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*Research Article*

## **The increasing mortality advantage of the married: The role played by education**

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## **The increasing mortality advantage of the married:**

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### **Abstract**

#### **BACKGROUND**

In several European countries the excess mortality of nonmarried people relative to the married has increased. In this study we describe in detail the increasing mortality advantage of the married in Norway and investigate the extent to which changes in educational composition of marital-status groups can account for this increasing mortality gap.

#### **METHODS**

Using register data for the entire population of Norway, we estimated discrete-time hazard models for mortality at age 50–89 in years 1975–2008. We also estimated one-year death probabilities by age, period, marital status, education, and spouse's education. These were used to calculate period-specific age-standardized death probabilities for marital-status categories and hypothetical versions of these, assuming constant death probabilities in each educational group in each marital-status category or constant educational distributions. Hypothetical and observed versions were then compared.

#### **RESULTS**

The mortality of nonmarried people relative to married people increased sharply over the years 1975–2008. During the first part of this period, mortality was constant or even increasing among the never-married, who at the end of the period could be considered as lagging 30 years behind the married. Educational patterns have changed markedly, but this explains only up to 5% of the increasing mortality disadvantage of the never-

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married. Educational changes have contributed more to the growing disadvantage of the widowed, while the picture is more mixed for the divorced.

## **CONTRIBUTION**

We demonstrate that there has been a large widening in the marital-status differences in mortality in Norway since the 1970s and that little of this difference can be attributed to changes in educational distributions.

## **1. Introduction**

In many richer countries, marriage rates have been decreasing for the past half-century, following an earlier increase in the middle decades of the 20<sup>th</sup> century. Nevertheless, most people marry, albeit at a later age and with a larger chance of seeing their marriage end in divorce (Sobotka and Toulemon 2008). Hundreds of studies carried out over more than 150 years have shown that the married have lower mortality than the never-married or the divorced or widowed, and evidence from several Western countries indicates that there have been increases in this mortality advantage over recent decades – in particular in the relative advantage, but in some cases also in the absolute (Valkonen, Martikainen, and Blomgren 2004). However, previous studies on the topic have suffered from limitations, including using death and exposure data from different sources (discussed in Murphy, Grundy, and Kalogirou 2007), using rather crude controls for age (e.g., Valkonen, Martikainen, and Blomgren 2004), or covering a short period of time (Murphy, Grundy, and Kalogirou 2007). Another limitation is that, even in studies using linked individual-level data (e.g., Martikainen et al. 2005), marital status typically has been measured only at a time some years before the observation window under consideration.

One previous study has investigated this issue in Norway. Using register data for the entire Norwegian population of older people (75–89 years) for the period 1970–2007, Berntsen (2011) analysed the relationship between an individual's marital status at the beginning of the year and his or her chance of dying within that year. She observed an increasing excess mortality of the nonmarried for many different causes of death. One aim of this study is to extend this previous research to consider a broader age group (50–89 years) that includes the middle-aged, among whom relative mortality differences by marital status have been found to be higher (Murphy, Grundy, and Kalogirou 2007). We also look in greater detail at absolute (in addition to relative) death probabilities for all marital-status categories to find out whether mortality has generally declined, or whether some marital-status categories have experienced an

increase (as reported for some countries by Valkonen, Martikaninen, and Blomgren 2004).

A number of societal changes might contribute to strengthen the association between marital status and mortality. Among these, we focus on the role of education. There is a well-known and strong negative association between a person's education and his or her mortality (Elo 2009). Additionally, among married people in Norway and some other countries, an association with the spouse's level of education has been reported (Kravdal 2008). At the same time, there has been a general expansion of education in recent decades, most strongly among women (Breen et al. 2012), and importantly, the changes over time in the educational distribution have varied across marital-status groups. In particular, whereas more highly educated women in Norway had lower marriage probabilities than the less-educated in the past, this is no longer the case (Kravdal and Rindfuss 2008). Indeed, a positive relationship between education and proportion currently married among women aged 40–49 has been reported for relatively gender-egalitarian European countries in recent years (Kalmijn 2013). Similarly, a study using U.S. data found that for women aged 35–44 in the late 2000s there was a positive relationship between education and the proportion ever-married (Manning, Brown, and Payne 2014). This change in the association between education and marriage among young or middle-aged married women compared to the never-married would imply an increased mortality advantage for married women in these age groups, given the association between higher levels of education and lower mortality. Additionally, changes in educational distributions by marital status may have further effects for spouses, given the evidence that a spouse's education is also associated with an individual's mortality risk. Thus, one may say that changes in educational distributions may have contributed to the increasing mortality advantage of the married, both through changes in the selection into marriage (i.e., how a person's education affects the chance of entering and remaining in marriage) and changes in the possible protective effects linked to a spouse's level of education.

The importance of a person's own education as a possible driver of the increasing mortality advantage of the married was assessed in the Finnish study mentioned above (Martikainen et al. 2005). The authors estimated a model with an interaction between marital status and period and included education to see how this changed the interaction. However, this study did not report the level of change and paid no attention to the possible role of the spouse's education, although, as just mentioned, other research has suggested that this may have an additional effect, and there has been an upward shift in its distribution.

The main aim of this study is to quantify explicitly the extent to which changes in the distribution of both a person's own education and their spouse's education have contributed to the widening mortality gap between the married and the nonmarried. To

do this, we calculate marital-status-specific death probabilities for hypothetical scenarios where educational distributions within each marital-status category change as observed, while the death probabilities in each educational group within each marital-status category remain constant, or vice versa. These hypothetical scenarios are compared with the observed marital-status-specific death probabilities. Women and men are analysed separately as many studies have concluded that there are gender differences in associations between marital status and mortality (Stahlin et al. 2012), and as there are also differences by gender in how educational distributions vary by marital status and in how this association has changed over time.

## **2. Theoretical considerations**

### **2.1 Contributions to the relationship between marital status and mortality**

It is well established that the association between marital status and health or mortality reflects not only causal effects but also selection (Waldron, Hughes, and Brooks 1996). For example, personal characteristics such as health, educational level, economic resources, and life style preferences influence the age at marriage and (more relevant for this study) the chance of ever marrying (Fu and Goldman 1996; Surkyn and Lesthaeghe 2004; Wiik 2009), and are also likely to have impact on long-term health and mortality. Such social and health factors of importance for marriage and health also affect the likelihood of marital dissolution (Lyngstad and Jalovaara 2010). Furthermore, the high mortality typically observed among the widowed is partly a result of shared environments and lifestyle characteristics that influence the health risks of both partners (Boyle, Feng, and Raab 2011).

The long-standing argument that marriage is health protective (the ‘causal’ side of the argument) focuses on how having a spouse may affect life circumstances that in turn promote better health. For example, spouses provide emotional and practical support in everyday life and during illness, and exert social control over health behaviours (Lewis and Butterfield 2007; Umberson and Montez 2010). The married are also more likely than the nonmarried to have children, who may provide similar social supports and further incentives for behavioural control (Kravdal et al. 2012; Umberson, Crosnoe, and Reczek 2010). Furthermore, there are economic benefits from marriage (Umberson, Pudrovska, and Reczek 2010; Wilmoth and Koso 2002) that may translate into health advantages through better living conditions or purchase of higher-quality health care. The exact nature of these economic and social marriage benefits obviously depends on spousal characteristics and the quality of the relationship (Hawkins and Booth 2005). In contrast, the never-married do not enjoy this type of social and

economic advantage, and the formerly married may have benefitted for a shorter duration than those continuously married. Additionally, the formerly married may be disadvantaged for a considerable period of time because of stress triggered by the divorce or the partner's death (Amato 2000; Carey et al. 2014). At least the divorced may tend to have a disadvantage compared to the majority of the married, while they may well be in a better situation than if they had remained in a poor marriage (Hawkins and Booth 2005). Below, we consider possible changes over time in these selective and causal influences that involve education.

## **2.2 Education and changes in the relationship between marital status and mortality**

### **2.2.1 Changes in the relationship between marital status and education**

In Western countries the widespread expansion of women's education over the past half century has been accompanied by changes in the association between education and marital status. As mentioned, the negative relationship between education and marriage has weakened in Norway (Kravdal and Rindfuss 2008), and there is evidence that higher education is now positively associated with marriage in the United States and in some gender-egalitarian countries of Europe (Kalmijn 2013; Manning, Brown, and Payne 2014).

This development may reflect the shift from a situation where the economic benefits from marriage were a result of 'specialization,' and would be particularly large if the woman had low wage potential (Becker 1991), to a situation where two wage earners can draw scale advantages by pooling their incomes and sharing a household. As argued by Oppenheimer (1997), the latter 'collaborative' regime is a strategy that makes the individuals less vulnerable, especially in modern industrialized societies. In such a regime, men can maximize their economic gains from marriage by choosing a woman who contributes substantially to the family income, which would favour more highly educated women. Furthermore, there are noneconomic rewards for both men and women to having a better-educated spouse, such as better communication skills that may help solve everyday problems (Oreopoulos and Salvanes 2011), and it is possible that men have placed stronger emphasis on these types of rewards over time. In any case, it is not only men's presumably stronger preference for having a better educated wife that increases the level of education of their wives. The general increase in women's education also contributes in this direction. However, the increase in wives' educational level may vary with the man's own education, partly as a result of the preferences for homogamous marriages and changes in these (Schwartz 2013).

Another implication of the shift from the specialization strategy to the collaborative strategy, where both partners have paid work, is that the male partner's income might become a less important determinant of marriage. (See Sassler and Goldscheider 2004, and Kalmijn 2011 for evidence in support of this idea, while Sweeney 2002 found a stable positive effect of men's income.) A weaker effect of income on marriage would contribute to weaken the positive association between men's educational level and marriage, unless the economic returns to education have increased. Such a change in the economic returns have actually taken place in several countries, but apparently not in Norway (Hægeland, Klette, and Salvanes 1999; OECD 2009). However, it is possible that any such development is counteracted by an increasing tendency among women to prefer better-educated men for noneconomic reasons, such as their more egalitarian gender role attitudes (Kalmijn 2013). In fact, a Norwegian study indicated that the latter was dominating, as there were signs of a gradually more positive association between men's education and marriage (Kravdal and Rindfuss 2008). This accords with the multicountry study by Kalmijn (2013), which showed that the relationship between men's education and being currently married was most strongly positive in countries where the gender roles are more egalitarian. Twisting the perspective again, such a development in the education–marriage association for men would also mean that women's spouses are better educated.

While there is some knowledge about recent educational changes among the never-married compared to the married or the ever-married, we know relatively little about changes further back in time. There is also little knowledge about the development among the formerly married. Härkönen and Dronkers (2006) have shown that the association between women's education and the chance of divorcing has become increasingly negative, or less positive, in many countries over past decades, including neighbouring Sweden. However, the educational distribution of the currently divorced is also influenced by the education–marriage relationship, as well as by the educational differences in the chances of remarriage (Grundy and Tomassini 2010). The trend in the educational distribution among widows also involves several factors: It is shaped by changes in the education–marriage association, in the level of educational homogamy, and in the education–mortality gradient.

### **2.2.2 The importance of own and spouse's education for mortality**

Given the inverse relationship between a person's own education and mortality, a particularly strong increase of the educational level among people in a certain marital-status group, such as among married women in recent years, should increase the



mortality advantage or decrease the mortality disadvantage of that group. The education–mortality relationship probably reflects a number of causal effects of education (Hayward, Hummer, and Sasson 2015), but also common determinants such as early-life deprivation. (For examples of the importance of selection, which one can never be sure is swept away even with the most advanced methods, see Behrman et al. 2011 and Clark and Royer 2013.) In either case, one can consider this a selection explanation for the changes in the marital-status differences in mortality, as the idea is that education, or factors linked to education, are determinants of marital status.

Similarly, a higher educational level of the spouse is associated with lower mortality independently of a person’s own education (Brown, Hummer, and Hayward 2014; Kravdal 2008; Skalica and Kunst 2008). This reflects to some extent selection through assortative mating (Schwartz 2013): For example, among persons with the same education, those with certain characteristics that are deemed attractive, and that could be linked to good health, may be particularly likely to get a partner with high education. However, there are also likely to be causal influences, including the health benefits that may be derived from the higher wages and better analytical skills of a better-educated spouse (although these health benefits may not have motivated the mating preference). Thus, it is a reasonable perspective that increases in spouse’s education, for reasons such as mentioned, can contribute to reduce mortality.

Another relevant issue is that associations between marital status and mortality may vary with the person’s own educational level, also given their spouse’s education. One reason is that better-educated women and men are more likely than the less educated to have attracted particularly resourceful spouses above and beyond what is measured by the spouse’s education. Furthermore, it is possible that the gains from marriage are highest among the most highly educated, net of the spousal characteristics. They may, for example, be able to deal in a better way with everyday problems, including the small conflicts that often arise in a relationship, which can benefit themselves as well as their partner. The implication of this possible education–marriage interaction is that, even if exactly the same educational expansion took place among the married as among the nonmarried, the difference in overall mortality between the two groups would increase. People would, so to speak, move up to higher educational levels, where effects of marriage are stronger. Also the differences in mortality between the three groups of nonmarried might be larger, or smaller, at the higher educational levels. This possibility that associations between marital status and mortality may vary with education, given the spouse’s education, is automatically taken into account in our calculations because we consider death probabilities (assumed to be constant) that are specific to each educational group within each marital-status category.

### **3. Data and methods**

#### **3.1 Data**

The core data source for this study was the Norwegian Population Register, which includes everyone who has lived in Norway at any point since 1964. Information about year of birth, death, immigration, and emigration (if any), and marital status at the beginning of each year since 1970, was taken from the 2008 version and older versions of the register. We distinguished four marital-status groups: the never-married, the currently married, the widowed, and the divorced/separated (referred to as ‘divorced’ below). Unfortunately, the data did not allow identification of those in cohabiting relationships, so this classification is based on de jure status. The remarried could only be identified if the remarriage took place after 1970, so they were not included as a separate category. For every individual, educational level in 1970, and every year since 1980, was added from the Educational Database operated by Statistics Norway. Similar information about the spouse (if any) was also added, using spouse identifiers that were available for the years after 1975. Because of the latter limitation, the analysis was restricted to 1975–2008.

#### **3.2 Statistical analysis**

##### **3.2.1 Estimation of hazard models and one-year death probabilities for separate groups**

Discrete-time hazard models were estimated from a series of one-year observations constructed for each individual. For those born in Norway, the first year of this series was when the person turned 50 years old, if he or she was born in 1925 or later; otherwise, the first year was 1975 (when the person was older than 50). The series started in the same year for immigrants or, if they had not yet immigrated at that time, in the year of immigration. The last year of observation was 2008, at age 89, or the year of emigration or death, whichever came first. Each one-year observation included information on the highest educational level achieved as of October the previous year or (for observations before 1980) in 1970. As very few people obtain further educational qualifications after the age of 40, the effect of this latter restriction is trivial. The observations also included marital status at the beginning of the year. Furthermore, for the married, we included the highest educational level attained by the spouse, defined in the same way as the person’s own education. If the individual was married at this time, but the spouse was not identified, or his or her education was not registered

(1.5%), the corresponding one-year observation was omitted. The one-year observations also included, of course, information on whether the person died within the year. Logistic regression models for the chance of dying within a year were estimated from the resulting series of one-year observations. The estimation was done separately for women and men and, in most cases, for separate periods of five or (at the end of the study period) four years.

Marital-status-specific one-year death probabilities were calculated for each five-year age group and the five-year (four-year) period from the one-year observations. This allowed us to consider absolute mortality levels and differences in addition to the relative differences.<sup>4</sup> These probabilities are shown for selected age groups and periods in an appendix table, but our interest primarily lies in the weighted sum over all age groups, with the age distribution among men in 1975–1979 used as weights. Such age-standardized one-year death probabilities for various marital-status categories were calculated for each period. The differences in these probabilities between marital-status groups or periods (or sexes) are, of course, not contaminated by the corresponding differences in age distributions.

### 3.2.2 Calculation of the implications of changes in educational distributions exclusively

For each age group and the first and last period, one-year death probabilities were also calculated (from the mentioned one-year observations) for each educational group in each marital-status category. These probabilities served as the basis for the assessments of how far educational changes have contributed to the widening of the marital-status differences in mortality. Note first that the death probability  $p_{na}^{(0)}$  for the never-married in age group  $a$  in 1975–1979 (period 0) is given by

$$p_{na}^{(0)} = \sum_i p_{nai}^{(0)} q_{nai}^{(0)},$$

where  $p_{nai}^{(0)}$  is the death probability for the never-married in age group  $a$  in 1975–79 who have educational level  $i$ , and  $q_{nai}^{(0)}$  is the proportion of the never-married in age group  $a$  in 1975–1979 who have educational level  $i$ . Both here and below, expressions for the widowed and the divorced are just as for the never-married, but for simplicity are not shown.

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<sup>4</sup> It should be noted that it is not misleading to compare mortality in various marital-status categories within a five-year age group, although the age distribution within this age group, in principle, may differ across marital status: Experimentation with hazard models showed that control for age within a five-year category mattered very little.

For the married, we also take into account the education  $j$  of the spouse, so their death probability is

$$p_{ma}^{(0)} = \sum_{ij} p_{maj}^{(0)} q_{mai}^{(0)} q'_{maj}{}^{(0)},$$

where  $q'_{maj}{}^{(0)}$  is the proportion who have a spouse with education  $j$  among those who themselves have education  $i$ .

However, we prefer to consider age-standardized probabilities instead of these probabilities for separate age groups, and therefore sum over age, using age-specific weights  $w_a$  given by the age distribution observed among men in 1975–1979 (regardless of their education and marital status). Thus, we obtain

$$p_n^{(0)} = \sum_a p_{na}^{(0)} w_a,$$

and

$$p_m^{(0)} = \sum_a p_{ma}^{(0)} w_a.$$

The mortality of the never-married compared to the married is

$$z_n^{(0)} = p_n^{(0)} / p_m^{(0)}.$$

Similarly, the death probabilities for the never-married and the married in 2005–2008 (period 1) are

$$p_{na}^{(1)} = \sum_i p_{nai}^{(1)} q_{nai}^{(1)},$$

and

$$p_{ma}^{(1)} = \sum_{ij} p_{maj}^{(1)} q_{mai}^{(1)} q'_{maj}{}^{(1)},$$

and the mortality of the never-married compared to the married, after having summed over age, using the age distribution for men in 1975–1979 as weights as above, is

$$z_n^{(1)} = p_n^{(1)} / p_m^{(1)}.$$

To get a reasonable measure of how much educational changes have contributed to the change in the ratio of the mortality among the never-married to that among the married (i.e., from  $z_n^{(0)}$  to  $z_n^{(1)}$ ) we need to construct corresponding ratios for

hypothetical situations. Consider first the situation (1') where the educational distributions in each marital-status category are as observed in 2005–2008, while the death probabilities in each educational group in each marital-status category are as in 1975–1979. In other words, we assume that the educational distributions have changed as observed from 1975–1979 to 2005–2008, while the death probabilities in each educational group have remained constant. In this case, the death probability among the never-married would be

$$p_{na}^{(1')} = \sum_i p_{nai}^{(0)} q_{nai}^{(1)},$$

and that among the married would be

$$p_{ma}^{(1')} = \sum_{ij} p_{maj}^{(0)} q_{mai}^{(1)} q'_{maj}^{(1)}.$$

The ratio of the corresponding age-standardized probabilities, after summing  $p_{na}^{(1')}$  and  $p_{ma}^{(1')}$  over age, would be

$$z_n^{(1')} = p_n^{(1')}/p_m^{(1')}.$$

To get an impression of how much the changes in educational distributions have contributed to the increase from  $z_n^{(0)}$  to  $z_n^{(1')}$ , one must somehow compare  $z_n^{(0)}$ ,  $z_n^{(1')}$ , and  $z_n^{(1'')}$ . We return to that below. However, one can also obtain a relevant measure of the importance of educational changes by considering the opposite hypothetical situation (1''), where the death probabilities in each educational group in each marital-status category are as in 2005–2008, while education distributions are as in 1975–1979 (i.e., a change in death probabilities from 1975–1979 as observed, while educational distributions remain constant). In this case, the death probability of the never-married would be

$$p_{na}^{(1'')} = \sum_i p_{nai}^{(1)} q_{nai}^{(0)},$$

while that of the married would be

$$p_{ma}^{(1'')} = \sum_{ij} p_{maj}^{(1)} q_{mai}^{(0)} q'_{maj}^{(0)}.$$

The ratio, after summing  $p_{na}^{(1'')}$  and  $p_{ma}^{(1'')}$  over age, would be

$$z_n^{(1'')} = p_n^{(1'')}/p_m^{(1'')}.$$

We consider

$$(z_n^{(1')} - z_n^{(0)}) / (z_n^{(1)} - z_n^{(0)})$$

or

$$(z_n^{(1)} - z_n^{(1'')}) / (z_n^{(1)} - z_n^{(0)})$$

to be reasonable measures of the relative importance of educational changes. These ratios plus the corresponding contributions from changes in the death probabilities in each educational group in each marital-status category (which are  $(z_n^{(1)} - z_n^{(1')}) / (z_n^{(1)} - z_n^{(0)})$  or  $(z_n^{(1'')} - z_n^{(0)}) / (z_n^{(1)} - z_n^{(0)})$ ) sum to 1. Below, we refer for simplicity to the use of these expressions as version 1 and version 2 of our approach, respectively.

It should be noted, however, that the two versions typically produce different results. In fact, there is a difference even if  $z_n^{(1)}/z_n^{(0)}$  and  $z_n^{(1)}/z_n^{(1'')}$  are equal (which they will be if the death probabilities are generated by certain simple models). The reason is, of course, that the differences in the numerator are the same as the ‘starting points’  $z_n^{(0)}$  or  $z_n^{(1'')}$  multiplied by  $z_n^{(1)}/z_n^{(0)}$  or  $z_n^{(1)}/z_n^{(1'')}$  minus one, and these ‘starting points’ are different because they are based on death probabilities in different years. In version 1, one applies changes in educational distributions to the death probabilities observed in 1975–1979, while in version 2, one applies them to the death probabilities observed in 2005–2008. An additional difference between version 1 and version 2 arises if  $z_n^{(1)}/z_n^{(0)}$  and  $z_n^{(1)}/z_n^{(1'')}$  are not equal. To give just one example of such a situation, the latter ratio will be larger (smaller) if education is more (less) negatively related to mortality among the married in the last period than in the first, while the relationship remains unchanged among the never-married.

One obviously cannot say that one of the versions provides a more reasonable picture of the importance of education than the other,<sup>5</sup> and we have used both of them in most of our analysis. The exception is that we, for simplicity, used only the first version when we assessed the separate contributions from changes in a person’s own education and changes in their spouse’s education. The first step of this analysis was to calculate the hypothetical death probability for the married if only the distribution of the person’s own education changes, which is

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<sup>5</sup> Note that there is a similar type of arbitrariness in the simpler situation where one deals with probabilities rather than the  $z$ ’s, which are ratios of probabilities. A death probability (let us call it  $C$ ) may be considered as a product of a vector of education-specific death probabilities ( $A$ ) and a vector representing an educational distribution ( $B$ ). Changes in  $C$  can be written as a sum of terms involving (changes in)  $A$  and  $B$  in various ways: (1)  $\Delta A \cdot (B + \Delta B) + A \cdot \Delta B$ , (2)  $\Delta A \cdot B + (A + \Delta A) \cdot \Delta B$ , or (3)  $\Delta A \cdot (B + \Delta B/2) + (A + \Delta A/2) \cdot \Delta B$  (Kitagawa 1955). Using expression (1), one may consider the part due to a change in  $B$  as  $A \cdot \Delta B$ , which would correspond to version 1 of our approach. The use of expression (2) would correspond to the second version.

$$p_{ma}^{(1')} = \sum_{ij} p_{maj}^{(0)} q_{mai}^{(1)} q'_{maj}^{(0)}.$$

This  $p_{ma}^{(1')}$  was used instead of the  $p_{ma}^{(1)}$  defined above to calculate  $z_n^{(1')}$ . The numerator of  $z_n^{(1')}$  (i.e., the probability  $p_{na}^{(1')}$  for the never-married and similarly for the other nonmarried) was as above.

The second step was to calculate the hypothetical death probability for the married if only spousal education changes, which is

$$p_{ma}^{(1'')} = \sum_{ij} p_{maj}^{(0)} q_{mai}^{(0)} q'_{maj}^{(1)}.$$

This  $p_{ma}^{(1'')}$  was then used instead of the  $p_{ma}^{(1)}$  defined above to calculate  $z_n^{(1'')}$ , while the numerator was  $p_{na}^{(0)}$  or similarly for the other nonmarried.

Note that, with this approach, the contribution from changes in a person's own education (to the growth in the excess mortality of the nonmarried) and the contribution from changes in their spouse's education do not necessarily sum up to the contribution from the combined changes of the two factors as estimated in the earlier stages of the analysis.

## 4. Results

### 4.1 Changes over time in the association between mortality and marital status and in the size of marital-status groups

Period-specific models controlling only for age show that the mortality gap between the nonmarried and the married widened over the period 1975–2008 (Table 1). The only exception is for divorced or separated men. The disadvantage of the never-married has increased most markedly, for both men and women.

**Table 1: Period-specific effects (odds ratios with 95% CI) of marital status in discrete-time hazard models for mortality. Norwegian women and men of age 50–89 in 1975–2008<sup>a</sup>**

	Married <sup>b</sup>	Never-married	Widowed	Divorced/separated
<b>Men</b>				
1975–1979	1	1.23*** (1.21–1.26)	1.24*** (1.22–1.26)	1.76*** (1.70–1.82)
1980–1984	1	1.29*** (1.27–1.32)	1.23*** (1.20–1.25)	1.79*** (1.74–1.85)
1985–1989	1	1.38*** (1.35–1.41)	1.29*** (1.27–1.31)	1.72*** (1.67–1.77)
1990–1994	1	1.47*** (1.44–1.50)	1.31*** (1.28–1.33)	1.71*** (1.66–1.76)
1995–1999	1	1.63*** (1.60–1.66)	1.32*** (1.30–1.35)	1.74*** (1.70–1.78)
2000–2004	1	1.78*** (1.74–1.82)	1.41*** (1.38–1.43)	1.78*** (1.74–1.83)
2005–2008	1	1.81*** (1.77–1.86)	1.44*** (1.41–1.47)	1.81*** (1.77–1.86)
<b>Women</b>				
1975–1979	1	1.16*** (1.14–1.19)	1.15*** (1.13–1.17)	1.34*** (1.29–1.39)
1980–1984	1	1.21*** (1.18–1.24)	1.17*** (1.15–1.20)	1.38*** (1.33–1.44)
1985–1989	1	1.26*** (1.23–1.29)	1.19*** (1.17–1.22)	1.45*** (1.40–1.50)
1990–1994	1	1.34*** (1.31–1.37)	1.23*** (1.20–1.25)	1.47*** (1.43–1.52)
1995–1999	1	1.43*** (1.39–1.47)	1.27*** (1.25–1.30)	1.49*** (1.44–1.53)
2000–2004	1	1.59*** (1.54–1.63)	1.34*** (1.32–1.37)	1.56*** (1.52–1.61)
2005–2008	1	1.71*** (1.66–1.77)	1.37*** (1.34–1.40)	1.60*** (1.55–1.64)

Note: <sup>a</sup> It was controlled for age in five-year categories. The estimates were almost identical if a linear effect of age was instead assumed. Moreover, controlling also for year within the five-year (four-year) interval had no impact on the estimates.

<sup>b</sup> Reference category. \*\*\* p<0.01.

As shown in Table 2, the proportion never-married in the broad age group 50–89 fell in the period considered, except over the last ten years of the observation period among men (Table 2). The proportion widowed has gone slightly down. However, the proportion divorced has, of course, increased markedly. Such numbers also reflect changes in age distributions, but when calculations were done separately for each five-year age group, a pattern resembling the overall pattern appeared in all of them (Appendix Table A-1). The only exception was that there was a clearly increasing proportion never-married over the last part of the study period among those in their 50s, while there was an opposite development among all other age groups. This reflects that marriage rates increased from the 1930s or earlier until the mid-1960s – giving a maximum proportion ever-married among those born about 1935 – after which the rates fell.<sup>6</sup>

<sup>6</sup> With regard to the sex differences, a relevant issue is that there is a boy surplus at birth that contributes to a larger proportion never-married among men than women. An opposite force in the oldest cohorts was the higher out-migration rates of men.



Given recent marriage trends, the increase in the proportion never-married that has taken place over the last decades among the youngest in our analysis will continue for some time, and a similar development will, after some years, be observed also at higher ages. Additionally, the proportion divorced at the higher ages will probably increase as the younger cohorts with more divorce experiences become older, depending on the development in remarriage.

**Table 2: Distributions (in percent) of exposure years over marital status, by periods, among Norwegian women and men of age 50–89**

	Married	Never-married	Widowed	Divorced/separated
<b>Women</b>				
1975–1979	57.7	12.7	25.7	3.9
1980–1984	56.9	10.9	27.7	4.5
1985–1989	55.7	9.3	29.5	5.6
1990–1994	55.8	7.8	30.0	7.5
1995–1999	54.8	6.7	28.3	10.2
2000–2004	55.2	6.3	25.6	13.0
2005–2008	55.3	6.8	22.5	15.4
<b>Men</b>				
1975–1979	77.0	11.7	8.0	3.4
1980–1984	76.4	11.2	8.0	4.3
1985–1989	75.3	10.7	8.2	5.9
1990–1994	73.9	10.0	8.1	8.0
1995–1999	72.2	9.5	7.5	10.8
2000–2004	70.4	9.7	6.7	13.2
2005–2008	68.1	10.9	6.0	15.0

#### 4.2 Development of absolute marital-status-specific death probabilities

Table 3 shows the age-standardized death probabilities for all marital-status categories in each of the five-year (four-year) periods. (The ratios between these, which are not shown in the table, are very similar to the hazard model odds ratios shown in Table 1.) Inspection of these probabilities reveals that the observed increase in the mortality of the never-married relative to that of the married is a result of a strong mortality decline among the married combined with a much weaker decline among the never-married. In fact, the death probability among never-married men increased from 1975–1979 to 1985–1989, and then fell slightly, but was in 1995–1999 still above the level in 1975–1979. After that, the death probability declined quite strongly. Among never-married

women, there was no improvement from 1980–1984 to 1990–1994, and the subsequent decline was modest. Thus, it is not only the relative mortality differences that have increased, but also the absolute. Interestingly, the never-married lag 30 years behind the married, both among women and men, in the sense that they had higher death probabilities in 2005–2008 than had the married in 1975–1979.

The widowed and divorced started with (essentially) the same or higher mortality than the never-married, but were at lower levels in 2005–2008. Mortality also increased among widowed men from 1980–1984 to 1985–1989, while it remained essentially unchanged among divorced or separated women over those years.

**Table 3: Age-standardized one-year death probabilities (per 1,000) among Norwegian women and men of age 50–89 in 1975–2008, by period**

	Married	Never-married	Widowed	Divorced/separated
<b>Women</b>				
1975–1979	17.18	20.24	19.44	22.40
1980–1984	15.47	19.08	18.03	20.78
1985–1989	14.69	19.02	17.66	20.86
1990–1994	13.67	19.26	17.00	19.87
1995–1999	12.30	18.76	16.00	18.30
2000–2004	10.85	18.55	15.44	17.32
2005–2008	9.45	17.65	14.07	15.70
<b>Men</b>				
1975–1979	29.07	35.32	38.06	46.41
1980–1984	28.08	35.93	34.98	45.63
1985–1989	26.86	37.18	36.61	42.48
1990–1994	24.56	36.58	33.54	39.35
1995–1999	21.75	36.24	30.46	35.71
2000–2004	18.36	33.27	27.98	31.25
2005–2008	15.56	30.00	25.03	27.49

A moderate decline, or even an increase, among the never-married also appeared when the various age groups were considered separately (see Appendix Table A-2, which also includes standard deviations of death probabilities). Furthermore, these figures also showed a less adverse development compared to the married among the other groups of nonmarried.

### 4.3 Own and spouse's education

As explained above, death probabilities for each educational group in each marital-status category are building blocks in our assessment of how much the changes in educational distributions have contributed to the increasing mortality advantage of the married. However, rather than show all these death probabilities for relevant periods and for all age groups, we show the estimated effects in a hazard model that includes a variable with the same categories, based on data for all ages and years considered (Table 4).<sup>7</sup>

**Table 4: Effects (odds ratios with 95% CI) of a person's marital status and education and their spouse's education in discrete-time hazard models for mortality. Norwegian women and men of age 50–89 in 1975–2008<sup>a</sup>**

	Spouse's education			
	Primary	Lower secondary	Higher secondary	Tertiary
<b>Men</b>				
<b>Married</b>				
Primary	1 <sup>b</sup>	0.89*** (0.88–0.90)	0.85*** (0.82–0.89)	0.76*** (0.73–0.80)
Lower secondary	0.89*** (0.88–0.90)	0.79*** (0.78–0.80)	0.75*** (0.73–0.77)	0.70*** (0.69–0.72)
Higher secondary	0.90*** (0.89–0.92)	0.78*** (0.77–0.80)	0.75*** (0.72–0.77)	0.66*** (0.64–0.69)
Tertiary	0.73*** (0.71–0.75)	0.66*** (0.65–0.67)	0.62*** (0.60–0.63)	0.54*** (0.53–0.55)
<b>Never-married</b>				
Primary	1.36*** (1.34–1.37)			
Lower secondary	1.18*** (1.16–1.20)			
Higher secondary	1.21*** (1.17–1.25)			
Tertiary	0.94*** (0.90–0.97)			
<b>Widowed</b>				
Primary	1.21*** (1.20–1.22)			
Lower secondary	1.11*** (1.09–1.12)			
Higher secondary	1.16*** (1.14–1.18)			
Tertiary	0.94*** (0.92–0.96)			
<b>Divorced/separated</b>				
Primary	1.71*** (1.68–1.73)			
Lower secondary	1.43*** (1.40–1.46)			
Higher secondary	1.30*** (1.26–1.33)			
Tertiary	0.90*** (0.87–0.93)			

<sup>7</sup> Such a variable that combines marital status and the person's own education and their spouse's education has been included in a recent paper by Kravdal (2017), but not in any earlier investigation. The education of the person and of the person's spouse have usually been included as separate variables. In the studies where these variables have been combined, the focus has been on either the married exclusively (Martikainen 1995) or on all groups of the ever-married combined (Spoerri et al. 2014), or all marital-status groups have been included without distinguishing between the various categories of nonmarried (Martelin 1994).

**Table 4: (Continued)**

	Spouse's education			
	Primary	Lower secondary	Higher secondary	Tertiary
<b>Women</b>				
<b>Married</b>				
Primary	1 <sup>b</sup>	0.89*** (0.87–0.90)	0.91*** (0.89–0.94)	0.82*** (0.78–0.85)
Lower secondary	0.82*** (0.80–0.84)	0.75*** (0.73–0.76)	0.74*** (0.72–0.76)	0.67*** (0.65–0.69)
Higher secondary	0.55*** (0.51–0.60)	0.61*** (0.58–0.65)	0.69*** (0.66–0.72)	0.60*** (0.58–0.63)
Tertiary	0.69*** (0.64–0.74)	0.61*** (0.58–0.65)	0.56*** (0.53–0.59)	0.54*** (0.53–0.56)
<b>Never-married</b>				
Primary	1.31*** (1.30–1.33)			
Lower secondary	1.08*** (1.06–1.09)			
Higher secondary	1.06*** (1.02–1.11)			
Tertiary	0.92*** (0.90–0.94)			
<b>Widowed</b>				
Primary	1.17*** (1.16–1.18)			
Lower secondary	0.99* (0.98–1.00)			
Higher secondary	0.87*** (0.84–0.89)			
Tertiary	0.86*** (0.84–0.88)			
<b>Divorced/separated</b>				
Primary	1.46*** (1.44–1.49)			
Lower secondary	1.17*** (1.15–1.20)			
Higher secondary	0.90*** (0.86–0.94)			
Tertiary	0.83*** (0.79–0.86)			

Note: <sup>a</sup> The models also included age and year in five-year (four-year) categories.

<sup>b</sup> Reference category. \*p<0.10; \*\* p<0.05; \*\*\* p<0.01.

The mortality difference between the extreme categories is large. For example, the odds of dying among men with tertiary education married to women with tertiary education are 46% lower than among men with primary education married to women with primary education (odds ratio 0.54, 95% CI 0.53–0.55). The odds among divorced men with primary education are 71% higher (odds ratio 1.71, 95% CI 1.68–1.73). The corresponding odds ratios for women are 0.54 and 1.46.<sup>8</sup>

<sup>8</sup> Even education beyond a Master's degree is associated with a further reduction of mortality (see Appendix Table A-3), but because of the relatively small proportions who have a Master's or PhD degree, those with some or completed tertiary education were combined into one group throughout our analysis. If a model such as that shown in Table 4 was estimated for men, and Master's degree and PhD were included as separate categories, the point estimate was 0.31 (95% CI 0.19–0.51) if both spouses had a PhD. For women, the corresponding estimate was 0.76 (95% CI 0.45–1.30).

#### 4.4 Changes in the educational distributions in different marital-status groups

Instead of showing how the distributions over four categories of a person's own education and their spouse's education have changed, we give a simpler description based on averages. For all marital-status groups, the average number of years of schooling was calculated by setting years of schooling to 10, 11, 12.5, and 15 in the four educational categories (Table 5). This was done separately for selected age groups because of the large differences in age distributions between marital-status categories and the large variation in educational distributions, and in the changes in these, across age.

Among men of age 50–54, the average education in 1975–1979 was higher among the married than among the nonmarried, and lowest among the never-married. The increase up to 2005–2008 was largest among the never-married, but the differences between the marital-status groups were not large. The education of spouses increased, of course, substantially. Note that the figure shown is the overall increase in spousal education, not the increase at a given level of the person's own education. It turned out, however, that there was an increase in spousal education also within each category of the man's own education. In the four educational categories, the average years of spouse's education increased from 10.32 to 11.48, from 10.79 to 11.84, from 11.11 to 12.19, and from 12.31 to 13.72, respectively (not shown). Thus, the increase in spousal education within a category of own education was between 1.05 and 1.41 years. Among men in the older age groups, the married experienced the largest increase in education, and the never-married experienced the smallest increase. Furthermore, in all these ages groups and for each category of the person's own education, there was an increase in the spouse's education.

**Table 5: Average years of education in 1975–1979 and 2005–2008, for selected age groups**

	Education 1975–1979 (years)	Education 2005–2008 (years)	Difference in education between 1975–1979 and 2005–2008 (years)
<b>Women</b>			
<b>Age 50–54</b>			
Married, own education	10.75	12.38	1.63
Married, spouse's education	11.18	12.50	1.32
Never-married	11.18	12.53	1.25
Widowed	10.62	11.92	1.30
Divorced/separated	10.84	12.22	1.38

**Table 5: (Continued)**

	Education 1975–1979 (years)	Education 2005–2008 (years)	Difference in education between 1975–1979 and 2005–2008 (years)
<b>Women</b>			
<b>Age 60–64</b>			
Married, own education	10.51	11.75	1.24
Married, spouse's education	10.87	12.15	1.28
Never-married	10.90	12.07	1.17
Widowed	10.45	11.36	0.91
Divorced/separated	10.61	11.79	1.18
<b>Age 70–74</b>			
Married, own education	10.45	11.17	0.72
Married, spouse's education	10.78	11.69	0.91
Never-married	10.78	11.62	0.84
Widowed	10.42	10.93	0.51
Divorced/separated	10.55	11.26	0.71
<b>Age 80–84</b>			
Married, own education	10.36	10.98	0.62
Married, spouse's education	10.65	11.51	0.86
Never-married	10.67	11.38	0.71
Widowed	10.34	10.74	0.40
Divorced/separated	10.48	11.07	0.59
<b>Men</b>			
<b>Age 50–54</b>			
Married, own education	11.26	12.58	1.32
Married, spouse's education	10.81	12.49	1.68
Never-married	10.59	11.98	1.39
Widowed	10.90	12.19	1.29
Divorced/separated	10.99	12.12	1.13
<b>Age 60–64</b>			
Married, own education	10.93	12.37	1.34
Married, spouse's education	10.57	11.91	1.34
Never-married	10.42	11.60	1.18
Widowed	10.67	11.93	1.26
Divorced/separated	10.81	11.96	1.15
<b>Age 70–74</b>			
Married, own education	10.82	11.74	0.92
Married, spouse's education	10.47	11.31	0.84
Never-married	10.38	10.92	0.54
Widowed	10.60	11.42	0.82
Divorced/separated	10.74	11.56	0.82
<b>Age 80–84</b>			
Married, own education	10.73	11.50	0.77
Married, spouse's education	10.41	11.04	0.63
Never-married	10.34	10.72	0.38
Widowed	10.50	11.24	0.74
Divorced/separated	10.73	11.38	0.65

In contrast to the situation among men of the same age, education increased more among married than nonmarried women of age 50–54, in line with the mentioned findings in an earlier study (Kravdal and Rindfuss 2008). To be more specific, a higher average number of years of education among the never-married than among the married in 1975–1979 turned to no difference in 2005–2008. The educational increases were also largest among the married at ages 55–59 (not shown in tables) and at ages 60–64, although the pattern was barely visible in the latter age group. At the higher ages, the upward shift in education was most pronounced among the never-married. It was least sharp among the widowed (a pattern that also appeared at age 55–64). There is no obvious explanation for the development among the widowed. As explained above, several factors – of which there is modest knowledge – have contributed. Among the married women, the education among spouses increased. With a few exceptions, it also increased given the woman’s own education, but less markedly than the corresponding increase in the spouse’s education among men (not shown).

#### **4.5 How much have the changes in educational distributions contributed?**

As already shown in Table 2, the age-standardized death probability in 1975–1979 was 35.32 (per 1,000) among never-married men and 29.07 among the married. The ratio between these probabilities is 1.215. The corresponding ratio in 2005–2008 was 1.928, while it would have been 1.232 in the hypothetical situation where death probabilities in each educational group within each marital-status category had remained as in 1975–1979, but the educational distributions had changed as actually observed between 1975–1979 and 2005–2008 (Table 6). In the opposite hypothetical situation, where the death probabilities in each educational group in each marital-status category had changed as observed between 1975–1979 and 2005–2008, while educational distributions had remained as in 1975–1979, the ratio of the mortality among the never-married to that among the married would have been 1.892. Thus, one can say that changes in educational distributions alone, while the death probabilities in each educational group in each marital-status category remain as in 1975–1979, are responsible for 2.4% ( $= (1.232 - 1.215) / (1.928 - 1.215)$ ) of the change in the ratio of the mortality among the never-married to that among the married. Alternatively, one may just as well say that the contribution is 5.0% ( $= (1.928 - 1.892) / (1.928 - 1.215)$ ), assuming that death probabilities in each educational group in each marital-status category are constant at the 2005–2008 level (and when the relationship between mortality and education may be different).

**Table 6: Age-standardized death probabilities (per 1,000) in 1975–1979 and 2005–2008, age-standardized death probabilities relative to the married, and the proportion of the increase in the age-standardized death probability relative to the married that is explained by changes in a person’s own education and their spouse’s education**

	Never-married	Married	Widowed	Divorced/ separated
<b>Men</b>				
Age-standardized death probability 1975–1979 (A: Relative to the married)	35.32 (1.215)	29.07	38.06 (1.309)	46.41 (1.596)
Age-standardized death probability 2005–2008 (B: Relative to the married)	30.00 (1.928)	15.56	25.03 (1.609)	27.49 (1.777)
Age-standardized death probability, if death probabilities for marital- status and education categories are as in 1975–1979 and educational distributions are as in 2005–2008 (C: Relative to the married)	33.85 (1.232)	27.47	36.52 (1.329)	44.35 (1.614)
Age-standardized death probability if death probabilities for marital- status and education categories are as in 2005–2008 and educational distributions are as in 1975–1979 (D: Relative to the married)	33.38 (1.892)	17.64	27.80 (1.576)	30.28 (1.717)
Proportion explained by changes in the educational distribution				
Version 1: (C–A)/(B–A)	0.024		0.067	0.103
Version 2: (B–D)/(B–A)	0.050		0.110	0.331



**Table 6: (Continued)**

	Never-married	Married	Widowed	Divorced/ separated
<b>Women</b>				
Age-standardized death probability 1975–1979	20.24	17.18	19.44	22.40
(A: Relative to the married)	(1.174)		(1.132)	(1.304)
Age-standardized death probability 2005–2008	17.65	9.45	14.07	15.70
(B: Relative to the married)	(1.863)		(1.489)	(1.661)
Age-standardized death probability, if death probabilities for marital- status and education categories are as in 1975–1979 and educational distributions are as in 2005–2008	18.72	15.45	18.01	20.18
(C: Relative to the married)	(1.206)		(1.202)	(1.304)
Age-standardized death probability if death probabilities for marital- status and education categories are as in 2005–2008 and educational distributions are as in 1975–1979	20.91	10.70	15.52	17.72
(D: Relative to the married)	(1.953)		(1.450)	(1.656)
Proportion explained by changes in the educational distribution				
Version 1: $(C-A)/(B-A)$	0.045		0.197	0.001
Version 2: $(B-D)/(B-A)$	-0.127		0.105	0.012

The corresponding proportions among women are 4.5% and -12.7%. The negative number arises because hypothetical changes in the education- and marital-status-specific death probabilities alone, while educational distributions remain as in 1975–1979, lead to a larger change in the mortality disadvantage for the never-married than is actually observed. Thus, given education- and marital-status-specific death probabilities as in 2005–2008, changes in education reduce the ratio of the mortality among the never-married to that among the married. Anyway, the conclusion is that, on the whole, changes in educational distributions have played a small role in the increase in the mortality among the never-married to that among the married, for women and men alike.

The educational changes have contributed more to the (less strongly) increasing mortality disadvantage of the widowed, 6.7% or 11.0% among men (depending on which of the two versions of the method is used) and 19.7% or 10.5% among women.

Among divorced women, the educational changes explain essentially nothing (0.1% or 1.2%) of the increasing disadvantage, while among divorced men, whose mortality disadvantage has increased much less, a larger proportion is explained (10.3% or 33.1%).

We also calculated the proportions explained by only the person's own education or only their spouse's education, but as mentioned used only the first of the two versions of the method. Changes in the distribution of the spouse's education have contributed to the growing ratio of the mortality among the nonmarried to that among the married for both sexes (Table 7). In contrast, changes in the distribution of the person's own education have contributed almost nothing or in the opposite direction. The only exception is the positive contribution to the increase in the mortality disadvantage of the widowed women.

**Table 7: Proportion of the increase in the age-standardized death probability relative to the married that is explained by changes in the person's own education and their spouse's education, according to version 1 of the comparison between actual and hypothetical ratios of death probabilities (see text and Table 6)**

	Never-married	Widowed	Divorced/separated
<b>Men</b>			
Proportion explained by changes in his own education exclusively	-0.005	-0.010	-0.060
Proportion explained by changes in his spouse's education exclusively	0.029	0.074	0.159
Proportion explained by changes in his own and his spouse's education (as version 1 in Table 6)	0.024	0.067	0.103
<b>Women</b>			
Proportion explained by changes in her own education exclusively	0.013	0.136	-0.069
Proportion explained by changes in her spouse's education exclusively	0.046	0.086	0.099
Proportion explained by changes in her own and her spouse's education (as version 1 in Table 6)	0.045	0.197	0.001

## **5. Supplementary regression-based analysis**

Many researchers would probably consider a regression-based analysis a suitable alternative to our approach. The strategy would then typically be to first include the main effects of marital status, age, and period (for example defined as 0 for 1975–1979 and 1 for 2005–2008) plus an interaction between marital status and period, and then add a main effect of education to see how much the interaction effect changes. However, there are three problems with such an approach (discussed in more detail in the supplementary material), which we think makes it less appealing than the method we have used.

First, it is generally problematic to interpret interaction effects in logistic models (Ai and Norton 2003; Greene 2010). Second, in logistic analysis it is difficult to learn about the importance of confounding or causally intermediate variables by adding these variables to the models. The reason is that when a variable is added to a model, the effects of the other variables can change considerably even if the added variable is uncorrelated with them. Third, reality may not be adequately reflected in a model that includes only a main effect of education. Some of the interactions with education would not cause any problems, but if there is a period-education interaction, the standard regression-based measure of the proportion explained by the added variables (in this case education variables) would differ from the measures used above, which have a simple interpretation. However, leaving the period-education interaction out of the model when there actually seems to be such an interaction structure in the data would not be a good solution either.

For comparison we carried out a regression analysis in spite of these concerns, and included the main effects of the person's own education and their spouse's education as well as interactions between marital status and the person's own education, between the spouse's education and the person's own education, and between the person's own education and the period. A three-step procedure suggested by Karlson, Holm, and Breen (2012), which involves residualized education variables, was used to handle the second of the mentioned problems.

According to the regression estimates, 17.4% of the increase in the excess mortality of never-married men can be accounted for by education (see details in the supplementary material). Educational changes explain more of the increase in the association between widowhood and mortality (34.2%), in accordance with the results reported above, while they dramatically 'overexplain' the very small increase in the mortality disadvantage of the divorced. Among women, educational changes explain 13.4% of the increasing mortality disadvantage among the never-married, while they explain – just as among men and in accordance with the results reported above – a larger part of the increasing disadvantage for the widowed (49.4%). The educational

changes appear to have contributed to reduce the mortality disadvantage of the divorced, and ‘explain’ –3.8%.

To summarize, the regression analysis points towards a somewhat larger contribution from educational changes to the increasing mortality disadvantage of the never-married and the widowed than is suggested by our other and preferred method. However, both methods show that educational changes have played a larger role with respect to the increasing mortality disadvantage of the widowed, and all results for the never-married are below 18%. The results for divorced men are not so interesting because their mortality disadvantage has changed very little, but among women, the regression analysis and the preferred method give quite similar results because the regression analysis suggests a very small negative contribution, while the preferred analysis suggests that educational changes have been unimportant.

## **6. Summary and conclusion**

### **6.1 The increasing mortality advantage of the married**

An increasing mortality advantage for the married appeared very clearly in the Norwegian data, which has fewer limitations than the data used in most of the earlier studies that showed such a trend. The excess mortality of the never-married increased markedly compared with that of the married among both sexes. (This result is in contrast to the meta-analysis carried out by Roelfs et al. (2011), which showed that the mortality gap between the married and the never-married widened most strongly among women.) In fact, mortality was almost constant, or even increasing, among the never-married in the first part of the study period, while in more recent years it has declined among all groups of the nonmarried – although not as sharply as among the married. At the end of the study period, mortality among the never-married was almost the same as that of the married three decades earlier.

The only group that has not experienced an increased mortality disadvantage is divorced men. This accords with a multicountry analysis by Valkonen, Martikaninen, and Blomgren (2004), which showed that divorced men did not experience the increasing mortality relative to the married that was observed for other groups of nonmarried. The pattern also bears some resemblance with the meta-analysis by Shor et al. (2012), which did not show any clear trend in the excess mortality of the divorced for either sex.

This mortality increase among the never-married is striking as it sits against a general trend within Western Europe for rising country-level life expectancy over the past decades, although with some variation in the pace of improvement (and some

notable recent exceptions; Hiam et al. 2017). Increases in mortality in a large subgroup of the population – such as among the never-married in Norway about three decades ago – have not often been observed. However, Valkonen, Martikaninen, and Blomgren (2004) reported a rising mortality among the nonmarried in some of the countries they studied, including Denmark – a country that experienced very little increase in the overall life expectancy during the 1980s. Interestingly, Norway also made less progress in life expectancy than most other countries in Western Europe during that period (Table 12 in Sardon 2002).<sup>9</sup> The rising mortality disadvantage (and presumably also health disadvantage) of the nonmarried is an important public health issue given that this population is quite large and will be increasing for several decades.

## **6.2 The importance of educational changes for the increasing mortality advantage of the married**

The study confirmed the well-known strong association between a person's chance of dying within a certain period and his or her education, as well as the less firmly established relationship between mortality and the spouse's education among the married. Moreover, while the general expansion of education appeared clearly in the data, the analysis showed that the magnitude of this expansion varied in complex ways. It was stronger in some marital-status groups than others, and this pattern varied across age and sex. For example, among women younger than 70, and especially those of age 50–59, education increased more among the married than among the never-married. Moreover, married men older than 60 also experienced a particularly large growth in education compared to the never-married, and there was an upward shift in the spouse's education, especially among men younger than 60.

However, these changes in educational distributions have not contributed much to the increasing mortality advantage of the married. More specifically, if the death probabilities in each educational group in each marital-status category had remained constant at their 1975–1979 level, and educational distributions had changed as observed between 1975–1979 and 2005–2008, the increase from 1975–1979 to 2005–2008 in the mortality among the never-married to that among the married would, on the whole, have been 2–5% of the observed increase. According to the opposite and equally reasonable approach, where the actual mortality pattern in 2005–2008 is compared with what it would have been if the education- and marital-status-specific death probabilities were as observed in 2005–2008, but no changes in educational distributions had taken place, the contribution from the educational changes were –13% among women and 5%

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<sup>9</sup> It is also worth noting that a rising mortality has been reported for Americans with low education (Montez and Zajakova 2014).

among men. Educational changes have played a larger role in the increasing mortality disadvantage of the widowed, for both sexes, and they have contributed considerably to the relatively small increase in the mortality disadvantage of the divorced men. However, they have contributed essentially nothing to the increasing mortality disadvantage of divorced women.

On the whole, changes in the spouse's education have had more impact than changes in the person's own education. This supports our idea that one should consider spousal education in such analyses, not only the person's own education, as has been done in earlier investigations (Martikainen et al. 2005).

Note that, throughout the analysis, it is the absolute educational level that is considered, while some of the mechanisms suggested as responsible for the education–mortality relationship may actually, to a larger extent, involve the education relative to the national average or some other measure of relative education. If relative education is important for mortality, it would be less reasonable to assume a constant mortality within each category of absolute education during general educational expansion, and such expansion would be less likely to produce lower overall mortality. However, changing the perspective to accommodate such ideas is difficult, not least because of the problems associated with constructing good indicators of relative education.

A regression approach that we consider less appealing suggested a somewhat larger educational contribution to the increasing mortality disadvantage of the never-married, but still below 18%. The difference between the methods with regard to the proportion explained by education was even larger when the increasing gap between the married and the widowed was considered. (See details in Section 5 and in supplementary material.)

### **6.3 Other possible reasons for changes in the relationship between marital status and mortality**

Apart from the educational changes, which appear to have been quite unimportant, which factors may have been responsible for the increasing marital-status differences in mortality? To start with an economic argument, a wife is now more likely than in the past (at any level of the spouses' education) to contribute to the family income through her own paid work, because of the mentioned shift from the 'specialization' strategy to the 'collaborative' strategy. However, it is not obvious that the current benefits from the collaborative strategy are larger than the benefits from the specialization strategy were in the past. The current benefits may simply be a better adaptation to contemporary life in the sense that, currently, the benefits of the specialization strategy would not be as

large. This is a relevant issue, especially for the oldest part of the population that we analyse.

For the younger women and men, the collaborative strategy may have been relevant through much of the period under study, and if the women's earnings then have increased (through larger work activity or higher wages), the families' economic situations would probably improve, which could push mortality down for both partners and thus strengthen the mortality advantage of the married. Similarly, if women increasingly prefer a husband with high income given his educational level – which we know little about – the marriage mortality advantage could be increased for both women and men. These mechanisms can be considered partly as involving selection (partners with high income are chosen and the higher incomes reduce the mortality of the married), partly as involving causal effects (the protective effect of being married is amplified by having a high-income spouse).

A related hypothesis could be that, even if the economic benefits from marriage may not have increased, they may have produced a larger mortality advantage because a high income has become a more important determinant of a healthy lifestyle and access to health care (Burström 2002). There is little evidence for this, however.

An increasing mortality gap between marital-status groups could also arise if a less socially cohesive society makes support from a spouse more important. However, there is no strong evidence for the often-assumed decline in social cohesion (Stolle and Hooghe 2005; Sarracino and Mikucka 2016). The measurements of cohesion have been very diverse, and discussions and analysis are muddled by inadequate conceptualization (Carpiano 2006).

Furthermore, assistance from a spouse may have become more valuable because the treatment and prevention that is offered in modern health care often requires active individual initiatives and participation, and at the same time may have become more important for survival. One relevant example is that especially the never-married seem to underuse medicine for cardiovascular diseases in Norway (Kravdal and Grundy 2014). The combination of a (possibly persistent) situation like this and increasingly efficient medicines and other kinds of treatment for such diseases (Ford et al. 2007; O'Flaherty, Buchan, and Capewell 2013) may have contributed to the increasing mortality advantage of the married. Also the growing differences in cancer survival between marital-status groups may partly reflect mechanisms of this type (Kravdal and Syse 2011).

These arguments are relevant for all groups of nonmarried and for both sexes. An additional argument when it comes to the widowed and divorced is that, in theory, their mortality could increase if it has become increasingly difficult to cope with the grief and stress from the loss of a spouse because of less social support from other people. For the same reason, especially divorce or widowed women might experience

increasing stress arising from the lone parent role (Berkman et al. 2015), which could explain why the growing mortality disadvantage of the divorced is restricted to women. However, in Norway, the welfare support system for single parents is quite generous (Bratberg and Tjøtta 2008) and has improved rather than deteriorated over the last few decades. Also, this argument is relevant only for the relatively young included in our study population. To conclude, it is not easy to understand why the development for divorced men should be different from that of all other groups of nonmarried.

Finally, the emergence of informal cohabitation as an alternative living arrangement may affect the mortality advantage of the married, through mechanisms of both causal and selective character. To start with the former, if a representative group of those who otherwise would marry instead cohabit, and if cohabitation has a protective effect similar to that of marriage (although not necessarily quite as strong; Koskinen et al. 2007), one would, so to speak, move a group from the married category (with low mortality) to the nonmarried category. The mortality disadvantage for the never-married compared to the married would therefore be smaller. To the extent that the growth in cohabitation is also a result of union formation among people who would not have formed a union if marriage had been the only possibility, there is a contribution in the same direction.

An example that involves selection is that those who are married in the last part of the study period, when informal cohabitation was more prevalent, may have relationships of particularly high quality (Wiik, Keizer, and Lappegård 2012), which tends to reduce mortality (Umberson and Montez 2010). Being married rather than cohabiting may also indicate certain life values that may tend to depress mortality (Soons and Kalmijn 2009). Both these factors may contribute to larger differences between the married and the nonmarried by producing a group of married that to a larger extent have health-promoting characteristics.

It would be valuable to obtain more evidence about the importance of these possible changes in selective or causal influences, as this would inform discussions about whether something should or could be done to reduce the mortality gap between married and nonmarried people. For example, should it turn out that it has become increasingly important to have spousal support during illness, a possible response could be to encourage health personnel to give special attention to those who live alone.

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## Appendix

**Table A-1: Distributions (in percent) of exposure years over marital status, for selected age groups and periods, among Norwegian women and men**

	Age 50–54				Age 60–64				Age 70–74				Age 80–84			
	M <sup>a</sup>	NM	W	D/S	M	NM	W	D/S	M	NM	W	D/S	M	NM	W	D/S
<b>Men</b>																
1975–1979	82.4	11.8	1.3	4.5	81.3	11.2	4.0	3.6	74.5	11.9	11.2	2.4	55.1	11.6	31.7	1.6
1990–1995	75.8	9.2	1.2	13.9	77.7	10.0	3.6	8.7	75.3	10.1	10.0	4.6	62.1	10.2	25.3	2.4
2005–2008	62.6	17.4	0.8	19.2	72.1	8.6	2.6	16.6	74.0	7.6	7.6	10.8	66.3	7.9	21.0	4.8
<b>Women</b>																
1975–1979	81.6	7.1	6.5	4.8	68.0	10.4	17.3	4.2	43.8	16.6	36.4	3.2	19.0	20.5	57.9	2.7
1990–1995	75.3	5.1	5.1	14.6	70.4	5.4	16.2	8.0	50.3	8.1	36.7	4.9	22.1	12.6	62.2	3.2
2005–2008	64.1	11.3	2.6	22.1	67.2	5.4	9.0	18.5	56.0	4.4	28.9	10.7	28.5	6.2	60.0	5.3

Note: <sup>a</sup> M=Married; NM=Never-married; W=Widowed; D/S=Divorced/separated.

**Table A-2: One-year death probabilities per 1,000 (with standard errors), for selected age groups and years, among Norwegian women and men**

	Age 50-54			Age 60-64			Age 70-74			Age 80-84						
	M <sup>a</sup>	NM	W	D/S	M	NM	W	D/S	M	NM	W	D/S				
<b>Men</b>																
1975-1979	6.03 (0.11)	10.20 (0.39)	10.45 (1.18)	14.89 (0.75)	16.48 (0.19)	22.35 (0.61)	23.89 (1.05)	30.66 (1.24)	43.11 (0.40)	50.08 (1.07)	53.61 (1.14)	67.25 (2.71)	102.50 (1.07)	112.49 (2.42)	113.46 (1.47)	135.74 (7.10)
1990-1994	3.66 (0.10)	10.44 (0.46)	6.16 (1.00)	8.25 (0.33)	12.28 (0.19)	23.30 (0.71)	20.62 (1.11)	25.38 (0.79)	36.11 (0.33)	51.17 (1.06)	49.75 (1.05)	60.42 (1.70)	94.81 (0.85)	113.84 (2.26)	114.56 (1.44)	125.41 (4.92)
2005-2008	2.09 (0.08)	6.70 (0.25)	5.24 (1.05)	5.33 (0.21)	6.79 (0.13)	17.32 (0.61)	13.32 (0.95)	15.42 (0.41)	20.06 (0.31)	42.87 (1.39)	35.03 (1.26)	39.16 (1.11)	67.42 (0.72)	103.66 (2.50)	91.68 (1.45)	102.59 (3.18)
<b>Women</b>																
1975-1979	3.05 (0.08)	4.84 (0.34)	4.12 (0.33)	5.36 (0.44)	7.54 (0.14)	10.18 (0.41)	9.08 (0.30)	10.08 (0.64)	21.91 (0.33)	25.02 (0.57)	25.03 (0.39)	27.48 (1.36)	72.81 (1.28)	78.71 (1.25)	81.26 (0.75)	90.00 (3.63)
1990-1994	2.32 (0.08)	5.21 (0.44)	3.34 (0.35)	4.30 (0.24)	6.44 (0.14)	10.77 (0.64)	8.94 (0.34)	10.66 (0.52)	17.30 (0.25)	25.21 (0.76)	21.93 (0.33)	26.42 (1.00)	58.04 (0.90)	69.55 (1.25)	66.44 (0.55)	76.98 (2.60)
2005-2008	1.79 (0.07)	4.03 (0.24)	3.64 (0.49)	3.16 (0.15)	4.62 (0.11)	11.39 (0.63)	7.68 (0.40)	8.30 (0.29)	11.54 (0.25)	22.19 (1.23)	17.02 (0.42)	21.28 (0.78)	38.72 (0.70)	62.20 (1.81)	53.41 (0.54)	61.76 (1.96)

Note: <sup>a</sup> M=Married; NM=Never-married; W=Widowed; D/S=Divorced/separated.

**Table A-3: Effects (odds ratios with 95% CI) of education on mortality among Norwegian women and men of age 50–89 in 1975–2008**

	All marital-status categories <sup>a</sup>	Married <sup>b</sup> Model 1	Married <sup>b</sup> Model 2
<b>Men</b>			
<b>Man's own education</b>			
Primary (10 years) <sup>c</sup>	1	1	1
Lower secondary (11 years)	0.87*** (0.86–0.87)	0.87*** (0.86–0.88)	0.90*** (0.89–0.91)
Higher secondary (12–13 years)	0.86*** (0.85–0.86)	0.87*** (0.86–0.88)	0.92*** (0.91–0.93)
Some tertiary (14–17 years)	0.67*** (0.66–0.68)	0.69*** (0.68–0.70)	0.75*** (0.74–0.77)
Master's degree	0.63*** (0.62–0.64)	0.65*** (0.64–0.66)	0.74*** (0.72–0.75)
PhD degree	0.48*** (0.45–0.52)	0.51*** (0.47–0.55)	0.60*** (0.55–0.65)
<b>Spouse's education</b>			
Primary (10 years) <sup>c</sup>			1
Lower secondary (11 years)			0.90*** (0.90–0.91)
Higher secondary (12–13 years)			0.88*** (0.86–0.89)
Some tertiary (14–17 years)			0.79*** (0.77–0.80)
Master's degree			0.80*** (0.76–0.84)
PhD degree			0.56*** (0.44–0.71)
<b>Women</b>			
<b>Woman's own education</b>			
Primary (10 years) <sup>c</sup>	1		1
Lower secondary (11 years)	0.82*** (0.81–0.83)	0.80*** (0.79–0.81)	0.84*** (0.83–0.85)
Higher secondary (12–13 years)	0.70*** (0.69–0.71)	0.68*** (0.66–0.70)	0.73*** (0.71–0.75)
Some tertiary (14–17 years)	0.67*** (0.66–0.68)	0.63*** (0.61–0.65)	0.69*** (0.67–0.71)
Master's degree	0.64*** (0.61–0.67)	0.61*** (0.56–0.66)	0.68*** (0.63–0.74)
PhD degree	0.53*** (0.42–0.66)	0.56*** (0.40–0.80)	0.65*** (0.46–0.93)
<b>Spouse's education</b>			
Primary (10 years) <sup>c</sup>			1
Lower secondary (11 years)			0.91*** (0.90–0.92)
Higher secondary (12–13 years)			0.93*** (0.92–0.95)
Some tertiary (14–17 years)			0.84*** (0.82–0.86)
Master's degree			0.85*** (0.83–0.88)
PhD degree			0.76*** (0.67–0.87)

Note: \*\*\* p<0.01.

<sup>a</sup> Controlled for age and year in five-year categories and marital status.

<sup>b</sup> Controlled for age and year in five-year categories.

<sup>c</sup> Reference category.

