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*Research Article*

### **Trends in living arrangements and their impact on the mortality of older adults: Belgium 1991–2012**

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## Trends in living arrangements and their impact on the mortality of older adults: Belgium 1991–2012

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*This article is dedicated to our colleague and friend Luc Dal, who passed away 3 November 2019. For more than 25 years, Luc made a significant contribution to our research by managing crucial administrative and statistical databases pertaining to the demographic characteristics of the Belgian population over the last several decades.*

### Abstract

#### BACKGROUND

Previous studies have shown that the distribution of older people by living arrangement has changed and that old-age mortality differs by living arrangement. However, how these changes affect the total number of deaths has not been investigated.

#### OBJECTIVE

Our aim is to differentiate the effects on mortality of the change in the distribution of the population and the change in mortality rates associated with each type of living arrangement.

#### METHODS

Continuous observation of the population aged 60 and older for the period 1991–2012 in Belgium provides a unique opportunity to analyze changes in the population and in mortality by living arrangement. A simple decomposition method is used to examine to what extent these changes have influenced the total number of deaths.

#### RESULTS

The distribution of the population by living arrangement and the age-standardised mortality rates by living arrangement have changed remarkably. The overall effects of these changes on the total number of deaths offset each other, whereas the distribution of the number of deaths by living arrangement displays a large variation.

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## **CONCLUSION**

This paper shows important changes in the distribution of the population and in mortality rates by living arrangement but only limited change in the total number of deaths. An important change occurred in the distribution of the population by their last living arrangement before death.

## **CONTRIBUTION**

This paper highlights long-term trends in population and mortality rates by living arrangement in older age and also the distribution of the last living arrangement before death, which has important implications concerning care of the most elderly.

## **1. Introduction**

The aim of this study is to examine the effect of recent changes in the distribution of the older population by living arrangement (LA) on total mortality. Continuous improvement in the survival of the elderly has occurred in Western societies in recent decades (Rau et al. 2008). Concurrently, family patterns have been influenced by important changes in the framework of the Second Demographic Transition (SDT) (Fokkema and Liefbroer 2008; Lesthaeghe 2014). The decline in fertility and changes in family composition since the 1970s are the main factors underlying the increasing diversification of living arrangements that other researchers have found (Lesthaeghe 1983, 2014; Audenaert 2003). Trends confirm not only the spread of unconventional living arrangements, such as unmarried cohabitation, but also a tendency towards more individualistic choices, such as single parenthood, childlessness, and the dissolution of marriages – processes that involve younger and older people alike (De Jong Gierveld 2001, 2004; Gaymu et al. 2008; Lesthaeghe 2014; Wagner and Valdés Cifuentes 2014). The results of decisions made earlier in life are reflected in the LA composition of the older population. As a result of the decline in fertility and the emergence of more individualistic LAs, older people are less likely to live with a close family member or have children to rely on (McGarry and Schoeni 2000; Gaymu et al. 2008). This has resulted in a relatively large proportion of older people living alone or in collective households, as observed in other Western European countries (Reher and Requena 2018). At the same time, unmarried cohabitation has become increasingly common and could offset the effect of divorce or de facto separation with regard to LA, as many people are still living with their partners in old age (United Nations 2017). The first situation is linked to the increase in divorces and separations, which also affects the older population, and the second is related to improved longevity (Seltzer and Yahirun 2014). Other changes, such as cohorts with a higher proportion of married people

entering old age and a decreasing gender gap in life expectancy, have also resulted in an increasing proportion of older adults living with partners (Gaymu et al 2008; Martikainen et al. 2019; United Nations 2017).

The life expectancy of older people in Western societies has been continuously improving over the last several decades (Rau et al. 2008), but differences exist between population groups according to their vulnerability to mortality (Vaupel, Manton, and Stallard 1979; Caselli, Vallin, and Wunsch 2006). In addition to age and sex, several authors have investigated marital status as a factor in the variation in mortality risks (Martikainen et al. 2005; Murphy, Grundy, and Kalogirou 2007). Studies have also suggested that mortality risks in old age may be associated with the type of LA (Davis et al. 1992, 1997; Koskinen et al. 2007; Staehelin et al. 2012; Poulain and Herm 2015; Poulain, Dal, and Herm 2016). Therefore, the changes observed in the proportion of the older population by LA are driven not only by the different family and LA patterns of generations that have recently entered old age but also by different levels and the evolution of mortality risks by LA. Due to the increase in life expectancy and a decreasing gender gap in mortality, married people are living longer with their spouses before being separated by death, and they have lower risks of dying compared with their contemporaries (Staehelin et al. 2012; Poulain and Herm 2015; Martikainen et al. 2019, Franke and Kulu 2017). The mortality risk for men and women living with their spouses also tends to converge at the oldest ages, which results in relatively more people still living with their spouses in old age but also implies an increase in widows and widowers living alone at a very old age (Poulain, Dal, and Herm 2016; Martikainen et al. 2019). From a different viewpoint, nonmarital cohabitation is becoming a more frequent alternative to remarriage, even among older people; however, according to Drefahl (2010), it might not have the same positive effect that marriage has on survival. Studies have shown that in most Western countries, excess mortality among those who are single tends to increase compared with those who are married (Valkonen, Martikainen, and Blomgren 2004). Among other results, recent studies have shown remarkably higher mortality rates for older people living in institutions that provide care for the aged. This excess mortality has been increasing relative to other LAs in recent decades and could plausibly be explained by selectivity in nursing home entry (Grundy 2011; Herm, Poulain, and Anson 2014).

The mechanisms by which mortality risks are associated with LA in old age are still not well known, and the findings contain some contradictions. This is partly because it is difficult to identify causal links between LA and mortality risk, as LAs in old age are quite dynamic (Feng et al. 2017). For example, the presence of the spouse or partner, who is the closest and most available caregiver, supports survival and reduces the need for formal care, such as entry into a nursing home (Chappell 1991; Antonucci and Ajrouch 2007; Freedman, Cornman, and Carr 2014). Accordingly, the increase in

persons living with a spouse or partner is associated with a decrease in total mortality. However, all marriages and partnerships end with the death of a spouse or partner, or divorce, which inevitably changes the LA of the survivor, and most LAs after bereavement or divorce are associated with a higher mortality risk (Herm, Anson, and Poulain 2016). A crucial question concerns the distribution of the last LA before death among those who no longer have a spouse or partner.

The prevalence of co-residence with a potential caregiver indicates the type of care that might be needed for older adults. Accordingly, the final LA is the most relevant to policy development, as the last years before death are associated with the highest need for care (Gaymu et al. 2008). This is one reason underlying the keen interest in investigating the LAs of older people (Grundy 2008). Several researchers have studied the place of death in old age (e.g., Houttekier et al. 2011); however, this information does not enable a reliable assessment of the care needs of the elderly because the place of death does not necessarily indicate the type of care needed during the period preceding death.

In summary, multiple factors have contributed to the change in the composition of the population of older people by LA. Some of these changes are the consequences of life events that occur at older ages, while others are driven by those that take place earlier in life. Simultaneous shifts have occurred in LAs and mortality improvement. Obviously, the net effect is a blend of changes in behaviour, choice (possibly involuntary) of LA, and developments in mortality. Examining the net effect of changes in mortality related to LA in light of changes in the distribution of population by LA and changes in mortality risk for each type of LA is therefore both pertinent and timely. In this context, the question arises as to whether and how much changes in the distribution of the population by LA and changes in LA-specific mortality risks are reflected in the number of deaths in each LA in old age and, more globally, in the evolution of the total number of deaths. Therefore, we distinguish the net impact of the change in the size of the population by LA from the LA-specific mortality risk. We may assume that a sizable reduction in mortality risk for most LAs might be outweighed by a substantial increase of the population in LAs in which the mortality risk is relatively higher. Accordingly, it might be that a possible increase in the total number of deaths may be at least partly attributed to an increase of the population in LAs that are less favourable or even detrimental to survival.

This study identifies how and to what extent the improvement in LA-specific mortality, combined with the dynamics of LA composition at older ages, is linked to changes in total mortality of older adults. So this study makes an innovative contribution to the existing literature on the association between living arrangements and mortality. Moreover, the results of this study have important policy implications, as

trends in LA shed light on the dynamics of the availability of informal care and help assess the evolution of needs for care in old age.

## **2. Data, methods, and typology of living arrangements**

Belgian data from the continuous population register are used to assess the impact of LA trends on the total number of deaths and its distribution by last LA. The same data have been used in previous studies of the association between LA and mortality of the older Belgian population (Herm, Poulain, and Anson 2014; Herm, Anson, and Poulain 2016; Poulain and Herm 2015; Poulain, Dal, and Herm 2016). These data enable the LAs of individuals aged 60 years and older to be tracked on a yearly basis from 1991 through 2012. Examining a period of more than 20 years allows the emergence of new types of LAs among older adults to be discerned, as well as changes in the age composition of the population by LA. Simultaneously, it makes it possible to determine the effect of these changes on the total mortality outcome in old age.

The administrative population register captures the changes in LA of each individual as well as the date of death. It is therefore possible to identify the final LA, where the need for care is highest (Gaymu et al. 2008). Based on these data, changes in the distribution of the population by LA as of the first of January of each year and annual age-specific LA mortality rates are computed and analysed. The exhaustive administrative database includes all individuals aged 60 years and older, which prevents problems related to sampling, non-response, or missing data.

The target population is comprised of 2.06 million people aged 60 years and over on 1 January 1991 and an additional 2.48 million people who reached the age of 60 during that period. During the observation period, 1.97 million deaths were registered, and 2.57 million people aged 60 years and over were still alive on 31 December 2012. For the sake of simplicity, we exclude a small number of international migrants, both emigrants and immigrants, who constitutes no more than 1.6% of the population. Those who did not die during the year are considered to be alive in the country on 31 December, as the limited number of people who emigrated abroad are excluded from the analysis.

The LA typology used in this analysis considers the type of household, relationship with the reference person, and marital status. The following groups of LAs are distinguished:

1. Individuals living with others in a private household
  - a. Individuals living with a spouse
  - b. Unmarried individuals cohabiting with a partner
  - c. Individuals living with someone who is neither a spouse or a partner
2. Individuals living alone
3. Individuals living in a collective household (mainly care homes for the elderly)

We further distinguish individuals living alone or in a collective household by marital status: never married, divorced or married but living separately, widowed. Individuals living with a spouse or partner may also have others living in the household. The choice of typology is dictated by the potential support that might be expected from a spouse or a cohabiting partner.

LA-specific mortality rates are calculated by dividing the number of deaths occurring in any given year by each year of age, according to sex and the individual's LA on 1 January of each year. A mobile average of three years is used to avoid a possible bias from one specific year. Furthermore, we decompose into four components the change in the total number of deaths from the beginning of the period (mobile average 1991–1993) to the end (mobile average 2010–2012). The formulas used for this decomposition are presented in Annex 1. The first two components show the effect of the change in the mortality rates and in the number of the total population (all LAs included) – A and B, respectively. The latter two components reveal the impact of the change in relative mortality in a given LA and in relative share of the LA among the total population – C and D, respectively. Strictly speaking, the latter two components can be viewed as independent of the overall changes in the number and the (age-specific) mortality rates of the total population. Therefore, they are indicative of the “pure” effect of the changes on the total number of deaths in relation to each LA.

### **3. Results**

#### **3.1 Change in the total number of deaths among the older population**

A comparison of the average number of deaths for 1991–1993 with the average for 2010–2012 shows that the total number of deaths among those aged 60 years and over slightly increased in Belgium over the two-decade period of observation (2.6% for men, from 42,606 to 43,691, and 4.8% for women, from 46,449 to 48,670; Table 2). If only the size of the cohorts had increased and the mortality rates observed in 1991–1993 had remained the same, the increase in the total number of deaths would be significant (48.2% for men and 34.8% for women). During that period a sizable reduction in



mortality occurred among the whole older-age population, which could be responsible for the decrease in the total number of deaths (45.6% for men and 30.0% for women if the size of the population is kept constant, as in the average for 1991–1993). These two counterbalancing trends resulted in a slight increase in the total number of deaths towards the end of the observation period, as shown above.

### **3.2 Changes in the living arrangements of the older population**

The number of men aged 60 years and older increased by one-third from 1991–1993 to 2010–2012, and the number of women increased by one-fifth (Table 1). Older people living with a partner, married or unmarried, became more numerous. Among those living alone or in collective LAs, a notable increase occurred in the number who were divorced or separated, as well as the number of widows and widowers in collective LAs. The relative increase in the number of divorced and separated individuals was the most substantial – almost threefold for both men and women living alone or in collective LAs. However, the trend was not even across all LAs. Fewer men and women were living with someone other than a partner at the close of the observation period. The number of widowed women living alone remains stable, whereas the number of never-married women living alone or in collective LAs decreases. The decrease among those living alone was rather small, but the number of never-married women living in collective LAs had decreased by one-third by the end of the observation period. In light of the decreasing trend in the number of never-married women living alone or in collective LAs, it is interesting to note that the number of never-married men in both LAs increased somewhat during the observation period.

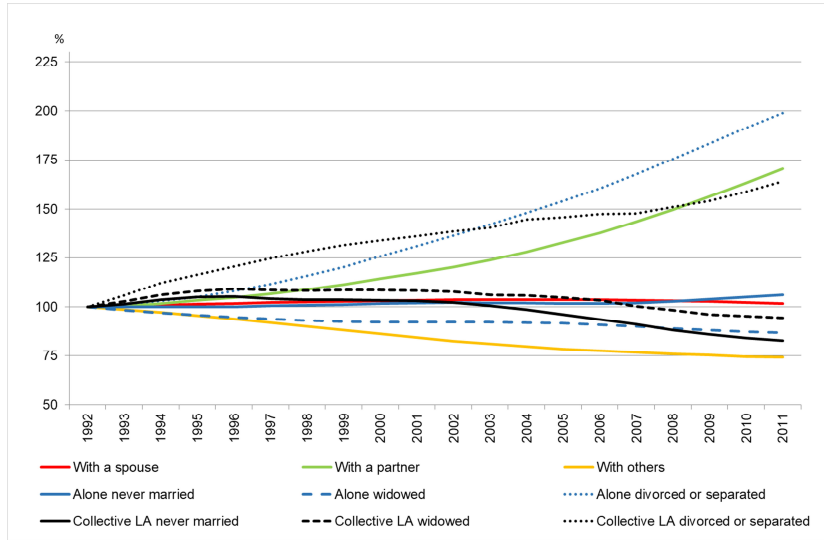
**Table 1: Belgian population aged 60+ by living arrangements and gender, 1991–1993 and 2010–2012**

SSS	Number		Percentage			
	Men		Men		Women	
	1991–1993	2010–2012	1991–1993	2010–2012	1991–1993	2010–2012
Living arrangements						
With spouse	520,768	676,241	59.6	60.6	37.5	42.6
With partner	21,884	47,601	2.5	4.3	1.8	2.8
With others	177,208	167,658	20.3	15.0	21.0	15.3
Alone never married	29,744	40,351	3.4	3.6	3.3	2.7
Alone widowed	75,150	83,219	8.6	7.5	27.8	23.9
Alone divorced or separated	29,362	74,542	3.4	6.7	3.1	7.0
Collective LA never married	7,670	8,104	0.9	0.7	1.8	1.1
Collective LA widowed	7,506	9,058	0.9	0.8	3.4	3.9
Collective LA divorced or separated	4,119	8,626	0.5	0.8	0.4	0.7
<b>All living arrangements</b>	<b>873,410</b>	<b>1,115,400</b>	<b>100</b>	<b>100</b>	<b>100</b>	<b>100</b>
				<b>1,414,419</b>		

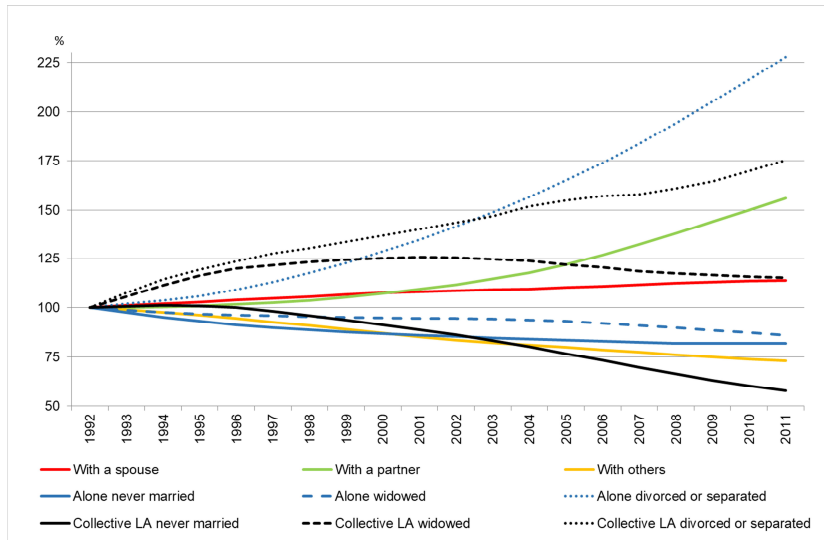
The changes in the proportion of individuals in each LA were uneven over the period 1991–2012, as detailed in Figure 1. The increase in the percentage of men living with a spouse was minimal, while the percentage of women in this LA increased significantly. The proportion of men and women cohabiting with a partner increased exponentially – by 70% for men and 60% for women in 2010–2012 compared with the early 1990s. On the contrary, a decrease was observed in the proportion of the population living with others, which indicates that these LAs became less prevalent among both men and women. Whereas the proportion of women living alone remained unchanged for the total population, a redistribution within this LA resulted in a smaller percentage of those who were widowed or never married and an increase in divorced or separated individuals. The percentage of men living alone who had never been married also increased. Nevertheless, only the proportion of divorced or separated increased significantly among the latter group. In fact, the percentage of men and women who were divorced or separated and living alone exhibited the strongest increase relative to all other LAs, while the percentage of both sexes who were widowed and living alone decreased. During the observation period, a dual trend appeared among those living in collective LAs. On the one hand, the percentage of people in collective LAs increased sharply during the first years of the 1990s, but the absolute numbers stabilised at the beginning of the 21<sup>st</sup> century and subsequently decreased towards the end of the observation period.

**Figure 1: Change in the distribution of the population aged 60+ by living arrangements, 1992–2011 (three-year mobile average, 1991–1993 = 100)**

Men



Women



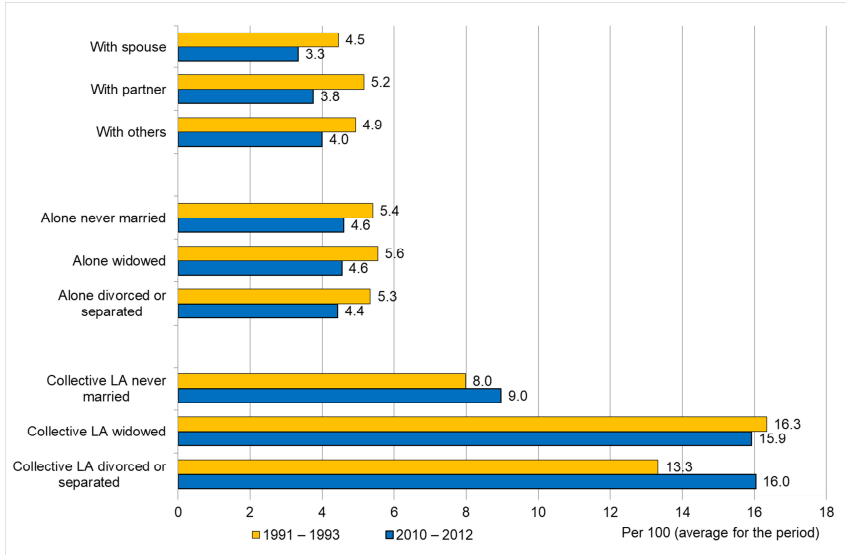
### **3.3 The association between living arrangements and mortality rates**

The LA-specific mortality rates for the population aged 60 years and older standardised on the age structure of the total population are displayed in Figure 2. Women exhibited lower mortality in all LAs, and the lowest mortality was observed among both men and women living with a spouse. The mortality risk for women living alone, regardless of marital status, was only slightly higher. For men, living with a spouse, partner, or others is clearly more conducive to survival than living alone. For both sexes, cohabiting with a nonmarried partner is associated with a 10% higher mortality risk than living with a spouse. For women, living with others who are not spouses or partners is associated with a mortality risk more than 25% higher relative to living with a spouse, but that risk is 20% higher for men. The gender gap is narrowest among those living with a spouse or living with others who are not spouses or partners. The mortality rates among those living in collective LAs are more than three times higher, with the exception of the never-married, especially women, for whom the mortality risk is lowest among those in this type of LA.

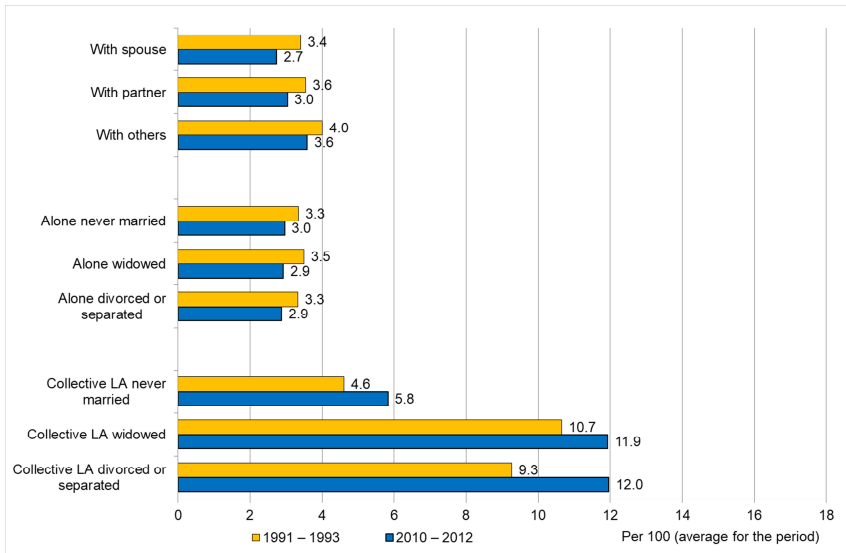
Figure 3 displays the trends in LA-specific mortality rates for men and women; the change in the three-year mobile-average age-standardised mortality rates is shown for each LA over the observation period relative to 1991–1993. The relative mortality rates decreased linearly for both men and women living in private households. The maximal reduction was found for women living with a spouse and for men living with a partner or spouse. The reduction was somewhat smaller among those living alone or living with others who were not spouses or partners. In contrast, the mortality rates among those in collective LAs showed an increase.

**Figure 2: Age-standardised mortality rates for the population aged 60+ by sex and living arrangements, average for 1991–1993 and 2010–2012**

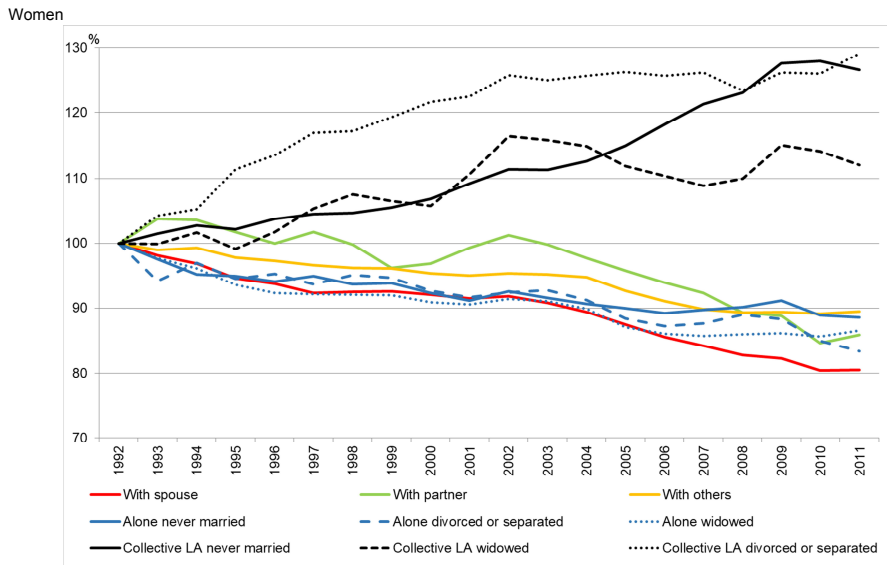
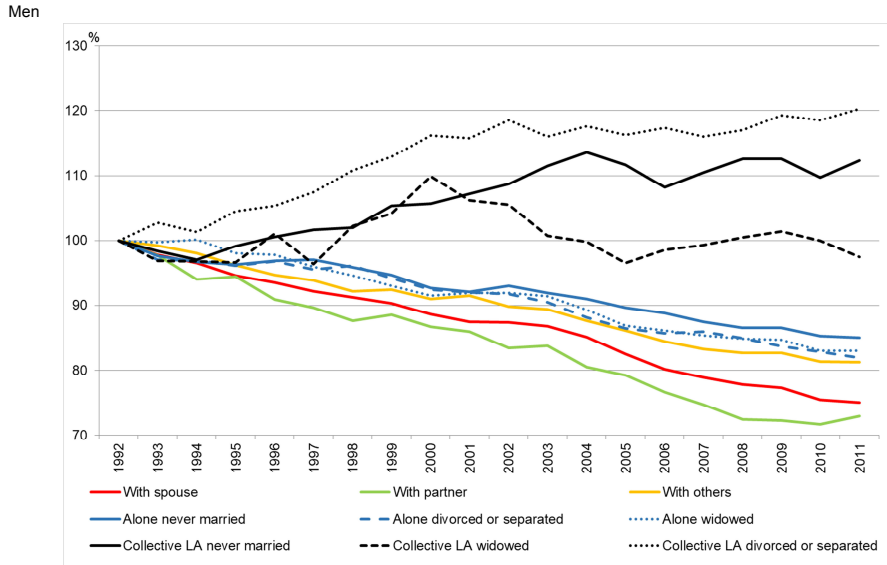
Men



Women



**Figure 3: Change of age-standardised mortality rates of the population aged 60+ by living arrangements, 1992–2011 (three-year mobile average; 1991–1993 = 100)**



### **3.4 Decomposition of the change in the number of deaths into four components**

Four components are distinguished in order to assess the impact of the changes occurring in the total population and those specifically related to each LA (Table 2) separately. The first two components measure the impact of the change in age-specific mortality rates and the size of the total population (columns A and B, respectively), whereas the latter two components show the effect of the change in the relative mortality rates and in the share of the population for each LA (columns C and D, respectively). The calculations were performed for each year of age, sex, and LA according to the formulas presented in Annex 1. The results were tallied separately for men and women for all ages 60 and above. By juxtaposing these numbers, the total impact of each component on the number of deaths by LA may be compared.

As expected, the change in the size of the total population (column B) led to an increase in the number of deaths in all LAs. However, the improvement in mortality contributed to a decrease in the number of deaths in all LAs, except for those divorced or separated living in collective LAs (column A). For the total population, the impacts of decreasing mortality rates and larger cohort sizes partially counterbalance each other. On the contrary, the total impact of the changes relative to LA is rather limited compared with the first components. Nevertheless, the reduced impact is the sum of larger influences specific to each LA, a finding that might have greater implications in terms of care needs of the elderly. The changes in relative mortality rates by LA (column C) contribute to a remarkable decrease in the total number of deaths among men and women living with their spouses and among widowed women living alone. On the contrary, the relative deterioration of the mortality risk among all three marital status groups in collective LAs contributed to the increase of deaths for both men and women. Differently, the change in the proportion of the population in some LAs is associated with a higher number of deaths, mainly among those living with spouses, and also among those divorced and living alone or in collective LAs. On the contrary, due to the smaller proportion of the population living with others, never married or widowed in collective LAs, and widowed living alone, the number of deaths in these LAs decreased.

Figure 4 compares the contribution of the changes related to LAs with the total number of deaths, including the impact of the usual changes in mortality rates and the size of the total population. The vertical axis (C + D) displays the impact of the changes attributed to each LA, and the horizontal axis (A + B) shows the joint effect of the changes in mortality rates and the size of the total population. Marks above the horizontal axis indicate that the relative changes in the proportion of the population and mortality rates by LA contributed to the increase in the total number of deaths, whereas for those located to the right of the vertical axis, the increase is related to changes in mortality rates and the size of the total population.



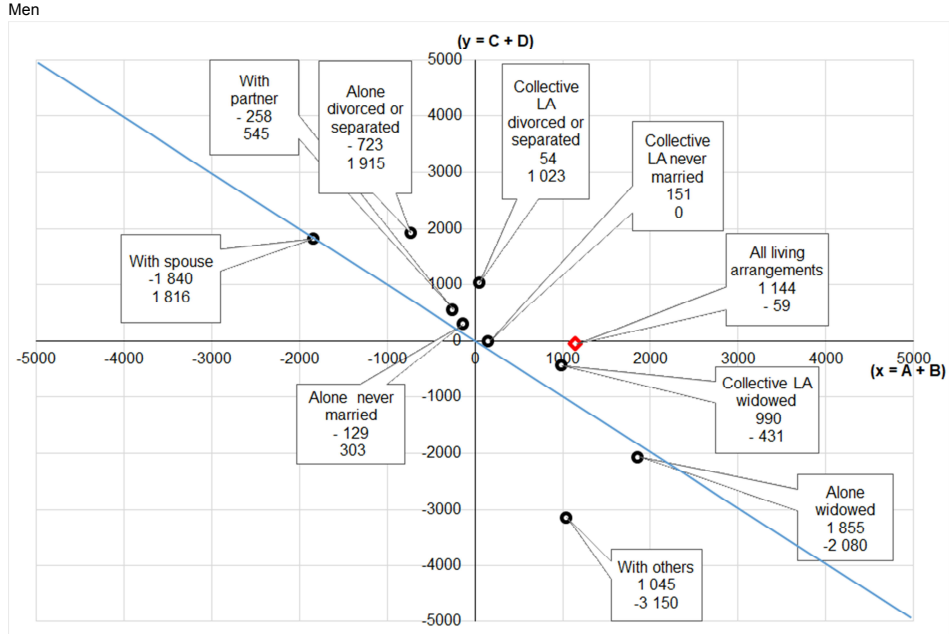
**Table 2: Decomposition of the difference between numbers of deaths by sex and living arrangements among the population aged 60+, 1991–1993 and 2010–2012**

Living arrangements	Observed number of deaths				Change in the number of deaths due to			
	Average for 1991–1993	Average for 2010–2012	Change in number of deaths	Changes in the total mortality rate (all LA)	Changes in the number of total population	Changes in the relative mortality rate by LA	Changes in relative share of population by LA	
Men	d1	d2	d2-d1	A	B	C	D	
With spouse	21,180	21,155	-25	-11,003	9,163	-1,576	3,392	
With partner	1,123	1,410	287	-760	502	-139	684	
With others	7,553	5,448	-2,105	-2,463	3,508	22	-3,172	
Alone never married	1,486	1,660	174	-722	593	182	121	
Alone widowed	6,335	6,110	-225	-2,219	4,074	91	-2,171	
Alone divorced or separated	1,371	2,562	1,191	-1,188	465	234	1,681	
Collective LA never married	771	922	151	-269	420	256	-256	
Collective LA widowed	1,962	2,522	560	-523	1,513	514	-945	
Collective LA divorced or separated	825	1,902	1,077	-486	540	61	411	
<b>All living arrangements</b>	<b>42,606</b>	<b>43,691</b>	<b>1,085</b>	<b>-19,633</b>	<b>20,777</b>	<b>196</b>	<b>-255</b>	

**Table 2: (Continued)**

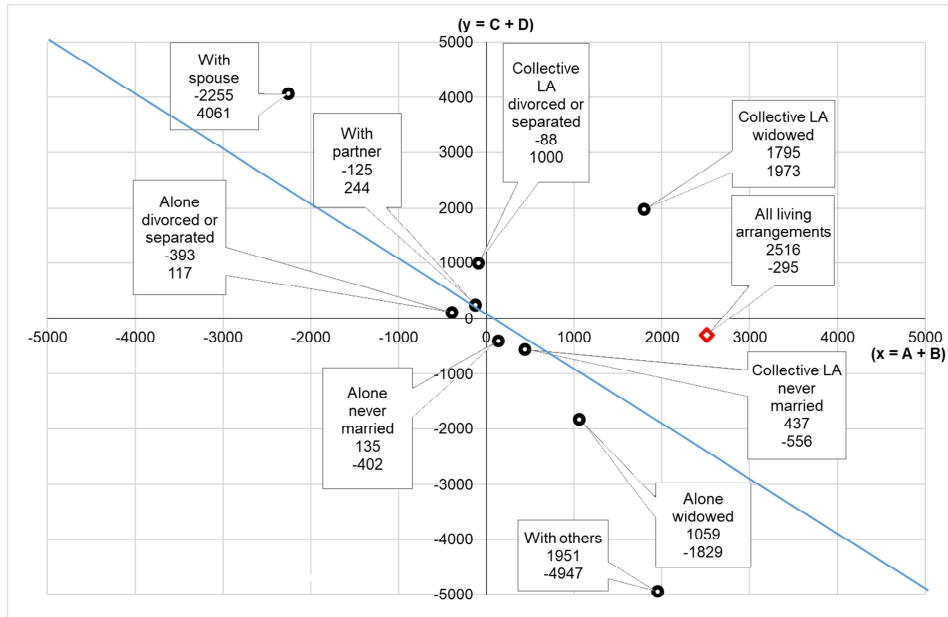
Living arrangements	Observed number of deaths					Change in the number of deaths due to				
	Average for 1991–1993	Average for 2010–2012	Change in number of deaths	Changes in the total mortality rate (all LA)	Changes in the number of total population	Changes in the relative mortality rate by LA	Changes in the relative mortality rate by LA	Changes in the relative share of population by LA		
Women	d1	d2	d2–d1	A	B	C	D			
With spouse	8,219	8,972	753	-3,881	1,626	-1,170	4,178			
With partner	579	697	118	-260	135	-44	288			
With others	10,799	7,803	-2,996	-2,338	4,289	-34	-4,913			
Alone never married	1,401	1,134	-267	-354	489	8	-410			
Alone widowed	14,603	13,833	-770	-4,456	5,515	-842	-987			
Alone divorced or separated	976	1,797	821	-621	228	-5	1,220			
Collective LA never married	1,605	1,486	-119	-294	731	229	-785			
Collective LA widowed	7,593	11,362	3,769	-2,036	3,831	2,026	-53			
Collective LA divorced or separated	674	1,586	912	-347	259	461	539			
<b>All living arrangements</b>	<b>46,449</b>	<b>48,670</b>	<b>2,221</b>	<b>-14,567</b>	<b>17,103</b>	<b>629</b>	<b>-924</b>			

**Figure 4: Changes in the number of deaths due to components C + D related to living arrangements compared with changes occurring in the total population (A + B)**



**Figure 4: (Continued)**

Women



The diagonal line in Figure 4 reveals how each LA contributed to the change in the number of deaths. LAs located to the right of that line contributed to the increase in the number of deaths, and the distance from the line shows the importance of the contribution; the maximum value is attributed to widows living in collective households. On the contrary, LAs situated below the diagonal line contributed to a reduction in the total number of deaths, with the maximum distance apparent for both men and women living with others. The changes in the total number of deaths that are directly attributable to changes affecting LAs concern their relative proportion of the total population or their relative mortality rate. For men, the main contributors to the increase in deaths are those divorced or separated and living alone or in a collective household. The LAs associated with a decrease are living with others and, in the case of widowers, living alone. For women, the situation is quite different. A large contribution comes from those living with a spouse, widows, and divorced or separated women in collective LAs. The listing of the various LAs in Figure 4 is meant to promote a better understanding of the changes occurring in the population relative to end-of-life LAs in old age and the policy implications with regard to the care needs of the elderly.

## **4. Discussion**

In the context of population aging, the older Belgian population has grown remarkably since 1991, and further growth is projected (Van den Bosch et al. 2011). Our study showed, as expected, that the number of older people increased in most LAs, but differences were observed between LAs in both absolute and relative terms. The more sizable absolute increase applied to both men and women living with their spouses but was relatively larger for men. The second group ranked in terms of absolute growth included divorced or separated individuals living alone. The number of people living with their partners also increased in absolute numbers, and the relative increase was among the highest in private households, after those who were divorced or separated and living alone. The number of people living with their spouses increased mainly due to improved survival of both men and women, and also due to the reduced gender gap in mortality, as found by Keilman and Christiansen (2010). The relatively rapid increase in the proportion of the population that was divorced or separated and living alone, or living only with a partner, indicates a tendency towards the emergence of more independent and “modern” LAs at older as well as younger ages, which can be viewed as a consequence of the SDT (Lesthaeghe 2014). Never-married women became less numerous among those living alone but also in collective LAs; no significant change was observed for never-married men. The decrease among never-married women is due to the fact that female cohorts arriving at older age had a higher proportion of members who were married. The only LA that experienced a decrease, both in absolute numbers and in proportions, was living with others who are not spouses or partners. This also reflects a change in family patterns and the emergence of more individualistic LAs, whereby older people are less likely to live with a close family member (McGarry and Schoeni 2000; Gaymu et al. 2008). A remarkable relative increase was observed among people living in collective LAs, which confirms that most people who reach a very high age spend their last years in a nursing or residential care home (Evans et al. 2014; Poulain and Herm 2015). The composition of older people in collective living arrangements changed in terms of marital status, reflecting developments among the general population in line with the SDT (Lesthaeghe 2014). Nevertheless, recent trends point to a stagnation in the number of persons in collective LAs. Contributing factors are that people are living longer together as couples, that they prefer to stay in their own homes, and that there are limited spaces in nursing homes (Van den Bosch et al. 2011).

Mortality risks varied between LAs, with the lowest mortality observed among older people living with their spouses; this group also had the smallest gender gap, which agrees with the findings of other researchers (Staehelin et al. 2012; Martikainen et al. 2019; Franke and Kulu 2017). On the contrary, individuals in collective LAs experienced higher mortality than those in private LAs, as also found by Grundy

(2011). Our findings reveal that women living alone and in collective LAs survived substantially longer than men in the same types of LAs. The direct comparison of private and collective LAs by marital status provides new insight into the analysis of mortality by LA. Trends observed over more than two decades are also informative, revealing an increasing divergence in mortality between private and collective LAs. Other research to date has not made use of a unique database to examine these trends comparatively. Those living with their spouses or partners show the most significant improvement in mortality, with a substantial gender difference: the narrowing gap in mortality between these LAs is more evident among men than women. This trend merits deeper investigation within the framework of the SDT and in line with the study by Drefahl (2012), which suggests that living with one's partner might not have the same positive effect that marriage has on survival. With regard to those in collective LAs, especially nursing homes, increasingly higher mortality could be associated with more advanced age and poorer health status at the time of entry.

The trend in the total number of deaths among the older Belgian population showed a slight increase during the two decades of the study. As everywhere in Western societies, the size of the older cohorts of the Belgian population increased, whereas the mortality risks at older ages decreased. These two changes offset each other and resulted in only a limited increase in the number of deaths. However, they affected each LA differently. In light of Pezzin, Pollac, and Schone's (2013) statement that "changing marital patterns and increased complexity in family life have adverse effects on late-life health outcomes," we were expecting to find an increase in the total number of deaths due to the change in the distribution of the population by LA. On the contrary, we found that the total number of deaths among older people was relatively stable. Nevertheless, considerable changes occurred in the number of deaths by final LA. This finding reinforces the importance of LA-related changes on mortality and their plausible implications. The question remained as to which of these two factors – trends in the proportion of the population by LA or changes in the relative mortality rate by LA – had the larger impact on the number of deaths in old age for each LA. The results presented in this study exhibit large differences between LAs. The number of deaths was stable among men living with their spouses but increased among women because the increase due to the growth of the population at risk surpassed the decrease resulting from the reduction in the mortality risk. The number of deaths dropped significantly among both men and women living with someone other than a spouse or partner. On the contrary, the number of deaths increased among those divorced or separated and living alone or in a collective household. Our results accord with previous findings from most Western countries that mortality among those who are single tends to increase in comparison with those who are married (Valkonen, Martikainen, and Blomgren 2004). The main driver of the increase in the number of deaths in collective

LAs is the increase in the associated mortality risk. However, the increase in deaths among those divorced or separated and living in a collective household may be largely attributed to the increase in the population at risk, as it is also among those divorced or separated and living alone. We identified a growing trend for those who died in nursing homes or at home while living alone. These findings are in line with those of Houttekier et al. (2011) who considered the place of death and found that the number of deaths in hospitals decreased. However, these results are difficult to compare, as the place of death is not necessarily the last LA. A positive impact was conclusively observed in the increase of the proportion of those living with a spouse or partner – the most favourable LA for survival – but this effect was diminished by the large increase in the number of divorced or separated individuals living alone or in collective LAs, among whom the relative mortality risk increased. However, even if these two factors largely offset each other, they affected the distribution of the final LA, which is highly relevant to the development of policies regarding the care of older people.

In addition to the novelty of the results described above, the strength of this investigation is also related to the use of a unique and detailed administrative database that enables population records to be linked with death records and allows the identification of final LA. Some limitations associated with the accuracy of the data do exist, especially with regard to delayed registration of place of residence when such residence is expected to be temporary. This primarily concerns those living in nursing homes but also to some extent those living with partners (Lodewijckx and Deboosere 2011). Therefore, the number of people living in these LAs may be underestimated. The fact that the final LA was recorded on 1 January and not on the date of death might also introduce a limited bias: mortality in collective LAs might be underestimated, as those entering nursing homes shortly before death are counted as living in their previous private arrangements, as registered on 1 January. Nevertheless, neither bias should affect our conclusion that an increasing number of persons are in collective LAs and have a relatively higher mortality risk.

Many studies have confirmed that living with one's spouse is beneficial; however, recent research on marriage and health has shown that its protective effect may be weakening due to the deinstitutionalisation of marriage (Tumin 2018). Such alterations in social norms and attitudes might also affect other LAs. Therefore, further study of trends in LAs and their association with mortality among older people would be useful. These changes could have implications for social welfare, as legal systems might not recognise new types of LAs early enough to ensure adequate support for vulnerable people (Sánchez Gassen and Perelli-Harris 2015). The use of sociocultural information, including education, former occupation, and perception of health status, might provide additional insights into this investigation, as would qualitative surveys describing the care needs and potential caregivers in various types of LAs. Those who are never-

married, whether living alone or in collective LAs, would also be an interesting topic of research, as this category includes people with different social backgrounds and preferences, who are completely reliant on formal care when they become dependent.

Discernible trends in the population and mortality of older people associated with LAs over the more than two decades analysed in this study shed light on the major challenges that policy-makers face in terms of creating the conditions for respectable aging and death. The outcome of this study highlights the need for policies that support older people living as long as possible in their homes and that adopt a gender-specific perspective, since older men and women differ with regard to their last LAs. Whereas older people living in private LAs are more numerous, the type of care they require is not the same as that provided in nursing homes. One's care needs are mainly derived from one's health status, but they also depend on the type of LA and on whether or not there is a potential caregiver in the household. Although there is a growing tendency for older people to live with a spouse or partner, who is the customary caregiver (Gaymu et al. 2008), spouses and partners also age and may not be able to cope with the care requirements (Freedman, Cornman, and Carr 2014). Therefore, informal caregivers, particularly older individuals who care for another older person at home, need effective support, which is the most pressing policy challenge in the near future. People living alone in their homes typically require ad hoc formal care during the last years of life, particularly when support from children is irregular or missing. For example, studies have shown that divorced or separated parents, particularly fathers, are less likely than those who are widowed to receive care from their children (Kalmijn and Saraceno 2008). For the same reason, informal care may not be available for those who live with a partner. Deeper investigation is needed with regard to the latter LA, as it is not yet clear whether living with a partner is equivalent to living with a spouse (Drefahl 2010). The larger number of deaths occurring in collective LAs reflects the aging of the population and epidemiological changes (Kalseth and Theisen 2017) and shows that the need for formal care increases significantly towards the end of life. The demand for nursing homes for those at higher ages and in poorer health is escalating, with the results that death is occurring sooner after entry and turnover in the nursing home population is more rapid. Nursing homes are becoming the main locus of end-of-life care, and it is foreseen that most people will die in that type of LA (Houttekier et al. 2011). Therefore, providing sufficient skilled medical resources in nursing homes to meet the end-of-life care preferences and needs of patients, as well as ensuring efficient support to older adults living at home, is essential. In summary, the results of this study call for improvements in both formal and informal care, which is in line with a previous analysis of LAs in older age (Audenaert 2003).



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## Annex: Decomposition method

Age-specific mortality rates are calculated for the total population and for each LA by dividing the number of deaths ( $d$ ) occurring in a given year ( $t$ ) at each year of age ( $x$ ) and for each sex ( $s$ ) by the size of the population of each age and sex on 1 January of that year:

$$m(x, t, s) = \frac{d(x, t, s)}{p(x, t, s)}$$

In the formulas below,  $M$  signifies the mortality rate of the total population and  $m$  the mortality rate for each LA;  $P$  indicates the total size of the population and  $p$  the population in each LA.

A simple method of decomposition is applied; using a three-year mobile average prevents the results from being biased due to random extremes in one year. The difference between the average number of deaths 1991–1993 ( $d1$ ) and 2010–2012 ( $d2$ ) is calculated for each year of age ( $x$ ), sex ( $s$ ), and LA as follows:

$$\begin{aligned} d2 - d1 &= p2m2 - p1m1 \\ &= p2m2 + p2m1 - p1m1 - p2m1 \\ &= p2(m2 - m1) + m1(p2 - p1) \end{aligned}$$

where

$$\begin{aligned} p2(m2 - m1) &= p2 \left( m2 - m1 \left( \frac{M2}{M1} \right) + m1 \left( \frac{M2}{M1} \right) - m1 \right) \\ &= p2 \left( m2 - m1 \left( \frac{M2}{M1} \right) \right) + p2 \left( m1 \left( \frac{M2}{M1} \right) - m1 \right) \\ &= p2 \left( m2 - m1 \left( \frac{M2}{M1} \right) \right) + p2m1 \left( \frac{M2 - M1}{M1} \right) \\ m1(p2 - p1) &= m1 \left( p2 - p1 \left( \frac{P2}{P1} \right) + p1 \left( \frac{P2}{P1} \right) - p1 \right) \\ &= m1 \left( p2 - p1 \left( \frac{P2}{P1} \right) \right) + m1 \left( p1 \left( \frac{P2}{P1} \right) - p1 \right) \\ &= m1 \left( p2 - p1 \left( \frac{P2}{P1} \right) \right) + m1p1 \left( \frac{P2 - P1}{P1} \right) \end{aligned}$$

Accordingly, the difference between the number of deaths in period  $t = 2$  and period  $t = 1$  for each age, sex, and LA may be decomposed into four components:

$$d2 - d1 = A + B + C + D$$

The first two components (*A* and *B*) represent the difference due to changes in population and mortality that took place among the whole population, and the last two (*C* and *D*) those that resulted from the change in the proportion of the population in each LA.

The total change in the number of deaths for each LA consists of these four components, each of which is calculated as a sum of the component values in this LA for all ages  $x$  where  $60 \leq x \leq 100$ :

$$A = \sum_{x=60}^{100} (p2_x m1_x \left( \frac{M2_x - M1_x}{M1_x} \right))$$

where *A* is the impact of the change in the total mortality rate of the total population (inclusive of all LA),

$$B = \sum_{x=60}^{100} (m1_x p1_x \left( \frac{P2_x - P1_x}{P1_x} \right))$$

where *B* is the impact of the change in the size of the total population (inclusive of all LA),

$$C = \sum_{x=60}^{100} (p2_x (m2_x - m1_x \left( \frac{M2_x}{M1_x} \right)))$$

where *C* is the impact of the change in the relative mortality rate for each LA, and

$$D = \sum_{x=60}^{100} (m1_x (p2_x - p1_x \left( \frac{P2_x}{P1_x} \right)))$$

where *D* is the impact of the change in the proportion of the total population in each LA.