Cause-specific mortality by partnership status: simultaneous analysis using longitudinal data from England and Wales

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ABSTRACT

Background This paper examines cause-specific mortality by partnership status. Although non-marital cohabitation has spread rapidly in industrialised countries, only a few studies have investigated mortality by partnership status and no recent study has investigated cause-specific mortality by partnership status.

Methods We use data from the Office for National Statistics Longitudinal Study and apply competing risks survival models.

Results The simultaneous analysis shows that married individuals have lower mortality than non-married from circulatory, respiratory, digestive, alcohol and accident related causes of deaths, but not from cancer. The analysis by partnership status reveals that once we distinguish premarital and postmarital cohabitants from other non-married groups, the differences between partnered and non-partnered individuals become even more pronounced for all causes of death; this is largely due to similar cause-specific mortality levels between married and cohabiting individuals.

Conclusions With declining marriage rates and the spread of cohabitation and separation, a distinction between partnered and non-partnered individuals is critical to understanding whether and how having a partner shapes the individuals' health behaviour and mortality. The cause-specific analysis supports both the importance of selection into partnership and the protective effect of living with someone together.

INTRODUCTION

Research shows that married people in industrialised countries have lower mortality levels than non-married individuals.[1–9] However, it is far from clear whether mortality differences by marital status are explained by the *protective effects* of marriage or the *selection* into marriage.[10–12] Many studies suggest that a combination between both protection and selection plays a role.[4 9 13] Health influences selection into marriage at younger ages, but mortality differences at older ages are also observed due to the cumulation of the protective effects of marriage.[9 14–16]

Although there is a large body of literature on mortality differences by marital status, mortality by causes of death has received much less attention. Previous studies show lower mortality rates for married individuals from circulatory and respiratory diseases as well as from accidents and self-harm. For cancer, research demonstrates the higher mortality risk for divorced in comparison to married people.[2 17–21] However, most research on mortality by partnership status does not distinguish between individuals who are single and those who are cohabiting treating them as one group. These studies are likely to underestimate mortality differences between partnered and non-partnered individuals and increasingly misrepresent the changing demographic reality.[16]

Marriage rates have significantly declined in many industrialised countries, with data showing the postponement of marriages combined with some decline of the percentage who marry.[22] In Britain, the median age of marriage for women born in the 1940s and 1950s was in the low 20s, whereas the same figure for cohorts born in the 1970s was in the low 30s; the share of married individuals declined from 90% among women born in the 1940s and 1950s to 80% among women born in the 1960s.[23] In contrast, premarital and postmarital cohabitation have rapidly increased over recent decades. While only 10% of individuals who were born in the 1940s ever cohabited by age 45, more than 50% of women who were born in the 1960s cohabited by the age of 30. For younger cohorts, the percentage of individuals having ever cohabited by age 30 is about 70%.[4 23 24] Divorce and separation levels have also increased. One-fifth of the marriages that were formed in the 1965–1974 period ended in divorce before their 15th anniversary, whereas more than one-third of marriages have experienced separation in the marriage cohorts from 1995 onwards. Separation levels have been even higher among cohabitants.[23] These significant changes in partnership patterns in industrialised countries suggest that any analysis of mortality differences by partnership should distinguish non-marital cohabitants from single and divorced individuals and treat them as separate groups.

The aim of this study is to investigate cause-specific mortality by partnership status. We build on previous research and extend it in two ways. First, we move beyond the non-married–married dichotomy and treat cohabitants as a separate group. Distinguishing cohabitants from other non-married groups (ie, single and divorced) in the cause-specific analysis of mortality is the first novelty of the study. Previous studies have either examined cause-specific mortality by marital status (eg, [2 3 17 25–31]) or all-cause mortality by partnership status (eg, [14 16 32–34]). There are very few (if any) recent studies that investigate cause-specific mortality by partnership status.

Second, we conduct simultaneous analysis of cause-specific mortality allowing us to explicitly distinguish the contribution of different causes to the all-cause mortality by partnership status. Simultaneous analysis is the second novelty of the paper; most previous studies on mortality by marital status have conducted separate analysis for each cause of death. We calculate cause-specific mortality rates by partnership status separately for men and women. We standardise the mortality rates to socioeconomic characteristics of individuals to examine mortality differences between non-married cohabiting and non-married not-cohabiting people. We show how all-cause mortality differences by partnership status in Britain translate into cause-specific mortality differences.

DATA AND METHODS
Data
We use the Office for National Statistics Longitudinal Study (ONS LS), which is a 1% sample of the population of England and Wales (see Hattersley et al[35] for more detail). We study cause-specific mortality of the population aged 30–85 between the 2001 and 2011 census. The ONS LS provides demographic and socioeconomic characteristics from the 2001 census, linked with yearly death and embarkation events. Our analysis was conducted for men (158 061) and women (171 706) separately. Individuals who leave the study at a known or unknown embarkation date before 2011 are censored after 3.9 years based on the sensitivity analysis by Franke and Kulu.[16]

Methods
We use competing risks survival analysis. The cause-specific hazard function, $h_k(t)$, is defined as follows:

$$h_k\left(t\right) = \lim_{\Delta t \to 0} \frac{Pr\left(t \le T < t + \Delta t, D = k | T \ge t\right)}{\Delta t}, k = 1, 2 \ldots, K, \quad (1)$$

where D denotes the cause of death with k as the number of different causes and T represents the duration of an episode or an individual's age. We define a cause-specific proportional-hazards regression model to study mortality by partnership status and cause of death.

$$lnh_k\left(t\right) = lnh_{k,0}\left(t\right) + \sum_l \beta_{kl} x_l\left(t\right) + \gamma_k z \quad (2)$$

where $h_k(t)$ denotes an individual's hazard of mortality and $h_{k,0}(t)$ is the baseline mortality risk for cause k at age t; $x(t)$ is a variable measuring individual socioeconomic characteristics and β is the parameter estimate for this variable, with l variables; γ_k represents the effect of variable z (partnership status) on mortality from cause k.

The advantage of the model defined in equation 2 is that the effect of age and all (other) covariates on mortality can vary by cause; however, the contribution of each cause to mortality by partnership status (our covariate of interest) is not easy to grasp from separate models. We extend this model to also measure the relative contribution of each cause to mortality variation by partnership status:

$$lnh_k\left(t\right) = lnh_0\left(t\right) + \sum_l \beta_l x_l\left(t\right) + \gamma_k z \quad (3)$$

The model defined by equation 3 is similar to the one defined by equation 2, but assumes a common baseline for all causes and the same effect of control variables across the causes. Only the effect of partnership status is allowed to vary by cause; γ_k is a cause-specific parameter for variable z, partnership status. The partnership status differences obtained are now directly comparable with the equivalent differences for all-cause mortality.

We use a Cox proportional-hazards model to estimate relative risks by partnership status without having to define the baseline hazard. We need to extend our data, so that we have k records per person with k being the number of possible causes. If an individual died from cause k, then our event variable has value 1 for this record (eg, cardiovascular disease, CVD); for all other records of this individual, the variable has value 0 (eg, cancer). We interact the cause of death variable with partnership status to simultaneously model cause-specific mortality among the population. We can then present mortality rates from each cause by partnership status (eg, cancer for singles) relative to a reference category (eg, CVD for married people). This approach has become common in some areas of mortality research,[36] but has not yet been used to study mortality by partnership status.

Causes of death
Ideally, we would prefer to analyse causes of death in as much detail as possible. However, this is not feasible due to (1) a small number of events per partnership status when using a detailed cause classification and (2) the independence rule of competing risks. When analysing cause-specific mortality within a competing risk setting the independence of those causes needs to be ensured. This means that the probability of two causes of death between $(t, t + \Delta t)$ should be negligible. One way to ensure this is to use broad disease categories.[37]

We used WHO's 10th revision of the International Classification of Diseases (see table 1 for more detail) to group our causes

Table 1	Cause of death categories and deaths by marital status					
Cause	**ICD-10 Category**	**Married**	**Single**	**Divorced**	**Widowed**	**Total**
Circulatory diseases	I00–I99	8142	1465	1336	5009	15 952
Cancer	C00–C97	8620	1012	1405	3006	14 043
Respiratory diseases	J00–J99	2780	567	575	1937	5859
Digestive diseases	K00–K93	827	185	182	570	1764
Nervous system diseases	G00–G99	851	157	114	373	1495
Accidents	U509, V01–Y89	464	180	156	221	1021
Alcohol-related*	F10, G31.2, G62.1, I42.6, K29.2, K70, K73, K74, K86.0, X45, X65, Y15, Y91	304	116	146	51	617
Other (diseases)		2135	559	364	1729	4787
Total		24 123	4241	4278	12 896	

*Besides *unspecified liver disease* (K73, K74), only wholly attributable conditions are considered; that suggests a long-term use.
ICD-10, International Classification of Diseases, 10th revision.
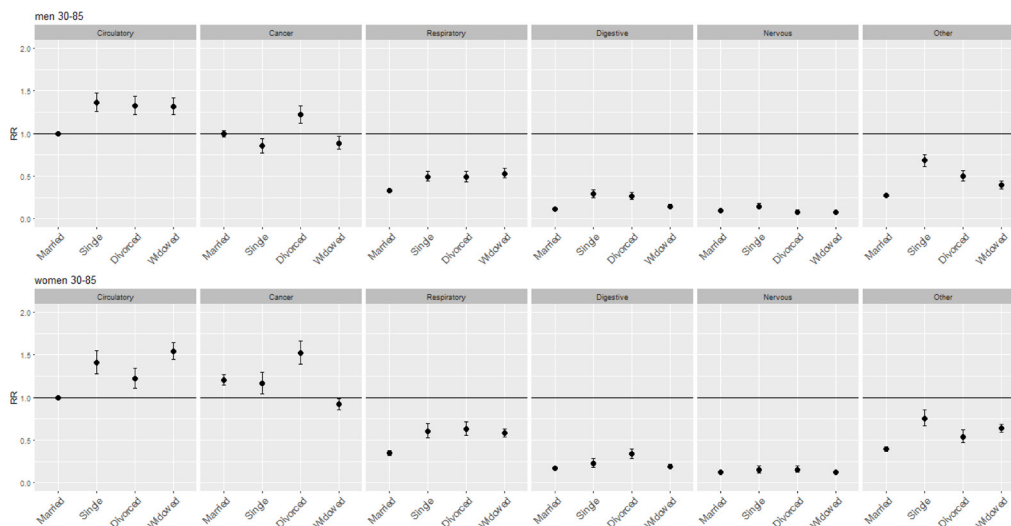
Figure 1 Comparative cause-specific mortality risk for men and women aged 30–85 years (description: risk for five causes compared with married-circulatory disease, source: ONS LS, authors' own calculation).

into the following categories—*circulatory diseases*, *cancer (or malignant neoplasm)*, *respiratory diseases*, *digestive disease,* and *nervous system diseases*, which comprise 85% of all deaths for the age group 30–85. We fitted additional models including *accidents and self-harm* and *alcohol-related* causes, but we discuss these only briefly.

Covariates

For all our models the first covariate is the interaction between marital status and cause of death. Marital status is hereby defined as 'married', 'single', 'divorced/separated' or 'widowed'. In the model which includes cohabitation, *partnership status* is defined as 'married', 'single' (not cohabiting), 'divorced/separated' (not cohabiting), 'widowed' (not cohabiting), 'premarital cohabitation' (cohabiting singles) or 'postmarital cohabitation' (cohabiting divorced/separated and widowed).

Control variables are as follows: country of birth ('England and Wales', 'Scotland or Northern Ireland', or 'Others'); ethnicity ('White', 'White mixed', 'Asian', 'Black', 'Chinese' or 'Other'); education ('No qualification', 'Low qualification', 'Medium qualification', 'High qualification' or 'Missing'); socioeconomic status ('Higher managerial and professional occupations', 'Lower managerial and professional occupations', 'Intermediate occupations (clerical, sales, service)', 'Small employers and own account workers', 'Lower supervisory and technical occupations', Semi-routine occupations', 'Routine occupations' or 'Others'). We also include in the analysis two variables on living arrangements: household size ('one person', 'two persons', 'three persons', 'four persons', 'five and more persons' or 'Unknown') and the presence of dependent children ('No children', 'Dependent children', 'Non-dependent children' or 'Not applicable').

RESULTS
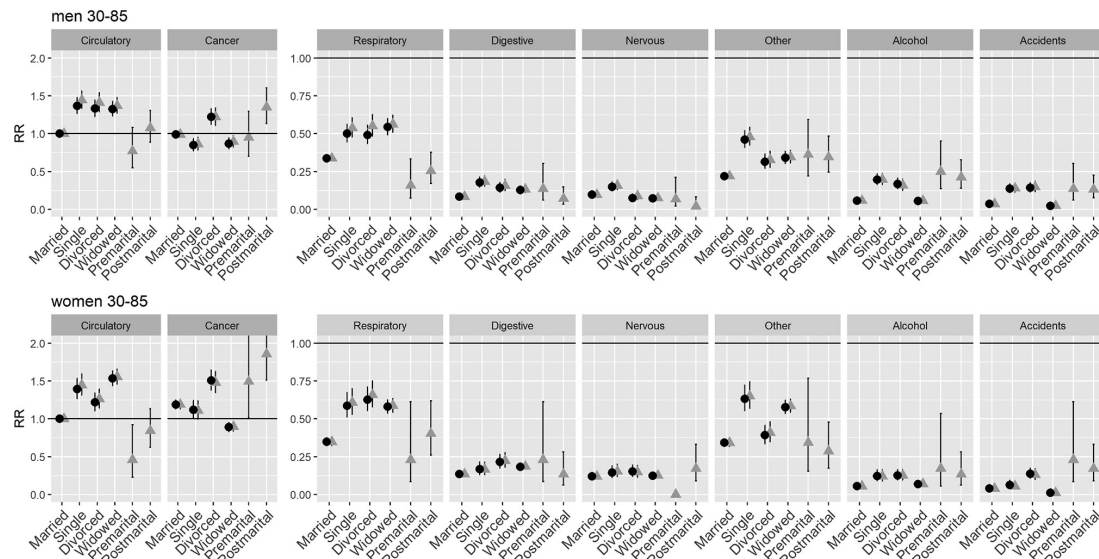### Mortality by marital status by five causes

We analysed mortality by marital status by five main causes: circulatory diseases, cancer, respiratory diseases, digestive diseases and nervous system diseases, and observed the following patterns. For both sexes, circulatory diseases and cancer are the leading causes of death, followed by respiratory and other diseases. The risk of dying from one of the latter two is only half of the risk of dying from a circulatory disease. Non-married individuals

have higher mortality from all causes, with the exception of cancer for singles and widowed and nervous system diseases for divorced and widowed (figure 1 and online supplementary table A1). Although there is some variation between men and women, overall the patterns are relatively similar.

In the next step, we extended the analysis in two ways. First, we added accidents (including self-harm) and alcohol-related causes. Second, we fitted one model with marital status and one model with partnership status, with both fitted separately for men and women. Comparing the results of the marital status model from the seven-cause analysis (dots in figure 2) with those of the five-cause analysis (dots in figure 1), we observe the following: the inclusion of alcohol-related diseases in the analysis leads to a decline in the effect of digestive system diseases. The inclusion of accidents results in a decrease in the impact of the 'Other causes' category. For both of these causes of death, single and divorced individuals have a significantly higher risk of dying than married people.

Next, we compared the results of the models for marital status and partnership status. For most causes, the differences between partnered and non-partnered individuals (triangles in figure 2) are bigger than those between married and non-married people (dots in figure 2). This is largely due to distinguishing cohabitants from singles in our analysis. For all causes but cancer and alcohol-related diseases, we find for men a significantly lower mortality risk for premarital cohabitants compared with non-co-habiting singles as well as lower risks for postmarital cohabitants than for non-cohabiting divorced/widowed individuals (online supplementary table A2). The results for women support a clear mortality difference between partnered and non-partnered individuals for the circulatory, respiratory and the 'Other causes' category .

The effects of covariates were largely as expected. Mortality levels were lower among individuals with higher educational level and higher social class, and among ethnic minorities and migrants from outside the UK. There were minor mortality differences by household size or number of dependent children (table 2). Mortality levels of control variables were similar to the effects found in the all-cause-mortality models by Franke and Kulu.[16] The similarity to the overall-mortality model suggests independence of the causes used in the competing risks model.

Figure 2 Comparative cause-specific mortality risk by marital and partnership status for men and women aged 30–85 years (description: risk for seven causes compared with married-circulatory disease, source: ONS LS, authors' own calculation).

SUMMARY AND DISCUSSION

This study investigated cause-specific mortality by marital and partnership status distinguishing between partnered and non-partnered individuals. Distinguishing cohabitants from singles in this way was the first novelty of the study. Another novelty was the use of simultaneous analysis of cause-specific mortality in order to distinguish the contribution of different causes to the all-cause mortality differences by partnership status. The analysis of mortality by marital status showed that married individuals have lower mortality from all causes with the exception of cancer compared to non-married individuals. Differences by marital status, and thus the relative contribution towards all-cause mortality differences, were highest for circulatory, respiratory, digestive, alcohol and accident related causes of deaths. The analysis by partnership status showed that once we distinguished cohabitants from other non-married groups, the differences between partnered and non-partnered individuals became even more pronounced for almost all causes of deaths. Increased differences between partnered and non-partnered individuals were largely due to similar cause-specific mortality between married and cohabiting individuals, although this is a topic that requires further investigation using a larger sample.

The study demonstrates the importance of cause-specific analysis and of distinguishing between partnered and non-partnered individuals. With declining marriage rates and an increase in cohabitation and separation, such a distinction is critical to understanding whether and how having a partner shapes the individuals' health behaviour and mortality. Like previous studies, we observed significant mortality differences by partnership status for circulatory and respiratory systems for both men and women (eg, [2 17 20]). Our study clearly showed that those differences are underestimated if cohabitants are not distinguished from single and divorced individuals. Additionally, we extended previous research by distinguishing alcohol-related deaths, which can be due to short-term causes such as alcohol poisoning or accidents, or long-term causes such as alcohol-related damage to the digestive or nervous systems. The majority of alcohol-related causes in our study was attributed to digestive system diseases. The analysis showed a clear marital/partnership advantage. Further, single and divorced individuals, especially

men, had a higher risk of death due to accidents and self-harm. These differences may be attributed to differences in lifestyle and both short- and long-term health behaviour. Therefore, having a partner provides protection from health-damaging behaviour.

The advantage of having a partner or a spouse was not found for malignant neoplasm (cancer). Cancer became the number one cause of death in the UK in 2011, mostly due to a larger decline in circulatory diseases.[38] Thus, for cancer, our analysis showed no advantage of people living with a partner in comparison with those living without a partner. Lower cancer mortality found in singles was more likely due to higher prevalence of other causes rather than to singlehood being a protection for cancer. Although we have mostly emphasised the importance of the protective effect of having a partner, relatively high mortality from nervous system diseases observed among non-partnered individuals supports the idea of selection into partnership by health status.

With circulatory diseases being the main cause of death, a decline in CVD mortality is expected to lead to a decline in overall mortality differences by partnership status. Previous research has suggested that mortality differences by partnership status may gradually disappear. Crucially, our findings show that there remain significant mortality differences by partnership status, for example, in respiratory diseases. Thus, a continued increase in life expectancy, as well as a continued decline in circulatory disease mortality, will not necessarily result in a declining mortality gap between partnered and non-partnered individuals.

In this study, survival models used the partnership status as recorded in the 2001 and 2011 Censuses since there is no information on partnership changes in the ONS LS. Methodologically, the simultaneous analysis of causes used in this study assumes a cause-independent baseline hazard, which is the same as the all-cause mortality baseline hazard. It is possible that different causes of death have different baseline hazards. In our preliminary analysis, we fitted separate models for the main causes of death—the baseline and covariate effects were thus cause specific. Most importantly, we observed similar cause-specific mortality differences by partnership status between separate and simultaneous analysis confirming that the results of our simultaneous analysis are robust.

Table 2 Relative mortality risks by seven causes of death for control variables

	Men 30–85						Women 30–85					
	Marital status			Partnership status			Marital status			Partnership status		
Model	RR	Sig	CI	RR	Sig	CI	RR	Sig	CI	RR	Sig	CI
Country of birth												
England & Wales	1			1			1			1		
Scot. & N. Ireland	1.18	***	(1.09 to 1.27)	1.18	***	(1.09 to 1.27)	1.20	***	(1.1 to 1.29)	1.20	***	(1.1 to 1.29)
Others	0.95		(0.9 to 1.01)	0.95		(0.9 to 1.01)	0.95		(0.9 to 1.01)	0.95		(0.9 to 1.01)
Missing	0.40		(0.12 to 1.32)	0.41		(0.12 to 1.37)	1.23		(0.28 to 5.38)	1.24		(0.28 to 5.43)
Ethnicity												
White	1			1			1			1		
White mixed	1.11		(0.87 to 1.42)	1.11		(0.87 to 1.42)	1.02		(0.79 to 1.32)	1.02		(0.79 to 1.32)
Asian	0.87	**	(0.79 to 0.97)	0.87	**	(0.79 to 0.97)	0.85	**	(0.76 to 0.96)	0.85	**	(0.76 to 0.96)
Black	0.76	***	(0.66 to 0.88)	0.76	***	(0.66 to 0.88)	0.85	*	(0.73 to 1)	0.85	*	(0.73 to 0.99)
Chinese	0.73		(0.53 to 1)	0.73	*	(0.53 to 1)	0.77		(0.54 to 1.09)	0.76		(0.53 to 1.09)
Other	0.56	*	(0.35 to 0.89)	0.55	*	(0.35 to 0.88)	0.63	*	(0.4 to 0.99)	0.63		(0.4 to 0.99)
SES												
Higher managerial	1			1			1			1		
Lower managerial	1.15	***	(1.07 to 1.23)	1.15	***	(1.07 to 1.23)	1.16	*	(1.01 to 1.34)	1.16	*	(1.01 to 1.33)
Intermediate	1.18	***	(1.07 to 1.31)	1.18	***	(1.07 to 1.31)	1.12		(0.97 to 1.29)	1.12		(0.97 to 1.29)
Small employers	1.19	***	(1.1 to 1.28)	1.19	***	(1.11 to 1.28)	1.17		(1 to 1.37)	1.17		(1 to 1.37)
Lower supervisory	1.37	***	(1.27 to 1.47)	1.37	***	(1.27 to 1.47)	1.38	***	(1.19 to 1.62)	1.38	***	(1.19 to 1.61)
Semi-routine	1.47	***	(1.36 to 1.58)	1.46	***	(1.36 to 1.58)	1.28	***	(1.11 to 1.48)	1.28	***	(1.11 to 1.48)
Routine	1.54	***	(1.44 to 1.66)	1.54	***	(1.43 to 1.66)	1.52	***	(1.32 to 1.76)	1.52	***	(1.32 to 1.76)
Others	1.85	***	(1.71 to 2)	1.84	***	(1.7 to 1.99)	1.90	***	(1.65 to 2.19)	1.9	***	(1.65 to 2.19)
Missing	1.16		(0.72 to 1.87)	1.18		(0.74 to 1.91)	2.13	***	(1.29 to 3.53)	2.14	***	(1.29 to 3.53)
Education												
Low qualification	1			1			1			1		
Medium qualification	1.11	*	(1.01 to 1.21)	1.11	*	(1.01 to 1.21)	0.93		(0.82 to 1.06)	0.93		(0.82 to 1.06)
High qualification	0.88	***	(0.83 to 0.94)	0.88	***	(0.83 to 0.94)	0.88	***	(0.82 to 0.95)	0.89	***	(0.82 to 0.95)
No qualification	1.20	***	(1.15 to 1.25)	1.20	***	(1.15 to 1.25)	1.24	***	(1.18 to 1.3)	1.24	***	(1.18 to 1.3)
Missing	1.32		(0.82 to 2.12)	1.30		(0.81 to 2.09)	0.68		(0.42 to 1.1)	0.68		(0.42 to 1.1)
Houshold size												
2 Person	1			1			1			1		
1 Person	1.07	*	(1.01 to 1.12)	1.03		(0.98 to 1.09)	0.96		(0.91 to 1.01)	0.95	*	(0.9 to 1.00)
3 Person	0.98		(0.91 to 1.05)	0.99		(0.92 to 1.06)	1.02		(0.96 to 1.09)	1.03		(0.96 to 1.09)
4 Person	0.96		(0.88 to 1.05)	0.97		(0.89 to 1.06)	1.00		(0.91 to 1.10)	1.01		(0.92 to 1.10)
5+Persons	1.08		(0.97 to 1.2)	1.08		(0.97 to 1.20)	1.11		(0.99 to 1.24)	1.11		(0.99 to 1.24)
Unknown	2.94	***	(2.71 to 3.19)	2.86	***	(2.63 to 3.10)	3.00	***	(2.79 to 3.21)	2.96	***	(2.76 to 3.18)
Dependent children												
No children	1			1			1			1		
Dependent	0.95		(0.86 to 1.04)	0.93		(0.84 to 1.03)	0.92		(0.83 to 1.03)	0.90		(0.81 to 1.01)
Non-dependent	1.19	***	(1.10 to 1.29)	1.15	***	(1.06 to 1.25)	1.10	*	(1.02 to 1.19)	1.08		(1.00 to 1.17)
Not applicable	1.16	***	(1.11 to 1.22)	1.13	***	(1.08 to 1.2)	1.06		(0.99 to 1.13)	1.04		(0.98 to 1.12)

Source: ONS LS, authors' own calculation.

RR, relative rates; SES, socioeconomic status.

P values: *0.05, **0.01, ***0.001.

In a competing risks setting with *k* competing causes, only the first failure is observed. We grouped the causes of death into seven groups under the assumption that they are independent of each other. The independence assumption has the advantage that the survival function of a specific cause derived from the joint-survival function or the multiple decrement function of all competing risks is reduced to a cause-specific survival function where we can simply censor failures due to different causes. This is because censored observations do not change the survival or hazard function as long as they are independent of the estimated failure. A limitation of this approach is that this independence hypothesis is not testable.[39] Future studies could compare the results of different competing risks approaches for cause-specific mortality analysis.

Future analysis on cause-specific mortality risks in England and Wales could also disaggregate the patterns by age (which

What is already known on this subject

► Married people have better health and lower mortality levels than non-married individuals.
► Married individuals have lower mortality from circulatory and respiratory diseases as well as from accidents and self-harm.
► Marriage rates have significantly declined in many industrialised countries over the last decades; in contrast, premarital and postmarital cohabitation have rapidly increased.
► However, most research on mortality by partnership status does not distinguish between singles and cohabitants, instead treating them as one group. These studies are likely to underestimate mortality differences between partnered and non-partnered individuals and increasingly misrepresent the changing demographic reality.

What this study adds

► Married individuals have lower mortality from all causes with the exception of cancer.
► Once we distinguish cohabitants from other non-married groups, the differences between partnered and non-partnered individuals become even more pronounced for all causes of deaths.
► For most of the causes, patterns are similar for cohabiting and married individuals, suggesting that having a partner is an important indicator and determinant of health behaviour.
► With declining marriage rates and the increase of cohabitation and separation, a distinction between partnered and non-partnered individuals is critical to understanding whether and how having a partner shapes the individuals' health behaviour and mortality.

we did in further analysis not reported here due to small sample size). Such analysis could also include measures of health differences like morbidity or social deprivation (eg, [40]). The detailed analysis of mortality and health differences between cohabiting and married individuals is another important avenue to proceed. With the spread of premarital and postmarital cohabitation among younger cohorts, this is increasingly feasible and important. To conclude, using longitudinal data from England and Wales this study showed first that partnered individuals had lower mortality from all causes with the exception of cancer. Second, the differences between partnered and non-partnered individuals became pronounced for all causes of death, once premarital and postmarital cohabitants were distinguished from other non-married groups.

or Selection'). He also held an Advanced Quantitative Methods (AQM) enhanced stipend.

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