex-specific death rates obtained from the model for each country. The fitted rates closely trace the observed death rates. The best fit of the model is observed for Bulgaria, where we have the largest number of observations. The model also provides a good fit to the data in all countries when disaggregated by educational attainment and marital status (results not shown).

The level and slope coefficients for education and marital status from all models are shown for men in Appendix 1B and for women in Appendix 1C. We find significant effects of education and marital status on mortality in all countries among both men and women, with some variation in the magnitude of these effects among countries and between men and women.

We used the coefficients shown in Appendix tables 1B and 1C to calculate the following life table measures to facilitate comparison among the three countries: the expected number of years of life lost (LE-lost) due to mortality between ages 40 and 70 (i.e., 30 years minus expected number of years lived between age 40 and 70), and the probability of dying by age 70 among those who survived to age 40. In addition, we also provide the approximate 95% confidence intervals for the LE-lost to reflect the uncertainty of our estimates. Appendix 2 describes the methodology we used to perform these latter calculations. To provide a measure of absolute inequality in mortality we calculate the differences in LE-lost and the probability of dying among the following groups:

(1) those at the highest and at the middle levels of education,
(2) those at the highest and at the lowest levels of schooling, and
(3) between the married and the unmarried. We assess relative inequality in mortality by calculating the ratio of the estimated probability of dying for those at the low and middle levels of schooling relative to those with the highest level of education.

5. Results

Descriptive statistics for the three countries are presented in Table 1. The age distribution in Bulgaria is slightly older than in Finland and the United States, a finding that is also reflected in a higher mean age at death in Bulgaria. Bulgarian men and women are more likely to be married than are men and women in the United States and Finland. The biggest difference among the countries is in the education distribution. More than 40% of

men and women in Bulgaria and Finland fall into the lowest level of education compared to only about 15% in the United States.

Bulgarian men have the highest mortality and can expect to live fewer years between ages 40 and 70 (25.6 years = 30-4.4) than either Finnish (27.1 years) or American men (27.6 years) (Table 2). Similarly, Bulgarian women have higher overall mortality than do Finnish and American women, although the cross-country differences are smaller for women than for men (Table 2). Because there is considerable variation in mortality patterns by gender within and between countries, we begin the next section with presenting first the results for men, followed by our findings for women.

5.1 Educational differences in male mortality

We find a clear education gradient in LE-lost in all three countries: the higher the level of education, the longer the lifespan between ages 40 and 70 and the fewer the expected years of life lost due to mortality. At the same time, male mortality is higher in Bulgaria than in Finland and the United Sates at all levels of education, with the largest cross-country difference found for men with low education. Men with low education reaching age 40 can expect to live about 2 years longer before age 70 in Finland and the United States than in Bulgaria, a difference that is statistically significant. These differences translate into the steepest education gradient in LE-lost in absolute terms in Bulgaria, where men with high education can expect to live 2.56 years longer than men with low education. The respective figure for Finland and the United States is 1.79 years (Table 2 and Figure 1). Moreover, 46% of 40 year-old Bulgarian men with low education will perish before reaching their 70th birthday, compared to 31% of men with high education. The respective percentages are 33% and 18% in Finland and 36% and 21% in the United States (Table 3). The greater absolute educational inequality in male LE-lost in Bulgaria reflects in part higher mortality at each level of education compared to Finland and the United States (upper left panel of Figure 1).

When educational inequalities in mortality are translated into relative terms, a somewhat different picture emerges. When measured as the ratio of the probability of dying between ages 40 and 70 at low relative to high levels of education, educational differences appear to be smaller in Bulgaria than in Finland and the United States: 1.52 in Bulgaria compared to 1.84 in Finland and 1.68 in the United States (Figure 1, lower left panel). When those with medium educational levels are compared to those with high education, the largest relative difference in the probability of dying is observed in Finland (1.47), while the values for Bulgaria and the United States are similar (1.23 and 1.20, respectively) (Table 2 and Figure 1, lower left panel).

We also document large differences in LE-lost by marital status, especially in Bulgaria and Finland, where married men between ages 40 and 70 live close to 3 years longer

Table 2: Life expectancy lost (LE-lost) by educational attainment and marital status, males and females, Finland, Bulgaria, and the United States in the 1990s [approximate 95%-confidence interval]

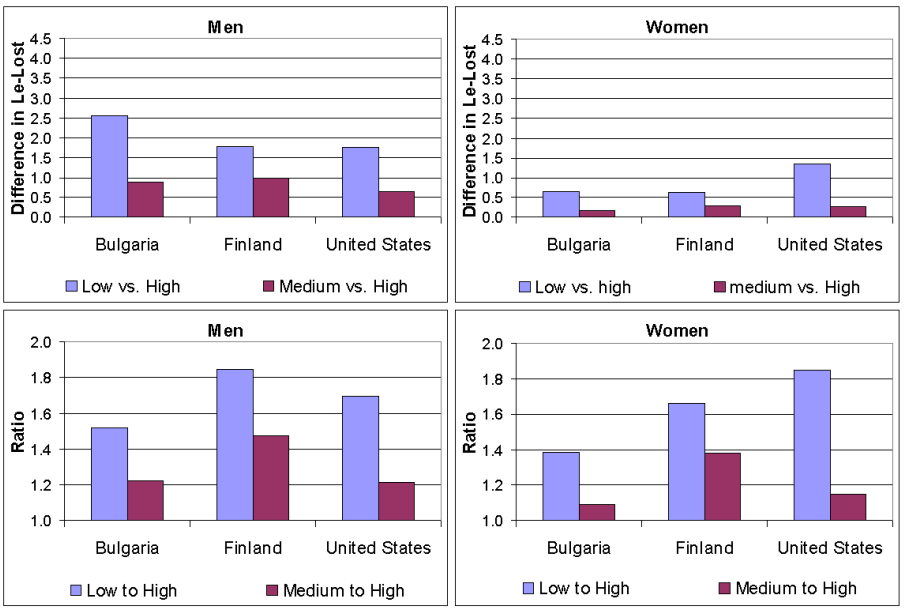
Educational attainment & marital status	Men			Women		
	Bulgaria	Finland	US	Bulgaria	Finland	US
	LE-Lost between age 40 and age 70 [1]					
All	4.36[4.33:4.39]	2.91[2.83:3.00]	2.40[2.30:2.50]	1.83[1.81:1.85]	1.20[1.14:1.26]	1.49[1.42:1.56]
Educational attainment						
Low	5.56[5.50:5.61]	3.46[3.32:3.60]	3.68[3.30:4.05]	2.12[2.09:2.16]	1.41[1.31:1.51]	2.55[2.22:2.88]
Medium	3.89[3.85:3.93]	2.64[2.51:2.78]	2.55[2.38:2.72]	1.65[1.62:1.67]	1.08[0.99:1.17]	1.44[1.32:1.56]
High	3.00[2.95:3.06]	1.67[1.49:1.85]	1.89[1.77:2.01]	1.48[1.44:1.52]	0.79[0.65:0.92]	1.19[1.09:1.29]
Marital status						
Married	3.91[3.88:3.94]	2.03[1.95:2.12]	2.05[1.94:2.15]	1.71[1.69:1.74]	0.98[0.91:1.04]	1.33[1.24:1.41]
Unmarried	6.89[6.81:6.98]	4.85[4.66:5.03]	4.04[3.75:4.33]	2.32[2.27:2.37]	1.66[1.53:1.78]	1.98[1.79:2.16]
Marital status & educational attainment						
Married						
Low	4.87[4.82:4.93]	2.29[2.15:2.43]	3.20[2.84:3.56]	1.97[1.93:2.01]	1.15[1.04:1.26]	2.27[1.93:2.61]
Medium	3.56[3.52:3.60]	1.94[1.80:2.07]	2.15[1.97:2.33]	1.54[1.51:1.57]	0.85[0.76:0.95]	1.31[1.18:1.43]
High	2.79[2.73:2.85]	1.39[1.21:1.57]	1.63[1.51:1.75]	1.36[1.32:1.41]	0.74[0.58:0.90]	1.04[0.93:1.14]
Unmarried						
Low	8.63[8.48:8.77]	5.45[5.17:5.73]	5.49[4.50:6.49]	2.79[2.69:2.89]	1.94[1.73:2.15]	3.33[2.65:4.01]
Medium	5.95[5.82:6.08]	4.41[4.10:4.71]	4.47[3.95:4.99]	2.07[2.00:2.15]	1.54[1.36:1.72]	1.87[1.58:2.17]
High	4.56[4.36:4.76]	3.04[2.46:3.61]	3.12[2.75:3.49]	1.89[1.78:1.98]	0.91[0.64:1.18]	1.62[1.36:1.88]

[1] LE-lost is calculated as follows: maximum life expectancy between ages 40 and 70 (e.g., 30 years) minus estimated life expectancy between ages 40 and 70.

Table 3: Probability of dying between ages 40 and 70 by educational attainment and marital status, males and females, Finland, Bulgaria, and the United States in the 1990s

Educational attainment & marital status	Men			Women		
	Bulgaria	Finland	US	Bulgaria	Finland	US
	Probability of dying between age 40 and age 70					
All	0.405	0.297	0.258	0.205	0.129	0.160
Educational attainment						
Low	0.463	0.332	0.355	0.226	0.143	0.238
Medium	0.374	0.265	0.254	0.178	0.119	0.148
High	0.305	0.180	0.212	0.163	0.086	0.130
Marital status						
Married	0.382	0.235	0.233	0.194	0.110	0.142
Unmarried	0.546	0.445	0.380	0.239	0.164	0.201
Marital status & educational attainment						
Married						
Low	0.432	0.257	0.324	0.214	0.121	0.217
Medium	0.354	0.214	0.223	0.166	0.098	0.134
High	0.291	0.160	0.198	0.150	0.085	0.113
Unmarried						
Low	0.615	0.471	0.472	0.267	0.181	0.287
Medium	0.498	0.419	0.413	0.212	0.156	0.188
High	0.411	0.290	0.289	0.196	0.092	0.169

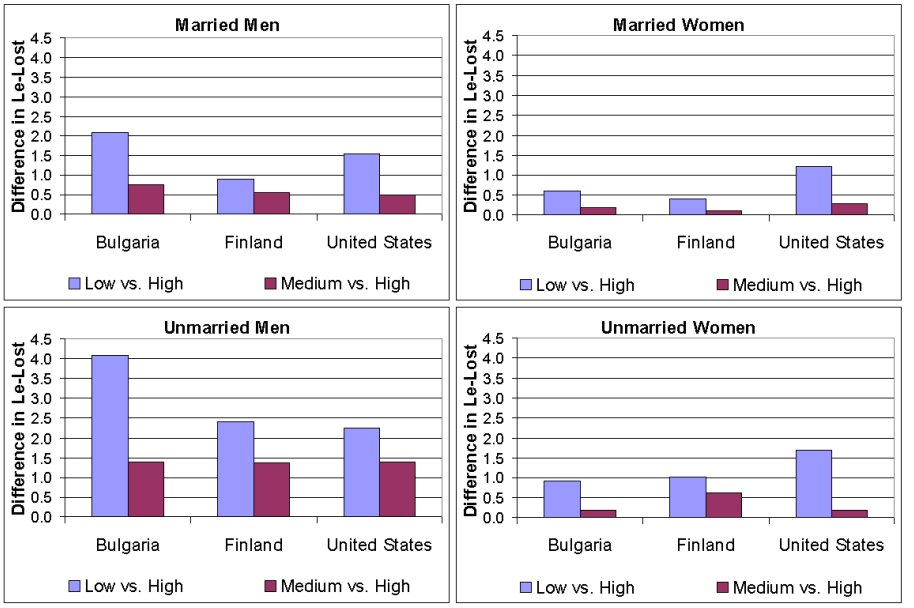
Figure 1: Absolute differences in LE-lost (upper panel) and relative differences in the probability of dying (lower panel) by education, ages 40-70



than do unmarried men. The difference in LE-lost by marital status is smaller in the United States (about 2 years) (Table 2). Within and between countries, these marital status differences are statistically significant. We further find that marital status modifies the association between education and mortality (Figures 2 and 3). Within each marital status group the absolute difference in LE-lost between men with low and high education is again most pronounced in Bulgaria: 2.08 years for married men and 4.07 for unmarried men compared to 0.90 years and 2.41 years, respectively, in Finland and 1.57 years and 2.37 years, respectively, in the United States. Although in all three countries unmarried men with low education have the highest mortality, this disadvantage is particularly striking in Bulgaria. Only 39% of 40 year old unmarried Bulgarian men with low education can expect to reach their 70th birthday. At the other extreme are highly educated married men in Finland, for whom the corresponding figure is 84% (Table 3).

Although absolute differences in LE-lost are largest in Bulgaria, again when assessed

Figure 2: Absolute educational differences in life expectancy lost (LE-Lost) by marital status, ages 40-70

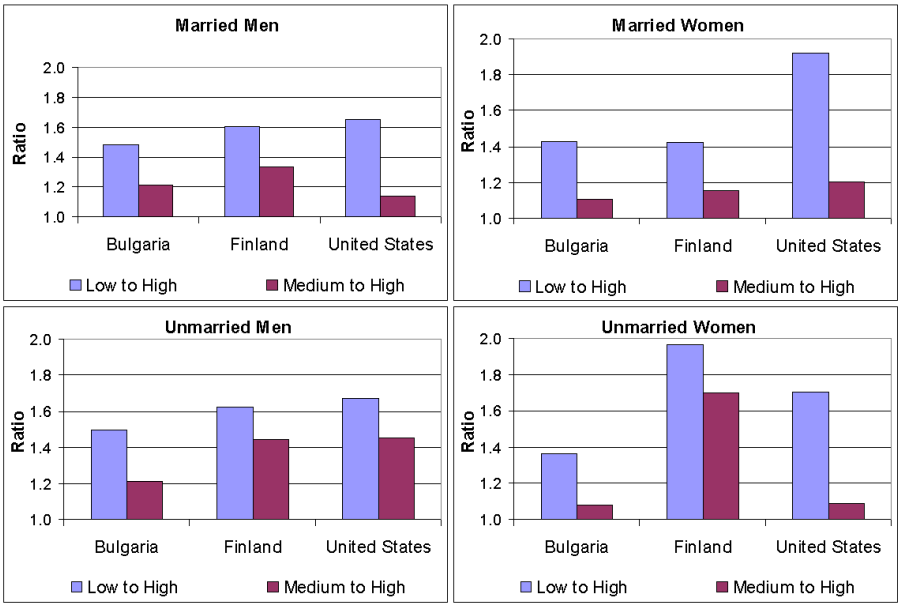


in relative terms the pattern of mortality differentials by education within marital status changes. Among married men, the relative low to high education differential in the probability of dying between ages 40 and 70 is largest in Finland and smallest in the U.S., while Bulgaria takes an intermediate position. Similar country ranking is observed when comparing medium to high education differences among married men (Figure 3, upper left panel). In contrast, Bulgarian unmarried men are characterized by the smallest relative differences in the probability of dying ${}_{30}q_{40}$ when comparing men with low versus high and medium versus high education. These differences are similar in Finland and the United States (Figure 3, lower left panel).

5.2 Educational differences in female mortality

Overall female mortality is slightly higher in Bulgaria than in Finland and the United States. The LE-lost between ages 40 and 70 for Bulgarian women is 1.83 years, about half a year higher than the corresponding estimate for Finnish women (1.20 years) and

Figure 3: Relative educational differences in probability of dying by marital status, ages 40-70



about a third of a year higher than the estimate for American women (1.49 years). These overall differences in LE-lost among the countries are statistically significant. We also observe clear educational and marital status differences in LE-lost in all three countries (Table 2).

We document not only the lowest LE-lost among Finnish women, but Finnish women also have significantly lower level of mortality than Bulgarian or American women whether mortality is stratified by educational attainment or marital status or both (Table 2). On the other hand, the pattern of absolute differences in LE-lost is less clear between Bulgarian and American women. For example, both married and unmarried Bulgarian women have higher mortality than married and unmarried American women. However, this pattern reverses at the lowest level of education whether or not we stratify by marital status. The estimated LE-lost among poorly educated American women is 2.27 among married women and 3.33 among unmarried women. The corresponding figures for Bulgarian women are 1.97 and 2.79. These differences between American and Bulgarian women

are not statistically significant. This Bulgarian female advantage, however, does not extend to higher levels of education (Table 2). Because of the higher mortality of the US women at the lowest level of education, the educational gradient in LE-lost also appears to be somewhat steeper in the United States than in Bulgaria.

Relative educational differentials in the probability of dying are smaller in Bulgaria than in the United States among both married and unmarried women. These differentials are also less pronounced among unmarried Bulgarian than unmarried Finnish women and they are similar in magnitude among married women in Bulgaria and Finland. The relative educational differentials in the probability of dying between ages 40 to 70 are most pronounced among unmarried Finnish women and married American women (Figure 3).

6. Discussion

6.1 Main findings and their interpretations

The present analyses focus on educational and marital status differentials in all-cause mortality in three developed countries - Bulgaria, Finland and the United States. For Bulgaria - and for Eastern Europe more generally - these analyses are of particular relevance, as they refer to the 1990s, a time period characterized by profound political, social and economic transitions. Furthermore, Bulgaria has not been previously included in comparative research, and little is known about how educational and marital status differentials in mortality in Bulgaria compare to those observed in other developed countries. An additional strength of our analysis is that we examine both relative and absolute differences in mortality using life table measures.

Consistent with previous literature, we document a clear education gradient in male and female mortality in Bulgaria, Finland, and the United States during the 1990s. We find greater absolute inequality in male mortality in Bulgaria than in Finland or the United States. This pattern, however, is less consistent in relative terms; relative differentials tend to be somewhat smaller in Bulgaria than in the other countries. These latter results are in contrast to findings by Mackenbach et al. (1999) and Shkolnikov et al (2004), who documented larger relative mortality differentials by educational attainment for men in the Czech Republic, Hungary, Estonia and Russia, compared to the United States, Finland, Norway, and Turin, Italy. These studies and ours, however, are not directly comparable as they cover different periods and age groups and use different methodologies.

We further find that the absolute educational difference in mortality is more pronounced among unmarried men than among married men in all countries. Unmarried men with low education have the highest level of mortality. This disadvantage is particularly striking in Bulgaria, where 61% of 40-year old unmarried men with low education can expect to die before their 70th birthday. This group may have also experienced high

mortality in the past as the combination of low education and being unmarried is strongly associated with social marginalization in Eastern Europe. We speculate that in Bulgaria the high mortality of unmarried men is partially due to the consequences of rapid social transformations, e.g., increases in male unemployment, declining access to health care, and worsening health behaviors (i.e., heavy drinking and high prevalence of smoking). Evidence from elsewhere shows that Bulgarian male mortality increased around the mid-1990s, with mortality from cardiovascular diseases being particularly high (Cruijsen and Ekamper 2004). Severe resource constraints in the health care sector may have also been a contributing factor by limiting access to more intensive cardiovascular care among men at the margins of society.

In contrast to men, Bulgarian women do not exhibit a similar mortality disadvantage. If anything, poorly educated Bulgarian women can expect to live somewhat longer than poorly educated American women between ages 40 and 70. Furthermore, the relative educational disparities in female mortality in Bulgaria are smaller than in Finland or the United States. At the same time, among women, the Finns are clearly better off in terms of LE-lost than Bulgarians or Americans. Finnish women have significantly lower mortality whether we stratify by educational attainment and/or marital status than American or Bulgarian women.

We also find that in each country, the LE-lost between the lowest and highest education group at ages 40 to 70 is bigger among men than women. Evidence from previous studies (Koskinen and Martelin 1994, Mackenbach et al. 1999) suggests that at least a part of this gender difference is due to differences in cause-of-death patterns among men and women. Such variation in causespecific patterns may also underlie the results reported here, but the investigation of this hypothesis is beyond the scope of this paper.

6.2 Data coverage and comparability

Although we have used the best data sources available for comparative analyses, we should note several limitations. Our first concern has to do with a difference in the type of data used. Both the Finnish and Bulgarian data come from censuses, which should better capture the entire population than do the survey data which cover only the non-institutionalized population as was the case in the United States. Nevertheless, the US data are considered highly reliable for analyses of SES differentials in US mortality (Rogers et al. 2000). To increase comparability, we excluded the institutionalized populations in Bulgaria and Finland.

Second, about 7% of the recorded deaths in Bulgaria were not linked to census records. Mitigating this limitation is the finding that education and marital status distributions of the nonlinked death records do not substantially differ from the linked death records. Non-linkage is thought to stem partly from incorrectly coded information on either the death

or the census record. Furthermore, a large segment of unlinked deaths are likely due to high migration after 1989 among such population subgroups as the Turkish minority and young individuals. Because we have excluded both the Turkish and Roma minorities, as well as the under 40 year-olds, we believe this non-linkage is unlikely to bias our results. In addition, non-linkage may bias estimates of mortality levels rather than educational differentials.

One of the challenges in conducting international comparisons of mortality differentials by any measure of SES is developing comparable measures (Valkonen 1993; Martikainen and Valkonen 1999). This issue is particularly important for our analysis, which compares educational differences in mortality in countries with different historical trajectories and socioeconomic and political contexts. To increase comparability, we classify educational attainment into three broad groups: low, medium, and high levels of schooling. Because of differences in educational systems, the low and medium educational categories differ slightly across countries in the number of completed years of education. In Bulgaria and Finland it is common for students who do not expect to advance to post-secondary-school education to enroll in vocational and technical schools that provide training for specific occupations. Because such training is commonly regarded as equivalent to completing a secondary school degree, we have included completion of such programs in the middle education categories in Bulgaria and in Finland. In the United States, on the other hand, completing a high school education is normative and regarded as a necessary precursor to enrollment in other educational venues. We believe that this coding of educational attainment better reflects differences in the educational systems across the three countries, as well as differences in educational achievement, life styles and the employment opportunities that schooling provides, than had we used the same number of completed years of schooling in each country. Furthermore, previous comparative analyses of Finland and the US show that these choices make relatively little difference (Elo et al. 2006).

6.3 Conclusions

We have shown both similarities and differences in mortality patterns by gender, educational attainment, and marital status in three countries with different economic and policy contexts. The striking similarity is the protective effect of higher educational attainment and being married on all cause-mortality in all three countries. The size of the absolute variation is remarkably similar for Finnish and American men and for Finnish and Bulgarian women despite the differences in context. We further find that in all countries, educational effects on mortality tend to be smaller among the married than the unmarried in absolute terms. The main differences have to do with the size of the education effects and the ranking of countries by gender. We find a steeper absolute (but not relative) edu-

cational gradient in mortality for Bulgarian men than for Finnish and American men. In contrast, the absolute education gradient in female mortality is not consistently larger in Bulgaria than in Finland or the United States.

Our results indicate that there may be a particular need to tackle health inequalities among men in Eastern European countries in transition. Although we are not able to examine trends in educational differentials in mortality in Bulgaria, evidence from Estonia (Leinsalu et al. 2003) indicates that life-expectancy differences by educational attainment at age 25 increased rapidly in that country during the 1990s. This increase was brought about by declining mortality at higher levels of education and increasing mortality at lower levels of schooling. Evidence from Estonia, together with our results for Bulgaria, suggests that men with low educational attainment are particularly vulnerable during the transition from socialist to free-market regimes. Whether high education confers benefits through increased income, life style choices that are health-related, or some other mechanism is not possible to examine with our data. Analysis of cause-specific mortality could help point to plausible explanations driving these patterns and shed light on whether cause-specific contributions to educational inequalities are similar across the three countries.

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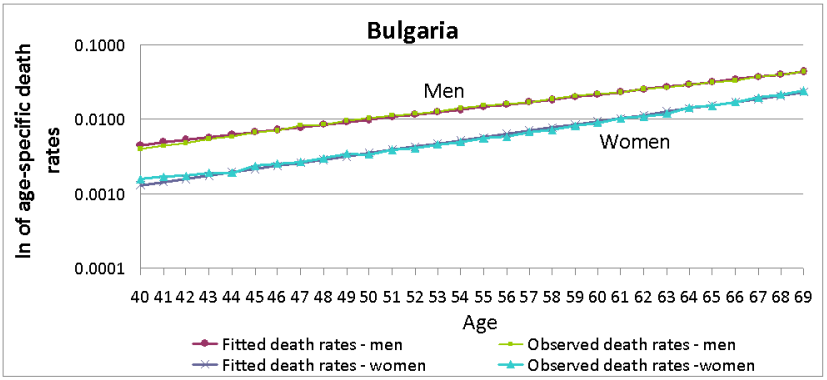
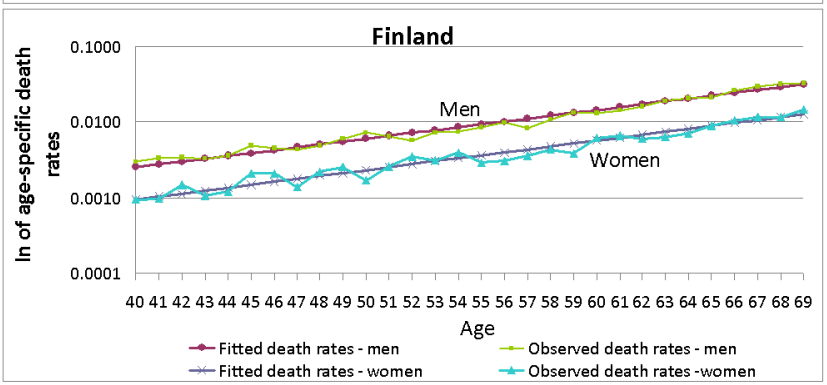
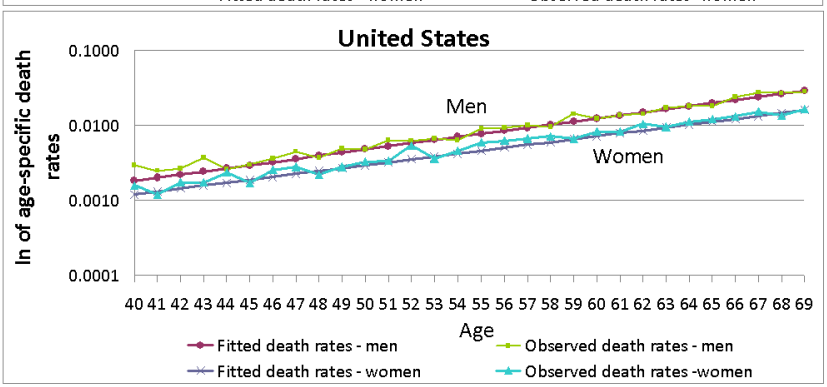
Appendix 1A: Observed and fitted death rates







Appendix 1B: Estimated coefficients from Gompertz models for men

	Bulgaria		Finland		U.S.	
	Level	**Slope**	**Level**	**Slope**	**Level**	**Slope**
Model 1 - no covariats						
	−8.558	**0.078**	**−9.523**	**0.087**	**−10.138**	**0.095**
	(0.023)	**(0.000)**	**(0.105)**	**(0.002)**	**(0.145)**	**(0.002)**
Model 2 - by educational attainment						
Constant	**−8.878**	**0.081**	**−9.403**	**0.083**	**−9.365**	**0.082**
(medium education)	**(0.038)**	**(0.001)**	**(0.182)**	**(0.003)**	**(0.205)**	**(0.003)**
Low education	**1.445**	**−0.019**	**0.522**	−0.004	0.427	−0.019
	(0.051)	**(0.001)**	**(0.231)**	(0.004)	(0.407)	(0.007)
High education	**−0.621**	**0.006**	**−0.911**	0.008	**−1.301**	**0.018**
	(0.078)	**(0.001)**	**(0.434)**	(0.008)	**(0.315)**	**(0.005)**
Model 3 - by marital status						
Constant (unmarried)	**−6.987**	**0.059**	**−8.436**	**0.078**	**−10.779**	**0.103**
	(0.045)	**(0.001)**	**(0.142)**	**(0.002)**	**(0.187)**	**(0.003)**
Married	**−2.063**	**0.026**	**−2.474**	**0.028**	**2.092**	**−0.025**
	(0.053)	**(0.001)**	**(0.210)**	**(0.004)**	**(0.360)**	**(0.006)**
Model 4 - by marital status and education [a]						
Married						
Constant	**−9.262**	**0.087**	**−10.521**	**0.098**	**−9.846**	**0.087**
(medium education)	**(0.043)**	**(0.001)**	**(0.258)**	**(0.004)**	**(0.273)**	**(0.004)**
Low education	**1.204**	**−0.016**	−0.083	0.005	0.387	0.001
	(0.059)	**(0.001)**	(0.343)	(0.006)	(0.432)	(0.007)
High education	**−0.500**	**0.004**	−0.595	0.004	**−1.670**	**0.025**
	(0.087)	**(0.001)**	(0.548)	(0.009)	**(0.388)**	**(0.006)**
Unmarried						
Constant	**−7.509**	**0.065**	**−8.785**	**0.082**	**−8.496**	**0.077**
(medium education)	**(0.079)**	**(0.001)**	**(0.265)**	**(0.005)**	**(0.395)**	**(0.007)**
Low education	**1.533**	**−0.020**	0.955	−0.013	0.721	−0.009
	(0.100)	**(0.002)**	(0.323)	(0.006)	(0.765)	(0.013)
High education	**−0.720**	**0.008**	−0.078	−0.006	−0.044	−0.007
	(0.172)	**(0.003)**	(0.747)	(0.013)	(0.571)	(0.010)

Note: Standard errors in parentheses. Coefficients significant at least at the 5% level are in bold.
[a] Model 4 estimated separately for married and unmarried individuals.

Appendix 1C: Estimated coefficients from Gompertz models for women

	Bulgaria		Finland		U.S.	
	Level	**Slope**	**Level**	**Slope**	**Level**	**Slope**
Model 1 - no covariats						
	−10.642	**0.099**	**−10.605**	**0.090**	**−10.328**	**0.089**
	(**0.037**)	(**0.001**)	(**0.164**)	(**0.003**)	(**0.175**)	(**0.003**)
Model 2 - by educational attainment						
Constant	**−10.374**	**0.092**	**−10.872**	**0.093**	**−10.049**	**0.083**
(medium education)	(**0.062**)	(**0.001**)	(**0.285**)	(**0.005**)	(**0.268**)	(**0.004**)
Low education	**0.279**	−0.002	**1.034**	**−0.014**	**1.325**	−0.013
	(**0.084**)	(0.001)	(**0.363**)	(**0.006**)	(**0.478**)	(0.008)
High education	−0.217	0.002	−0.223	−0.002	−0.615	0.008
	(0.116)	(0.002)	(0.669)	(0.012)	(0.483)	(0.008)
Model 3 - by marital status						
Constant (unmarried)	**−9.714**	**0.086**	**−9.537**	**0.076**	**−10.423**	**0.088**
	(**0.071**)	(**0.001**)	(**0.234**)	(**0.004**)	(**0.227**)	(**0.004**)
Married	**−1.075**	**0.014**	**−1.604**	**0.019**	0.743	−0.006
	(**0.083**)	(**0.001**)	(**0.326**)	(**0.005**)	(0.393)	(0.006)
Model 4 - by marital status and education [a]						
Married						
Constant	**−10.380**	**0.091**	**−11.402**	**0.098**	**−10.046**	**0.081**
(medium education)	(**0.072**)	(**0.001**)	(**0.401**)	(**0.007**)	(**0.315**)	(**0.005**)
Low education	0.046	**0.004**	**1.044**	−0.013	1.052	−0.009
	(0.098)	(**0.002**)	(**0.510**)	(0.009)	(0.558)	(0.009)
High education	**−0.298**	0.003	−0.164	0.000	−0.721	0.009
	(**0.139**)	(0.002)	(0.864)	(0.015)	(0.508)	(0.009)
Unmarried						
Constant	**−9.718**	**0.084**	**−9.836**	**0.081**	**−9.587**	**0.080**
(medium education)	(**0.124**)	(**0.002**)	(**0.401**)	(**0.007**)	(**0.473**)	(**0.008**)
Low education	**0.811**	**−0.009**	0.985	−0.014	**1.751**	**−0.021**
	(**0.164**)	(**0.003**)	(0.513)	(0.009)	(**0.788**)	(**0.013**)
High education	−0.201	0.002	−0.281	−0.005	−0.457	0.006
	(0.217)	(0.004)	(1.069)	(0.018)	(0.835)	(0.014)

Note: Standard errors in parentheses. Coefficients significant at least at the 5% level are in bold.

[a] Model 4 estimated separately for married and unmarried individuals.

Appendix 2: Estimation of standard errors and 95% confidence intervals based on Gompertz model

To account for uncertainty of our estimates, we calculate standard errors and 95%-confidence intervals using the following approach. The life expectancy ${}_{30}e_{40}$ and ${}_{30}e_{40}^{\text{lost}}$ are defined as the persons years lived, ${}_{30}e_{40} = \frac{{}_{30}L_{40}}{l_{40}}$, and the person years not lived, ${}_{30}e_{40}^{\text{lost}} = 30 - {}_{30}e_{40}$ between ages 40 and 70, conditional on surviving to age 40.

In the Gompertz model, both ${}_{30}e_{40}$ and ${}_{30}e_{40}^{\text{lost}}$ are nonlinear functions of the model parameters a and b, and the approximate variance of ${}_{30}e_{40}$ and ${}_{30}e_{40}^{\text{lost}}$ can thus be obtained using the *Delta Method* (Green 1997) that is, the general technique for determining the asymptotic distribution of non-linear functions of estimated model parameters. Other methods that have been suggested for the calculating the variance of the life expectancy in life tables (e.g., Chiang 1984), are not applicable to the present context because the calculation of ${}_{30}e_{40}$ is not based on a period life table (in which the ${}_{n}m_{x}$ are independent across age groups) but rather on a Gompertz model that is estimated on individual-level survival data, or cohort data.

The Gompertz model is implemented in STATA 10 as $\mu(x) = \exp(a + bx)$ and can be estimated via maximum likelihood estimation based on individual-level mortality data. In particular, the STATA command streg is used in our analyses to estimate the parameters a and b of this Gompertz model along with their variance-covariance matrix V. For the U.S. data, the estimation is additionally adjusted for the complex sampling design of the National Health Interview Survey (NHIS) using the svy command. The probability ${}_{n}p_{x}$ of surviving from age x to $x + n$ is then calculated from the Gompertz parameters as

$$ {}_{n}p_{x} = e^{\frac{\mu(x)-\mu(x+n)}{b}}, $$

where $\mu(x) = e^{a+bx}$. In addition, the derivatives $\frac{\mathrm{d}}{\mathrm{d}a}\,{}_{n}p_{x}$ and $\frac{\mathrm{d}}{\mathrm{d}b}\,{}_{n}p_{x}$, which are necessary for the Delta Method below, are given by

$$ \frac{\mathrm{d}}{\mathrm{d}a}\,{}_{n}p_{x} = {}_{n}p_{x} \cdot \log({}_{n}p_{x}) $$

and

$$ \frac{\mathrm{d}}{\mathrm{d}b}\,{}_{n}p_{x} = {}_{n}p_{x} \cdot \frac{x\,\mu(x) - (x+n)\,\mu(x+n) - \log({}_{n}p_{x})}{b}. $$

Summing the survivorship probabilities ${}_{n}p_{x}$ across ages then yields

$$ {}_{30}e_{40} = \frac{{}_{30}L_{40}}{l_{40}} = \sum_{x=41}^{70} \frac{1}{2\,l_{40}}(l_{x-1} + l_{x}) = \sum_{n=1}^{30} \frac{1}{2}({}_{n-1}p_{40} + {}_{n}p_{40}). $$

Using the Delta Method, the (asymptotic) variance of the estimated ${}_{30}e_{40}$ and ${}_{30}e_{40}^{\text{lost}}$ can then be obtained using $\text{var}({}_{30}\hat{e}_{40}) = \text{var}({}_{30}\hat{e}_{40}^{\text{lost}}) = G\hat{V}G'$, where $\hat{V}$ is the variance-covariance matrix of the estimated Gompertz parameters $\hat{a}$ and $\hat{b}$, and G is the gradient vector $G = \left(\frac{\mathrm{d}}{\mathrm{d}a}\,{}_{30}e_{40}, \frac{\mathrm{d}}{\mathrm{d}b}\,{}_{30}e_{40}\right)$, with

$$\frac{\mathrm{d}}{\mathrm{d}a}\,{}_{30}e_{40} = \sum_{n=1}^{30} \frac{1}{2}\,(\frac{\mathrm{d}}{\mathrm{d}a}\,{}_{n-1}p_{40} + \frac{\mathrm{d}}{\mathrm{d}a}\,{}_{n}p_{40})$$

and

$$\frac{\mathrm{d}}{\mathrm{d}b}\,{}_{30}e_{40} = \sum_{n=1}^{30} \frac{1}{2}\,(\frac{\mathrm{d}}{\mathrm{d}b}\,{}_{n-1}p_{40} + \frac{\mathrm{d}}{\mathrm{d}b}\,{}_{n}p_{40}).$$