

# Individual and spousal education, mortality and life expectancy in Switzerland: a national cohort study

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## ABSTRACT

**Background** Household measures of socioeconomic position may better account for the shared nature of material resources, lifestyle, and social position of cohabiting persons, but household measures of education are rarely used. We aimed to evaluate the association of combined educational attainment of married couples on mortality and life expectancy in Switzerland.

**Methods** The study included 3 496 163 ever-married persons aged  $\geq 30$  years. The 2000 census was linked to mortality records through 2008. Mortality by combined educational attainment was assessed by gender-age-specific HRs, with 95% CIs from adjusted models, life expectancy was derived using abridged life tables.

**Results** Having a less educated partner was associated with increased mortality. For example, the HR comparing men aged 50–64 years with tertiary education married to women with tertiary education to men with compulsory education married to women with compulsory education was 2.05 (1.92–2.18). The estimated remaining life expectancy in tertiary educated men aged 30 years married to women with tertiary education was 4.6 years longer than in men with compulsory education married to women with compulsory education. The gradient based on individual education was less steep: the HR comparing men aged 50–64 years with tertiary education with men with compulsory education was 1.74 (1.67–1.81).

**Conclusions** Using individual educational attainment of married persons is common in epidemiological research, but may underestimate the combined effect of education on mortality and life expectancy. These findings are relevant to epidemiologic studies examining socio-demographic characteristics or aiming to adjust results for these characteristics.

## INTRODUCTION

Education, occupation, income and wealth are core indicators of socioeconomic position (SEP) used in epidemiological research.<sup>1</sup> Educational attainment measures have the advantage of being ordered by increasing levels, widely collected and predictive of income and wealth (ie, representing earning potential).<sup>1</sup> Another benefit of using education in research settings is that it is less fluid than other SEP measures over time. In most cases education is completed in early-adulthood and does not change much in later life. Education can have an effect on health outcomes via multiple pathways. More highly educated persons are more inclined towards healthier lifestyles and have higher levels of health literacy and better access to healthcare.<sup>2–6</sup> Education also provides formal qualifications for

the labour market and can directly influence earning potential and the acquisition of material resources that influence health outcomes.<sup>7</sup>

Measurement issues are critical in epidemiological research. Household measures of SEP, for example, household equivalent income or wealth are thought to better account for the shared nature of material resources, lifestyle, and social position of cohabiting persons. For education, household measures are rarely used.<sup>8–9</sup> Instead education is typically measured by highest achieved educational level of an individual. However, married couples and nuclear families share material resources, social privilege, and lifestyles when they live together. The impact of these shared health-related characteristics are unlikely to be fully reflected by an individual family member's education alone: it may be more comprehensively captured by the combined educational attainment of the married couple. Yet, few studies have looked at differences in mortality based on the combined education of married pairs.<sup>10–11</sup> Studies generally use separate measures for each partner without considering modification of effects by combined education. Furthermore, results from large population-based studies using combined marital education that also examine life expectancy are even scarcer.<sup>12</sup>

Our aim was to use the data of the Swiss National Cohort (SNC), a comprehensive national longitudinal research platform, and evaluate mortality risk and life expectancy in Switzerland based on combined marital (individual and spouse) educational attainment.<sup>13</sup> Our a priori hypothesis was that the education level of a spouse would be associated with their partner's mortality risk and life expectancy.

## METHODS

### Study population

The SNC has been described in detail elsewhere.<sup>13–14</sup> In brief, the study used probabilistic record linkage to link 1990 and 2000 census records to Federal death or emigration records.<sup>15–16</sup> Linkage was based on a set of key variables available in datasets (eg, sex, date of birth (DOB), place of residence, marital status, religion, nationality). Because participation in the Swiss census is mandatory, enumeration is virtually complete; coverage of the 2000 census was estimated at 99%.<sup>17–18</sup> The present analysis was based on the 2000 census population and included ever-married individuals aged 30 years or older, for two reasons: (1) 30 years is the age by which most tertiary education is completed in Switzerland, and (2) it reflects the average age at marriage (in 1960 31/27 years and

2012 32/30 years, men/women respectively).<sup>19</sup> We excluded all persons with no educational attainment information.

### Variables and definitions

Marriage was defined as those married and living together at the 2000 census, or divorced and widowed at the 2000 census but married and living together at 1990 census. Educational attainment was defined by the most recent census data on education (ie, 2000 unless missing, then 1990). We grouped individual and spousal education into three categories: 'compulsory education' (compulsory schooling up to 9 years of education or less); 'secondary education' (high school, teachers training colleges, vocational education); and, 'tertiary education' (all university undergraduate, post-graduate, higher professional training). Combined education was defined by the nine possible categories of the married pair (individual-spouse): compulsory-compulsory, compulsory-secondary, compulsory-tertiary, secondary-compulsory, secondary-secondary, secondary-tertiary, tertiary-compulsory, tertiary-secondary, tertiary-tertiary.

Socio-demographic variables were from the 2000 census. We included gender, age at census, marital status (married/widowed/divorced), duration of marriage ( $\leq 10$  years, 11–20 years,  $\geq 21$  years), nationality (Swiss/non-Swiss), language region (German/French/Italian), type of household (single-person/multi-person/institution), urbanisation (urban/peri-urban/rural), religion (Protestant/Catholic/no affiliation/other-unknown). We categorised age as 30–49 years, 50–64 years, 65–79 years, and 80+ years. Questionnaires and variable lists are available from the SNC website at <http://www.swissnationalcohort.ch>.

### Mortality

Cause and date of death of all deaths between 5 December 2000 and 31 December 2008 were recorded from official Swiss death certificates. Since 1995, causes of death have been coded according to the tenth revision of the International Classification of Diseases, Injuries and Causes of Death (ICD-10). Cause-specific deaths included: all-cancer (ICD-10 C00-C97); colorectal cancer (ICD-10 C18-C21); breast cancer (ICD-10 C50); prostate cancer (ICD-10 C61); stomach cancer (ICD-10 C16); lung cancer (ICD-10 C33-C34); cardiovascular diseases (ICD-10 I00-I99); myocardial infarction (ICD-10 I21-I22); stroke (ICD-10 I60-I64); respiratory diseases (ICD-10 J00-J99); transport accidents (ICD-10 V01-V99); suicide (ICD-10 X60-X84); alcohol-related causes (ICD-10 F10, G31.2, G62.1, I42.6, K29.2, K70, K73, K74.0-K74.2, K74.6, K86.0, X45, X65, Y15); external causes without suicide (ICD-10 V01-V99, W00-W99, X00-X59, X85-X99, Y00-Y98). We used the underlying cause of death to determine the cause of death, except for alcohol-related deaths, which included any mention of an alcohol-related ICD-10 on the death certificate.

### Statistical analyses

We calculated HRs of death from all causes and specific causes with 95% CIs across educational categories using Cox proportional hazard regression models. We calculated time from the DOB of the individual and used age as the underlying timescale in all age-adjusted models. In persons aged 30 years or older time of observation was from the date of census (5 December 2000) to the date of death, emigration, or the end of the study period (31 December 2008), whichever occurred first. In those <30 years at census date time of observation started on the 30th birthday. The day a person reached an upper age-group limit their person-years were thereafter assigned to the next older age-group. Cox models were stratified by age-group and

sex to examine effect modification. Final models included age in years, marital status, nationality, religion, type of household, language region, urbanisation, and calendar year.

To estimate life expectancy by educational attainment, we calculated mortality rates by gender, 5-year age-groups and combined education for ever-married persons. Using Chiang's method we constructed an abridged life table starting at age 30 years (conditioned on survival up to age 30 years) with the

**Table 1** Socio-demographic characteristics at census 2000 of ever-married men and women aged 30 years or older, N=3 496 163

Characteristic	Male N=1 698 932 N (%)	Female N=1 797 231 N (%)
Age (years)		
<30*	61 130 (3.6)	111 124 (6.2)
30–49	744 382 (43.8)	817 577 (45.5)
50–64	523 914 (30.9)	501 891 (27.9)
65–79	297 782 (17.5)	298 680 (16.6)
80+	71 724 (4.2)	67 959 (3.8)
Marital status		
Married	1 586 976 (93.4)	1 577 180 (87.8)
Widowed	40 226 (2.4)	136 484 (7.6)
Divorced	71 730 (4.2)	83 567 (4.6)
Education		
Compulsory	291 279 (17.1)	569 561 (31.7)
Secondary	867 226 (51.1)	1 003 839 (55.9)
Tertiary	540 427 (31.8)	223 831 (12.4)
Combined education (individual-spouse)		
Tertiary-Tertiary	148 362 (8.7)	153 263 (8.5)
Tertiary-Secondary	332 780 (19.6)	61 923 (3.4)
Tertiary-Compulsory	59 285 (3.5)	8645 (0.5)
Secondary-Tertiary	54 767 (3.2)	334 335 (18.6)
Secondary-Secondary	562 292 (33.1)	594 904 (33.1)
Secondary-Compulsory	250 167 (14.7)	74 600 (4.2)
Compulsory-Tertiary	6775 (0.4)	58 497 (3.3)
Compulsory-Secondary	64 382 (3.8)	265 857 (14.8)
Compulsory-Compulsory	220 122 (13.0)	245 207 (13.6)
Nationality		
Swiss	1 353 195 (79.6)	1 491 171 (83.0)
Non-Swiss	345 737 (20.4)	306 060 (17.0)
Language region		
German	1 230 048 (72.4)	1 300 651 (72.4)
French	391 315 (23.0)	413 932 (23.0)
Italian	77 569 (4.6)	82 648 (4.6)
Type of household		
Single-person	92 035 (5.4)	142 182 (7.9)
Multi-person	1 592 907 (93.8)	1 636 795 (91.1)
Institution	13 990 (0.8)	18 254 (1.0)
Urbanisation		
Urban	432 940 (25.5)	464 395 (25.9)
Peri-urban	798 370 (47.0)	839 687 (46.7)
Rural	467 622 (27.5)	493 149 (27.4)
Religion		
Protestant	626 613 (36.9)	688 507 (38.3)
Catholic	725 207 (42.7)	793 442 (44.1)
No affiliation	192 658 (11.3)	160 978 (9.0)
Other-unknown	154 454 (9.1)	154 304 (8.6)

Swiss National Cohort.

\*Study inclusion date after census 2000 when having reached 30 years of age.

oldest open-ended age-group (95+ years) derived from a Gompertz model.<sup>20 21</sup>

In additional analyses we compared the characteristics of the study population to ever-married persons who were excluded because of unknown educational attainment. We also examined results in the population restricted to couples married at the 2000 census, adjusted for duration of marriage based on date of marital status change (single to married) reported in 2000 census and examined effects by language region. All analyses were performed using Stata 11.<sup>22</sup>

## RESULTS

### Characteristics of the study population

The 2000 census population included 7 280 246 individuals. We excluded 135 204 persons (1.9%) with missing data on educational attainment. We excluded a further 3 648 879 individuals (50.1%) who did not meet inclusion criteria. The characteristics of the study population of 3 496 163 persons are listed by gender in [table 1](#) (online supplementary file - alternative

[table 1](#)). The median age (IQR) was 51.1 years (40.7–62.9) in men and 49.2 years (38.6–61.9) in women. Most individuals (90.5%) were married at census 2000. More males than females had a tertiary education (31.8% vs 12.4%). The proportion of secondary and tertiary education decreased as age increased. This was most evident in the markedly decreased proportions of more highly educated females in the older age-groups. For example, among 30–49 years old women 16.7% had tertiary education compared 3.0% among those 80+ years. Other characteristics were similar across gender.

Most men with compulsory education also had a partner with compulsory education ([table 1](#) and see online supplementary figure S1). In contrast, over half of women with compulsory education had a partner with higher educational attainment. Gender differences were most pronounced in the highest educational levels. Only 27.5% of men with a tertiary education had a spouse with tertiary education, whereas 68.5% of tertiary educated women were also married to tertiary educated men.

**Table 2** HRs with 95% CIs for all-cause mortality by different education measures with and without adjustment for spousal education in ever-married men and women aged 30 years or older

	Education			
	Individual alone HR (95% CI)	Individual controlled for spouse HR (95% CI)	Spouse alone HR (95% CI)	Highest in couple HR (95% CI)
<i>Male</i>				
30–49 years				
Compulsory	1.78 (1.64 to 1.94)	1.63 (1.49 to 1.79)	1.56 (1.43 to 1.70)	1.64 (1.49 to 1.81)
Secondary	1.50 (1.42 to 1.59)	1.46 (1.37 to 1.55)	1.23 (1.13 to 1.33)	1.48 (1.40 to 1.56)
Tertiary	1	1	1	1
50–64 years				
Compulsory	1.74 (1.67 to 1.81)	1.52 (1.46 to 1.59)	1.67 (1.60 to 1.75)	1.71 (1.64 to 1.79)
Secondary	1.43 (1.39 to 1.47)	1.35 (1.31 to 1.39)	1.28 (1.22 to 1.34)	1.43 (1.39 to 1.47)
Tertiary	1	1	1	1
65–79 years				
Compulsory	1.51 (1.48 to 1.55)	1.37 (1.34 to 1.41)	1.48 (1.43 to 1.53)	1.53 (1.49 to 1.56)
Secondary	1.28 (1.26 to 1.31)	1.22 (1.07 to 1.25)	1.20 (1.16 to 1.24)	1.29 (1.27 to 1.32)
Tertiary	1	1	1	1
80+ years				
Compulsory	1.24 (1.21 to 1.26)	1.17 (1.15 to 1.20)	1.22 (1.18 to 1.26)	1.25 (1.22 to 1.27)
Secondary	1.11 (1.09 to 1.13)	1.09 (1.06 to 1.11)	1.07 (1.04 to 1.11)	1.11 (1.09 to 1.13)
Tertiary	1	1	1	1
<i>Female</i>				
30–49 years				
Compulsory	1.45 (1.31 to 1.61)	1.35 (1.21 to 1.50)	1.34 (1.22 to 1.48)	1.31 (1.16 to 1.47)
Secondary	1.11 (1.02 to 1.21)	1.06 (0.97 to 1.17)	1.17 (1.09 to 1.25)	1.21 (1.14 to 1.29)
Tertiary	1	1	1	1
50–64 years				
Compulsory	1.40 (1.32 to 1.49)	1.25 (1.17 to 1.33)	1.40 (1.33 to 1.48)	1.41 (1.33 to 1.49)
Secondary	1.15 (1.09 to 1.22)	1.09 (1.02 to 1.15)	1.24 (1.19 to 1.29)	1.25 (1.20 to 1.30)
Tertiary	1	1	1	1
65–79 years				
Compulsory	1.27 (1.21 to 1.33)	1.15 (1.09 to 1.21)	1.31 (1.27 to 1.35)	1.31 (1.26 to 1.35)
Secondary	1.12 (1.06 to 1.17)	1.06 (1.01 to 1.12)	1.17 (1.13 to 1.20)	1.17 (1.13 to 1.20)
Tertiary	1	1	1	1
80+ years				
Compulsory	1.20 (1.15 to 1.27)	1.14 (1.08 to 1.20)	1.17 (1.14 to 1.20)	1.18 (1.15 to 1.21)
Secondary	1.10 (1.05 to 1.16)	1.07 (1.02 to 1.13)	1.09 (1.06 to 1.11)	1.09 (1.07 to 1.12)
Tertiary	1	1	1	1

Swiss National Cohort, 2001–2008.

Analyses based on 1 698 932 men and 1 797 231 women. Cox models adjusted for age in years, marital status, nationality, religion, type of household, language region, level of urbanisation and calendar year.

### Mortality by educational attainment

During 26 321 153 person-years of follow-up 285 013 deaths from all causes were recorded, including 88 073 deaths from any type of cancer; 17 097 lung cancer deaths; 9026 colorectal cancer deaths; 6671 breast cancer deaths; 8536 prostate cancer deaths; 3110 stomach cancer deaths; 102 333 deaths from cardiovascular diseases; 14 540 deaths from myocardial infarction; 16 357 deaths from stroke; 17 647 deaths from respiratory diseases; 1743 deaths from transport accidents; 5740 suicides and 9606 alcohol-related deaths. Table 2 shows HRs for all-cause mortality using three-category education measures with and without controlling for spousal educational attainment. Results varied by model and interaction terms for individual-spousal education were statistically significant.

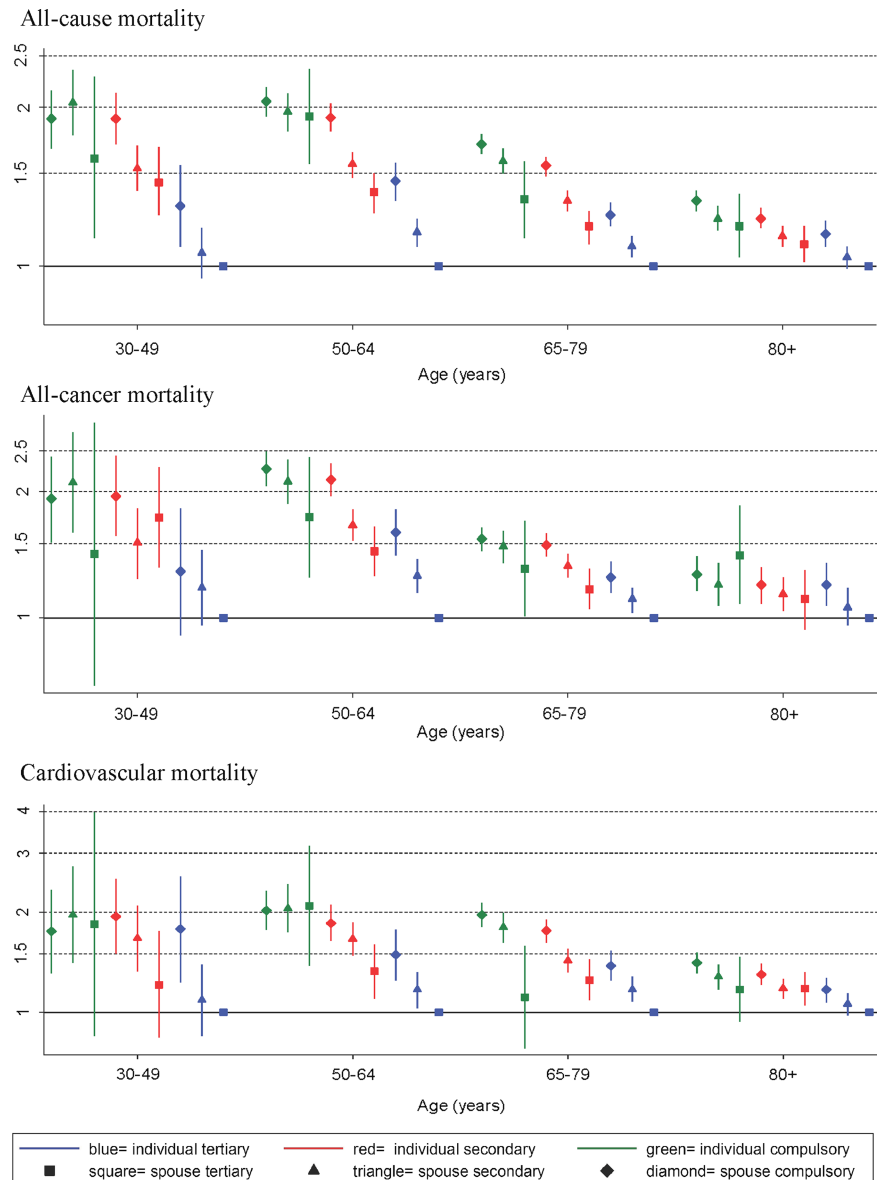
Figure 1 shows HRs and 95% CIs for all-cause, all-cancer and cardiovascular mortality for ever-married men by nine categories of combined educational attainment and age. Figure 2 shows the corresponding data for women. Both in men and women all-cause, all-cancer and cardiovascular mortality was inversely related to combined marital education, with mortality decreasing with higher individual attainment, and within groups of individual educational attainment, with increasing spousal

education. For example, compared to men with tertiary education married to women with tertiary education, the HR for all-cause mortality in men aged 65–79 years with compulsory education who were married to women with compulsory schooling was 1.70 (1.63–1.78) but 1.34 (1.13–1.58) for men of the same age with compulsory education married to women with tertiary education and 1.19 (1.10–1.27) in men with secondary education married to women with tertiary education. The difference in all-cancer mortality is likely a reflection of the different patterns of cancer in women and men, with breast cancer (less strongly associated with SEP) dominating in women. All HRs and 95% CIs shown in figures 1 and 2 are also given in online supplementary tables S1 and S2 and additional cause-specific mortality in supplementary tables S3–S5.

### Life expectancy by educational attainment

Table 3 shows remaining life expectancy by marital educational attainment and gender for selected ages. Both for men and women the spouse's education had a positive (if tertiary) or negative (if compulsory) association with life expectancy for all educational levels, gender, and ages. For example, the estimated remaining life expectancy in tertiary educated men aged

**Figure 1** HRs with 95% CIs for all-cause, all-cancer and cardiovascular mortality in ever-married men aged 30 years or older across categories of combined marital education. Swiss National Cohort 2001–2008.



30 years married to women with tertiary education was 4.6 years longer than in men with compulsory education married to women with compulsory education. The corresponding differences in life expectancy for men aged 50, 65 and 80 years and older were 4.2, 3.4 and 1.6 years, respectively. They were smaller in women: 2.9, 2.8, 2.4 and 1.6 years at ages 30, 50, 65 and 80+ years.

**Additional analyses**

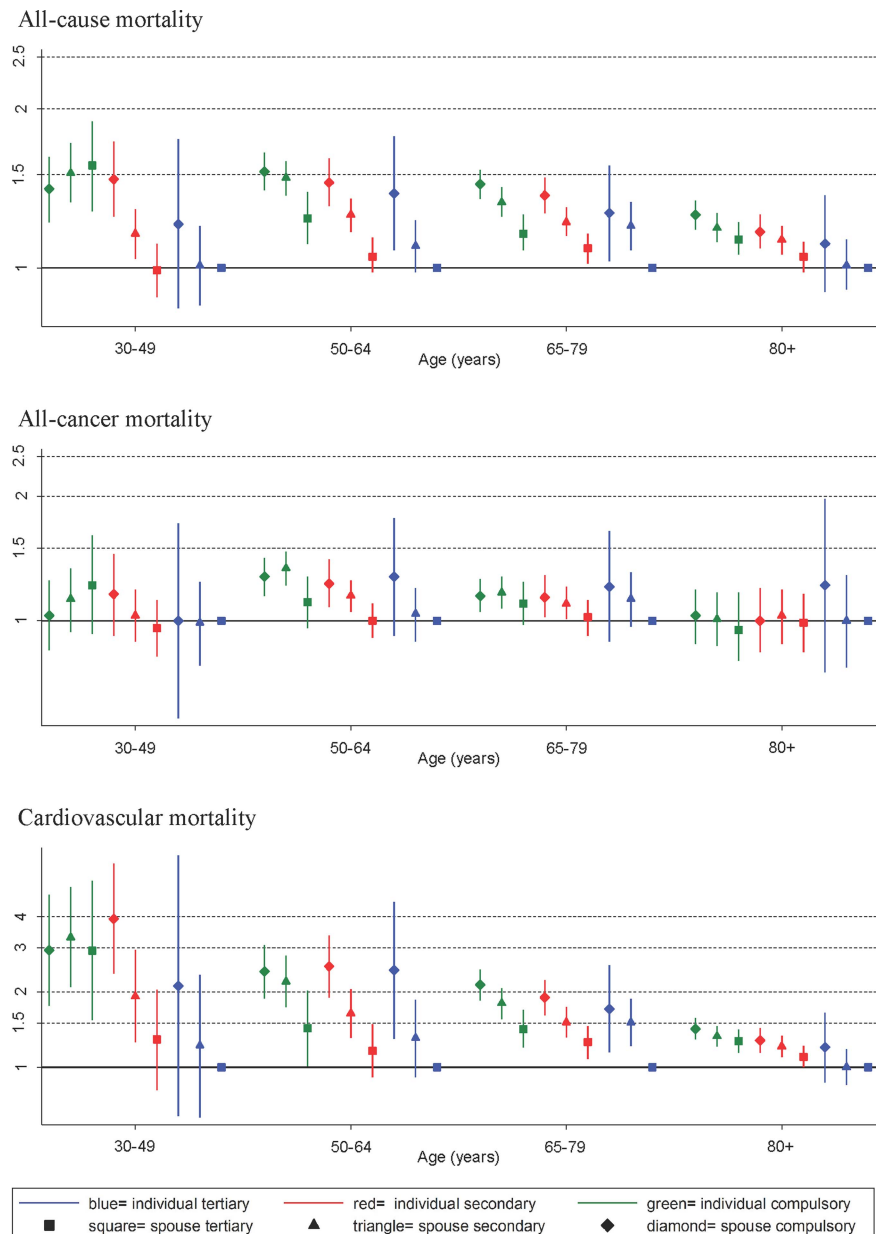
The characteristics of the study population included in the main analysis and the 102 299 excluded because of unknown combined educational attainment were similar (see online supplementary table S5). Results were closely similar when restricting analyses to couples married at 2000 census (see online supplementary tables S6 and S7) and remained substantially unchanged when adjusted for duration of marriage. Stratified analyses showed no significant effects by language region (see online supplementary tables S8 and S9).

**DISCUSSION**

In this study mortality in ever-married persons was not only associated with their individual educational attainment but also with their spouse’s education. We found that mortality decreased and life expectancy increased the higher the spouse’s education was. This finding was evident for all-cause mortality and many but not all specific causes of death and was present in men and women, and across age-groups. The different mortality rates translated into substantial differences in estimated life expectancy. What was new in this study is that mortality risk and life expectancy varied by spouse’s educational attainment within individual education levels. These results emphasise the potential importance of incorporating combined educational levels of married pairs in epidemiologic research.

This is one of few population-based studies investigating differences in mortality risk by categories of combined educational attainment.<sup>10–12 23 24</sup> To our knowledge this is the first study done in a national population-based sample and examining life expectancy. Our results are consistent with previous studies. For example, a wife’s education was the only spousal SEP indicator

**Figure 2** HRs with 95% CIs for all-cause, all-cancer and cardiovascular mortality in ever-married women aged 30 years or older across categories of combined marital education. Swiss National Cohort 2001–2008.



associated with mortality across all causes of death except stroke in Norwegian men.<sup>11</sup> Results from Israeli and Swedish studies also showed important mortality differences by controlling for spouse's education.<sup>12-24</sup> Our results were most similar to Jaffe et al who examined differences in married pairs' education and found that a husband's risk of dying was inversely related to his wife's education.<sup>24</sup> Egeland et al also found an inverse relationship between a wife's education and a husband's cardiovascular mortality, concluding that a spouse's education level can add valuable information to epidemiologic investigations.<sup>23</sup> Recent studies in the USA have shown that income may be a better predictor of mortality than education, and that education matters more for a woman's self-rated health than a man's but has a stronger effect on men's mortality.<sup>25-26</sup> Skalicka et al found that a wife's education was associated with a husband's all-cause mortality but a husband's occupation and income (not education) were more specifically related to a wife's cardiovascular and lung cancer mortality.<sup>11</sup> Disentangling the effects of different SEP measures, comparing effects across studies, and deciding which measures and what level to use in epidemiological research is a challenge.

A married couples' combined education may function as a proxy measure for shared resources, lifestyles and health behaviours. Effects of spousal education seem to persist over the life course. We found regardless of age the difference in life expectancy associated with a wife's education is generally similar to or larger than the difference in life expectancy associated with a husband's education. However, differences in all-cause and cause-specific HRs generally lessened with age as indicated by a smaller range of HRs in the 80+ age-group. A potential explanation for the decreased range of HRs in older persons may be that with increasing age socio-economic factors become less important, and genetic factors more important. It may also be

related equilibration of both shared material resources and social privilege. In this study most persons >65 years old were married >20 years. The effect of a spouse's higher educational attainment might moderate over long periods of living together. Because Switzerland has federally mandated health insurance, it is unlikely any age-specific effects were due to any systemic differences in access to care. Likewise education is generally fixed by early-adulthood and therefore not affected by changes in health status over the life course.

The use of combined educational attainment has some advantages over income and occupation. Income information is not as widely collected as education and considered more sensitive in epidemiological research. For example, income information was not available for this study because it is not collected in the Swiss census. Income is also liable to change over follow-up. In many cases older women may never have had an individual income to report. Like income, occupation may change with time. It may also not accurately reflect an older person's SEP (ie, retirement does not reflect SEP and many older women never worked outside the home). Additionally, differences in material resources and social privilege do not directly or uniquely translate to distinct occupational categories. Our study suggests that taking the combined education of ever-married persons into account could potentially strengthen the description and interpretation of the effects of education (as SEP measure) on mortality risk and life expectancy. It does not, however, investigate the effects of combined education on other outcomes or uses beyond epidemiological research. We also acknowledge that our nine-category measure, albeit simple to employ, may not be the only or best methodological approach to account for important variations in health outcomes.

There are a number of strengths and weaknesses of this research. Major strengths are the population base of the study

**Table 3** Life expectancy by combined marital education of ever-married men and women at selected ages

	Life expectancy at age			
	30 years Remaining years of life (95% CI)	50 years	65 years	80 years
<b>Male</b>				
Tertiary-Tertiary	53.3 (53.1 to 53.5)	33.9 (33.7 to 34.1)	20.4 (20.2 to 20.6)	9.0 (8.8 to 9.2)
Tertiary-Secondary	52.5 (52.4 to 52.6)	33.2 (33.1 to 33.3)	19.9 (19.7 to 20.0)	8.8 (8.7 to 8.9)
Tertiary-Compulsory	51.0 (50.8 to 51.3)	31.8 (31.6 to 32.1)	18.9 (18.7 to 19.0)	8.2 (8.1 to 8.3)
Secondary-Tertiary	51.5 (51.2 to 51.9)	32.5 (32.1 to 32.8)	19.4 (19.1 to 19.7)	8.5 (8.2 to 8.8)
Secondary-Secondary	50.7 (50.6 to 50.8)	31.6 (31.5 to 31.7)	18.7 (18.6 to 18.8)	8.2 (8.1 to 8.3)
Secondary-Compulsory	49.1 (49.0 to 49.3)	30.2 (30.1 to 30.3)	17.7 (17.6 to 17.8)	7.8 (7.7 to 7.8)
Compulsory-Tertiary	50.2 (49.3 to 51.1)	31.2 (30.3 to 32.0)	18.7 (17.9 to 19.4)	8.2 (7.6 to 8.8)
Compulsory-Secondary	49.1 (48.8 to 49.3)	30.2 (30.0 to 30.4)	17.7 (17.5 to 17.9)	7.9 (7.7 to 8.0)
Compulsory-Compulsory	48.7 (48.6 to 48.9)	29.7 (29.6 to 29.8)	17.0 (17.0 to 17.1)	7.4 (7.3 to 7.4)
<b>Female</b>				
Tertiary-Tertiary	57.1 (56.8 to 57.3)	37.6 (37.3 to 37.9)	23.7 (23.4 to 24.0)	11.2 (10.9 to 11.5)
Tertiary-Secondary	56.1 (55.7 to 56.6)	36.7 (36.3 to 37.1)	23.0 (22.6 to 23.4)	11.0 (10.6 to 11.4)
Tertiary-Compulsory	55.1 (54.1 to 56.1)	35.7 (34.8 to 36.7)	22.3 (21.4 to 23.3)	10.5 (9.6 to 11.5)
Secondary-Tertiary	56.6 (56.4 to 56.7)	37.1 (36.9 to 37.2)	23.3 (23.1 to 23.4)	10.9 (10.8 to 11.0)
Secondary-Secondary	55.5 (55.4 to 55.5)	36.1 (36.0 to 36.1)	22.5 (22.4 to 22.5)	10.3 (10.3 to 10.4)
Secondary-Compulsory	54.4 (54.1 to 54.6)	35.1 (34.9 to 35.3)	21.7 (21.5 to 21.9)	10.0 (9.8 to 10.2)
Compulsory-Tertiary	55.5 (55.3 to 55.8)	36.3 (36.0 to 36.5)	22.6 (22.4 to 22.8)	10.4 (10.2 to 10.5)
Compulsory-Secondary	54.5 (54.4 to 54.6)	35.2 (35.1 to 35.3)	21.8 (21.7 to 21.9)	9.9 (9.8 to 10.0)
Compulsory-Compulsory	54.2 (54.1 to 54.3)	34.8 (34.7 to 34.9)	21.3 (21.2 to 21.4)	9.6 (9.5 to 9.6)

and the consistency of our findings with other studies supporting generalisability. Given the large sample size our main findings had statistical precision while we were able to conduct thorough stratified and additional analyses supporting our main results. A general limitation of the SNC is that linkage is less successful in adolescents and younger adults, who are a highly mobile group.<sup>13</sup> This was not an issue in the present study that focussed on married couples >30 years or old and their level of education. We were unable to characterise health and lifestyle factors such as smoking, levels of exercise or diet. Another limitation is the lack of information on individual financial resources in the SNC. Lastly, we were only able to evaluate duration of marriage in persons married at the 2000 census. Thus we could not identify how long persons were married if they were divorced or widowed, whether or not they were previously married and if so for how long. Therefore, some uncertainty (in these limited cases) remains, possibly introducing a non-differential bias attenuating true effects.

In conclusion, the use of individual educational attainment, although commonplace, may not provide a good estimate of the true effect of a household's level of education on mortality risk and life expectancy. These findings are relevant to epidemiologic research into effects of social, economic and behavioural factors on health that may be associated with and mediated by education, and for research into specific exposures, for example, air pollution, which may be confounded by education. Researchers should consider collecting information on the education level of married pairs whenever possible. A more detailed understanding of persons' living situations, which is not only based on marital status and individual education, will inform public health strategies to reduce health disparities.

#### What is already known on the subject

Education is typically measured by highest achieved educational level of an individual, which does not account for the shared nature of material resources, lifestyle and social position of the household.

#### What this study adds

Use of individual educational attainment, although commonplace, may not provide a good estimate of the true effect of a household's level of education on mortality and life expectancy. This is relevant to epidemiologic research into effects of social, economic and behavioural factors on health that may be associated with and mediated by education, and for research into specific exposures, which may be confounded by education.

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