SZAKDOLGOZAT

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2017
What doesn’t break you makes you stronger?
The survivor’s mortality during conjugal bereavement

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Abstract

This paper investigates the bereavement effect on the mortality hazard of the widowed by comparing it to those who are still married. A difference is made between the short- and the long-term consequences of losing a spouse: after an initial shock that results in an elevated mortality the survival chances are returning to a certain level that does not depend on income or gender. In the meantime, these predictors seem to make a distinction between the mortality rates of those who are still married and who are just recently widowed. We show that the absolute age difference between partners is a significant predictor of one’s mortality risk during the married years, but it becomes insignificant once someone loses their partner.

Acknowledgement

The author wishes to thank the Society of Actuaries, through the courtesy of Edward (Jed) Frees and Emiliano Valdez, for allowing use of the data in this paper.
1 Introduction

In the insurance business independence between two lives is usually assumed, mostly because of computational convenience. Nevertheless, life - and life insurance - is much more complex. One’s lifetime is not only influenced by well-known factors, such as education or income, but it is also influenced by unobserved heterogeneity deriving from the same lifestyle, same environment one shares with their partner. Besides the long-term influence, there is also a particular event that makes a significant impact on one’s mortality: a partner’s death. In most cases this results in an elevated risk of death, which transitions back to a lower level over time, see for example Spreeuw and Owadally (2013).

Dependency between two lives therefore has dual nature: there is a long-term dependency deriving from the unobserved heterogeneity, but there can also be a shock-effect, which rather has short-term consequences. In other words, each couple is affected by common random effects, and unless they die at the same time, one of them (usually the woman) is also exposed to the shock of losing a spouse. In any case, this study observes if a partner’s death makes a significant influence on one’s lifetime both during and after the initial bereavement period in opposite-sex marriages.

Given the increase in life expectancy that has occurred in the past decades the need for long term care also increased according to Frank (2012). Therefore it is utterly important for insurers and partners to develop an appropriate model to estimate mortality rates of the elderly as precise as possible. But since 2012, a once widely applied, significant predictor, gender is no longer allowed to be used for mortality estimations in the European Union. Hence, finding significant predictors of survival chances became even more relevant than before.

In this paper we focus on the changes in mortality triggered by the loss of a spouse. We prefer to use the terms “short-term” and “long-term” in the conventional form: the first one refers to a relatively short time-period after the partner’s death, whereas the expression “long-term” refers to a longer time-period, namely the whole remaining lifetime. To avoid ambiguity in this manner (given that other papers use “short-term” and “long-term” in a different context, see for example Hougaard (2012)), we will refer to the mortality changes related to these time-frames as the “shock period” and the “long-term widowhood”. Nevertheless, we shall note, that this framework is perfectly in line with other literature.
The questions for which we are seeking an answer in this paper are therefore the following: Does the loss of the spouse affect the survival chances of the widow(er)? If so, to what extent? Is there a difference between the survival chances of the survivors during the “shock period” and the “long-term widowhood”? Do gender, income and the absolute age difference between the partners make a difference in the results?

We find that recently widowed individuals are more at risk than the ones who have lost their spouse a while ago. Gender and income seem to play an important role in the survival chances for those who are recently widowed, but we found no evidence for differences in the survival chances of those who have successfully survived the “shock period”. We also observe the role of the absolute age difference: while this covariate is significant for those who are not widowed yet, it seems to be insignificant for both type of widows and widowers (the recently widowed and the ones who have ended the grieving period).
2 Literature review

Conjugal bereavement is a topic that interests researchers of multiple fields of science: the term “broken heart” was in fact first used by Parkes, Benjamin, and Fitzgerald (1969) and in this context the focus was less on mortality patterns but more on the heart as an organ itself. Nevertheless, the question they tried to answer was whether conjugal bereavement leads to an elevated mortality. According to their suggestion, in the case of a married couple short-term dependence is more relevant than long-term dependence, where the expressions of “short-term” and “long-term” were used in the classical sense. They show that, within about 6 months after the death of their partner, the mortality of widowers is comparable with that of married men. Moreover, according to their findings, in the first 6 months of widowers the greatest increase of mortality occurred due to coronary thrombosis and other atherosclerotic and degenerative heart diseases.

Several other studies have been conducted which made an attempt to describe the nature of dependency between two lives. Different settings lead to different methods, but the focus often differs as well: in some cases the study is about the long-term effect, whereas other papers observe the so-called Broken Heart phenomenon. The latter one refers to the hypothesis that mortality rates increase directly after the loss of a partner, but it gradually diminishes back to a “normal” level later. But even the phrases “short-term effect” and “long-term effect” are ambiguous and are often dependent on the given settings.

Spreeuw (2006), Spreeuw and Wang (2008), Spreeuw and Owadally (2013) and Hougaard (2012) all use the terms “short-term dependence” and “long-term dependence” in such a way, that they both refer to the mortality changes of the survivor in the long-run. According to their definition, the remaining lifetimes exhibit short-term dependence if the survivor’s conditional force of mortality is an increasing function of the time of death of the partner, and they exhibit long-term dependence if it is a constant or decreasing function of the time of death of the spouse. Although these concepts on dependence are reasonable and relevant, the terminology suggests a bit of ambiguity: for example, in this setting short- and long-term dependence are mutually exclusive concepts.

Other studies investigated the conjugal bereavement effect shortly after the loss of the spouse and a while later. The time-frame however differs greatly for most studies, which is why it seems to be difficult to make a conclusion whether the impact of losing a spouse
changes over time.

Helsing and Szklo (1981) investigated the mortality rates based on person-years at risk; they found no difference between the mortality rates of widows and married women, but they found that for men widowhood decreases survival chances. They controlled for some demographic, socioeconomic and behavioral variables. Moreover, they investigated the time-aspect of widowhood: they found no evidence for elevated mortality in the first or second 6-months intervals directly after the loss of the spouse for either gender, when comparing the widowed to married people with the same age.

As opposed to making comparisons between “within 6-months” and “after 6 months” Hart, Hole, Lawlor, Smith, and Lever (2007) chose to compare mortality risks in a 5-year long term. They made a comparison between bereaved and non-bereaved people in terms of mortality risk with respect to different causes of death. With the exception of lung cancer bereaved participants had a higher mortality rate in comparison to the non-bereaved. But similarly to Helsing and Szklo (1981) they found no evidence of mortality risk changes over time when comparing those within and after 5 years of bereavement.

Although they investigated a different kind of shocking life-event, Metsä-Simola and Martikainen (2013) were also making comparisons between mortality rates. According to their results divorce results in an increase in mortality, especially for men, both on short- and long-term. They have taken into consideration re-divorce and post-divorce social and economic conditions as predictors. In the meantime, they found no evidence for changes over time, but once again the time-frame for such comparison was chosen to be within and after 6 months of the divorce.

The papers above all operated under different assumptions and employed different methods, but there is a common ground: none of them found any evidence for the existence of an elevated mortality risk within a relatively short time-frame, and afterwards. On the other hand, the choice of the time-frame might be a bit too wide to detect the shock effect of losing a spouse. The following papers all used shorter time-frames for the same purpose and they were all able to detect a shock effect.

Kaprio, Koskenvuo, and Rita (1987) conducted research on a 5-year long observation period based on the Finnish Population Register and cause-of-death files. The proportion of death 0-7 days after bereavement was 44% for men and 49.2% for women, but the majority of these was reported as a traffic accident. What is remarkable though, that
even after eliminating the traffic accidents the first week after the bereavement seems to have the highest mortality rate among almost all causes of death, regardless of gender.

Similarly, Martikainen and Valkonen (1996) conclude that the loss of the spouse has a causal effect on one’s mortality and that this effect is larger for men than for women. They also found that the excess mortality due to bereavement was higher in the first week than 6 month after. These findings suggest that in order to detect a shock effect one should consider a shorter time-frame than 6 months.

Moon, Glymour, Vable, Liu, and Subramanian (2013) experimented with a 3 months long time-frame while analyzing the widowhood effect over time. They controlled for socioeconomic status criticizing previous studies in this sense: they claim that the previous papers were inadequately doing so. Evidence was found for elevated mortality within 3 months and decreased rapidly afterwards. It is also important to mention that they did not find evidence on gender differences in this sense.

The shock effect can also be observed in a different way, namely making a distinction between those who unexpectedly lost their spouse and those who had time to prepare for this event since the partner was suffering from a long-term chronic disease. This is the distinction made for example by Shah, Carey, Harris, DeWilde, Victor, and Cook (2013). They found that the impact on one’s mortality was larger if the spouse passed away unexpectedly. Siflinger (2013) distinguishes between the bereavement effect and the caregiver burden effect. She also examined what role anticipation on the partner’s death plays in one’s mortality.

In Jagger and Sutton (1991) the focus is on the mortality change over time, after bereavement. Using the proportional hazard model of Cox they tested several hypotheses, where they modeled the bereavement effect as a time-dependent covariate with different functional forms. In case of the best fitting model they found that the elevation of the mortality gradually disappears within approximately 6 months after the loss of the spouse. This result also might explain the different outcomes regarding the mortality changes over time: it seems that the elevated mortality can be captured only within a relatively short time-frame.

Similarly, Van den Berg, Lindeboom, and Portrait (2011) analyzed health and mortality risks at older ages, taking the effect of spousal bereavement into consideration as a function of time. Their model allows the mortality of the spouse to affect an individual
both directly and indirectly, via health indicators. Endogeneity of health and the timing of the bereavement are both considered. It is a somewhat surprising result (given the results of others) that the mortality rate of the survivor increases for approximately 2.5 years after the loss of the spouse, after which it gradually starts to decrease. Hence, according to their data the shock effect can also be captured on a longer time-span.

In Schmidpeter et al. (2015) once again not the effect of the spousal bereavement was investigated, but the loss of another beloved family member, namely a child: the paper investigates how such tragic event affects the parents’ survival chances. They observed different channels and found that this type of stress makes a direct effect on the parents’ health and mortality rates, but it is not represented in their future wages or unemployment days. They found that many years later the mortality of these parents is still higher, and that especially the fathers are at risk. Hence, losing a child seems to make an impact on one’s mortality in the long-run.

The asymmetry of bereavement impact with regards to genders has been pointed out among others by Van den Berg and Gupta (2015). In their paper the authors observe the relation between the early life conditions, marriage and mortality; interestingly they found very different impacts on men and women. For women, the protection that marriage provides is dependent on the economic conditions of their early life. In comparison to unmarried women those who were born during adverse economic conditions have less protection from mortality due to marriage, whereas the ones who were born in more favorable economic conditions benefit from marriage in terms of longevity. This implies that the effect of marriage is not the same for all women. Nevertheless, early life conditions do not seem to affect the rate of marriage. For men, marriage serves as a protection of mortality in every age, and the effect does not show any dependence with the early life conditions. However, an autonomous effect can be captured: the early life conditions seem to influence the marriage rate, which influences mortality later. This means that the early life conditions determine mortality on their own, the size is not affected by marriage.

The bereavement effect has also been approached from the point of view of health: it is reasonable to assume that the loss of a spouse does not necessarily translate in death, but it can lead to serious deterioration of health. Simeonova (2013) investigates the relationship between bereavement, mortality and the use of health care for chronically ill elderly men. According to this study, changes in the use of health care due to bereavement
have a significant impact on mortality but they only account for a small part of the overall negative effect of widowhood on longevity. Meanwhile Tseng, Petrie, Leon-Gonzalez, et al. (2014) found evidence that bereavement deteriorates (self-reported) health in elderly ages. In addition, they found that more educated people are less at risk than less educated ones regarding the deterioration of health. Chang, Lu, Lan, and Wu (2013) identified heterogeneous and multidimensional health-transition patterns in middle-aged and older populations. They have showed that several factors might have an effect on health-transition patterns.

There is ample papers with a focus on applications of duration dependence instead of forecasting. Frees, Carriere, and Valdez (1996) use copula models to capture the dependence between the lifetimes of couples and show that the annuity values are significantly lower when the dependence is taken into consideration in comparison to the standard models where independent lives are assumed. However, in their approach they did not take the age difference between the spouses into consideration, they solely focused on the ages of the spouses at death. But dying at the same age does not necessarily mean that the partners die at the same time: it is very much possible that the younger party outlived the older one even for years. Hence, this model can only explain duration dependence to a limited extent and is not suitable to capture the shock effect.

The research of Brown and Poterba (1999) should also be mentioned at this point, given that it was conducted in the topic of annuity valuations. They showed that single individuals value the opportunity of purchasing an annuity product more than married couples value the opportunity to purchase a joint and survivor annuity. However, during their research they completely ignored the possible dependence between the two lives, which they admit that it could influence the results described before.

Ji, Hardy, and Li (2011) also used the copula approach in combination with Markovian models to model the dependence between the lifetimes of married couples. Although they also did not take the age difference into consideration, they pointed out that the annuity ratios are lower when the gap between the partners’ age is larger.

However, there could be a possibility to use copulas for modeling duration dependence. Wang, Yang, and Huang (2015) use copula models with a time-varying element: they employ the Lee-Carter model for multiple countries, allowing mortality to change over time. This research however does not investigate duration dependence between spouses.
The nature of duration dependence between partners seems to exhibit similarities in different studies, even though the presented studies operate under various settings. Some were able to show evidence on conjugal bereavement, some were not, but the seemingly contradicting results have a pattern: the shorter the observed time-frame is after the loss of the spouse, the more likely it is that a study will reveal an elevated mortality for the partner. Based on the studies presented above we conclude that the threshold in this sense lies around the length of 6 months. The only exception to this finding is the research of Van den Berg et al. (2011), who have found evidence on a longer time-span. Therefore, this paper will also focus on a shorter time horizon, which we will further specify in Section 5.
3 Model characteristics

3.1 Three stages of life

This paper divides lifetimes into three stages, namely the “happily married stage”, the “shock period” and the “long-term widowhood”. The description below and the example that follows are intended to clarify what these concepts mean. Note that the focus is always on the age of the person in question, which is why if someone is being observed, the observation period always starts at his or her date of birth.

The following notations will be used for couple \(i = 1, 2, ..., n\), in the above mentioned three stages of life \(j = 1, 2, 3\), where \(x\) and \(y\) indicate the male and the female respectively:

- \(c\) : end date of the observation period
- \(s\) : length of the shock period
- \(b_{x,i}\) : date of birth of the male
- \(b_{y,i}\) : date of birth of the female
- \(D_{x,i}\) : date of death of the male
- \(D_{y,i}\) : date of death of the female
- \(t_{x,i}^j\) : observed lifetime of the male in stage \(j\)
- \(t_{y,i}^j\) : observed lifetime of the female in stage \(j\)

If any of the dates of death is not available, it is assumed that it occurs later than the end of the observation period, so these observations will be right censored. Also, this study considers such couples only got married once until the end date of the observation period. Therefore we will not observe the effects of divorce or getting married again.

1. The happily married stage - the baseline

In this stage both parties of the couple are still alive, hence, none of them has had to cope with the loss of the spouse yet. Note that in this stage one might already be aware of the fact that the other is dying, and in the cases of long-term illnesses getting the bad news might as well be as shocking (or even more shocking) than the actual loss of the spouse. Nevertheless, due to the lack of information this can’t be observed in our model, hence we will refer to the first stage as the “happily married
stage” or the baseline of our study.\footnote{It is a well known fact that there exists a difference in the mortality of single and married people, see for example in Shurtleff (1956). Hence, it is important to establish the baseline for married people before observing the consequences of widowhood.}

The end date of the happily married stage ($St_{x,i}^1$ for the male and $St_{y,i}^1$ for the female of couple $i$) is subject to a set of variables:

$$St_{x,i}^1 = St_{y,i}^1 = \min(D_{x,i}, D_{y,i}, c)$$

Note that the end date of the happily married stage is always the same for both parties of the couple.

Using the formula above the observed lifetime of the male and the female of couple $i$ can be calculated for the happily married stage:

$$t_{x,i}^1 = St_{x,i}^1 - b_{x,i} = \min(D_{x,i}, D_{y,i}, c) - b_{x,i}$$

$$t_{y,i}^1 = St_{y,i}^1 - b_{y,i} = \min(D_{x,i}, D_{y,i}, c) - b_{y,i}$$

We define an event variable for both the male and the female of couple $i$ which equals to 1 if someone passes away during the happily married stage and 0 if (s)he does not, formally:

$$e_{x,i}^1 = \begin{cases} 0 & \text{if } St_{x,i}^1 > D_{x,i} \\ 1 & \text{if } St_{x,i}^1 = D_{x,i} \end{cases} \quad \text{and} \quad e_{y,i}^1 = \begin{cases} 0 & \text{if } St_{y,i}^1 > D_{y,i} \\ 1 & \text{if } St_{y,i}^1 = D_{y,i} \end{cases}$$

Even though both parties of the couples were observed during the first stage, at most one of them can be widowed. Hence, at most one of them will enter the next stage, the shock period.

2. The shock period

The shock period is only relevant for those, who outlived their partner, which also means that at most one person for each couple is observed. Once again, the expression of “shock period” refers to the initial days of the bereavement period when the survivor might still be under a higher emotional burden than later.

If someone is being observed in the shock period that means
This person must have already lost a spouse, hence

- either \( D_{y,i} < D_{x,i} \) : in this case the wife passed away first, hence, the male of couple \( i \) is observed

- or \( D_{x,i} < D_{y,i} \) : in this case the husband passed away first, hence, the female of couple \( i \) is observed

The death of the spouse occurred before the end date of the observation period, therefore

- either \( D_{y,i} < c \) : in this case the wife passed away first, hence, the male of couple \( i \) is observed

- or \( D_{x,i} < c \) : in this case the husband passed away first, hence, the female of couple \( i \) is observed

The end date of the shock period stage (\( St_{x,i} \) for the male and \( St_{y,i} \) for the female of couple \( i \)) depends on who we observe:

\[
St_{x,i}^2 = \min(D_{x,i}, D_{y,i} + s, c) \\
St_{y,i}^2 = \min(D_{x,i} + s, D_{y,i}, c)
\]

Similarly to the previous stage, we calculate the observed lifetime of the male and the female of couple \( i \) for the shock period stage the following way:

\[
t^2_{x,i} = St_{x,i}^2 - b_{x,i} = \min(D_{x,i}, D_{y,i} + s, c) - b_{x,i} \\
t^2_{y,i} = St_{y,i}^2 - b_{y,i} = \min(D_{x,i} + s, D_{y,i}, c) - b_{y,i}
\]

The corresponding event variables in this stage (for the male and the female of couple \( i \), respectively):

\[
e^2_{x,i} = \begin{cases} 0 & \text{if } St_{x,i}^2 > D_{x,i} \\ 1 & \text{if } St_{x,i}^2 = D_{x,i} \end{cases} \quad \text{and} \quad e^2_{y,i} = \begin{cases} 0 & \text{if } St_{y,i}^2 > D_{y,i} \\ 1 & \text{if } St_{y,i}^2 = D_{y,i} \end{cases}
\]

Note that for each couple maximum one of the above formulas is applicable, because at least one of the spouses is not observed in this stage. It is also not certain that
any of them will enter the next stage; only those are observed in the long-term widowhood stage who have lost their spouse and successfully survived the critical shock period before the end date of the observation period.

3. The long-term widowhood

The last stage, the long-term widowhood observes those, who not only outlived their partner but survived the shock period, the initial days of the bereavement as well (before the end date of the observation period).

If someone is being observed in the long-term widowhood period that means

- This person must have already lost a spouse and survived the shock period, hence

  \[ D_{y,i} + s < D_x: \text{ in this case the male of couple } i \text{ is observed} \]
  \[ D_{x,i} + s < D_y: \text{ in this case the female of couple } i \text{ is observed} \]

- The shock period elapsed before the end date of the observation period, therefore

  \[ D_{y,i} + s < c: \text{ in this case the male of couple } i \text{ is observed} \]
  \[ D_{x,i} + s < c: \text{ in this case the female of couple } i \text{ is observed} \]

The end date of the long-term widowhood stage (\( St^3_{x,i} \) for the male and \( St^3_{y,i} \) for the female of couple \( i \)) is again dependent on the party we observe:

\[
St^3_{x,i} = \min(D_{x,i}, c)
\]
\[
St^3_{y,i} = \min(D_{y,i}, c)
\]

The corresponding observed lifetimes to this stage (male and the female of couple \( i \), respectively) are:

\[
t^3_{x,i} = St^3_{x,i} - b_{x,i} = \min(D_{x,i}, c) - b_{x,i}
\]
\[
t^3_{y,i} = St^3_{y,i} - b_{y,i} = \min(D_{y,i}, c) - b_{y,i}
\]

And finally, the event variable for both the male and the female of couple \( i \) for the long-term widowhood stage are the following:

\[
e^3_{x,i} = \begin{cases} 
0 & \text{if } St^3_{x,i} > D_{x,i} \\
1 & \text{if } St^3_{x,i} = D_{x,i}
\end{cases}
\]

\[
e^3_{y,i} = \begin{cases} 
0 & \text{if } St^3_{y,i} > D_{y,i} \\
1 & \text{if } St^3_{y,i} = D_{y,i}
\end{cases}
\]
The following example will illustrate the definitions of the time and event variables for the different stages.

**Example 3.1.** Consider 6 couples with the dates of death of Table 1. For the sake of simplicity assume that all males were born on the 1st of January 1950 and that all females were born on the 1st of January 1955. The end of the observation period is the 1st of January 2015. Assume a shock period of 10 days. Instead of providing the explicit duration of certain time periods in the example the start and end dates will be shown for the sake of transparency.

<table>
<thead>
<tr>
<th>Nr</th>
<th>Date of death</th>
<th></th>
<th></th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>male</td>
<td>female</td>
<td></td>
</tr>
<tr>
<td>1</td>
<td>-</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>2</td>
<td>1 Jan 2000</td>
<td>-</td>
<td></td>
</tr>
<tr>
<td>3</td>
<td>1 Jan 2010</td>
<td>1 Jan 2000</td>
<td></td>
</tr>
<tr>
<td>4</td>
<td>1 Jan 2000</td>
<td>6 Jan 2000</td>
<td></td>
</tr>
<tr>
<td>5</td>
<td>-</td>
<td>25 Dec 2014</td>
<td></td>
</tr>
<tr>
<td>6</td>
<td>1 Jan 2000</td>
<td>1 Jan 2000</td>
<td></td>
</tr>
</tbody>
</table>

Table 1: Example dates of death

Table 2-4 illustrate in which stage which member(s) of the couples are observed and for what time period. In addition, the tables present the corresponding event variables.

1. **The happily married stage - the baseline**

   When estimating the baseline survival curve we observe the happily married stage of every couple. This either lasts until the end date of the observation period or until the first death. Below is a comprehensive overview about the potential events, also references to the example. The time periods and the corresponding events can be found in Table 2.
Table 2: Example observation periods and events for the happily married stage

<table>
<thead>
<tr>
<th>Nr</th>
<th>Time (male)</th>
<th>Time (female)</th>
<th>Event (male)</th>
<th>Event (female)</th>
</tr>
</thead>
<tbody>
<tr>
<td>1</td>
<td>1 Jan 1950 - 1 Jan 2015</td>
<td>1 Jan 1955 - 1 Jan 2015</td>
<td>0</td>
<td>0</td>
</tr>
<tr>
<td>2</td>
<td>1 Jan 1950 - 1 Jan 2000</td>
<td>1 Jan 1955 - 1 Jan 2000</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>3</td>
<td>1 Jan 1950 - 1 Jan 2000</td>
<td>1 Jan 1955 - 1 Jan 2000</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>4</td>
<td>1 Jan 1950 - 1 Jan 2000</td>
<td>1 Jan 1955 - 1 Jan 2000</td>
<td>1</td>
<td>0</td>
</tr>
<tr>
<td>5</td>
<td>1 Jan 1950 - 25 Dec 2014</td>
<td>1 Jan 1955 - 25 Dec 2014</td>
<td>0</td>
<td>1</td>
</tr>
<tr>
<td>6</td>
<td>1 Jan 1950 - 1 Jan 2000</td>
<td>1 Jan 1955 - 1 Jan 2000</td>
<td>1</td>
<td>1</td>
</tr>
</tbody>
</table>

- The male dies first, before the end date of the observation period:

\[
S_{t_{x,i}} = S_{t_{y,i}} = D_{x,i} \implies t_{x,i}^1 = D_{x,i} - b_{x,i} \text{ and } e_{x,i}^1 = 1 \\
\implies t_{y,i}^1 = D_{x,i} - b_{y,i} \text{ and } e_{y,i}^1 = 0
\]

(This is the case for couple nr. 2 and 4.)

- The female dies first, before the end date of the observation period:

\[
S_{t_{x,i}} = S_{t_{y,i}} = D_{y,i} \implies t_{x,i}^1 = D_{y,i} - b_{x,i} \text{ and } e_{x,i}^1 = 0 \\
\implies t_{y,i}^1 = D_{y,i} - b_{y,i} \text{ and } e_{y,i}^1 = 1
\]

(This is the case for couple nr. 3 and 5.)

- The male and the female die on the same day, before the end date of the observation period:

\[
S_{t_{x,i}} = S_{t_{y,i}} = D_{x,i} = D_{y,i} \implies t_{x,i}^1 = D_{x,i} - b_{x,i} \text{ and } e_{x,i}^1 = 1 \\
\implies t_{y,i}^1 = D_{y,i} - b_{y,i} \text{ and } e_{y,i}^1 = 1
\]

(This is the case for couple nr. 6.)

- None of the spouses die before the end date of the observation period:

\[
S_{t_{x,i}} = S_{t_{y,i}} = c \implies t_{x,i}^1 = c - b_{x,i} \text{ and } e_{x,i}^1 = 0 \\
\implies t_{y,i}^1 = c - b_{y,i} \text{ and } e_{y,i}^1 = 0
\]

(This is the case for couple nr. 1.)
2. The shock period

In the shock period only those people are observed who have already lost their spouse before the end date of the observation period. They are observed from their date of birth until the end of the shock period (or the end date of the observation period, whichever occurs first), which in this example is considered to be 10 days after the loss of the spouse. Once again, there are multiple scenarios to be taken into consideration. For this stage the time periods and the corresponding events are in Table 3.

Table 3: Example observation periods and events for the shock period

<table>
<thead>
<tr>
<th>Nr</th>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>male</td>
<td>female</td>
</tr>
<tr>
<td>1</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>NA</td>
<td>1 Jan 1955 - 11 Jan 2000</td>
</tr>
<tr>
<td>3</td>
<td>1 Jan 1950 - 11 Jan 2000</td>
<td>NA</td>
</tr>
<tr>
<td>4</td>
<td>NA</td>
<td>1 Jan 1955 - 6 Jan 2000</td>
</tr>
<tr>
<td>5</td>
<td>1 Jan 1950 - 1 Jan 2015</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

- Those who haven’t lost their spouse (either because the loss of the spouse did not occur until the end of the observation period, or because they died first, or because they both died on the same day) are not observed in this stage. (This is the case for both parties of couple nr. 1 and 6, the males of couple nr. 2 and 4, and the females of couple nr. 3 and 5.)

- The survivor dies within the shock period:

\[ \text{either } S_{x,i}^2 = D_{x,i} \implies t_{x,i}^2 = D_{x,i} - b_{x,i} \text{ and } e_{x,i}^2 = 1 \]

\[ \text{or } S_{y,i}^2 = D_{y,i} \implies t_{y,i}^2 = D_{y,i} - b_{y,i} \text{ and } e_{y,i}^2 = 1 \]

(This is the case for the female of couple nr. 4.)

- The survivor does not die within the shock period:

\[ \text{either } S_{x,i}^2 = D_{y,i} + s \implies t_{x,i}^2 = D_{y,i} + s - b_{x,i} \text{ and } e_{x,i}^2 = 0 \]

\[ \text{or } S_{y,i}^2 = D_{x,i} + s \implies t_{y,i}^2 = D_{x,i} + s - b_{y,i} \text{ and } e_{y,i}^2 = 0 \]
(This is the case for the male of couple nr. 3, and the female of couple nr. 2.)

- The survivor can not be observed throughout the entire shock period (because the end date of the observation period is earlier than the end of the shock period), but (s)he is still alive at the end date of the observation period:

\[
\begin{align*}
\text{either } St^{2}_{x,i} &= c \implies t^{2}_{x,i} = c - b_{x,i} \text{ and } e^{2}_{x,i} = 0 \\
\text{or } St^{2}_{y,i} &= c \implies t^{2}_{y,i} = c - b_{y,i} \text{ and } e^{2}_{y,i} = 0
\end{align*}
\]

(This is the case for the male of couple nr. 5.)

3. The long-term widowhood

The long-term widowhood is the stage where we have the least observations. Only those are considered in this stage who have lost their spouse and then survived the entire shock period.

There are also less scenarios in this stage, Table 4 summarizes these for the example.

Table 4: Example observation periods and events for the long-term

<table>
<thead>
<tr>
<th>Nr</th>
<th>Time</th>
<th>Event</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>male</td>
<td>female</td>
</tr>
<tr>
<td>1</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>2</td>
<td>NA</td>
<td>1 Jan 1955 - 1 Jan 2015</td>
</tr>
<tr>
<td>3</td>
<td>1 Jan 1950 - 1 Jan 2010</td>
<td>NA</td>
</tr>
<tr>
<td>4</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>5</td>
<td>NA</td>
<td>NA</td>
</tr>
<tr>
<td>6</td>
<td>NA</td>
<td>NA</td>
</tr>
</tbody>
</table>

- Those, who have passed away during the happily married stage or during the shock period will not be observed anymore, neither are those who are still in their shock period at the end date of the observation period.  
(This is the case for both parties of couple nr. 1 and 6, the males of couple nr. 2, 4 and 5, and the females of couple nr. 3, 4 and 5.)

- The (long-term) survivor dies before the end date of the observation period:

\[
\begin{align*}
\text{either } St^{3}_{x,i} &= D_{x,i} \implies t^{3}_{x,i} = D_{x,i} - b_{x,i} \text{ and } e^{3}_{x,i} = 1 \\
\text{or } St^{3}_{y,i} &= D_{y,i} \implies t^{3}_{y,i} = D_{y,i} - b_{y,i} \text{ and } e^{3}_{y,i} = 1
\end{align*}
\]
(This is the case for the male of couple nr. 3.)

- The (long-term) survivor does not die before the end date of the observation period:

$$
\text{either } St_{x,i}^3 = c \implies t_{x,i}^3 = c - b_{x,i} \text{ and } e_{x,i}^3 = 0 \\
\text{or } St_{y,i}^3 = c \implies t_{y,i}^3 = c - b_{y,i} \text{ and } e_{y,i}^3 = 0
$$

(This is the case for the female of couple nr. 2.)

Note that every stage is conditional on the survival of the observed people: in the happily married stage it is assumed that someone got old enough to get married, the shock period assumes that one outlived the partner, whereas the long-term widowhood is conditional on the survival of the entire shock period. This is clearly visible from the visual representation of Figure 1, which also summarizes the presented example.

![Timelines of the example](image)

**Figure 1: Timelines of the example**

### 3.2 The applied survival models

For all stages survival functions were fitted, as in Kaplan and Meier (1958) and Cox (1972). The following, additional notations will be used for couple $i = 1, 2, ..., n$:

- $T_{x,i}^j$: the random variable for the lifetime of the male in stage $j$
- $T_{y,i}^j$: the random variable for the lifetime of the female in stage $j$
- $z_{x,i}^j$: the realized set of values of the covariates for the male in stage $j$
- $z_{y,i}^j$: the realized set of values of the covariates for the female in stage $j$
The realized set of values of the covariates are only available on the date of query. The survival functions will be defined for males and females in every stage the following way:

\[ S^j_x(t) = Pr(T^j_x > t) \quad \text{and} \quad S^j_y(t) = Pr(T^j_y > t), \]

where we impose no assumptions on the dependency of \( T^j_x \) and \( T^j_y \).

In the case of the Cox proportional hazard model the hazard function is assumed the following way (one for each gender in each stage):

\[ \lambda^j_x(t, z^j_x) = \lambda_{x,0}(t) \exp(z^j_x \beta^j_x) \quad \text{and} \quad \lambda^j_y(t, z^j_y) = \lambda_{y,0}(t) \exp(z^j_y \beta^j_y). \]

Note that the the covariates in each stage correspond to those who are entering that particular stage. This allows us to separately observe the effect of every covariate in every stage. It is very well possible that certain covariates make an impact on the survival curve in the early stages, but in later stages their effect becomes insignificant.

An example could be the effect of the age-difference: in the happily married stage the age-difference between the spouses could have a significant influence on the survival functions, but after the first death it is probably irrelevant from the widow’s point of view how big the age-difference used to be with the partner. Hence, modeling the survival this way not only allows for event-splitting, but also makes it possible to observe the interaction effect between certain covariates and the event of losing a spouse.
4 Data characteristics

The data set used in this paper is the one used in Frees et al. (1996) and Spreeuw and Owadally (2013). It contains 14,947 contracts which were in force at a large Canadian insurer between the 29th of December 1988 and the 31st of December 1993. The contracts were held by couples, which provide essential variables for an analysis: birth and death dates. In addition, there is information available on the couples’ income.

We eliminated some observations, namely same-sex couples (given that we focus on gender-differences with respect to the survival chances of widows and widowers), duplicates, and obvious typos (such as people who got married at the age of 5). As a result, we end up with 11,543 couples. For more details on cleaning the data, please see the appendix.

Unfortunately there is no information available on whether someone got married again after the loss of the spouse. We also do not know whether the marriage that we observe is the first marriage, and we cannot even be sure whether these are in fact marriages or did the insurer also allow cohabiting couples to purchase an insurance. But at first glimpse, this database contains enough observation to conduct a reliable analysis on duration dependency of couples. Nevertheless, for the dependency analysis there are some deficiencies. The biggest issue is that the number of deaths in the database is rather low: there are only 382 males and 1,190 females who have lost their spouses. When widows are in focus of the analysis, these numbers seem to be a bit low, which would result in higher model and estimation uncertainty. Also, since becoming a widow is not a life event that occurs at the same age to everyone, specific ages or age-groups should be observed, for which the size of this dataset is rather low. Hence, the results of this paper carry some uncertainty, but the research question, namely whether the loss of the spouse influences the survival chances of the survivor can still be answered.
5 Results

5.1 The length of the shock period

In order to make a distinction between the short and long term consequences of losing a spouse one should first define the length of the “shock period” - the length of time until someone is more exposed to the shock of losing a spouse. To get a better understanding of the mortality of survivors, Figure 2 was created. These graphs present the number of those male and female survivors who are alive over time after the spouse’s death among those who could be observed for at least one year. Hence, due to the latter restriction, not all 382 widowers and 1,190 widows are considered now, only 285 and 866 respectively.

![Number of male survivors alive over time](image1)

![Number of female survivors alive over time](image2)

Figure 2: Number of survivors alive over time

Even though these graphs do not control for age or socio-economic status (due to the relatively small sample size) there is a striking peak for males in the very beginning of the graph suggesting that shortly after the loss of their wives many pass away. A logical explanation could be that the couple was exposed to a common shock (such as an accident), and the death of one party occurred only a few days later. However, the asymmetry - namely that the steep decrease in the early days only occurs for males - can
hardly be explained using the above explanation. In any case, the graph suggests that male survivors are more at risk shortly after the loss of their spouse than females in the same situation.

Among others, Van den Berg et al. (2011) discussed several reasons on why the loss of the spouse might have a different effect on men and women. These differences could all be traced back to the traditional male breadwinner and female carer model. Even today, in most families the husband is responsible for the wealth of the family, he is the one whose job is to provide financial security. Meanwhile the role of a woman is more focused on the household, she is responsible for the every day family matters, taking care of every member of the family. The carer role of the woman is usually still typical (even if the woman is also working), and it never really changes over time, not even when the husband stops working and retires, see for example in Sullivan (2000), Lewis (2001), Voicu, Voicu, and Strapcova (2008) and Van Hooff (2011).

The above mentioned gender equality contains different risks for widows and widowers. The vulnerability of widowers often originates from the difficulty of taking over the roles in the household. Rosenbloom and Whittington (1993) has shown that widowhood changes one’s social environment, which makes an impact on the eating habits as well. Older men are more likely to experience difficulties with cooking which may lead to insufficient calorie intakes or nutritional deficits which may result in deterioration in their health in the long run. Boyle (2014) found that older men are often unwilling or unable to take over the role of cooking even when their wives suffer from dementia, while the wives take better care of their husbands in case he is the one with this condition. Since in most cases women had always been the caretakers of the family, they can probably carry on with life more easily after the loss of the spouse.²

Meanwhile, widows also face a severe risk when their husband passes away. In their case the higher risk is associated with poverty, which was investigated by Ecob and Smith (1999), Benzeval and Judge (2001) and McGarry and Schoeni (2001). These empirical studies all found evidence that the loss of the husband could result in greater poverty for the wife. On the other hand, the widow’s pension might help to ease such financial

²However, care taking can also be overwhelming: Schulz and Beach (1999) showed that those who are taking care of a sick family member have higher mortality risks than noncaregivers. Nevertheless, in this paper the term “carer” is used in the everyday sense and it is not meant to be a person taking care of a sick family member.
difficulty and therefore decreases the mortality risk for widows.

With regards to different risks, one should mention the unexpectedness of the loss of the spouse. It is common knowledge that women have a higher life expectancy than men, which is why the loss of the wife might come more as a shock than the loss of the husband. Hence, in terms of expectations, widowers can be considered more at risk than widows.

The differences in mortality risks suggest that in a wealthier country (such as Canada in our case) men could be more at risk when losing their wives than the other way around. But in the meantime, wealthier widowers might have the opportunity to purchase care and therefore protect themselves against the elevated mortality risk. Unfortunately our data does not allow to investigate this option, and therefore we have to point out that a strong income effect on mortality might originate from omitted variable bias.

In this particular data as can be seen on Figure 2 the steep drop in the number of male survivors ends around day 10, by then 16.14% of male survivors pass away (for women this value is only around 1.36%). Therefore, in this study we will consider the first 10 days of widowhood as the “shock period”, or in other words, the “short-term”. The phrase “long-term” will refer to the period which starts after day 10 of widowhood.

At this point another question naturally arises: What more can we learn about the people who pass away so shortly after their spouse? As a first step the distribution of the age at death was observed for each stage, this can be seen in Figure 3.

![Figure 3: Age at death in different stages](image)

Given that the median age at death for each stage is conditional on survival until that particular stage it is not surprising that the median age is increasing with the stages for males. For females however it is interesting to see that the median age at death for the
shock period and the long-term widowhood are in reversed order than expected. The median age of death for each stage is in Table 5.

<table>
<thead>
<tr>
<th></th>
<th>Stage 1</th>
<th>Stage 2</th>
<th>Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td>Male</td>
<td>73.69</td>
<td>79.29</td>
<td>80.19</td>
</tr>
<tr>
<td>Female</td>
<td>72.04</td>
<td>75.75</td>
<td>75.91</td>
</tr>
</tbody>
</table>

Table 5: Median age at death for each stage

The differences between the median age at death in different stages were tested for both genders using the Kruskal-Wallis test. For males this resulted in a $\chi^2$ test statistic of 53.145, corresponding with a p-value of 0.0000, for females the test yielded a $\chi^2$ value of 25.445 with a p-value of 0.0000. Therefore we can conclude that the medium age at death does not differ in the different stages neither for males nor for females. A pairwise comparison using the Mann-Whitney U-test was also made, the results of this can be found in Table 6.

<table>
<thead>
<tr>
<th></th>
<th>Stage 1 vs Stage 2</th>
<th>Stage 2 vs Stage 3</th>
<th>Stage 1 vs Stage 3</th>
</tr>
</thead>
<tbody>
<tr>
<td></td>
<td>U-test</td>
<td>p-value</td>
<td>U-test</td>
</tr>
<tr>
<td>Male</td>
<td>17,520</td>
<td>0.0000</td>
<td>1,056</td>
</tr>
<tr>
<td>Female</td>
<td>791.5</td>
<td>0.0140</td>
<td>472</td>
</tr>
</tbody>
</table>

Table 6: Median age at death for each stage, Mann-Whitney U-test

It seems that the median age at death differs significantly when comparing stage 1 and 2. On the contrary, stage 2 and 3 does not exhibit significant difference (assuming a 5% significance level). This implies that passing away in either of these stages is not age-specific.

In addition, the age at death of those who lost their spouse were plotted against the age of death of their partner, this can be observed on Figure 4. The age of the spouse who passes away first is depicted on the horizontal line, whereas the age of the partner (who dies second) can be found on the vertical axis. The upper two graphs represent the shock period, whereas the bottom two depicts the long-term widowhood stage.
The difference which was mentioned previously is obvious: in the shock period the graph of the females contains less observations. Nevertheless, the tendencies are similar in all graphs. Also, the above described age-specific characteristics can be observed: the median age at death of males on the upper left graph is somewhat lower than the median age at death of those males who enter the long-term widowhood stage. For women the order is reversed, but the difference is not significant.

It could also be interesting to observe more closely the age differences between the spouses: do the age-differences differ for those who pass away in the shock period in comparison with those dying in the long-term widowhood stage? Figure 5 illustrates the question using box-plots.
The Mann-Whitney test was used to formally test the equality of median age differences between the males who pass away during the shock period and the males who enter the long-term widowhood. The U-value equals 1.173 which corresponds to a p-value of 0.2471. The same test for females yields a test-value of 497 and a p-value of 0.5883. Therefore we can reject the null hypothesis which states that the age-differences differ in these stages: the shock period does not exhibit any difference from the long-term widowhood in this sense.

5.2 The Kaplan-Meier survival curves in the three stages

As a first stage of the analysis Kaplan-Meier survival curves were fitted for each stage. This allowed us to separately observe the survival chances of those who never had to experience the loss of their spouse (happily married stage, Figure 6), those who had been happily married but recently lost their partner (shock period stage, Figure 7) and the survival chances of those who have already survived the critical initial bereavement period after the loss of the spouse (long-term widowhood stage, Figure 8).
All graphs start from the age of 60 and end at the age of 100 for two reasons. The first reason is that the percentage of those who pass away before the age of 60 or after the age of 100 is very low. The second reason is that the common scale in all three stages allows us to make a visual comparison between these plots. However, it should be emphasized again that all these survival probabilities are conditional, moreover, they all employ different conditions, which is why we should not draw major conclusions from the differences at this point.

What is common in all stages is that the survival curve of females is always higher than the survival curve of males in every single age. The confidence intervals however are overlapping in some ages. In the first two stages this is mostly happening above the age of 90.

In the second stage (the shock period stage, Figure 7) it is also visible that the number of observations differ for the two genders: while the survival function’s curve for males is
fairly smooth, for females it has bigger steps. The difference is clear however: males who recently lost their wife are more at risk than females who recently lost their husband.

Figure 8: Survival probabilities in the long-term widowhood stage

What is most interesting is that in the last stage (Figure 8) the confidence intervals overlap throughout all ages, which implies that for those survivors who have survived the critical initial bereavement phase there is no significant difference between the survival probabilities of males and females. Gender therefore only seems to be a good predictor of survival chances if the spouse is either still alive or s(he) recently passed away. Once a survivor gets through the critical initial bereavement time the gender no longer serves as a good predictor for his or her survival chances.

5.3 The age-dependent widowhood

As it was emphasized before, the previously presented survival curves all display conditional survival probabilities. These conditional survival curves are nevertheless suitable for constructing an “updated” survival curve at the time when someone loses their partner. Figure 9 represents the expectations on the survival of such males and females who are widowed at the age of 75. Note that this graph (also the ones that follow in this section) use a 1-year long shock period instead of 10 days to make the shock period visible on the plots.
Figure 9: Survival probabilities of those who are widowed in the age of 75

Figure 10: Survival probabilities in the long-term widowhood stage

In order to emphasize the effect of losing a spouse the estimated hazard function was also created for those who are widowed at the age of 75, this can be seen on Figure 10. The plot clearly reveals the elevated mortality rate directly after the loss of the spouse, for both genders. Furthermore, it is also visible that the hazard function is elevated during the long-term widowhood for both genders, but the increment seems higher for males. This is in line with the findings of Spreeuw and Owadally (2013).
A comparison was also made between the long-term widowhood survival curves for those who lost their spouse at different ages. These plots are separated by gender on Figure 11. What catches one's eye first is that for males the age at which they lose their partner has a bigger influence on the survival chances than for females; the later a man becomes a widow the worse his survival chances are during his long-term widowhood. For females there is no such tendency: the age at which they become a widow does not seem to have any influence on their survival chances at all.

Studies found different reasons why widowers could be more vulnerable than widows with regards to widowhood. Such reasons according to Lee, DeMaris, Bavin, and Sullivan (2001) could be that men usually die first, therefore widowers have greater difficulties with finding other widower friends who they can share their emotional burden with. This is becoming especially difficult because men tend to become a widower at an older age, when they are also less healthy and have less social connections. Another important distinction could be the role in the household: usually women are the carers of the household and over age it becomes harder for a widower to take over this role. We should note however that the differences on the graph do not appear to be significant: the confident intervals overlap in every case.

For women there is no distinctive difference in the survival chances among those who lose their husband in an earlier age than those who widow later. Although Hungerford (2001) concluded that widows are more at risk of poverty than widowers due to the loss of income associated with the loss of the spouse, this effect do not seem to translate into
their mortality for this data. Nevertheless, it should be noted that Canada is a country with a pension plan for the survivors, hence, the system moderates the loss of income of the partner.

The next section aims to find predictors of the survival chances separately in the three stages. Hence, the effect of income (among other predictors) will be observed separately for those whose spouse is still alive, those who are recently widowed and those who have entered the long-term widowhood stage.

### 5.4 The Cox model: the predictors of survival probabilities in the three stages

In this section the focus will be on the predictors of survival probabilities with regards to the three stages. The observed predictors are gender, the absolute age difference between the partners and income. As the Kaplan-Meier survival curves revealed, in certain stages even gender does not seem to be a significant predictor of the survival chances, hence the effect of age difference and income may also vary with the stages. Below is a comprehensive overview, see Tables 7-9.

<table>
<thead>
<tr>
<th>Happily married stage</th>
<th>Beta</th>
<th>exp(Beta)</th>
<th>SE</th>
<th>2.5 %</th>
<th>97.5 %</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>gender</td>
<td>-0.71</td>
<td>0.49</td>
<td>0.06</td>
<td>-0.84</td>
<td>-0.59</td>
<td>0.00</td>
</tr>
<tr>
<td>absolute age diff.</td>
<td>-0.02</td>
<td>0.98</td>
<td>0.01</td>
<td>-0.04</td>
<td>-0.01</td>
<td>0.00</td>
</tr>
<tr>
<td>income</td>
<td>-0.01</td>
<td>0.99</td>
<td>0.00</td>
<td>-0.01</td>
<td>-0.00</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 7: Estimates of the Cox model for the happily married stage

<table>
<thead>
<tr>
<th>Shock period</th>
<th>Beta</th>
<th>exp(Beta)</th>
<th>SE</th>
<th>2.5 %</th>
<th>97.5 %</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>gender</td>
<td>-1.84</td>
<td>0.16</td>
<td>0.34</td>
<td>-2.51</td>
<td>-1.16</td>
<td>0.00</td>
</tr>
<tr>
<td>absolute age diff.</td>
<td>-0.03</td>
<td>0.97</td>
<td>0.04</td>
<td>-0.10</td>
<td>0.04</td>
<td>0.44</td>
</tr>
<tr>
<td>income</td>
<td>-0.02</td>
<td>0.98</td>
<td>0.01</td>
<td>-0.04</td>
<td>-0.01</td>
<td>0.00</td>
</tr>
</tbody>
</table>

Table 8: Estimates of the Cox model for the shock period
According to the results, gender, the absolute age difference and income are all significant predictors in the happily married stage, but none of them is significant during the long-term widowhood. Gender and income are both significant in the shock period, but the absolute age difference is not.

The results regarding gender are not surprising at this point: the Kaplan-Meier survival curves already revealed that there is no clear difference between the survival chances of males and females during the long-term widowhood stage. This also means that for an insurance company it is even more informative whether the policyholder has already lost their partner a while ago than the gender of the person. During the shock period gender is still relevant information: the survival chances during the initial bereavement significantly differ for males and females - this is again in line with the results of the Kaplan-Meier model. The survival chances of females are significantly better for females than for males in the first two stages.

The absolute age difference between the partners is a significant predictor of the survival chances during the happily married stage, but later, during widowhood it becomes insignificant. This makes sense: the bigger age difference one has with their partner the less is the uncertainty about who is going to pass away first and therefore the less shocking the death of the spouse can be. Later however, when the death of the partner occurred it is not relevant how big the age difference used to be, the survivor’s mortality does not depend on this variable any more.

The role of income is similar to the role of gender when it comes to the survival chances: it is a significant predictor in the happily married stage, also in the shock period, but later becomes insignificant during the long-term widowhood. In the first two stages a higher income results in a lower hazard rate, which implies better survival chances. During the long-term widowhood income becomes an insignificant predictor: irrespective of one’s income both wealthier and poorer widows have approximately the same survival chance.

<table>
<thead>
<tr>
<th>Long-term widowhood</th>
<th>Beta</th>
<th>exp(Beta)</th>
<th>SE</th>
<th>2.5 %</th>
<th>97.5 %</th>
<th>p-value</th>
</tr>
</thead>
<tbody>
<tr>
<td>gender</td>
<td>−0.17</td>
<td>0.84</td>
<td>0.19</td>
<td>−0.54</td>
<td>0.19</td>
<td>0.35</td>
</tr>
<tr>
<td>absolute age diff.</td>
<td>−0.02</td>
<td>0.98</td>
<td>0.03</td>
<td>−0.08</td>
<td>0.03</td>
<td>0.38</td>
</tr>
<tr>
<td>income</td>
<td>−0.01</td>
<td>0.99</td>
<td>0.01</td>
<td>−0.02</td>
<td>0.01</td>
<td>0.52</td>
</tr>
</tbody>
</table>

Table 9: Estimates of the Cox model for the long-term widowhood
6 Discussion

The results above clearly indicate that the unfortunate event of losing a partner can make a significant impact on one’s mortality, especially for males in the shock period. Also, in the widowhood stage of life there are different factors that make an influence on one’s survival than in the happily married stage. Traditionally gender is used as a predictor of survival chances, but in the long-term widowhood stage (after the effects of the shock that comes with the loss of the spouse have vanished) it does not seem to make a difference anymore. This is especially relevant for the insurance business, given that in the EU since December 2012 it is not allowed for insurers to make a distinction between genders when it comes to pricing. Hence, there is a need to find other relevant predictors for the survival chances.

As it turns out, gender on its own is not even a significant predictor for those who outlived their partner and survived the initial bereavement period. In this analysis we found that neither gender nor the absolute age difference or income makes a distinction between the survival chances of long-term widows and widowers. All of these covariates are significant however during the happily married stages.

The age at which someone loses their spouse might be relevant for males. Our results suggest that the higher age a man loses his wife the worse his survival chances will be on the long-run. These differences are not significant, but the clear tendency suggests that further research is advisable in this manner. This dataset unfortunately did not allow us to investigate this question further, given the low count of widowers. But in any case, it is interesting to note that among widows this tendency was not observable in our data.

All in all, we can conclude that the loss of a spouse makes a great impact on the survival chances: the differences between genders, income and the age differences with the partner all vanish once someone is widowed, whereas these factors do make a difference before this unfortunate event occurs. This suggests that the survival chances of widows or widowers are the same, irrespective of their age difference with their partner or their income. Therefore we would strongly recommend to any insurance companies to consider an investigation on one’s marital status when assessing their mortality. Also, updating the mortality estimations over time could be useful when estimating future liabilities.

In addition, it is also advisable to pay special attention to those who just lost their partner, especially widowers. It is quite surprising to see that more than 15% of widowers
pass away within a very short time-span, directly after the loss of their wife, which seems to be a bit too high to be called an unfortunate coincidence. We have also showed that this occurrence is not age-specific: men from every age are exposed to sudden death shortly after the death of their wife. Although the reasons of this phenomenon could not be further investigated, it is in any case recommended to pay more attention to those who are being exposed to the shock of losing their partners. This information can literally save lives for example in care facilities.

We also recommend further research on the effect of receiving bad news on the spouse’s health conditions; in many cases this might even be a greater shock than the actual death of the partner. After a long-term sickness of the partner it is even possible that someone is even relieved at the death, given that (s)he does not have to take care of the sick spouse anymore.

Last, we shall note that our research is rather a case study due to data limitations. The interesting characteristics presented here might be data specific, which is why we would recommend to check our findings with different data as well.
7 Conclusion

Our results support the findings of previous research on this field. We used a relatively short time-frame to detect the short-term consequence on the survivor’s mortality, and similarly to those who focused on the survival chances within 6 months of the partner’s death we were able to observe an increase in the mortality of the grieving party. We conclude that the loss of one’s spouse makes a significant impact on one’s mortality. Not only it is clear from the survival functions and the associated hazard functions that the mortality rate of the survivor spikes shortly after the partner’s death, but we have also showed that the traditionally used predictors (such as gender and income) do not make a significant impact on one’s mortality in every stage of life. These predictors make a difference while someone is not widowed yet, but once they are over the bereavement period neither gender nor income make an impact on the survival chances anymore.

On top of the traditionally used predictors we have also investigated whether age difference between partners makes a difference in one’s mortality. We found that it does while both parties of the couple are alive, but the age difference becomes insignificant after the loss of the spouse. The survival chances of widows do not seem to differ with respect to any of the observed factors. In any case, we can conclude that the loss of the spouse is a good predictor of one’s survival chance and it is highly recommended to be taken into consideration when estimating future liabilities for insurance companies or pension funds.
References


A Appendix

The data originally consisted of 14,947 couples. Due to the nature of our research we decided to eliminate same-sex couples, a total of 58 of them.

We checked the remaining 14,889 couples for duplicates. Since we did not have any ID numbers, only the date of birth, date of death and the income information of both parties, we used these for searching for duplicates. We found 3,343 records that looked like duplicates and therefore we removed these. Unfortunately, there is a possibility that some of these records were identical only due to coincidence and therefore it would not have been necessary to delete them. Nonetheless, it seems unlikely that this would be the primary reason of having so many duplicates in the data.

At this point we had 11,546 couples among which we found some obvious typos: there were three records where at least one party had a date of birth which was in the range of the five-year long observation window (1988-1993). This would have implied that these people had to get married before the age of 5. These ages were strikingly low, therefore we deleted them. In our final data (consisting of 11,543 couples) the youngest person observed was born in 1969.