Large and Growing Social Inequality in Mortality in Norway: The Combined Importance of Marital Status and Own and Spouse's Education

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In all countries, age-specific death probabilities vary between sociodemographic groups. Numerous studies have documented large mortality differences between married and non-married persons (Roelfs et al. 2011; Shor et al. 2012a, 2012b), and mortality is associated with a person's number of children, which in turn is related to marital status (Grundy and Kravdal 2010). The evidence for differences between educational groups is large as well (Elo 2009), and there is growing interest in the association between mortality and spousal education (Brown et al. 2014; Kravdal 2008; Skalická and Kunst 2008). Furthermore, several studies have shown differences in mortality by income, occupation, or ethnicity (Bævre and Kravdal 2014; Harper, Rushani, and Kaufman 2012; Tarkiainen et al. 2015; Wada et al. 2012), and there are differences between geographic regions of a country that are probably not fully explained by differences in socioeconomic composition (Kravdal et al. 2015). These mortality differences reflect the importance of social support and control, knowledge, purchasing power, and various other factors, including selective influences.

When studying differences in mortality between sociodemographic groups, it has been common to focus on only one variable, but many investigators have taken a broader perspective and shown and discussed the main effects of a number of variables. Some have even taken into account interactions between variables (Kohler et al. 2008; Smith and Waitzman 1994). However, estimates from multivariable studies have rarely been used to predict differences between sociodemographic groups defined by combinations of the considered variables. This means that we have an inadequate impression of how much variation exists in the population—which may have implications for discussions about the need for policy interventions.

The goal of this article is to offer a fuller description of mortality variation in a country by considering a variable that combines two of the strongest correlates of mortality: education and marital status. Data from Norwegian population registers are used. For married Norwegians, spouse's education is added to obtain a better indicator of the available socioeconomic resources. This is the first study to examine the relationship between this sociodemographic variable and mortality.[1]

In addition to describing the overall association between the combined variable and mortality, the article addresses the change in this association over three decades. It would be reasonable to expect increasing variation, given the widening mortality gap between the married and the non-married that has been observed in Norway (Berntsen 2011) and in several other countries (Martikainen et al. 2005; Murphy, Grundy, and Kalogirou 2007; Valkonen et al. 2004), as well as the growing differences across educational categories (Montez and Zajakova 2014; Shkolnikov et al. 2012; Steingrímsdóttir et al. 2012). However, the association between mortality and the combined variable also reflects the importance of spouse's education and interactions with own education. It is possible, for example, that advantages related to being married or having a spouse with high education are smaller for those who themselves have high education, which under certain conditions can make the difference between the highest and lowest mortality considerably smaller than suggested by the overall net effects of marital status and own and spouse's education. Nothing is known about the time changes in these interactions and in the importance of spouse's education.

Norway has experienced a substantial increase in educational attainment over many decades, as has been the case in other rich countries (Breen et al. 2010). Among women and men aged 50–89 in 1975–79, 63 percent had only primary education, 31 percent had secondary education, and 6 percent had some or completed tertiary education. In 2005–08, the corresponding figures were 31, 48, and 21 percent. In recent years, the educational expansion has been greater among women than men. Family structure has also changed markedly. Norway and other Nordic countries are among those that have experinced the most pronounced retreat from formal marriage, although combined with relatively high fertility outside marriage (Sobotka and Toulemon 2008). After a few decades with increasing marriage rates, a turn-around took place in the 1960s when Norway entered the second demographic transition (ibid.). Thus, the proportion never-married in the age group 50–89 was about the same in 1975–79 (reflecting marriages back to the beginning of the twentieth century) as in 2005–08: 12 percent and 9 percent, respectively. However, the proportion never-married at ages 50–54 increased more markedly, from 10 percent to 15 percent. In addition to an increase in the age at marriage and the proportion who never married, which to a large extent was compensated for by consensual unions, relationships have become more unstable over the last half century. The

proportion divorced or separated at ages 50–89 increased from 4 percent in 1975–79 to 15 percent in 2005–08.

Causal pathways

Explanations for associations between education and mortality

The strong association between education and mortality documented in Norway and elsewhere no doubt reflects a variety of causal influences (Elo 2009; Hayward, Hummer, and Sasson 2015). In particular, the knowledge obtained through advanced education greatly increases the likelihood of obtaining a well-paid job with few occupational hazards. Higher income may reduce mortality through the purchase of health-promoting goods including (in many countries) access to high-quality health care. Additionally, knowledge and analytical skills may have a more direct effect on health behavior and increase the chance of making good use of available health care. By contrast, individuals who have low education relative to the population average typically have low relative income as well. It has been argued that a feeling of inferiority compared to better-off segments of the population may cause psychosocial stress that can have direct physiological consequences or that may manifest itself through unhealthy lifestyles such as smoking and obesity (Marmot and Wilkinson 2001; Pham-Kanter 2009). There are also selective influences (Clark and Royer 2013). In particular, the socioeconomic resources in the family of origin, childhood health, intellectual endowments, and the degree of self-discipline have a bearing on educational attainment as well as later health and mortality (Hayward, Hummer, and Sasson 2015).

Explanations for associations between marital status and mortality

Similarly, the relationship between marital status and mortality reflects a combination of causal effects and selection (Brockmann and Klein 2004). Marriage is assumed to be protective for a number of reasons. For example, a partner typically provides emotional and practical support in everyday life and during illness and exerts social control over health behaviors (Umberson and Montez 2010; Lewis and Butterfield 2007). Married individuals are also more likely than the non-married to have children, who may provide similar social supports and also influence health behavior (Umberson, Crosnoe, and Reczek 2010; Kravdal et al. 2012). There are economic benefits from marriage as well (Wilmoth and Koso 2002) because of specialization or (more relevant nowadays) pooling of resources and scale advantages (Oppenheimer 1994). The never-married do not enjoy these economic and other benefits, and the formerly married do so to a

lesser extent than the currently married. In addition, the formerly married may be disadvantaged for a considerable period of time because of stress triggered by divorce or the partner's death (Amato 2000; Carey et al. 2014).

As regards selection, a person's general level of knowledge, economic prospects or resources, health, lifestyle preferences, and values affect his or her chance of forming a relationship (Fu and Goldman 1996; Surkyn and Lesthaeghe 2004; Wiik 2009). Availability of alternative partners is another factor of importance. Thus, education is one of the determinants of partnership formation, operating especially through these factors. They also have a bearing on the choice of marriage versus consensual union and on the chance of divorce or union dissolution. Most of these factors also affect health and mortality. With respect to widowhood in particular, selection arises because a person may have certain characteristics that increase mortality and that are linked to spousal characteristics with the same effect—for example, spouses may share an unhealthy lifestyle.

In addition to the benefits associated with being married, the characteristics of the spouse also affect one's health and mortality. In particular, a person may draw advantages from a spouse's knowledge and income in much the same way as one may benefit from one's own knowledge and income. Further, one may be affected by a spouse's health behavior through imitation or learning, and for obvious reasons one may also benefit from having a healthy spouse. Again there are selective influences as well. Determinants of the spouse's education may affect his or her health and health behavior or in other ways influence the health and mortality of the individual under study. Further, a person with certain characteristics that are deemed attractive, and that could be linked to good health, may be particularly likely to marry a partner with high education (Kravdal 2008).

Interaction effects

As indicated above, a person who has high education and is married does not necessarily have a health advantage that is as large as the sum of the overall advantage of being married and the overall advantage of having high education (net of each other). This is because associations with one of these variables may depend on the other. Only a few studies have addressed these possible interaction effects. Theoretically, it is not clear what kind of pattern one should expect. On the one hand, it might be argued that a person with high education would have sufficient resources so that additional resources or support from a spouse would matter relatively little. This idea accords with the findings reported by Kohler et al. (2008). On the other hand, one could argue that persons with high education would benefit more from marriage because they are more likely to have a better-educated spouse. Given the spouse's higher education, it is also possible that they are able to deal

more effectively with everyday problems, including the small conflicts that often arise in a relationship. A third possible contribution is that a well-educated person may have attracted a particularly resourceful spouse who provides resources and advantages beyond what the spousal education variable can capture.

Similarly, for the married, the total benefit of having high education and a well-educated spouse may differ from what the main effects of these two characteristics would suggest. For example, the value of having a spouse with high education, and who therefore perhaps has high income and more knowledge of relevance for health, may be modest for a person who also benefits from such types of resources because of his or her own education. However, the interaction could also be the opposite. For example, if a person with low education is unable to make use of some of the advantages potentially derived from a well-educated spouse, this might affect the quality of the relationship, with further implications for health (Umberson and Montez 2010). Similarly, educational differences between spouses may themselves be seen as problematic by one or both of them.

Data and methods

Data

The core data source was the Norwegian Central Population Register, which includes everyone who has lived in Norway sometime after 1964. Information about year of birth, death, immigration and emigration (if any), and marital status as of January 1st of each year since 1975 was taken from the 2008 version of the register. For every individual and his or her spouse (if any), educational histories were added from the Educational Database operated by Statistics Norway. An increasing proportion of the non-married cohabit, but the data did not include information about cohabitation.

Statistical analysis

Discrete-time hazard models were estimated. For each individual, a series of one-year observations was constructed, starting at age 50, in 1975 or at the time of immigration (whichever came last) and ending at age 89, in 2008, or at the time of emigration or death (whichever came first). Each one-year observation included marital status and the highest education level achieved by the individual and (if relevant) the spouse as of October of the previous year or, for observations before 1980, in 1970.[2] For simplicity, those with some or completed tertiary education were pooled into one group. Logistic regression models for the chance of dying within one year were estimated from the one-year observations, separately for women and men.[3]

Some models were estimated for the entire period 1975–2008, others for the two sub-periods 1975–79 and 2005–08. The intention behind the latter models was to ascertain how the association between the combined variable and mortality, and the changes over time in this association, are built up from main and interaction effects. Some of these models therefore included main effects of marital status and own and spouse's education as well as interactions between own education and the two other variables. Education was grouped into two categories to simplify these models. To provide further indications of the importance of considering interactions, period-specific models including only main effects of marital status and own and spouse's education were also estimated, and predictions from these models were compared with the estimates from a model including the combined variable.[4]

In addition to estimating hazard models (and predicting from these estimates), one-year death probabilities were calculated for each of the categories of the combined variable from the one-year observations. This was done separately for women and men and for different five-year age groups and five- (or four-) year periods (see an example of such probabilities in Appendix Table A1).[5] A weighted sum of these probabilities over all five-year age groups between ages 50 and 89 was then calculated for each period, using the proportions in these age groups in 1975–79 in the entire male population as weights. With this age standardization, differences in death probabilities between time periods, sociodemographic groups, and the two sexes do not reflect corresponding differences in age distributions.

The remaining life expectancy from age 50 to age 89 was also calculated by estimating a hazard model from the one-year observations for each category of the combined variable separately. The model included a linear effect of age minus 70 years and a constant term (interpreted as mortality at age 70). It was then drawn 1,000 times from two independent normal distributions with means and standard deviations equal to those estimated for the hazard model coefficients. (The estimated covariances were very small.) Life expectancies were then calculated from the drawn parameters, and finally the mean and standard deviation of these life expectancies were calculated. The point estimates of the life expectancies were almost identical to the results from supplementary calculations based on death probabilities for five-year age groups. According to official national life tables for the last four-year period considered, the 89-year limit reduces life expectancy by only about 0.6 years.

When describing how variation in mortality has changed over time, differences between the highest and lowest life expectancy or age-standardized death probability were considered, as well as the corresponding ratios of these extreme death probabilities or (from hazard models) odds of dying. Additionally, two alternative indicators of variation that take into account all categories of the combined variable were computed: the

standard deviation of the death probabilities (referred to below as the STD indicator) and the average inter-group difference (AID indicator). The STD indicator was constructed by assuming that each person in each category has an age-standardized death probability equal to what is observed for that category; then, the standard deviation of the age-standardized death probabilities over the whole population was calculated. The AID indicator is the population-weighted average inter-group difference of the age-standardized death probabilities (described e.g. in Shkolnikov et al. 2012).

Results

The proportions in different categories of the combined variable are shown in Table 1 for men and women for the first and last five- (or four-) year period. As one would expect given the general expansion of education, the proportion of men and women who are married and have tertiary education, and whose spouse also has tertiary education, increased from 1–2 percent in 1975–79 to 7–9 percent in 2005–08. This is the category where mortality is lowest, with some exceptions mentioned below. The proportion in one of the other "extreme" categories, the never-married with primary education, decreased from 8–9 percent to 2–4 percent.

Estimates from hazard models for the entire 34-year period show that the mortality difference between the extreme categories is large (Table 2). For example, the odds of dying among men with tertiary education whose wives also have tertiary education are 46 percent lower than among men with primary education married to women with primary education (odds ratio 0.54). The odds among divorced men with primary education are 71 percent higher (odds ratio 1.71). The corresponding odds ratios for women are 0.54 and 1.46. Thus, the ratio between the highest and lowest odds of dying is 3.17 for men and 2.70 for women.

Age-standardized one-year death probabilities are shown in Figure 1 for selected groups. Among men, mortality has declined in all groups except the never-married with primary education, among whom mortality increased slightly over a few decades and fell only after 2000. Thus, whereas mortality was higher among the divorced with primary education than among the never-married with primary education in 1975–79, this was reversed in 2005–08. Among never-married men with secondary education, mortality was nearly constant over the first two decades of the study period (not shown). The picture is similar for women. The most notable differences are the lack of mortality decline in the latest years among never-married women with primary education and the generally lower mortality of divorced women compared to the never-married (although there was the same kind of cross-over as among men).

TABLE 1 Proportion of exposure time (in percent) in different marital status and education categories, among Norwegian men and women aged 50–89 in 1975–79 and 2005–08

MEN 1975–79				
	Spouse's education			
Own education	Primary	Lower secondary	Higher secondary	Tertiary
Married				
Primary	34.04	6.71	0.27	0.40
Lower secondary	10.29	8.46	0.71	0.82
Higher secondary	3.49	3.50	0.77	0.57
Tertiary	1.04	2.96	1.17	1.78
Never-married				
Primary	8.67			
Lower secondary	2.13			
Higher secondary	0.53			
Tertiary	0.36			
Widowed				
Primary	5.56			
Lower secondary	1.54			
Higher secondary	0.53			
Tertiary	0.36			
Divorced/separated				
Primary	2.02			
Lower secondary	0.72			
Higher secondary	0.38			
Tertiary	0.24			
MEN 2005–08				
	Spouse's education			
Own education	Primary	Lower secondary	Higher secondary	Tertiary
Married				
Primary	8.71	5.04	1.73	0.90
Lower secondary	5.55	7.95	2.75	2.18
Higher secondary	4.00	5.82	3.19	2.76
Tertiary	1.43	4.00	2.92	9.22
Never-married				
Primary	4.24			
Lower secondary	2.71			
Higher secondary	2.00			
Tertiary	1.90			
Widowed				
Primary	2.39			
Lower secondary	1.72			
Higher secondary	1.02			
Tertiary	0.85			
Divorced/separated				
Primary	4.23			
Lower secondary	3.44			
Higher secondary	3.60			
Tertiary	3.25			

/...

TABLE 1 (continued)

WOMEN 1975–79				
	Spouse's education			
Own education	Primary	Lower secondary	Higher secondary	Tertiary
Married				
Primary	26.52	7.75	2.63	0.76
Lower secondary	4.85	6.14	2.50	2.12
Higher secondary	0.18	0.49	0.54	0.81
Tertiary	0.28	0.57	0.39	1.22
Never-married				
Primary	7.56			
Lower secondary	3.48			
Higher secondary	0.40			
Tertiary	1.24			
Widowed				
Primary	18.94			
Lower secondary	5.52			
Higher secondary	0.52			
Tertiary	0.75			
Divorced/separated				
Primary	2.46			
Lower secondary	0.98			
Higher secondary	0.21			
Tertiary	0.21			

WOMEN 2005–08				
	Spouse's education			
Own education	Primary	Lower secondary	Higher secondary	Tertiary
Married				
Primary	7.37	4.53	3.09	1.09
Lower secondary	4.43	6.94	5.04	3.49
Higher secondary	1.26	2.01	2.25	2.24
Tertiary	0.66	1.65	2.00	7.19
Never-married				
Primary	2.00			
Lower secondary	2.01			
Higher secondary	0.93			
Tertiary	1.89			
Widowed				
Primary	11.73			
Lower secondary	7.38			
Higher secondary	1.61			
Tertiary	1.78			
Divorced/separated				
Primary	4.68			
Lower secondary	4.79			
Higher secondary	2.55			
Tertiary	3.41			

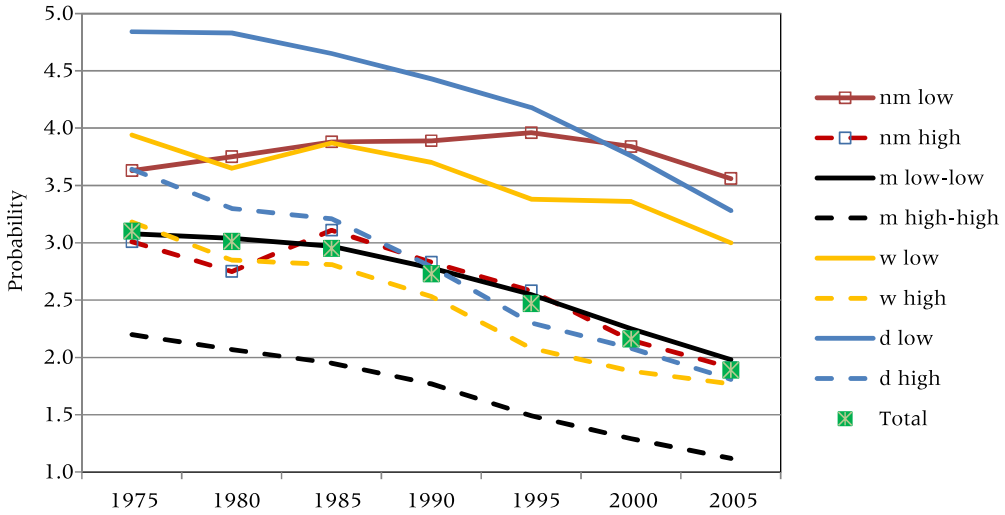
TABLE 2 Effects (odds ratios) of marital status, own education, and spouse's education on mortality among Norwegian men and women aged 50–89 in 1975–2008[a]

	MEN			
	Spouse's education			
Own education	**Primary**	**Lower secondary**	**Higher secondary**	**Tertiary**
Married				
Primary	1[b]	0.89	0.85	0.76
Lower secondary	0.89	0.79	0.75	0.70
Higher secondary	0.90	0.78	0.75	0.66
Tertiary	0.73	0.66	0.62	0.54
Never-married				
Primary	1.36			
Lower secondary	1.18			
Higher secondary	1.21			
Tertiary	0.94			
Widowed				
Primary	1.21			
Lower secondary	1.11			
Higher secondary	1.16			
Tertiary	0.94			
Divorced/separated				
Primary	1.71			
Lower secondary	1.43			
Higher secondary	1.30			
Tertiary	0.90			
	WOMEN			
	Spouse's education			
Own education	**Primary**	**Lower secondary**	**Higher secondary**	**Tertiary**
Married				
Primary	1[b]	0.89	0.91	0.82
Lower secondary	0.82	0.75	0.74	0.67
Higher secondary	0.55	0.61	0.69	0.60
Tertiary	0.69	0.61	0.56	0.54
Never-married				
Primary	1.31			
Lower secondary	1.08			
Higher secondary	1.06			
Tertiary	0.92			
Widowed				
Primary	1.17			
Lower secondary	0.99*			
Higher secondary	0.87			
Tertiary	0.86			
Divorced/separated				
Primary	1.46			
Lower secondary	1.17			
Higher secondary	0.90			
Tertiary	0.83			

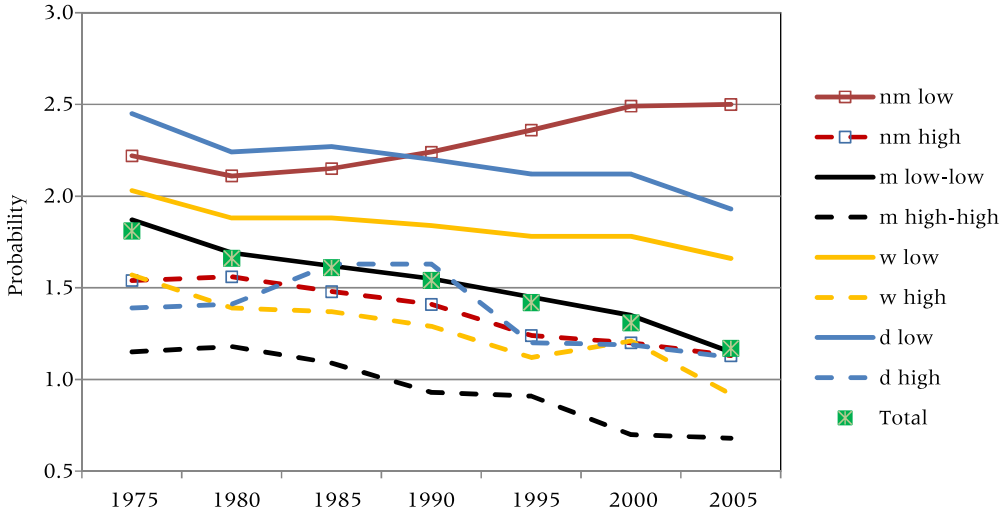
[a]Controlled for age and period in 5-year categories; [b]Reference category. All odds ratios significantly different from 1 at $p<0.01$ except as noted: *$p<0.10$. Confidence intervals available from author on request.

FIGURE 1 Age-standardized one-year death probabilities (per 100) for selected marital and educational categories of men and women aged 50–89, Norway 1975–2008

Men



Women



NOTE: nm: never married; m: married; w: widowed; d: divorced/separated; low: primary education; high: tertiary education; low-low and high-high refer to both spouses' education; total: all men or women. 1975 refers to 1975–79, 1980 refers to 1980–84, and similarly for other periods; 2005 refers to 2005–08.

On the whole, the lowest mortality is observed for persons with tertiary education who are married and whose spouse also has tertiary education. The mortality trend for this group is shown in Figure 1. For simplicity, mortality in this group is referred to as the "lowest mortality" in the further description below, although in some five-year periods one

TABLE 3 Remaining life expectancy from age 50 to age 89 in years for Norwegian men and women in selected marital and educational categories, 1975–79 and 2005–08

	1975–79	2005–08
Men		
All	25.83	30.02
Married, both primary education	25.86	30.00
Married, both tertiary education	28.94	33.55
Never-married, primary education	24.05	24.20
Divorced, primary education	20.98	25.27
Max-min:	7.96	9.35
Women		
All	30.40	32.94
Married, both primary education	30.30	33.27
Married, both tertiary education	33.36	35.66
Never-married, primary education	29.15	27.16
Divorced, primary education	28.14	29.58
Max-min:	5.22	8.50

NOTE: Standard errors are between 0.04 and 0.33; details available from author on request.

or two smaller groups of married women with higher secondary or tertiary education have slightly lower mortality (as indicated by the point estimates).

Life expectancies for selected groups and for the entire population are shown in Table 3. They must not be considered realistic predictions of remaining years of life up to age 89 for people who are, for example, widowed at age 50, since the underlying assumption is that individuals remain in the same category through the entire age span (and at every age experience the death probability observed for that category at that age in the relevant period).[6] Life expectancy for the total population accords well with official national life tables. For example, in 2005–08 the calculated remaining life expectancy up to age 89 for men at age 50 was 30.0 years, while the official figures for 2006 were 29.7 up to age 89 and 30.3 up to age 105. There is a large difference between the lowest life expectancy, among the divorced or never-married with primary education, and the life expectancy seen among married persons with tertiary education whose spouse also has tertiary education (which is usually the highest). Among men, this difference increased from 8.0 to 9.4 years, while among women it increased from 5.2 to 8.5 years. There is not much uncertainty in these estimates; the standard errors (not shown) in the extreme categories were only 0.1–0.3. (For completeness, life expectancies for all categories of the combined variable are shown in Appendix Table A2.)

The STD indicator increased among men in the first part of the 34-year period, but changed little after 1995 (Table 4). For women, there was an increase in the middle of the period. A similar pattern appears with the

TABLE 4 Measures of variation in mortality across the categories of the combined marital status and education variable, among Norwegian men and women aged 50–89 in 1975–2008

	1975–79	1980–84	1985–89	1990–94	1995–99	2000–04	2005–08
Men							
STD indicator	0.48	0.53	0.60	0.65	0.71	0.72	0.69
AID indicator	0.24	0.28	0.32	0.35	0.38	0.38	0.37
Women							
STD indicator	0.27	0.25	0.28	0.31	0.36	0.41	0.41
AID indicator	0.15	0.14	0.16	0.17	0.20	0.23	0.22

NOTE: See text for explanation of the STD and AID indicators.

TABLE 5 Differences and ratios between highest and lowest mortality, among Norwegian men and women aged 50–89 in 1975–2008

	1975–79	2005–08
Men		
Difference between maximum and minimum age-standardized death probability	2.64	2.44
Ratio between maximum and minimum age-standardized death probability	2.20	3.18
Ratio between maximum and minimum odds of dying according to hazard model including a variable combining marital status and own and spouse's education	2.57	3.43
Ratio between maximum and minimum odds of dying predicted from estimates from hazard model including main effects of marital status and own and spouse's education	2.38	3.42
Women		
Difference between maximum and minimum age-standardized death probability	1.30	1.82
Ratio between maximum and minimum age-standardized death probability	2.13	3.67
Ratio between maximum and minimum odds of dying according to hazard model including a variable combining marital status and own and spouse's education	2.27	3.66
Ratio between maximum and minimum odds of dying predicted from estimates from hazard model including main effects of marital status and own and spouse's education	2.20	3.47

AID indicator. The ratio of the highest to the lowest age-standardized death probability also increased: from 2.20 in 1975–79 to 3.18 in 2005–08 among men and from 2.13 to 3.67 among women (Table 5). The absolute difference between the highest and lowest death probability increased only among women, while (as mentioned) the difference between the highest and lowest life expectancy increased for both sexes.

Estimates from logistic models including main and interaction effects are shown in Table 6. The interaction between own and spouse's high

TABLE 6 Effects (odds ratios) of marital status and own and spouse's education on mortality among Norwegian men and women aged 50–89 in 1975–79 and 2005–08[a]

	1975–79	2005–08
Men		
Own education		
Primary or lower secondary[b]	1	1
Higher secondary or tertiary (HST)	0.94***	0.81***
Marital status		
Married[b]	1	1
Never-married	1.22***	1.77***
Widowed	1.22***	1.35***
Divorced/separated	1.76***	1.78***
Spouse's education		
Primary or lower secondary[b]	1	1
Higher secondary or tertiary (HST)	0.93***	0.80***
Marital status*education		
Never-married*HST	0.96	0.86*
Widowed*HST	1.06***	1.02
Divorced/separated*HST	0.92*	0.84***
Spouse's education*own education		
HST*HST	0.87***	0.93***
Women		
Own education		
Primary or lower secondary[b]	1	1
Higher secondary or tertiary (HST)	0.72***	0.68***
Marital status		
Married[b]	1	1
Never-married	1.15***	1.70***
Widowed	1.12***	1.28***
Divorced/separated	1.33***	1.59***
Spouse's education		
Primary or lower secondary[b]	1	1
Higher secondary or tertiary (HST)	0.84***	0.85***
Marital status*education		
Never-married*HST	1.09	0.92
Widowed*HST	1.10	1.04
Divorced/separated*HST	0.87	0.82***
Spouse's education*own education		
HST*HST	1.16**	0.99

[a]Controlled for age in 5-year categories; [b]Reference category; *p<0.10; **p<0.05; ***p<0.01. Standard errors available from author on request.

education is significantly greater than 1 (at this odds ratio scale) for women in 1975–79, while the pattern is the opposite for men in both periods. Furthermore, especially in the 2005–08 period, the interaction effects suggest that education is less negatively related to mortality for the married than for

the non-married, except the widowed. However, ignoring these interactions would not give a much different picture of the gap between the highest and lowest mortality. When it was predicted from main effects models, again using four-category education variables (estimates not shown in tables), the ratio between the highest and lowest predicted odds of dying was 2.38 and 3.42 among men in 1975–79 and 2005–09, respectively, while the corresponding ratios for women were 2.20 to 3.47 (Table 5). In comparison, the ratios were 2.57 and 3.43 for men and 2.27 and 3.66 for women (Table 5) according to a model that includes the variable combining marital status and own and spouse's education. Note also that these ratios are quite similar to the aforementioned ratios of the standardized death probabilities (Table 5), as one would expect.

To elaborate on the time-change perspective, one can conclude from the models with main and interaction effects that associations between marital status and mortality have become stronger, as have associations between own and spouse's education and mortality (because if the interaction for women in 1975–79 is taken into account, the overall effects of own and spouse's education are weaker than in 2005–08). Furthermore, there are indications that the strengthening of the association between own education and mortality has been particularly pronounced among the divorced and the never-married.

Discussion and conclusion

When the Norwegian population is grouped according to a combination of two sociodemographic characteristics that are known to be strongly associated with mortality, there are large differences between the highest and lowest mortality. The high-mortality groups are the never-married and divorced with primary education, and the low-mortality group is (with a few exceptions) married individuals who have tertiary education and whose spouse also has tertiary education. In terms of remaining life expectancy at age 50 (up to age 89), the difference is as large as 9.4 years among men and 8.5 years among women in 2005–08. The death probabilities differ by a factor of more than three.

Many persons in the high-mortality groups likely have multiple disadvantages. They may have low income, a low level of general knowledge and analytical capacity, and an unhealthy work environment. Additionally, they may lack support from and social control exerted by a spouse, and not having a spouse may weaken their economic situation. Also, certain values and personality traits linked to being single and having low education tend to produce high mortality.

The difference in mortality between the extreme groups has increased over time. For example, the difference between the highest and lowest

life expectancy increased by 1.4 years between 1975–79 and 2005–08 among men, while the corresponding increase among women was 3.3. Not surprising, the ratio between the highest and lowest death probability also increased over time. An interesting aspect of this widening gap is that mortality actually increased over a large part of the study period among never-married individuals with low education. Mortality increases in population sub-groups have been reported in very few earlier studies from rich countries (Montez and Zajakova 2014; Valkonen et al. 2004), where the national average mortality has generally declined.

The group with the lowest mortality included only 1–2 percent of the population in 1975–79, and the group with the highest mortality included only 2 percent in 1975–79 and 2–4 percent in 2005–08. However, the two measures of variation that take into account mortality in all 28 sociodemographic groups (with consideration of their size) also show increasing variation over the 34-year period.

If each of the population groups in this study had been divided further by considering additional individual or community characteristics known to be associated with mortality (in which case some of the resulting groups would be very small), the difference between the lowest and highest mortality would probably have been even larger. There would typically also be more variation according to other measures. However, it is not obvious how the variation would have changed over time; that would depend on the time trends in the importance of the additional variables.

The logistic models estimated for the first and last sub-period showed that the stronger association between the combined variable and mortality is a result of increases in the associations between mortality and all three sociodemographic variables—that is, marital status and own and spouse's education. Strengthening of the first two of these associations has also been seen in earlier studies from Norway (Berntsen 2011; Steingrímmsdóttir et al. 2012) and other countries (Montez and Zajakova 2014; Valkonen, Martikainen, and Blomgren 2004). Interaction estimates suggest that strengthening of the negative association between education and mortality has occurred particularly among the never-married and divorced. However, despite this and other interaction effects, one would get a good picture of the widening gap between the highest and lowest mortality from predictions based on a model with only main effects of marital status and own and spouse's education.

A number of factors may have contributed to changes over time in the importance of marriage and own and spouse's education. For example, marriage may have become more economically beneficial because women contribute more directly to family income through paid work (Oppenheimer 1994). Besides, it has been argued that the economic returns to education have increased in many countries (OECD 2009), although apparently not in Norway (Hægeland, Klette, and Salvanes 1999). Higher income may also

have become more important for health and access to health care (Burström 2002), but as yet there is little evidence for such a development. Furthermore, if it is the case that rich countries have become less socially cohesive (Carpiano 2006; Putnam 1995; Sarracino and Mikucka 2016; Stolle and Hooghe 2005), this may have contributed to making support from a spouse generally more important. Additionally, assistance from a spouse, and the knowledge and analytical skills that are typically linked to education, may have become more valuable because the treatments and preventive care that are offered in modern health systems—and that perhaps have become increasingly important for survival—often require individual initiative and participation. An example supporting this idea is that never-married Norwegians, in particular, seem to receive inadequate drug treatment for cardiovascular diseases (Kravdal and Grundy 2014), while improvements in the medical and surgical treatment for such diseases have contributed greatly to the mortality reduction over the last decades (Ford et al. 2007; O'Flaherty, Buchan, and Capewell 2013). A related issue is that the better educated may be the first to adopt new ideas about healthier lifestyles and be better equipped to distinguish sound advice from misleading or erroneous information related to health and well-being. The sharper decline in smoking among the better educated may be partly a result of such factors (Giskes et al. 2005).

A possible selection argument is that, as informal cohabitation has become a more common alternative living arrangement, marriage may have become more indicative of a high-quality relationship (Wiik 2012), which may provide particular health benefits (Umberson and Montez 2010). However, the group of non-married then also includes more cohabitants, who have many of the same advantages as the married (Koskinen et al. 2007). In principle, it is also possible that other factors linked to good health have become increasingly important determinants of marriage, but evidence for that is lacking. The role played by educational expansion is not obvious. On the one hand, fewer resources and less self-discipline may now be necessary to attain high education. On the other hand, this may be counterbalanced by more negative selection into the diminishing group with only primary education.

Even if there were stronger evidence about the mechanisms responsible for the growing mortality differences by education and marital status, developing effective interventions would not be easy. For example, if future research shows that lack of emotional and practical support from a spouse during everyday life and in illness is an increasingly critical factor, one possible response would be to encourage health personnel to give special attention to those who live alone. But it is difficult to see how such a policy, straightforward in theory, could be implemented in practice. Much remains to be done to reduce social inequalities in health and mortality, even in a very rich welfare country such as Norway.

Notes

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1 Own and spousal education have usually been included as separate variables, and in the studies where they have been combined the focus has either been on the married exclusively (Martikainen et al. 1995) or all groups of ever-married combined (Spoerri et al. 2014), or all marital status groups have been included without distinguishing between the various categories of non-married (Martelin 1994). A richer picture of mortality variation between sociodemographic groups would be established if other sociodemographic characteristics were considered as well. For example, a recent study showed large differences between highest and lowest mortality when marital status history and number of children were combined (Kravdal et al. 2012). However, complete information about reproduction in the Norwegian registers is available only for those born after 1935. There was no information on occupation, and the only source of income that was included was labor income, which is of little relevance for those above retirement age.

2 1970 is up to ten years before the current year, but this is unproblematic since few persons in the age groups considered have had any further education during the previous ten years.

3 If the individual was married in the year under consideration, but the spouse was not identified (1.5 percent), the observation was omitted.

4 One must be careful when analyzing interactions in logistic and other nonlinear models (Ai and Norton 2003; Greene 2010). If the estimates show, for example, that the odds of dying among women with tertiary education divided by the odds of dying among women with primary education is lower among the divorced than the married, the pattern could in principle be very different if ratios of probability ratios had been considered rather than ratios of odds ratios. The magnitude of this difference depends on the magnitude of the overall death probabilities. As probabilities become smaller, ratios of odds approach ratios of probabilities. Fortunately, predictions showed that, in the youngest age group, the ratios of the probability ratios were almost identical to the ratios of the odds ratios, when considering both the divorced with high education (compared to the reference categories) and other groups. Even at the oldest ages, where death probabilities are generally much higher, the ratios of the probability ratios were only slightly different. In other words, the point estimates of the interactions at the "relative odds scale" give us a highly reasonable impression of the interaction patterns in the "relative probabilities." However, since there are some differences between the "scales," one should not let a significance level below 0.05 at the "relative odds scale" be a strict criterion for paying attention to an interaction.

5 Appendix tables are available at the supporting information tab at wileyonlinelibrary.com/journal/pdr.

6 In reality, a person who is widowed at age 50 may remarry later, and if not, the mortality he or she experiences at age 80 may not be the same as the average for others who are widowed at that age. There are two reasons for the latter difference. Many of those who are widowed at age 80 have quite recently lost their spouse, which typically increases mortality. A second and opposite moderating effect is that, at a given duration since the spouse's death, those who lost their spouse at an unusually early age may tend to have certain characteristics predictive of high mortality.

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