Impact of Deaths from Dissolved Households on Mortality Measurement: Evidence from the Ouagadougou HDSS

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Abstract

Providing reliable estimates of mortality in countries with imperfect vital statistics requires addressing the issue of omissions of deaths in general population surveys. Using data from the Ouagadougou health and demographic surveillance system, we rely on event history analysis to describe the impact of deaths on household survival. Furthermore, we assess the potential omissions of deaths caused by dissolved households and their overall impact on mortality estimates.

Keywords: *Household, dissolution, survival, omission, bias, mortality*

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1 Background

In countries with poor vital statistics, censuses and surveys remain the main national data sources for measuring adult mortality. Regardless of the source, the entry point for the collection of these data is the households to which the population belongs. However, several errors could affect these data, including age errors due to individuals not knowing their true ages when they were alive, and the fact that the ages of deceased individuals are reported by others in the household after they died. This adds uncertainty to the age at death reporting. In addition to these errors, which have been discussed extensively (Masquelier et al., 2021; Helleringer et al., 2014; Randall and Coast, 2016; Pison and Ohadike, 2006; Murray et al., 2010; Preston et al., 1999), there is also the possibility of voluntary omissions, which occur when respondents avoid mentioning deceased persons to avoid awakening painful memories. These omissions may also be involuntary and result from recall errors by the respondents leading to the evocation of deaths that occurred outside the reference period of the deaths to be recorded. Finally, they may be the result of less obvious involuntary omissions, notably through the dissolution of some households.

From a demographic perspective, households undergo the same events as the individuals composing them, i.e. they get born (formation), live in a given geographical space from which they often move (migration) and may die (dissolution). The dissolution of a household can lead to its total extinction in the case of a one-person household who dies or a household that migrates entirely to a new area different from its usual territory of residence. It can also lead to a fragmentation and a displacement of household members into one or more other existing households after a death. Thus, migration and death are the major events that drive the dynamics of household survival (Compaoré, 2021). When recording deaths within households during the previous twelve months as it is generally done in censuses and some surveys, household dissolution can lead to substantial biases depending on the proportion in which deaths had occurred. Whether it concerns the whole population or a sample, any household that has been completely dissolved by migration outside the reference territory during the twelve-month interval of interest has a null probability of being recorded. Therefore, any deaths that occurred in such households can not be captured. As a result, any deaths that occurred in such households are de facto omitted from the death headcounts. This would contribute to under-reporting of deaths.

In this manuscript, we address the latter bias and analyse its implications for mortality measurement using prospective data from local population in an urban agglomeration of Ouagadougou in Burkina Faso.

Objective

The main objective of this research is to understand the death-related biases due to household dissolution. Specifically, we seek on one hand to assess the impact of deaths over time on the dissolution of households. On the other hand, we aim to estimate mortality rates with and without these potentially omitted deaths.

2 Methods

As a case study, the data used for this research are from the Ouagadougou Health and Demographic Surveillance System (HDSS). This site is established since 2008 and is composed of a settled area covering two districts and a non-settled area covering three districts, all in the neighbourhood of Ouagadougou, the capital of Burkina Faso.

From the follow-up of households residing on the site, it is possible to track their dynamics over time and identify those that are turning into zero member. To achieve this, the demographic balance equation is reduced to the household as follows:

$$NHH = ENU + BTH + IMG + ENT - EXT - OMG - DTH$$

Where

$$\begin{aligned}
NHH &= \textit{Household size}\\
ENU &= \textit{Enumerated people in the household at the beginning}\\
BTH &= \textit{Birth recorded within the household}\\
IMG &= \textit{Immigration from outside the HDSS into the household}\\
ENT &= \textit{Immigration from inside the HDSS into the household}\\
EXT &= \textit{Outmigration from the household inside the HDSS}\\
OMG &= \textit{Outmigration from the household outside the HDSS}\\
DTH &= \textit{Death recorded within the household}
\end{aligned}$$

Within each household, the household size is calculated at the beginning of the enumeration and updated after any birth, immigration or outmigration from the HDSS area, after any internal migration within the HDSS area, or after a death. Similarly, any new household that immigrates into the HDSS area is captured and tracked. In this way, any household that ends up with a zero size is considered dissolved. Considering that our interest was death-related dissolution of households and the impact of these dissolution on mortality measurement, our analysis has been restricted to households in which at least one death had occurred. From an event history perspective, we observed these households from the time of the first death up to a one year (d_1), two years (d_2) and three years (d_3). We assume that the impact of deaths on household dissolution should be observable throughout the first few years. Nevertheless, we focus on the first year with reference to the 12-month reference period used to record deaths in conventional surveys. At these pre-specified observation times, the event of interest is the dissolution of households. Any household surviving beyond these time periods will be considered as right-censored. Assuming T as the survival time of a randomly chosen household that had experienced a death, and given having survived to a given time t, the force of dissolution or instantaneous risk for being dissolved $h(t)$ in a short time interval $(t, t + \delta t)$ immediately after t can be expressed as :

$$h(t) = \lim_{\delta t \to 0} \frac{P(t \leq T < t + \delta t | T \geq t)}{\delta t}$$

Using the existing relationship between the hazard and survival functions, we analyzed the survival of households at observation times d_1, d_2 and d_3 using Kaplan-Meier estimates. Considering different dissolution time t_i, the estimator $\hat{S}(t)$ at a given time t is obtained by :

$$\hat{S}(t) = \prod_{t_i \leq t} (1 - \hat{q}_i), \quad \text{with} \quad \hat{q}_i = \frac{d_i}{n_i}$$

where n_i is the number of households at risk of dissolution at time t_i and d_i is the number of dissolved households at that time.

Besides the instantaneous dissolution rates of households in which deaths have occurred, an assessment has been made of the biases in the measurement of mortality that could result from these deaths, regarded as being at risk of omission. Let us illustrate our remarks with the crude death rate (CDR) which is obtained as follows:

$$CDR = \frac{Dx}{PY}$$

where Dx denotes the total number of deaths and PY the population at risk. Dx can be decomposed into deaths from surviving households (Dx_1) and deaths from dissolved households (Dx_2). As Dx_2 are deaths considered to be at risk of omission, we can then derive a crude omission rate (COR) as the bias on the overall mortality level as follows:

$$COR = CDR - \frac{Dx_2}{PY}$$

We estimate COR at the three observation periods of one, two and three years. Subsequently, the construction of mortality tables made it possible to assess the impact of omission bias on life expectancies within the HDSS.

3 Results

3.1 Household survival from the Kaplan-Meier curves

The analysis of the Kaplan-Meier curves for the survival of households that experienced a death reveals statistical differences according to the characteristics of the deceased (see Figure 1 below).Considering three age groups, namely children (0-14 years), young adults (15-34 years) and adults aged 35 or over, the deaths that have the greatest impact on household survival are those of young adults. In households where the deceased were young adults, around 13% did not survive after 12 months. This proportion rises to around 16% and 19% after 24 and 36 months respectively. Similarly, in households where the deceased were the head of household, the probability of survival drops by 10% after 12 months and reaches around 19% after 36 months. The probability of survival falls more sharply in cases where the deceased were poor. It falls from 10% after 12 months to around 24% after 36 months. However, analysis of the survival curves for households according to the sex of the deceased did not reveal any differences.

3.2 Findings from the Cox regression

The multivariate Cox regression confirmed the effects of the characteristics of the deceased individuals on household survival (see Figure 2 below). Splitting the analysis by area of residence shows that the instantaneous rate of dissolution (IRD) is 29% much higher in households where the deceased lived in an informal district than in households where the deceased lived in a formal district. Compared with adults aged 35 or over, the deaths of young people were accelerated by the dissolution of the household to which they belonged, with an IRD 4.8 for those aged 0-14 years and 3.2 for those aged 15-34 years. The bivariate analysis suggested that the sex of the deceased had no effect on the survival time of their household, unlike the relationship of the deceased to the head of household. However, interaction of these two variables reveals statistical differences. Compared to the death of a man heading a household, the death of a woman heading a household increased the IRD of their household by around 77%.

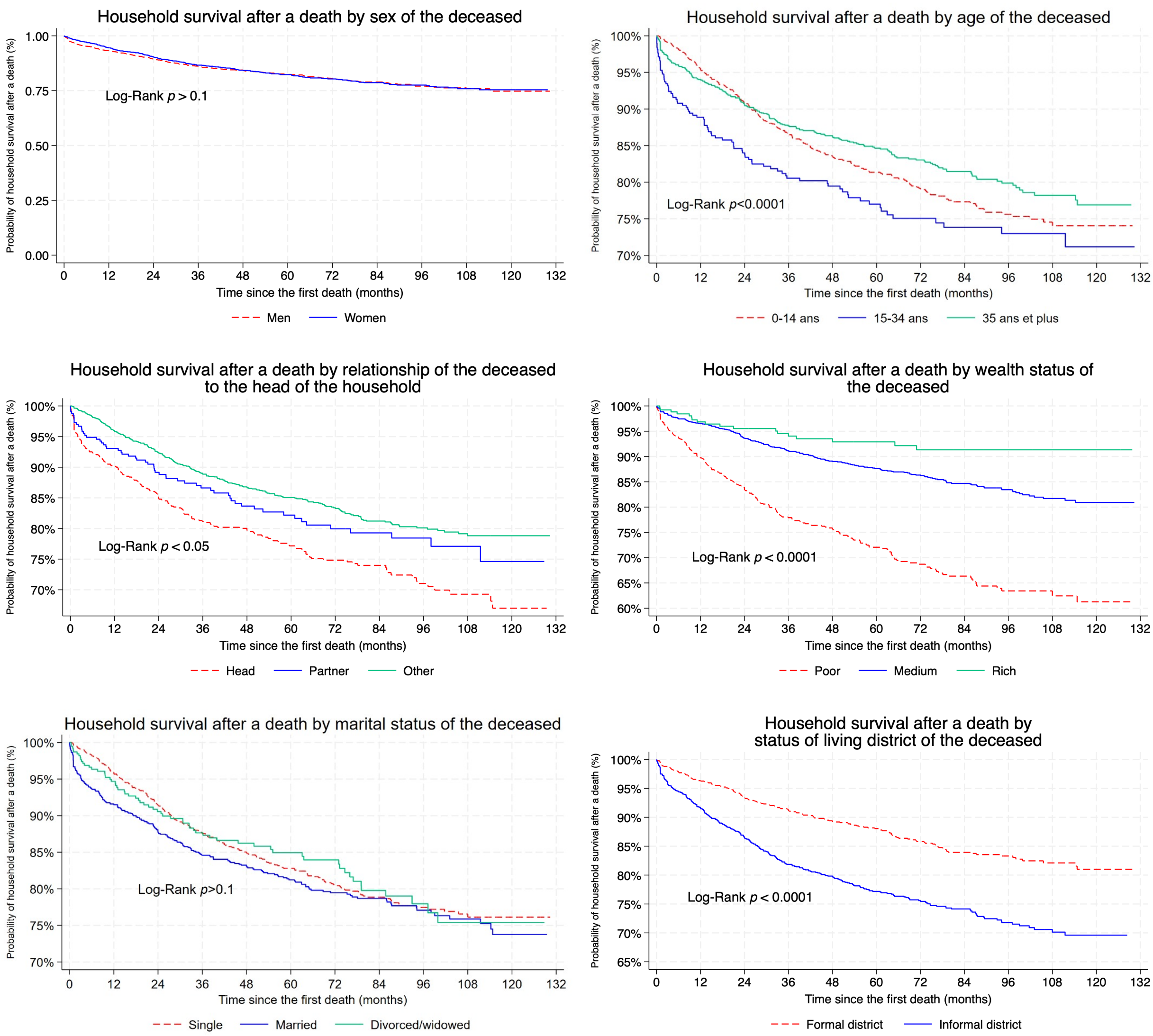

Figure 1: Household survival after a death by deceased characteristics

When the death involved the husband of the household head, there was no obvious difference. In all other cases, the IRD is reduced, notably by 67% when the deceased is a man who is not heading the household nor the partner of the household head. The IRD is reduced by 45% when the deceased is the spouse of the household head, and by 69% when the deceased is a woman who is not heading the household nor the partner of the household head. It also emerges that the marital status of the deceased is important in analysing the instantaneous risk of household dissolution. For divorced or widowed people, their death multiplies the IRD by 2.84 compared with that of married people. However, there is no obvious difference in the risk of dissolution with unmarried people in the event of death.Considering the wealth status, we observed that the IRD in case of death of a middle-class person did not statistically differ from that of a person considered to be rich. However, this risk is multiplied by 3.3 when this person is considered poor.

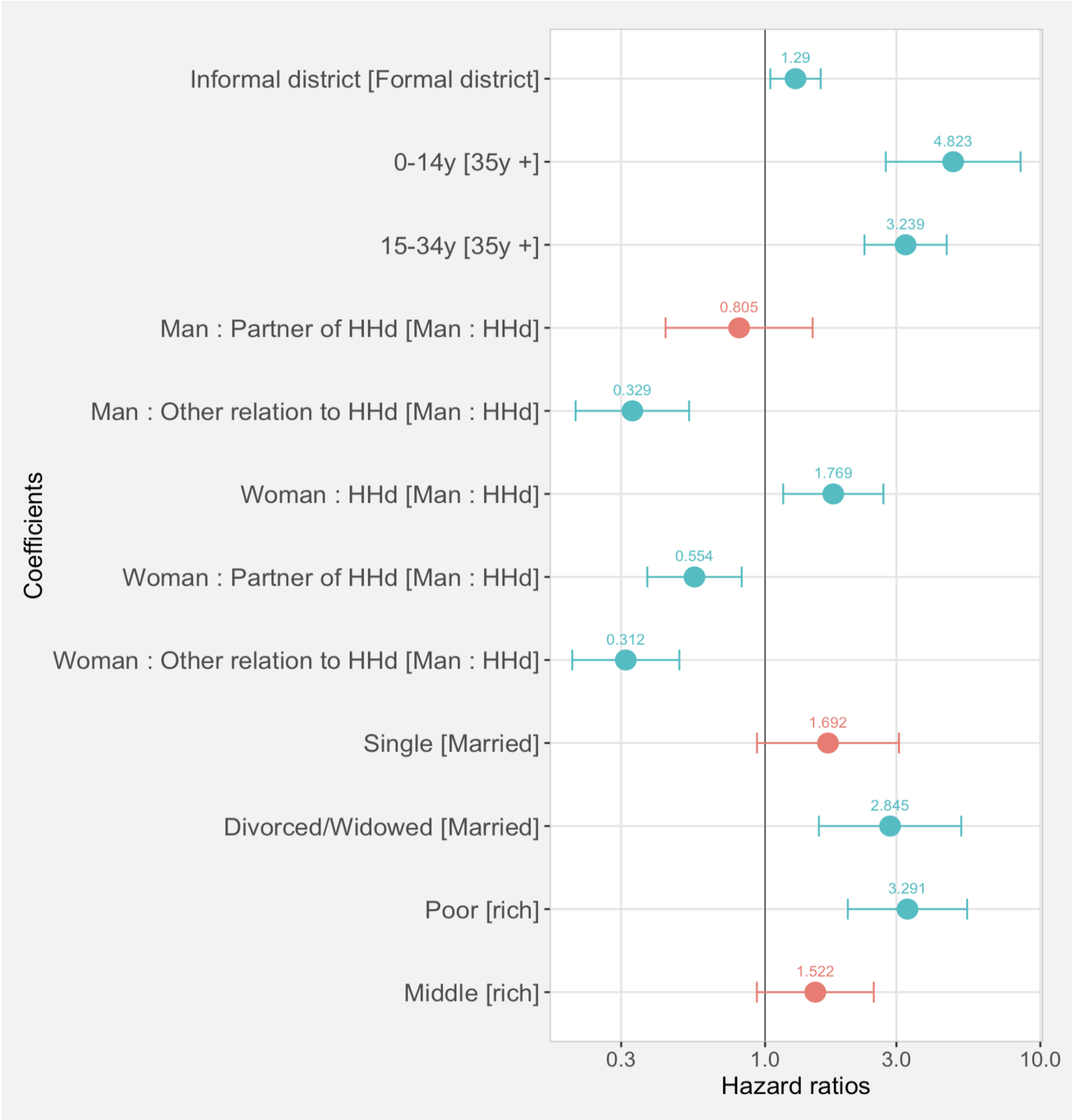

Figure 2: Crude death rates and Average life span gaps due to deaths from dissolved households Hazard

3.3 Impact of death from dissolved households

In terms of overall impact of omitted deaths from dissolved households showed in Figure 3, we estimated mortality indicators by accounting for deaths from all households, whether dissolved or surviving (CDR_{tot}). We also calculated this indicator for only surviving households (CDR_{srv}). The annual series of these indicators showed a tendency to underestimation when only surviving households were considered. However, it is generated from a small population, this trend was disrupted by erratic fluctuations and confidence intervals which suggest that the differences observed were not statistically significant. Rather, when we calculated these indicators for the entire 12 years of follow-up, the statistical evidence of the differences in mortality became apparent. As a result, we observe a CDR_{tot} (4.0 ‰) logically higher than the CDR_{srv} (3.5‰), a difference attributable to 598 deaths representing 14.4% of the total deaths recorded from 2009 to 2020 within the Ouagadougou HDSS. This is reflected in the average life span, which stands at 73.5 years if all household deaths ($e_{x_{tot}}$) were accounted for, instead of the 71.6 years that would have been obtained if only deaths in surviving households ($e_{x_{srv}}$) were considered.

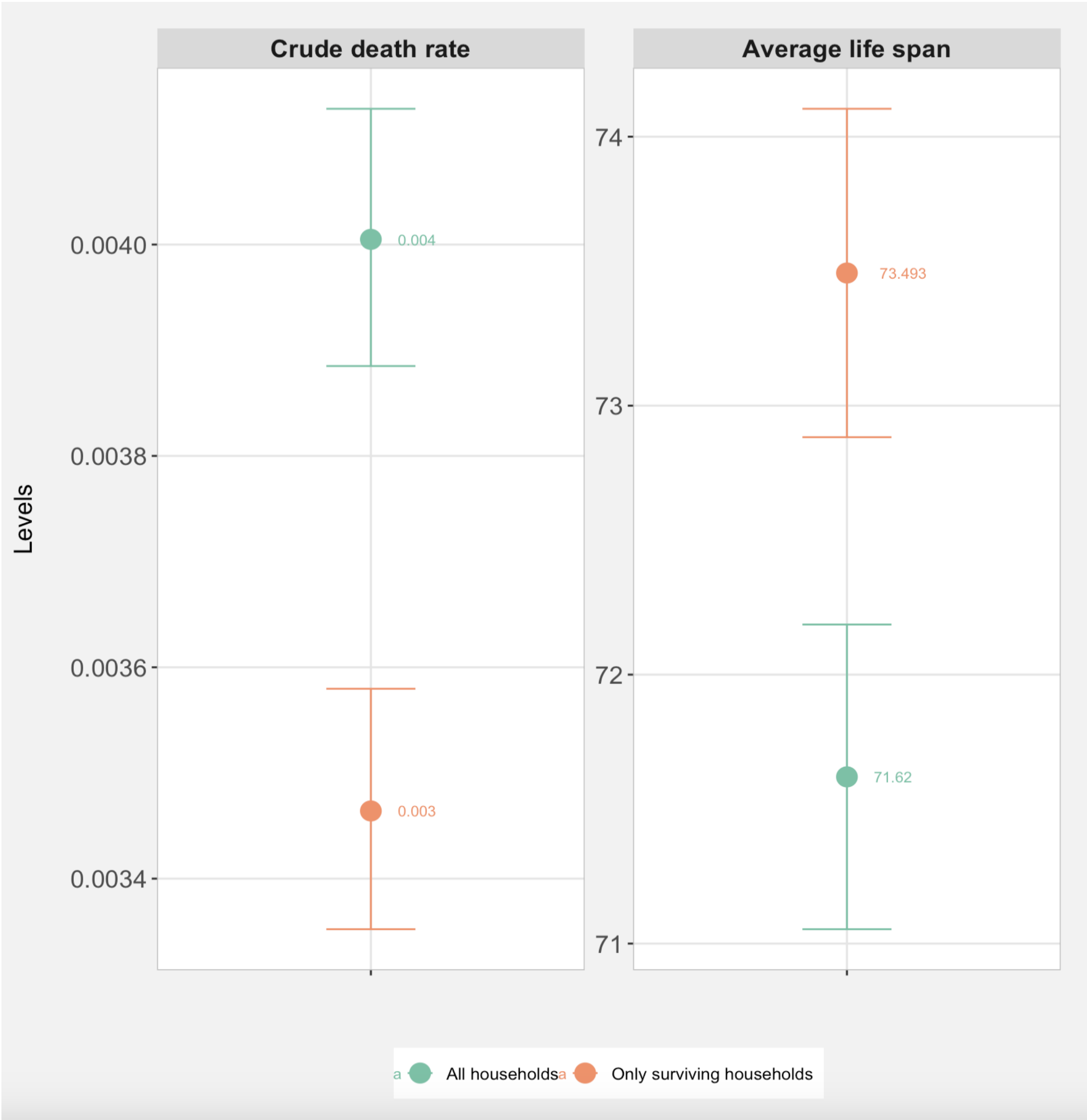

Figure 3: Crude death rates and Average life span gaps due to deaths from dissolved households Hazard

4 Discussion and Conclusion

This is an ongoing study which will require further refinement of the results. Rather than considering the impact of the first death as has been done, we intend to take into account the occurrence of multiple deaths in a time-varying approach for the Cox modeling. Furthermore, in line with the results of the Cox model, it would be interesting to analyse the impact of deaths from dissolved households by splitting the results by district (informal and formal) and by wealth status, in order to better identify the social groups most affected. These preliminary results have important implications, which we will discuss in detail once we have completed the additional analyses mentioned above. That said, the analysis of the KM survival curves combined with the results of the Cox regression of the ages of the deceased indicates that the ages most affected by the omission of deaths due to household dissolution are children and young adults. The contribution of the older age groups, however, is negligible. Moreover, applying this approach to other HDSS could help to highlight similarities and differences between contexts.

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