Evolution and Human Behavior 38 (2017) 536–545

Contents lists available at ScienceDirect

Evolution and Human Behavior

journal homepage: www.ehbonline.org

Original Article

How does marriage affect length of life? Analysis of a French historical dataset from an evolutionary perspective

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ARTICLE INFO

Article history:
Initial receipt 26 January 2016
Final revision received 3 February 2017

Keywords:
Marriage
Longevity
Sex differences
Spousal age gap
Sexual selection

ABSTRACT

There are broadly two explanations for why human longevity appears to be extended by marriage. First, there is the social explanation, whereby the companionship, division of labour and the economic support that marriage offers is thought to extend life. Second, there is a selective explanation, whereby those individuals with high potential longevity are more attractive to the opposite sex and therefore more likely to get married. Here we analyse the "TRA" dataset from 19th century France, using an evolutionary approach to address the question of why marriage is linked to longevity, focussing particularly on sex differences. The dataset is based on death and marriage records from all of France between 1798 and 1901 and includes information on age at death, marriage and wealth for individuals whose surnames began with the letters TRA. We find that marriage is positively associated with longevity, particularly for men. In part, this is related to the higher rate of deaths for single males during marriageable age, as compared to a higher rate of deaths for females during marriage. There is a positive association between wealth (at death) and longevity for individuals who were single or married at death, with a stronger effect for singles. Analysis of the effect of spousal age gap on duration of survival after first marriage indicates that men who were married to younger women lived longer, whereas the longevity of women was not associated with the spousal age gap. We put forward an evolutionary perspective on marriage and longevity, hypothesizing that there is an important role for sexual selection in the association between marriage and longevity, with women selecting on characteristics associated with longevity, whilst men select on characteristics associated with reproductive potential.

1. Introduction

Evidence from a number of studies has shown that married persons, and particularly men, tend to live longer than their unmarried counterparts (e.g. Hu & Goldman, 1990; Lillard & Waite, 1995; Tucker, Friedman, Wingard, & Schwartz, 1996) but the reasons for this are not completely clear. A review and meta-analysis of those studies which have examined the issue, conducted by Rendall, Weden, Favreault, and Waldron (2011), reached the following conclusions: (1) There is a survival advantage of marriage for men and women, when comparing all married categories (married, widowed, divorced) with the unmarried group. (2) There is a greater overall marriage advantage for men than for women (controlling for employment and earnings), which tapers off for men into older age. (3) The protective effect of marriage attenuates with age, and the gender difference in survival disappears; however, the use of household survey data may confound this, because it misses those elderly in nursing homes. (4) The claims of differences between married groups (married, widowed, divorced) are based on weak statistical evidence, with explicit tests between the groups almost always absent, whilst hypotheses to explain higher mortality of one or other married category are inconsistently applied.

There are broadly two theories that have been put forward to explain survival differences between married and non-married individuals:

The first of these theories is that marriage, in itself, has a protective effect on survival, which results in enhanced longevity; this idea usually takes into account the socio-economic benefits that come along with marriage. On one hand, marriage has traditionally been the socially desired institution for cohabitation of couples, causing people to be accepted in a society and to possess certain rights. On the other hand, marriage may be associated with better economic circumstances and better living conditions, which positively affect survival.

The second theory is that there is selection into marriage of individuals who are most likely to live longer. In other words, those individuals who are better equipped to survive into old-age are more likely to marry. In fact, this was suggested as long ago as 1858 by William Farr in a study of marriage and mortality in France (Farr, 1858). He suggested that those with mental and physical disabilities were less likely

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http://dx.doi.org/10.1016/j.evolhumbehav.2017.02.002

to marry, whilst also being less likely to live long lives, whereas those who were healthy were not only mutually attracted to each other, but their union in marriage was promoted and supported by society.

According to Goldman (1993), the relationship between marital status and longevity is inextricably linked to the process of selection into marriage. In the modern debate, the notion of selection relates to the preference for 'high quality' partners on the marriage market, which may be indicated by social status, health, beauty and behaviors which are positive for health and longevity, because these 'quality-traits' are indicative of higher survival prospects (e.g. Livi-Bacci, 1985). The greater success of individuals with these "quality-traits" in attracting partners and getting married, results in those with better survival prospects being better represented in the married group, whilst those with lower survival prospects are better represented in the single group.

It has been difficult to disentangle the evidence for a protective effect of marriage with that for selection into marriage, in relation to longevity, and it is possible that both processes are occurring (Murray, 2000). The ability of individuals to move from the single into the married group, then from the married group into widowed and divorced groups, means that any attempts to make distinctions between the groups are fraught with difficulty (Bernard, 1982; Goldman, 1993). For example, using a longitudinal survey from the United States, Liu (2009) identified the widowed as a group which is particularly vulnerable, exhibiting a higher mortality rate. It follows, therefore, that marriage may not only have a protective effect for those that are married, but a detrimental effect for those who are married and then lose their spouse. It has similarly been found that divorcees show the highest mortality rates among the unmarried groups, though this may be due to the destabilizing effect of becoming divorced, rather than being due to the loss of the protective effect of marriage (Hu & Goldman, 1990; Tucker et al., 1996). Indeed, Joung, van de Mheen, Stronks, van Poppel, and Mackenbach (1998) found that where individuals had previously reported health problems, this was a significant factor in individuals becoming divorced, which suggests that there is not a simple cause and effect relationship, where we can say that being either divorced or married is a determinant of survival prospects, but survival prospects may also affect marital status.

The interest in marriage as a factor in human longevity has mostly been studied within the social sciences, for the obvious reason that marriage is a social phenomenon, which plays an important role in the demographic constitution of a population. The topic has not been addressed to any significant extent from an evolutionary perspective, although the concept of selection is central to the study of evolutionary biology and, as mentioned, many authors have argued that selection is central to the interaction between marriage and longevity. In this study, we add an evolutionary perspective to the topic, focussing on the concepts of selection and biological resource allocation. We conduct an analysis of a French historical dataset (see Bourdieu, Kesztenbaum, & Postel-Vinay, 2014b), which has not previously been used to investigate this topic, and which is quite unusual among historical data sources, in that it contains information on age and marital status at death for a representative national sample, including individuals who did not marry. It predominantly covers the nineteenth century, and is known as the "TRA" dataset, because it is constructed from death and marriage records of individuals whose surnames began with the letters TRA. In particular, we focus on the difference between the sexes, to gain an understanding of how the social and selective forces related to marriage may affect longevity.

First of all, we look at the association between marital status at death and longevity, we test whether being ever-married or never-married was related to lifespan in nineteenth century France, and whether this differed for men and women.

Second, we test whether any association between marital status at death and longevity was related to wealth, which in the TRA data we are able to observe in terms of financial assets, real estate value and transferable securities, which is aggregated into an overall measure of wealth at death in francs.

Third, we test whether the spousal age gap (husband's age – wife's age) had any influence on either male or female longevity. It has been shown in contemporary Danish data that there is a survival advantage to men of marrying younger women and a disadvantage to both sexes of marrying an older spouse (Drefahl, 2010). However, these findings are somewhat contradictory to those of Kemkes-Grottenthaler (2004), who showed with historical German data that women who married a younger man lived longer, whereas men lived longer when married to a younger or older woman, but shorter when married to a woman of similar age. There are other studies which have shown a longevity advantage for men of marrying younger women (Foster, Klinger-Vartabedian, & Wispe, 1984; Fox, Bulusu, & Kinlen, 1979; Rose & Benjamin, 1971) or an advantage to women of marrying younger men and disadvantage of marrying older men (Klinger-Vartabedian & Wispe, 1989). However, a limitation with these earlier studies is that they did not take the duration of marriage into account or accurately measure the spousal age gap, because the age of spouses was only available in 5 year cohorts (Drefahl, 2010). It can also be argued that marriage age and marriage order (i.e. first marriage, second marriage, etc.) needs to be taken into account, because these may be important factors for selection into marriage. The social or biological basis of longevity differentials related to spousal age gap is not yet understood; we therefore wanted to test for the phenomenon in an altogether different study population, in which we have detailed information about age at marriage, remarriage and longevity.

Finally, we discuss our findings within the framework of evolutionary biology, considering the different aspects to selection as they relate to marriage and longevity, with an aim to formalizing an evolutionary perspective on this topic.

2. Data and methods

2.1. The dataset

The TRA dataset was acquired from the digital media included with the book: *L'enquête TRA, histoire d'un outil, outil pour l'histoire* (Bourdieu, Kesztenbaum, & Postel-Vinay, 2014a). It was produced by a project that began in the 1980s, aiming to reconstitute the genealogies of 3000 French couples, one of whom had a surname beginning with the letters TRA. It was then extended to study the wealth of individuals with such surnames across the whole of France during the 19th century, using the "Tables de Successions et Absences" (TSA) [Tables of Deceased and Missing Individuals], and "Registres de Mutations par Décès" (RMD) [Registers of Transfers by Death], which were available from local fiscal administration offices throughout the country. It became law in 1799 to notify the fiscal administration of every death, and also personal wealth at death, because this was seen as vital for the principle of universal taxation, which had been established by the French revolution.

It is unlikely that all deaths were registered in all administrative regions, but the fact that the legal requirement existed is important from the perspective of using the TRA data for a historical demographic study, because it gives us some confidence that the sample is representative of the population, and that the characteristics of those who died do not only represent a specific sub-sample. In genealogical data, for example, we see that deaths in childhood are under-represented, whilst those who married and had children are over-represented (Hacker, 2010; Zhao, 2001). However, the TRA dataset does not suffer from these problems. It is unbiased with respect to wealth, age, sex and marital status, which means that the data is well suited for addressing our research questions.

There are two primary types of record in the TRA dataset: death records and marriage records. The death records include name, year of birth, year of death, age at death, marital status at death, town of residence at death, place of birth, profession at death, succession value (including transferable securities, real estate values and financial

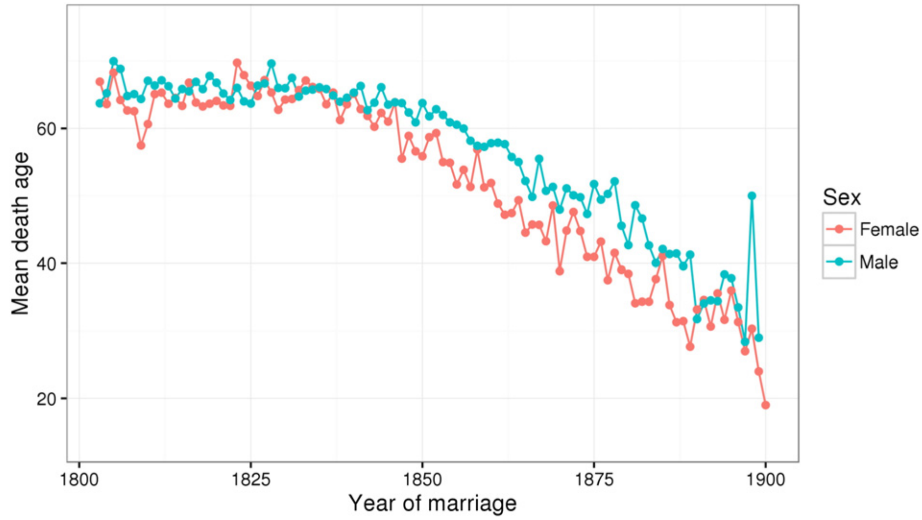

Fig. 1. Mean death age by year of marriage, without correction for truncation.

assets). The marital status of individuals is recorded as either married, widowed, single [célibataire] or non-single [non-célibataire] at death. The non-single value means that the person is known to have been married, but it is not known if the person was married or widowed at the time of death. Notably, divorce was not permitted in France until 1884, and as such, there are only 19 individuals in the dataset who died as divorced, which are excluded from the analyses because they are such a small group. The TRA marriage records include marriage date, spouse names (at least one spouse will have a surname beginning with TRA), dates and towns of birth, professions and whether or not it is a remarriage; also included are the names, ages, professions and towns of residence of the parents of the bride and groom. If the parents were not alive, then their date of death is given.

The marriage and death records have been linked together where this has proved possible, to partially reconstruct the life events of a number of "TRA" individuals from birth until death. This linkage allows us to address questions about the role of marriage age and spousal age gap on mortality risk, because although the death records contain information on marital status at death (i.e. married, widowed, single, non-single or divorced), they do not contain information on the date of the marriage, whether there were any remarriages, or any information about the spouse or spouses, whereas this information is available in the marriage records. The main limitation with the linked records is that there are far fewer linked records than either death or marriage records separately.

The overall number of death registrations is 56,110, from 1798–1901 and the number of marriage registrations is 44,713, from 1803–1900. There are 11,315 marriage and death registrations that are linked for the spouse with the TRA surname, including 6852 males and 4463 females.

The sex ratio (measured as proportion of males) of all individuals in the death registrations is 0.512, which is about the same as the current sex ratio at birth in France, and suggests that there is no under-reporting of either sex in the data.

2.2. Lifespans of ever-married and never-married individuals

First of all, we used the TRA death records to test whether there was any difference in lifespan for men and women depending on whether they had been ever-married (married, widowed or non-single) or never-married (single). The non-parametric log-rank test (Therneau, 2015) was used to compare the age at death distributions. The test was carried out at progressively higher age thresholds, starting with

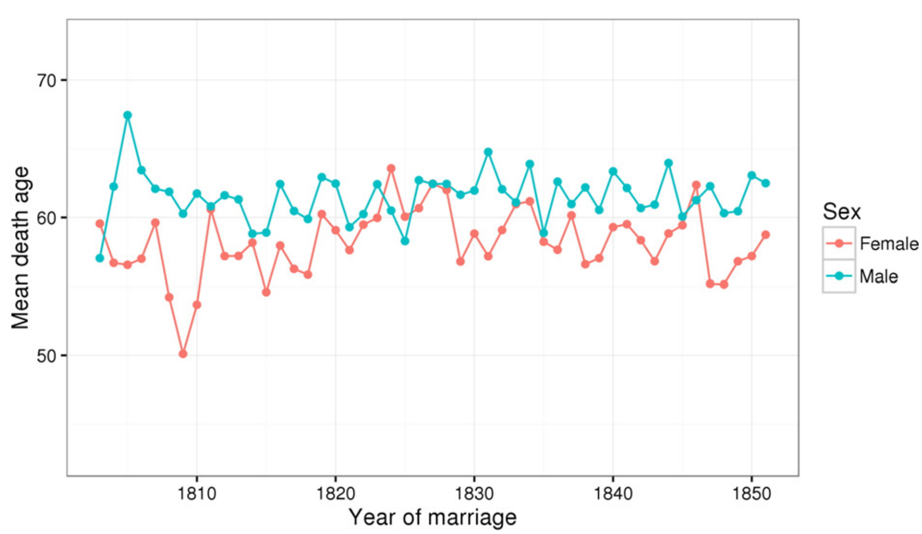

Fig. 2. Mean death age by year of marriage, with imposed censoring to correct for truncation.

Table 1
Mean lifespan for ever-married and never-married persons, based on marital status at death, over progressively higher age thresholds. The null hypothesis of no difference in mean age at death between the ever-married and never-married groups was tested using the non-parametric log-rank test to compare the survival distributions of the samples. $P < 0.05$ in bold.

Age threshold	Sex	Mean lifespan		n		Log-rank test	
		Ever-married	Never-married	Ever-married	Never-married	χ^2	*P*
>**20**	**M**	62.15	41.72	12,679	2836	2031	<**0.001**
	F	60.67	50.78	13,324	2390	252	<**0.001**
>**30**	**M**	63.36	54.52	12,257	1621	321	<**0.001**
	F	63.37	60.32	12,353	1745	26.7	<**0.001**
>**40**	**M**	66.03	61.55	11,171	1192	97.5	<**0.001**
	F	66.90	65.47	10,956	1446	7.3	**0.007**
>**50**	**M**	69.25	67.19	9633	882	28.1	<**0.001**
	F	70.12	69.44	9505	1199	1.6	0.2
>**60**	**M**	73.17	72.21	7456	617	8.9	**0.003**
	F	73.66	73.78	7579	907	0.1	0.703
>**70**	**M**	78.14	77.54	4420	335	3.2	0.073
	F	78.49	78.38	4643	570	0.1	0.802

those who had lived to >20 years of age to those who had lived to >70 years of age.

2.3. Overlap between age at death and age at marriage

To determine the extent to which deaths of individuals were occurring during the period of marriageable age, kernel density functions were calculated for age at marriage and age at death, using the marriage and death registration records respectively, starting at age 13. The overlap was calculated using the coefficient of overlapping method (Weitzman, 1970) and the *overlap* package in R (Meredith & Ridout, 2016a). The 'overlapEst' function with the Delta ^4 estimator was used, in line with recommendations in Meredith and Ridout (2016b).

2.4. Survival by marital status and wealth at death

To examine how survival differed according to wealth, we analyzed the TRA death records using Cox proportional hazard models (Therneau, 2015). The single, married and widowed groups were analyzed in separate models for males and females, rather than in a single model, in order to deal with the problem of non-proportional hazards when the sex and marital status variables were analyzed in a single model. The data was limited to over 20s and birth decade was included as a stratified variable, in order to deal with changes in wealth over the century. The total wealth at death variable was converted from francs into quintiles, based on wealth among the over 20s only (1 = poorest: 5 = wealthiest).

2.5. Spousal age gap and duration of survival after marriage

We calculate spousal age gap as husband's age (in years) – wife's age (in years), so spousal age gap is positive when the husband is older and negative when the husband is younger. In all but a few cases (in which the spouse's pre-marriage name also began with TRA), the age at death of the spouse is not known, we therefore ran separate analyses of the effect of spousal age gap on survival using Cox proportional hazard models (Therneau, 2015), in which either men (with the TRA surname) or women (with a TRA surname prior to marriage) were the focal individuals. The effect of spousal age gap from first marriages only was examined, though remarriage was tested as a binary explanatory variable. Marriage age was included as an explanatory variable and the effect of wealth (at death) was also tested, using additional models which contained fewer records (due to absence of information on wealth at death for many individuals).

To make use of the linked TRA marriage and death records for this analysis, we had to deal with the problem of truncation in the data. This problem is frequently found in historical life course data when there is a cut-off point for particular vital registration records. In this case, there are no death records after 1901. It is a problem, because we can only be sure that individuals who we observe at marriage didn't die after 1901 if there is a death registration prior to 1901, or if they were born approximately 110 years before 1901. If, for example, we want to compare the survival of individuals who married in 1800 with those who married in 1850, then we are faced with the problem that many more of the deaths in the 1850 cohort will be missing, because they would have occurred after 1901, but all the deaths from the 1800 marriage will not be missing (unless they are missing for another reason, such as emigration). The problem is simply demonstrated by taking a mean of duration from marriage until death for the whole dataset, which we observe declining rapidly as the cut-off point is approached, because only the shortest marriage durations are captured, whilst the longer durations are missing because deaths occur beyond the cut-off point (Fig. 1).

In some studies, it may be appropriate to impute values for deaths occurring beyond the cut-off point (Jonker & van der Vaart, 2007; Van Leeuwen & Oeppen, 1983). However, this would be inappropriate for the present study, because we are using the data to test statistically whether spousal age gap and marriage age affect the duration of survival after marriage, whilst imputed survival values would potentially have a decisive outcome on the statistical tests.

Instead, we use the approach of imposing additional censoring on the data, so that all deaths to individuals that occur more than 50 years after marriage become censored and all individuals married after 1851 are excluded. In effect, this creates a 50 year window after all marriages in or before 1851, where we can observe the individuals that died or did not die. Information is excluded (censored) for those individuals that died more than 50 years after any marriage, whether or not that information exists in the raw data. This has the effect of excluding very long-lived individuals from the analyses, but it also has the effect of extracting a dataset based on marriages between 1803 and 1851, in which each yearly cohort is comparable and the biases caused by the truncation of the data are eliminated.

Table 2
Percentage of men and women getting married for the first time above successive age categories.

% married over age	Male	Female
>12	100	100
>20	97.51	79.36
>30	33.67	19.8
>40	10.91	5.57
>50	4.38	1.64
>60	1.41	0.47
>70	0.22	0.05

The difference in mean duration of marriage with imposed censoring can be seen in Fig. 2, as compared to Fig. 1. The decline in mean death age (caused by truncation) that begins in about 1835–40 in the raw data (Fig. 1) is gone. The result is an artificially low mean death age, because long lived individuals are censored. However, we know that the degree of censoring is the same for each annual marriage cohort, so we are able to use this data to compare how spousal age gap affects survival in the 50 years that follow marriage.

3. Results

3.1. Lifespans of ever-married and never-married individuals

The comparative analysis of survival distribution between ever-married and never-married individuals in Table 1, shows that higher survival for ever-married men extends beyond the age of 60, but not 70, whereas for women it extends beyond the age of 40, but not 50. The difference in lifespan between the ever and never-married groups is overall much greater for men. However, men were also joining the married group later (Table 2), so we have to ask whether men were living longer as a result of marriage, or whether marriage was favoring longer lived men.

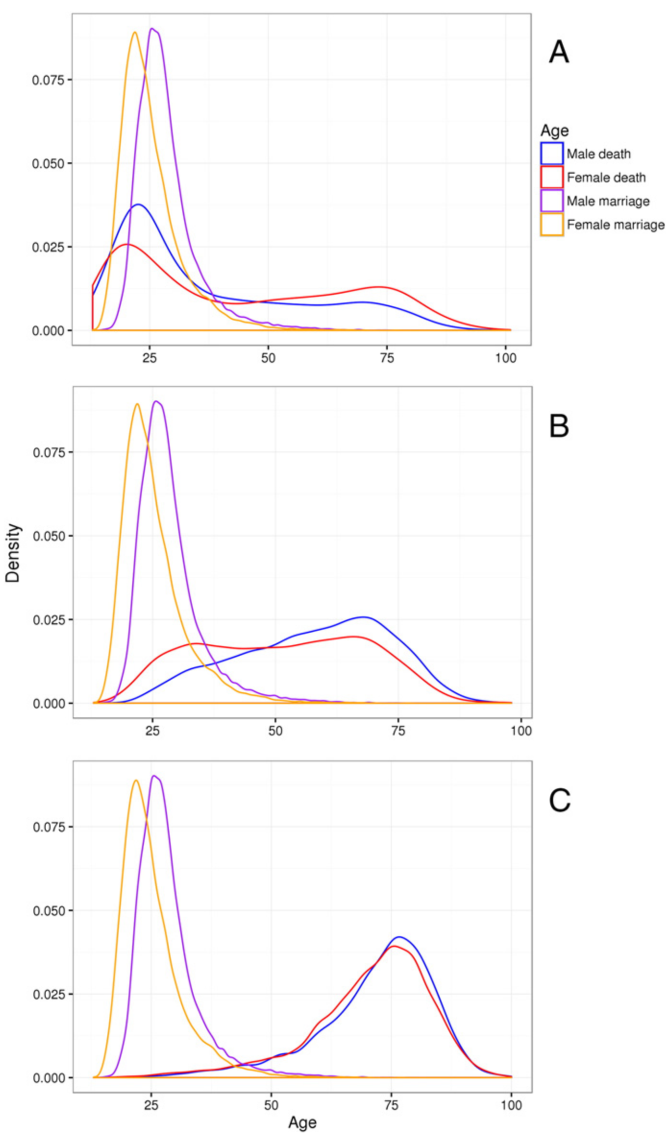

Fig. 3. Density plot of age at first marriage, as compared to age at death for individuals who were registered as lifetime single (A), married (B), or widowed (C) at death.

3.2. Overlap between age at death and age at marriage

It is clear that much of the difference in longevity between ever-married and never-married individuals is due to 'de-selection' from the marriage market of those who died before they could marry, as we can see that there were high levels of mortality for singles before marriageable age (Fig. 3A). The overlap in the distribution of age at death and age at first marriage was greater for single males than single females (Table 3), indicating that de-selection from the marriage market was higher for males. In contrast, the overlap was greater for married females than married males, showing that women who were registered as married at death were more likely to have died during marriageable age than men (Fig. 3B and Table 3), probably due in large part to deaths in childbirth.

There is an older distribution of deaths for widowed than for married individuals (Fig. 3C), which is due to the fact that individuals are always older when they get widowed than when they get married. There is very little difference in overlap of death age and marriage age between male and female widows (Table 3).

3.3. Longevity by marital status and wealth

To investigate how being widowed, married or lifetime single related to longevity in old age, we look separately at wealth in these three groups for each sex. The distribution of deaths by age and median wealth (at death) is shown for the single, married and widowed groups in Fig. 4. The results of the survival analyses are shown in Table 4.

3.4. Spousal age gap and duration of survival from age at first marriage

The distribution of marriage age and spousal age gap are shown in Figs. 5 and 6. Spousal age gap is found to be significantly associated with survival for men, but not women (Table 5). There is improved survival for men who were older than their wives, whilst there was also an interaction between marriage age and spousal age gap, due to a larger spousal age gap for men who married later (Model M1). Inclusion of the wealth (at death) variable in this model did not indicate any effect of wealth on survival (not shown), however, this also resulted in violation of the proportional hazards assumption for the wealth and marriage age variables. Therefore, to deal with this, we included marriage age as a stratified variable (Model 2), in which there is again no detectable effect of wealth on survival, but the proportional hazards assumptions are satisfied.

There was no significant effect of spousal age gap on survival for women and no interaction between marriage age and spousal age gap, according to Model F1. However, there was mild violation of the proportional hazards assumption for marriage age variable in this model, so a further model stratified on the marriage age variable was run (Model F2), in which the proportional hazards assumption is satisfied and we

Table 3
Coefficient of overlap between age at first marriage and age at death according to sex and marital status at death. This is a quantitative measure ranging from 0 (no overlap) to 1 (identical distributions), gained by fitting kernel density functions to the marriage and age at death distributions and calculating the coefficient of overlapping.

Marital status at death	Male	Female
Single	0.55	0.48
Married	0.20	0.29
Widowed	0.07	0.06
Married and widowed	0.17	0.20

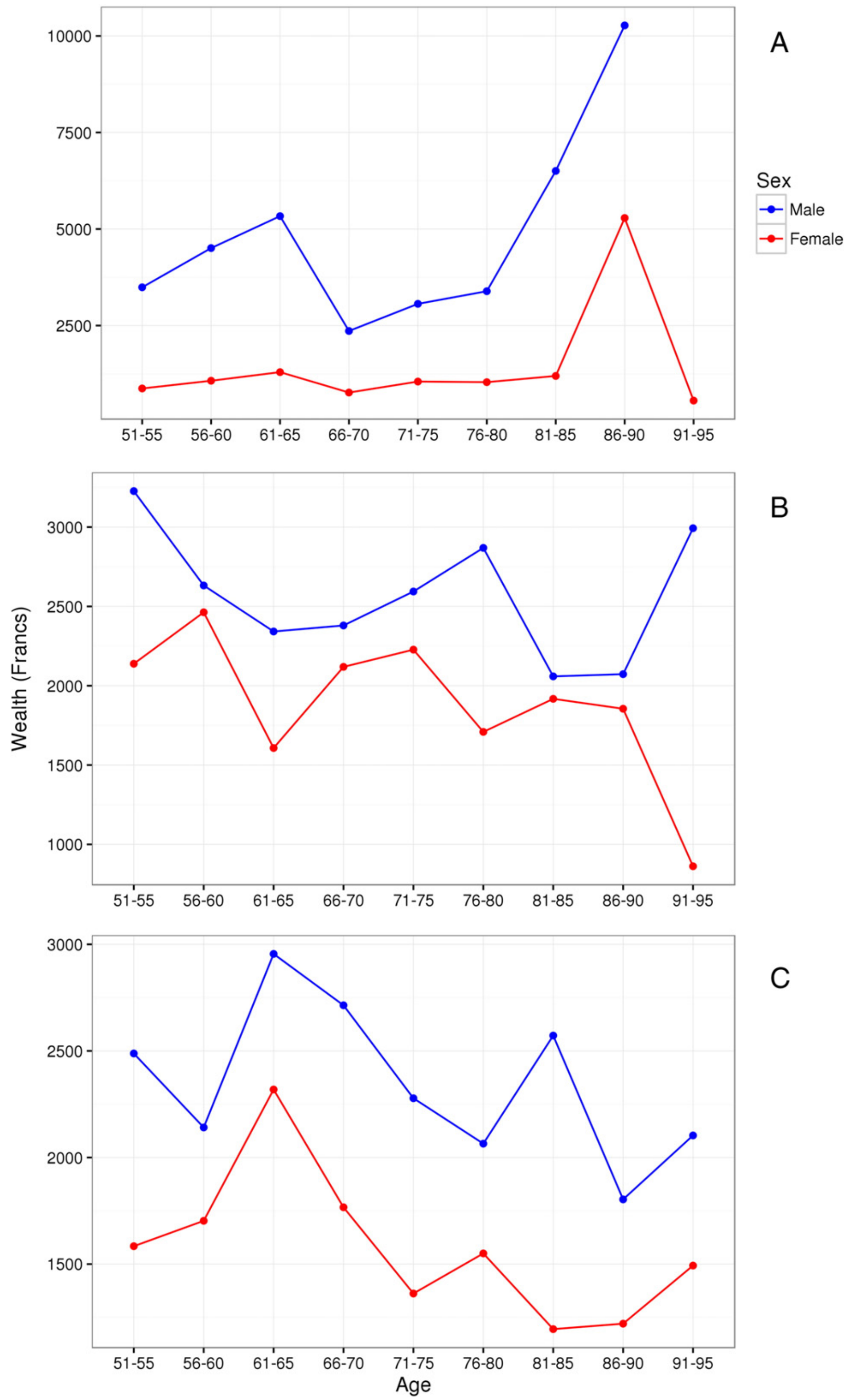

Fig. 4. Median wealth at death by age at death for individuals who were registered as lifetime single (A), married (B), or widowed (C) at death.

find again that spousal age gap had no effect on survival. In Model F3, wealth (at death) is included as an explanatory variable with marriage age stratified and we see that wealth was positively associated with survival in marriage for women.

The ever-remarried variable was tested for, but was removed from all the models as it showed no sign of significance.

4. Discussion

Here we show that the longevity advantage of marriage was primarily experienced by men in nineteenth-century France. Information contained in the TRA death records on marital status and age at death shows that men who were ever-married were longer lived than those

Table 4
The effect of wealth (at death) on survival for individuals >20 years of age. Exp(B) gives the relative risk of mortality for each increase in quintile of wealth (1 = poorest : 5 = wealthiest), <1.0 is a lower risk of death, >1.0 is a higher risk of death. $P < 0.05$ in bold.

Sex	Marital status	n	Z	*P*	Exp(B)	SE
M	Married	2823	-2.962	**0.003**	0.961	0.013
	Widowed	1057	1.139	0.255	1.025	0.022
	Single	503	-5.157	<**0.001**	0.8414	0.034
F	Married	2046	-2.774	**0.006**	0.956	0.016
	Widowed	1445	0.12	0.904	1.002	0.998
	Single	442	-4.18	<**0.001**	0.855	0.037

who were never-married, and this advantage extended beyond 60, but not 70 years of age. The lifespan of ever-married women exceeded that of never-married women beyond 40 years of age, but not 50 years of age. However, information on marriage age shows that more men were getting married when they were older, so the advantage of marriage for men, as compared to women, was partly due to men joining the married group later in life. Furthermore, analysis of the extent of overlap in marriage age with age at death shows that men were more likely to die as singles before marriageable age, whereas women were more likely to marry earlier and die within marriage. This gives the impression that marriage is more advantageous for the longevity of men, because a higher proportion of men died before getting married, whilst women were suffering more during marriage, probably due in large part to deaths in childbirth.

Analysis of the TRA death records also showed that wealth had a significant positive effect on survival for those who were registered as married or single when they died, with the strongest effect for singles. However, there was no detectable effect of wealth on survival of widows, which may relate to the fact that they were the group that lived the longest regardless of wealth.

Analysis of the linked marriage and death records for an effect of the spousal age gap on survival showed that there was a survival advantage to men of marrying younger women, but no effect of spousal age gap on the survival of women. It was found that wealth affected survival of married women in this dataset, though did not affect survival of married men. It is surprising that wealth did not affect the survival of men in the linked marriage and death records, given the finding that wealth was associated with survival in analysis of the death records. This may relate to the imposed censoring method that we used to deal with the problem of data truncation, which meant that deaths to the oldest individuals were not analyzed, or it may relate to the smaller size of the dataset. However, this is not a reason to reject the finding of a significant effect of spousal age gap on male survival, as that finding is based on a larger data extraction from the linked marriage and deaths dataset, because the number of married individuals with information on spousal age gap alone is much larger than those with information on wealth and spousal age gap.

The imposed censoring method had the advantage that it allowed us to use more of the marriage cohorts in the data, without worrying about bias caused from data truncation, although this came at the cost of losing some data from the analysis (namely people who had been married for more than 50 years and those who married after 1851). However, it meant that we were unable to observe any advantages or disadvantages of the spousal age gap that may occur in very old age, particularly for women, who were (on average) younger after 50 years of marriage than men.

It has been found in some studies that well-being is not only influenced by marital status, but by partner history and time since dissolution of a marriage. For example, the loss of a partner has been found to be detrimental to the well-being of the remaining spouse (the 'widowhood effect', see Schaefer et al., 1995) and particularly when the remaining spouse is a man (Peters & Liefbroer, 1997). In our analysis of the effect of marital status and wealth at death on longevity, we could not control for the time since dissolution of marriage, because this was not known in most cases. However, use of large samples ought to negate the variability in time from widowhood-to-death between individuals. Moreover, in the analysis of the effect of spousal age gap on longevity, we were able to control for remarriage, which showed no significant effect within the survival analysis model, whilst we might expect that those who remarried spent less time widowed.

It is interesting that the distribution of age at death extends further into old age for single women over the age of 50 than for single men (this can be seen in Fig. 3A), which we don't see for married women compared to married men or widowed women compared to widowed men (Fig. 3B and C). It is well known that single males tend to take greater risks with their safety and indulge in more health adverse behaviors than single women (Kruger & Nesse, 2006; Wilson & Daly, 1985), but arguably this is primarily a feature of the behavior of young men (Kaplan & Kronick, 2006). Can we really attribute the relatively high longevity of single women beyond 50 to adverse male behaviors, despite the fact that single males were wealthier than single females at death? Or, is there reason to think that the longevity of women is enhanced by remaining single? It is clear that women suffer lower

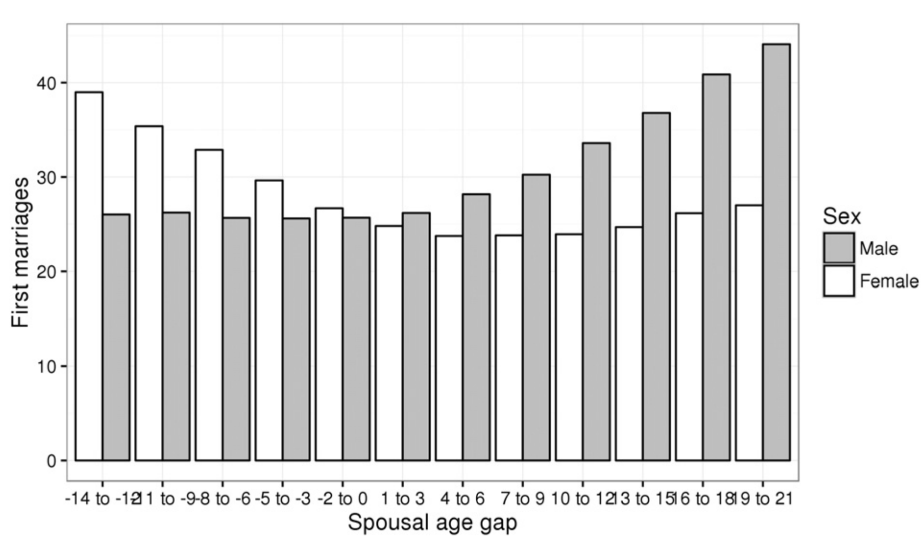

Fig. 5. Mean first marriage age by spousal age gap groups.

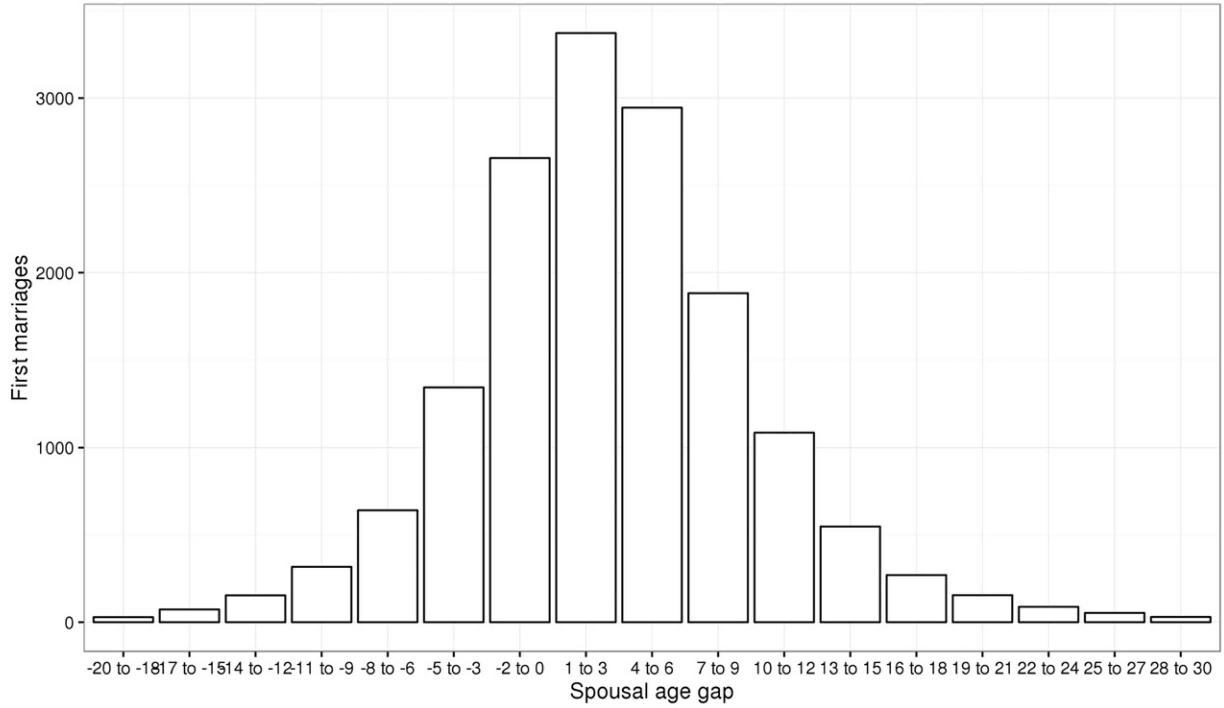

Fig. 6. Frequencies of first marriages by spousal age gap groups.

survivorship within marriage, as compared to men (Table 3, also Fig. 3B), which may be explained by deaths in childbirth, but this is a separate issue to the comparatively higher longevity of single women beyond the childbearing years.

In relation to the theory that marriage has a protective effect through the social and economic advantages that it offers, and moreover that becoming widowed or divorced can have a detrimental effect on survival (see e.g. Liu, 2009), it is tempting to think that men gain greater longevity from marriage because they are more likely to be married in old age, whereas women are more likely to be widowed. But, then we have to explain why women's longevity does not benefit, and may even suffer (Drefahl, 2010) from marrying younger men, despite these women having a lower likelihood of becoming widowed. It may be concluded on the basis of the finding that men who married younger women lived longer, that marriage has a protective effect for men, due to provision of care. However, that begs the question of why we do not see a comparable effect for women who married younger men. It is also possible to conclude that the spousal age gap effect is not due to a protective effect of marriage, but due to selection for longevity, whereby wealthier men, or men with a phenotype signaling health, social dominance and incidentally longevity, were marrying later and to younger women. As with all previous studies on this subject, the question of whether marriage extends longevity or whether marriage selects for longer lived individuals is seemingly intractable. However, we can make progress on this problem by applying an evolutionary framework.

4.1. Evolutionary perspective on marriage and longevity

There has been a lack of attention paid to the evolutionary dimension of marriage and longevity, despite the concept of 'selection into marriage' being well established as an explanation for the enhanced longevity of married persons, and despite the fact that marriage has no doubt been a major factor in human sexual selection for many

Table 5
The duration of survival within first marriages, according to marriage age and spousal age gap, based on yearly marriage cohorts from 1803 to 1851 and imposed censoring beyond 50 years of marriage. Exp(B) gives the relative risk of mortality for each unit of increase (<1.0 is a lower risk of death, >1.0 is a higher risk of death). $P < 0.05$ in bold. Males are the focal spouse in model M1 and M2 and females in F1-F3. Model M2, F2 and F3 include marriage age as a stratified variable.

Model	Variable	n (deaths)	n (censored)	Z	*P*	Exp(B)	SE
M1	Spousal age gap	2665	6291	-3.5	<**0.001**	0.966	0.010
	Marriage age			7.816	<**0.001**	1.037	0.005
	Spousal age gap X Marriage age			3.5	<**0.001**	1.001	0.000
M2	Spousal age gap	1062	227	-1.228	0.220	0.984	0.013
	Wealth			0.507	0.612	1.013	0.026
	Spousal age gap X Wealth			0.450	0.653	1.001	0.004
F1	Spousal age gap	1737	6116	-0.574	0.566	0.991	0.015
	Marriage age			4.527	<**0.001**	1.020	0.004
	Spousal age gap X Marriage age			0.442	0.659	1.000	0.000
F2	Spousal age gap	1737	6116	-0.965	0.334	0.996	0.004
F3	Spousal age gap	678	151	-0.384	0.701	0.995	0.007
	Wealth			-2.168	**0.03**	0.928	0.029
	Spousal age gap X Wealth			0.277	0.782	1.001	0.005

centuries. We propose the following framework to describe the evolutionary aspects to selection for longevity by marriage:

1) **De-selection**; whereby individuals do not survive long enough to get married, so are effectively de-selected from the marriage market.
2) **Direct selection**; where selection into marriage is based on proven survival (i.e. having already lived a certain amount of time).
3) **Indirect selection**; where selection into marriage is based on traits that are indicative of survival prospects and correlated with longevity, e.g. health, wealth or beauty; or, conversely, where selection out of marriage is due to outward indications of a low prospect of surviving (e.g. higher divorce rate for people reporting illness, as shown by Joung et al. (1998).

When we think about selection into marriage, it is worth asking, "who does the selecting"? Is it mostly men or mostly women? And, what features are being selected on? Evolutionary theory predicts that women should be much more careful about partner choice than men, because women invest more in reproduction and have complete certainty that they are the biological parents of their children. In comparison, men invest less in reproduction, have lower certainty of biological parenthood and are potentially able to have many more children over the course of their lives.

It is reasonable, therefore, to argue that those men who married in 19th century France were more carefully selected than the women, and that this potentially explains why there was a greater difference in survivorship between married and single men, than between married and single women. We might then ask whether this was the result of direct or indirect selection. The finding that those individuals who were wealthier at death had better survival, whilst men who were married to younger women lived longer, indicates that there could be some degree of indirect selection, whereby certain men were more likely to be selected by women, whilst those men were subsequently longer lived. This might not necessarily indicate any sort of selection based on genetic quality, but could instead indicate a type of selection based on status and wealth, which has the indirect consequence of conferring improved survival.

The predominant pattern for marriage in nineteenth century France was that men, on average, married when they were older than women. Taking the evolutionary perspective, this may explain why there was stronger deselection from the marriage market for men than women, not only because of young male deaths, but also because men had to live longer to get married. We may therefore ask whether there was some degree of direct selection on survivorship, in which men who married in their thirties or later were selected by younger women, because they had survived the dangers of early adulthood and had more years of proven survivability. Indications from sociological studies with twentieth century data indicate that women express a stronger preference for an older man, than men do for a younger woman (Bozon, 1991). It is not clear why this should be, but the reasons given by women for the preference tend to relate to a desire for a dominant and mature partner. This may have much to do with the need for a woman to find a "provider" who can help raise her children, because reproduction (including parental care) is the primary biological incentive driving marriage choices, at least for the first marriage, whereas other considerations, such as a desire for companionship in old age, are secondary.

The evolutionary benefits to a man of marrying a younger woman are clear, because younger women have the potential to bear more children. However, perhaps we should also ask why men with better survivability would want to wait until they were older to get married, because they could presumably have gained the same (or more) reproductive success by marrying young women when they were themselves young. It may be the case that a longer bachelorhood phase of life was important for men to gain the skills needed for financial success, which in turn made them more attractive to women.

It is particularly interesting that the distribution of age at death for single women extends further into old age than for single men, whereas we do not see this difference for widowed or married individuals. One possible explanation for this comes from an evolutionary theory of aging known as the disposable soma theory (Kirkwood, 1977; Westendorp & Kirkwood, 1998), which posits that each organism has only a limited amount of resources to invest in maintenance and reproduction, leading to a trade-off between the two. High investment in maintenance (cell repair, immune system, etc.) increases longevity, but this is negatively affected when investment in reproduction is sufficiently high. This interpretation would assume that lifetime single women were able to invest more highly in somatic maintenance, because they did not have children. However, based on the present study, we cannot rule out the possibility that the survival difference between single men and women owes more to the risk-taking behaviors of men, than to women foregoing reproduction.

The question of whether the enhanced longevity of married individuals is due to a protective effect of marriage or selection into marriage remains challenging to answer. However, some insight may come from considering why there is such a difference between men and women, firstly in terms of the greater disparity in old-age survivorship between single men and married men, and secondly in terms of the greater longevity of men who marry younger women.

Here we suggest that the greater disparity in old-age survivorship between single and married men, as compared to single and married women, may relate, in part, to sexual selection and the different choices that men and women make about their partners. By typically choosing men who are older, women are selecting men with more years of demonstrated survival (direct selection on longevity), whilst also choosing men who have often postponed marriage to gain skills and education, thereby giving them improved income and social status and subsequent longer life (indirect selection on longevity). In contrast, men typically choose women who are younger, because younger women have the potential to have more children (a fact with greater significance in societies where infant mortality is high and it is normal to have larger families, i.e. societies in the pre- or early demographic transition phase). The features that attract women to their husbands may be selecting for longevity in men, both directly and indirectly, whereas the features that attract men to their wives may be more focused on reproductive potential, which does not necessarily indicate survivability. The outcome is that we see less disparity in longevity between married and single women, than between married and single men.

In relation to the greater longevity of men who marry younger women, it may be argued that these men are more likely to avoid the negative effects of becoming widowed in their old age, but this does not explain why the impact on longevity of having a younger spouse may be absent or negative (Drefahl, 2010) for women. There is some evidence that men are more adversely affected by widowhood than women (Antonucci and Akiyama, 1987; Peters & Liefbroer, 1997), but it seems unlikely that this offers a full explanation. Here we have put forward the hypothesis that men who marry younger women live longer, due to a preference by women for older, more highly-skilled and wealthier men, which results in selection of those men who are destined to live longer. This sexual selection is reinforced by a preference for younger women with greater reproductive potential by men.

Acknowledgements

We thank Lionel Kesztenbaum for assistance with the dataset, also Tine De Moor, Anita Boele and Marion Petrie for comments on the manuscript. This study was part of the project 'Nature or nurture? A search for the institutional and biological determinants of life expectancy in Europe during the early modern period' (276-53-008) and was funded by the Netherlands Organization for Scientific Research (NWO).

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