Impact of marital status on health

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Abstract
The Farr-Bertillon law states that the mortality rate of single and widowed persons is about three times the rate of married people of same age. This excess mortality can be measured with good accuracy for all ages except for young widowers. The reason is that, at least nowadays, very few people become widowed under the age of 30. Here we show that disability data from census records can also be used as a reliable substitute for mortality rates. In fact excess-disability and excess-mortality go hand in hand. Moreover, as there are about ten times more cases of disability than deaths, the disability variable is able to offer more accurate measurements in all cases where the number of deaths is small. This not only allows a more accurate investigation of the young widower effect; it confirms that, as already suspected from death rate data, there is a huge spike between the ages of 20 and 30.

By using disability rates we can also study additional features not accessible using death rate data. For example we can examine the health impact of a change in living place. The observed temporary inflated disability rate confirms what could be expected by invoking the “Transient Shock” conjecture formulated by the authors in a previous paper.

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Introduction

The Farr-Bertillon law (Bertillon 1872, Richmond et al. 2016a) states that married persons have a lower death rate than non-married persons be they single, divorced or widowed. In its simplest form this law has been known for over one century. In a previous paper (Richmond et al. 2016) the present authors added several new features to our knowledge of this effect.

- As a function of age the death ratio, namely the ratio (rate of non-married)/(rate of married), has the same shape today as it had 130 years ago.
- The law holds not only for the global death rate but also separately for all major classes of diseases, e.g. heart disease, cerebrovascular diseases, pulmonary diseases. The law is also valid for suicide and accidental causes of death.
- Chinese data for 1990 show a pattern that is very similar to that observed in western countries. These data provide a more accurate picture of the young widower effect than that provided by western data due to: (i) the sheer size of the Chinese population and (ii) the tradition of early marriage which was still common even in 1990 for some rural provinces. It turns out that, around the age of 20, for men as well as for women, the widowed/married death ratio displays a huge spike with amplitude about 20.

As a reminder and for the purpose of comparison with subsequent disability-based graphs, Fig. 1 shows the shape of the death rate ratio for widowed and single persons. Mortality data are based on death certificates which record basic information about the deceased and the circumstances and causes of the death.

In this paper we use census data. This is a completely different type of statistical in the sense that mortality data rely on continuous monitoring through the vital statistics network whereas censuses are taken every 10 years and provide a static picture of the whole population. It is difficult to decide which one of the two sources is more reliable but for our present study what is important is the fact that they are independent and very different from one another.

One might suspect the young widower effect observed from death rate data is a statistical artifact because under the age of 25 the number of cases is very small which makes these data very sensitive to any under-recording. It is therefore important to observe this effect through a different data source. If census data display the same effect it will make us more confident that it is indeed genuine.

The census data that we use here are disability variables. Thus, the death ratio will be replaced by a disability ratio. A distinct advantage of the census data is that it is possible to compute the disability ratio for every year of age. This contrasts with mortality data which are given for only 5-year or 10-year age intervals. This dif-
Fig. 1  Age-specific death ratio with respect to married persons in the United States. The death ratio is the death rate of widowed persons divided by the death rate of married persons. This renormalization removes the exponential behavior common to both rates. These curves should be compared with the curves of Fig. 2b which, instead of death, are based on disability. The data points give the death ratio for 10-year age intervals. The error bars represent $\pm \sigma$ where $\sigma$ is the standard deviation of the average. This corresponds to a confidence level of 0.68. The curve for “single” is the average of 15 annual series which is why the error bars are so small that they are hardly visible. Source: Richmond et al. (2016): widowed: p.757, single: p. 755.

The paper proceeds as follows.
In section 2 we describe the disability data and explain our methodology. Section 3 shows the results of our investigation. Next we explore the effect of a housing relocation on the disability rate from which we see that there is a distinctive increase albeit of a much smaller magnitude than for the effect of marital status. Finally, we examine the adverse short-term effect of marriage.

Before we start note that the present paper follows exactly the methodology associated with physics. Thus in physics a newly identified phenomenon is accepted as being real only after it has been observed in different experiments and under diverse conditions. For example, the speed of light was ultimately measured hnumeros times using various methods and with ever increasing accuracy. As a result it has become an unshakable pillar of modern physics. By way of contrast, what is striking in social science is that conflicting observations are cited in review papers and apparently accepted without any real attempt being made to discriminate between fact
and artifact. How can something solid be built on such shaky foundations? Our present analysis, based on disability data, of the incidence of marital status is akin to setting up a new experiment. If it confirms and supplements previous observations that strengthens our confidence in the Farr-Bertillon law and the young widower effect.

Data and methodology

Disability data
The US censuses of 1980 and 1990 asked the following question:
“Does this person have a physical, mental, or other health condition which has lasted for 6 or more months and which prevents this person from working at a job?”
At first sight it might seem that the question concerned only persons who are not retired and it is true that in the census of 1970 the question concerned only persons under the age of 65. But in the censuses of 1980 and 1990 the question was asked of every person above the age of 15. In these cases “prevents this person from working at a job” must be understood as a condition serious enough to prevent you from working at a boldpossible job”. As a matter of fact, the data show a steady increase with age of the proportion of the persons afflicted with a disability. By the age of 85 the percentage reaches about 50% (see Fig. 4).

The census of 1980 (but not the one of 1990) contained another question about disability which was the following:
“Does this person have a physical, mental, or other health condition which has lasted for 6 or more months and which limits or prevents this person from using public transportation?”
Naturally one would expect the two disability variables to be strongly correlated and this is indeed the case. In what follows we use only the work disability variable because the other data is not available for 1990.

A consistency test consists in checking whether the age-specific disability variable is correlated with the age-specific death rate. This is indeed true not only for the whole population but also for its subsets. For instance, for widowed persons, if one denotes the number of persons with a disability in the 5% sample of the 1980 census by \( d_h \) and the number of deaths in the whole population by \( D \) one gets:\(^1\)

\[
D = 1.18d_h^a, \quad a = 1.06 \pm 0.07
\]

[^1]: The death data by age and marital status are from the 1980 volume of “Vital Statistics of the United States”, table 1-31.
This relationship shows two things:

1. The two variables are almost proportional to one another. However, as death numbers are available only for 10-year age intervals equation (1) indicates a global rather than a year-by-year proportionality. Actually, on a yearly scale one would not expect a close connection for a fairly simple reason. The death numbers are annual variables whereas the disability numbers are cumulative variables in the sense that disabilities which last more than one year will be added together. Thus, in a given year, in addition to the current number the disability level will also reflect extant past disabilities.

2. As $D$ and $d_h$ are of same magnitude in populations of different sizes, we see that for the entire population the number of persons with a disability would be about 20 times larger than the number of deaths. Therefore, if one could get disability data for the whole population one would be in an excellent position to study the young widower effect. Unfortunately, as explained in the next subsection only 1% and 5% samples are so far available.

The IPUMS database

Now that we know the 1980 and 1990 censuses contain the data we need, how can we access it? Over the past decades the University of Minnesota has developed a database containing individual records of all US censuses except that for 1890 which was destroyed in a fire. “Individual” means that the database will deliver files in which each line corresponds to one person and contains as many coded variables as the user selects. Access is free and the data are provided in several formats. For our research we have used the “text only” format, formerly called the ASCII (American Standard Code for Information Interchange) format. However, there are two limitations.

- The data are available only in the form of random samples, either 1% or 5% samples. The results given below are based on the 5% samples of the 1980 and 1990 censuses. As the disability variable exists only above the age of 15 and under 90 we limited our samples to the age interval (16, 1989). As a result the files of the 5% sample of 1980 and 1990 contained 8,746,006 and 9,529,970 lines respectively.

- For reasons of confidentiality the variables we use proposed do not allow precise localization of the individuals. Information about their place of residence is limited to county level or even to a cluster of several counties when the counties are small. As the present investigation does not use residence location variables this limitation is of no concern.

The small $n$ difficulty

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2Full scale data are available only for a few censuses, for instance in 1940.
As already explained one of our main objectives is to explore the Farr-Bertillon effect for widowed persons in the age interval from 20 to 30. The main difficulty comes from the fact that even for a large country like the United states there are only few young widowers and among them only a small percentage with a disability. This difficulty is illustrated in Table 1 which gives the number of widowed persons and the numbers within this group with a disability.

### Table 1  Number of widowed persons in the 5% sample of the US census of 1980

| Age | Men with disability | Women with disability | Men+women with disability | Men+women with disability |
|-----|---------------------|-----------------------|---------------------------|---------------------------|
| 16  | 10                  | 0                     | 6                         | 6                         |
| 20  | 42                  | 4                     | 128                       | 9                         |
| 25  | 93                  | 5                     | 464                       | 21                        |
| 30  | 139                 | 4                     | 699                       | 30                        |
| 35  | 209                 | 17                    | 1,005                     | 64                        |

Notes: All numbers are for widowed persons. “Disability” refers to a condition which prevents people from working. This “work disability” variable was given in the censuses of 1980 and 1990. Needless to say, the small number of cases in the 16-30 range gives rise to strong inter-age statistical fluctuations.

Source: 5% sample of the census of 1980: Ruggles et al. 2017 (IPUMS).

Two measures were taken to limit the impact of statistical fluctuations arising from such small numbers.

1. The analysis used both the samples of 1980 and 1990 which together comprise 18 million individual records.
2. A centered moving window averaging was applied. We tried widths of 5 and 11 years and the later proved the most satisfactory,

#### Uniformity test

In order to make sure that the shape of the age-specific disability ratio is not brought about by a sub-sample of outliers, we tested some 10 sub-samples each comprising 2 million records. They all led to curves of same shape peaking in the 20-30 age interval and decreasing toward 1.2 at old ages.

#### Results

**Observations**

The term “disability ratio” refers to the following variable:

\[
r(t; s) = \frac{f(t; s)}{f(t; m)} \text{ where: } t = \text{age}, \ s = \text{marital status}, \ m = \text{married}
\]
Fig. 2a, b  Age-specific disability ratio with respect to married persons in the United States. (a) The disability ratio is the disability rate of widowed persons divided by the disability rate of married persons. (b) The curve for widowed persons is the average of the male and female curves of (2a); “single” refers to persons who never got married. Fig. 2b should be compared with Fig. 1 which is similar except that disability is replaced by death. Because there is a data point for each year, the error bars are not drawn as bars but are shown as a (yellow) error band. It represents $\pm \sigma$ where $\sigma$ is the standard deviation of the average. Source: 5% samples of the US censuses of 1980 and 1990; available from Ruggles et al. 2017 (IPUMS).

$f(t; s)$ and $f(t; m)$ represent the fraction with disability in each group, that is to say:

$$f(t; s) = \frac{\text{Number of persons of marital status } s \text{ with a disability}}{\text{Total number of persons of marital status } s}$$

Fig. 2a shows the disability ratios for $s =$ widowed males and $s =$ widowed females respectively.

Fig. 2b compares the disability ratios for $s =$ widowed persons (male or female) and $s =$ single (i.e. never married) persons respectively.

These figures lead to the following conclusions.

- Between the ages of 20 and 35 the curves for widowed and single are very different: decreasing with age for widowed and increasing for single persons. This observation confirms what was found with Chinese death-ratio data. For US data (Fig. 1) the difference was less striking in the sense that in the age interval (20, 30) the two curves are parallel.

- Fig. 2a does not show any fundamental difference between men and women except that the disability ratio of widows is slightly lower than for widowers.

- The peak for widowed persons reaches a level of about 10 which is intermediate between the value of 6 observed in the US (Fig. 1) and the value of 20 observed in China.
Incidentally, it should not come as a surprise that the shape of the death ratio for young people is country-dependent. This is due to the fact that between 16 and 30 the main causes of death are not diseases but external causes such as traffic accidents, homicide or suicide. The frequency of traffic accidents is of course conditioned by the number of young people who drive cars or motorbikes.

**Other groups of non-married persons**

So far we have considered only disability ratios for widowed and single persons. But the marital status variable of the census defines 6 different situations. Their definitions and respective fractions in 1980 are as follows (in 1990 the percentages are almost identical).

1. married, spouse present: 56%,
2. married, spouse absent: 1.2%,
3. separated: 2.2%,
4. divorced: 6.2%,
5. widowed: 7.6%,
6. single: 26%.

Groups 2 and 3 are too small to be analyzed in a meaningful way. Group 4, divorced persons, leads to a disability ratio curve which is intermediate between “widowed” and “single”. This contrasts with “widowed” which has an rising part which peaks around the age of 32 which is slightly earlier than the curve for “single”. The peak reaches a level of about 3, about 2/3 the level reached by the curve for “single” and only 1/3 the level reached by the curve for “widowed”.

**Health impact of a change in living place**

**A testable prediction of the “Transient Shock” conjecture**

For death occurrences the only data available about the deceased are those recorded on the death certificate. This includes only basic information such as age, cause of death, marital status. For the persons enumerated in a census much more information is available which can be linked to the data about disability. Here this kind of linkage is illustrated by a particular interesting case which yields a test of the transient shock conjecture proposed in one of our earlier papers. The “Transient Shock” conjecture introduced in Richmond et al. (2016b) posits that:

“Any abrupt change in living conditions generates a mortality spike which acts as a kind of selection process.”

Moving from one place to another is a fairly sudden change although hardly as dra-
Fig. 3a,b  Age-specific disability ratio according to time of residence in one and the same place. The disability ratio is the disability rate of persons who have been moving to another place in the 18 months preceding the census interview divided by the disability rate of persons who have remained in the same place for more than 18 months. For the sake of clarity the error bands have been omitted; they have basically the same shape as in Fig. 2. Source: The results are based on the 18,037,222 records of the 5% samples of the US censuses of 1980 and 1990; available from Ruggles et al. 2017 (IPUMS).

matic as moving from home into a nursing home. This conjecture leads us to expect that a change of residence will have an adverse effect on health; although because such changes are fairly common one expects a small impact. Yet thanks to the disability variable it is possible to test this prediction.

Data and methodology

In the censuses of 1980 and 1990 the question about the living place was as follows. “When did the person move into this house or apartment?” Because it is well known that recollection of the date of past events is fairly unreliable, the questionnaire proposed a number of fairly broad time intervals. In 1980 the first interval was 1979–1980, the second was 1975–1978 and the latter corresponded to longer stays in the same place. Altogether there were 6 code numbers with the final one standing for “moved in more than 31 years ago”.

Based on the analysis conducted in Richmond et al. (2016b) we expect adverse effects to appear fairly quickly after the change. This led us to consider only two cases:

(i) Short stay: 1979–1980 (ii) Long stay: all years before 1979.

If we admit that the census question was asked in mid-1980, the first case corresponds to a stay of between 0 month (for a change occurring just prior to the census...
interview) and 18 months (for a change occurring on 1 January 1979). Thus, for this short-stay case the average length is 9 months.

Because we expect the long-stay case to have a lower disability rate than the short-stay case, it will be the analog of the married status considered in the previous section. Thus, in the same way as we computed disability ratios with respect to the married status, here we will compute disability ratios with respect to the long-stay case. As before we compute this ratios for all ages between 16 and 89. In addition we repeat this calculation for different marital statuses.

**Results**

With respect to the analysis conducted in the previous section adding a new variable namely the length of stay will further reduce the number of persons who qualify. For that reason we need big samples and this led us to analyze the merged data of both the 1980 and 1990 censuses.

The curves presented in Fig. 3 were computed from the eighteen million data lines of this merged file. They correspond to the following disability ratio:

\[ r(t; s) = \frac{f(t; \text{shortstay}; s)}{f(t; \text{longstay}; s)} \]

where \( t, s \) and \( f \) have the same meaning as previously. For ages over 25 the curves show indeed disability ratios which are larger than one, thus confirming the prediction based on the “Transient Shock” effect.

**Discussion**

The curves have also some surprising features.

- The maximum level which is reached between the ages of 40 and 60 is almost independent of the marital status.
- After the age of 60 the curves fall until converging towards a stationary level of 1.07.

What is surprising in these observations can be summarized by saying that one would expect the impact of relocation to be stronger for more “fragile” groups. It would be reasonable to think that widowed persons are more fragile with respect to relocation than are married persons. However, the results show basically the same effect for widowed and married people.

Similarly one would expect elderly people to be more fragile than people in their 40s. However, the results of Fig. 3a,b show the opposite. They reveal a relocation effect that is smaller for elderly groups than for midlife people.

One can propose the following explanation.

With increasing age come more and more disability factors mostly related to health issues; relocation represents one of these factors but as the number of the other fac-
Fig. 4 Fractions of widowed groups with disability: short stay versus long stay. “Short stay” means same residence during a lapse of time comprised between 0 and 18 months. As both fractions increase along with age, the relocation effect becomes drowned in the other many disability causes; as the later are common to the two subgroups the impact of the length of stay is reduced. Source: 5% samples of the US censuses of 1980 and 1990; available from Ruggles et al. 2017 (IPUMS).

In the next section we use the disability data to test (or rather re-test) a surprising effect already identified in Richmond et al. (2016b).

**Short-term disability increase following marriage**

**Method and data**

Based on the “Transient Shock” conjecture it was predicted in Richmond et al. (2016b) that after marriage there should be a temporary increase in the mortality rate. This prediction was tested and confirmed by three different methods which all relied on mortality data. The fact that disability rates can be used as a proxy for death rates opens a new possibility and it is therefore interesting to see whether our previous tests can be complemented.

This investigation is based on the answers to the following question which was asked...
in the 1% censuses conducted between 2008 and 2015\(^4\).

“In the past 12 months did this person get married?”

If there is a temporary surge in disability in the months following marriage, one should see an inflated rate for the persons who got married within the past 12 months with respect to those who have been married for a longer time. Fig. 5 shows that this is indeed the case except (for reasons as yet unknown) for the youngest and oldest age intervals, namely 16-25 and 76-85.

![Fig. 5](image)

**Fig. 5** Disability rate of persons who got married in past 18 months divided by the disability rate of persons who have been married for a longer time. The data points are for 10-year age intervals: \((16 - 25), (26 - 35), \ldots, (75 - 85)\). The four thin lines in green correspond to: (i) 2008-2010 (7,203,967 persons), (ii) 2011-2012 (4,988,147 persons), (iii) 2013-2014 (5,035,986 persons), (iv) 2015 (2,542,244 persons). **Sources:** Data from the annual American Community Surveys from 2008 to 2015; available from Ruggles et al. 2017 (IPUMS).

**Selection of the disability variable**

Note that for the ACS surveys the disability variable is not defined in the same way as in the censuses of 1980 and 1990. Here, there are 3 different disability variables corresponding to different aspects of the situation of the persons: \(d_1\): mobility at home, \(d_2\): mobility outside home, \(d_3\): difficulty in bathing, dressing. It turns out that as a function of age, \(\log(d_1), \log(d_2), \log(d_3)\) are highly correlated: \(r(1, 2) = 0.93, r(1, 3) = 0.97, r(2, 3) = 0.99\). With respect to the mortality rate \(D\) in seven

\(^4\)Actually as they are done on 1% samples they are not real full scale censuses. Such surveys are called “American Community Surveys” (ACS).
10-year age intervals from 16 to 85 they have the following relationships.
\[ d_1 \sim D^{1.21}, \ d_2 \sim D^{1.93}, \ d_3 \sim D^{1.53}. \]
So we compute our results using \( d_1 \) as the condition most closely connected with the mortality rate; the two variables have a coefficient of correlation of 0.98.

**Discussion**

The short term disability surge observed in the months following marriage is nothing mysterious. It is a direct consequence of the fact that at same age single persons have a higher disability rate than married persons. Naturally, although the marriage itself is instantaneous, the transition from condition 1 (single) to condition 2 (married) is certainly not instantaneous. Thus, among the persons who responded that they got married in the past 12 months, there are some which still carry their former disability rate.

The investigation done in Richmond et al. (2016b, Fig. 9b) showed that in the age interval 30-40 the death rate in the months following marriage was even higher than the death rate of single persons. A comparison of Fig. 1b and Fig. 5 shows that this does not hold for disability rates. The reason of that discrepancy remains an open question.

**Conclusion**

**Overall results**

In this paper we exploited the fact that disability rates can be used as near-substitutes for mortality rates. Whereas the second are based on death certificates, the first are recorded individually in some (but not all) censuses. This gives much more flexibility because censuses record more personal information than that given on death certificates.

As a result we were able to estimate the impact on health of three different conditions: (i) marital status (ii) moving from one living place to another (iii) getting married. For (i) and (iii) we had a prior knowledge of what to expect from a previous study based on mortality rates. Our observations led to effects similar to what was seen with mortality rates thus confirming that the disability rates are acceptable substitutes for mortality rates.

The effect (ii) of a living place change in the 18 months preceding the census interview could be predicted based on the “Transient Shock” conjecture. The results show that, on average over all ages, disability rates are inflated by a factor 1.5 with respect to the persons of same age and same marital status who did not move.

**Assets and promises of biodemography**
We finish with a word about the field of biodemography. A few physicists have recently begun to explore this field (see in particular Viswanathan et al. 2011), but so far it has not attracted their attention to the same degree as has finance. When econophysics began some 20 years ago it mainly focused on finance and in particular the study of stock prices. Moving from stock markets to biodemography may seem a big shift but unlike 200 hundred years ago when John Graunt and Edmund Halley were exploring similar data the two fields now share at least one characteristic, namely the existence of broad and massive data bases.

As attested by our recent papers, such data sets can now be readily interrogated in order to illuminate regularities whose level of noise is much lower than that of stock prices, not to speak of transaction volumes which are even more volatile. Moreover, in biodemography there are numerous well-defined and intriguing questions that can be asked. By way of illustration we note two: (i) Why are suicide rates highest in May and lowest in December? (ii) Why are the death rates of young widowers some 6 times higher than those for married persons of the same age? At the moment the answers elude us.

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