PAA SAN FRANCISCO

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The Longevity of Nuns and Monks:

A Gender Gap Issue Investigated with new Belgian Data

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The question addressed

Nowadays women outlive men everywhere even in the poorest countries (Barford et al. 2006). In developed countries excess male mortality is observed since more than one century and the gender gap reached a level as high as seven years of life expectancy (Human Mortality Database). Nevertheless this gender gap turned down during the last decades of the last century (Mesle 2006) but is still found above 5 years in most developed countries today. Such large gender gap means more concretely that the mortality risk for men overpasses that for women by 50 to 100% at all ages above 50 years.

The reasons why women live longer than men have been largely investigated. In general, it has been observed that during the life course, the occurrence of certain diseases such as cardiovascular diseases, and lung cancers, and accidents, are more frequent among males (Guralnik et al. 2000) and this trend is confirmed when extending the comparison to the top 12 causes of deaths (Austad, 2006). Accordingly, disease-specific incidence rates may explain the observed sex differences in mortality patterns but the factors invoked to explain the female advantage in longevity are various.

The first group of factors relates to biology. Among these, the role of gender-specific genes has been investigated. Women have two X chromosomes, one from their father and the other from their mother, while males have only one X chromosome and one Y chromosome. Because of this, women have two cell lines, i.e. they have two different sources for some key genes (Christensen et al. 2000). In females, if any recessive allele detrimental for survival is inherited, the allele on the second X chromosome could compensate the expression of the first one, a protective strategy that is lacking in males. The role of mitochondrial DNA on gender differential longevity has also been investigated. In particular, the frequency of a polymorphic variant called J haplogroup was reported to be increased in male centenarians from continental Italy (Debenedictis et al. 1999). Hormonal differences have also been associated with the gender gap in

longevity mainly through their effects on cholesterol metabolism and endothelial function. For instance, low serum testosterone levels have been proved to be associated with increased risk of mortality in elderly men independently from the overall health status (Laughlin et al. 2008).

The second group of factors is related to individual behaviour and socio-cultural traits of the population. They include possible differences in nutrition, smoking and alcohol consumption between males and females, but also in physical activity and energy balance. Such differences in behaviour are partly linked to the different occupations of males and females as well as other aspects of life style as the men's tendency to face dangerous situation. Nevertheless specific character traits of males compared to females like less stress, more optimism, and in some population a better ability to take quickly advantage of the positive aspects of the health transition, could have positive role in male longevity compared to female. Some specific socio-cultural traits of the population and the community environment should also be considered. It is well established that a stronger family support and long standing living arrangement in a married couple may help to live longer (Gaymu et al. 2008) while some gender stereotypes and related social norms may favour men compared to women.

The balance between the role of the biological factors and the behavioral ones is still unclear. The current trend with more reduced behavioral differences between men and women is the main explanation for the observed reduction of the gender gap. Nevertheless this question is still a challenge for researchers.

One way to investigate the question is to address populations where the gender gap in mortality risks is more reduced or even inexistent. Such investigations could be carried out with the population of Calabria, Sicily and Sardinia in Italy where the femininity ratio among centenarians has been found very low (Robine and al. 2006). An on-going in-depth analysis of the population of Villagrande in Sardinia, a village when men live as long as women do, should bring concrete findings in order to investigate the role of biologic and behavioural factors to reach extreme longevity in a population without mortality gender gap (Poulain et al. 2011).

Nuns and monks represent also a population group experiencing a reduced mortality gender gap. The impact of living arrangement on mortality risks has been largely investigated (Koskinen et al. 2007) showing that the longevity gender gap differs by living arrangement. Living in religious communities is the living arrangement showing the smaller gender gap in mortality (see the poster presented by Herm in PAA 2012) and accordingly that specific group represents a perfect population to analyze for contributing to the discussion on the factors explaining this longevity gender gap.

Several studies analyzed the mortality patterns of nuns and monks, most of them demonstrating their lowest mortality risk (Taylor et al. 1959, Flannelly et al. 2002). The well-known Nun Study initiated by Snowdon compared the trends in mortality of nuns with old women in the US (Butler and Snowdon 1996). More recently Luy (2003, 2011) studied the mortality of German nuns and monks. By considering the relative advantage of monks compared to nuns in comparison with the overall population and showing a

reduced mortality gender gap between monks and nuns, Luy is bringing a new dimension to disentangle the respective role of biological and behavioural factors to explain the variation in the universally observed mortality gender gap.

Data and methods

The last census carried out in Belgium on 1st October 2001 allows identifying persons living in religious communities with their characteristics at census time including age, sex and level of education. Based on their address, the same religious communities have been found in the previous census on 1st March 1991.

In total 15,404 persons have been identified being member of a religious community in 1991 and their survival up to 2006 was followed by using the continuous population registration system. Among these 13,921 were born before 1941 and were aged 50 years and above on the 1st January 1991. 240 did not die in Belgium and were not found in 2006. These monks and nuns emigrated and have been excluded from the analysis. Finally we consider 13,681 persons living in convents and monasteries in 1991 and their 15 years' survival up to 2006.

Among these, 1,524 monks out of 2,779 and 5,576 nuns out of 10,902 died and the proportion alive on the 1st January 2006 was close for men (45.2%) compared to women (48.9%). The exact date of death is known for those who died between 1991 and 2006.

In addition to age and sex we collected data on the level of education in 1991 as a binary variable (age at the end of education below 18 = low educated or 18 and over = high educated).

For comparative purpose we use the total population of Belgium aged 50 years and over in 1991 (3,14 millions) and followed for survival up to 2006 (1,77 millions died between 1991 and 2006). This data is extracted from the same data sources and follows the same rules as the ones applied to nuns and monks. Accordingly the group of monks and nuns can be directly compared with the total population without introducing any biases that could be linked to differences in data sources or in extraction methods.

For a better comparison, we classify the whole Belgian population according the following living arrangements as observed in 1991 (Table 1):

- Those living alone and were never married in 1991
- Those living alone and were widowed in 1991
- Those living alone and were divorced or married and separated in 1991
- Those living in a married couple in 1991
- Other persons living in a private household in 1991
- Other persons living in a collective household in 1991 (residential home, nursing home and other institutions)

In addition to the simple comparison of the different survival curves by sex and age groups for nuns and monks and the total population, we apply the Cox PH survival analysis method in order to control the impact of education, age and sex and thereafter the KM method to compare the survival of different population groups.

Table 1. Population under study by age groups, gender and living arrangement including nuns and monks as observed on 1st January 1991.

WOMEN	50	55	60	65	70	75	80	85	90	All 50+
NUNS	786	1.132	1.342	1.609	1.415	1.782	1.570	878	388	10.902
WOMEN ALONE SINGLE	5.970	7.179	9.182	10.383	6.943	7.415	5.769	3.164	1.246	57.251
WOMEN ALONE WIDOWED	7.301	18.127	37.210	63.381	60.244	82.855	69.082	35.135	11.752	385.087
WOMEN ALONE OTHER	13.900	13.854	12.750	10.761	5.918	5.196	3.271	1.280	339	67.269
WOMEN IN MARRIED COUPLE	83.180	123.130	139.874	129.258	68.389	49.082	20.561	4.777	543	618.794
WOMEN LIVING WITH OTHERS	162.964	124.205	88.636	63.103	34.743	34.623	28.760	17.674	7.871	562.579
WOMEN IN OTHER COLLECTIVE HH	949	1.352	1.869	2.912	3.410	7.904	12.479	12.076	6.513	49.464
MEN	50	55	60	65	70	75	80	85	90	All 50+
MONKS	290	309	419	494	420	410	264	116	57	2.779
MEN ALONE SINGLE	10.226	11.064	11.078	9.023	4.383	3.816	2.247	785	202	52.824
MEN ALONE WIDOWED	2.046	4.575	8.578	13.584	12.322	18.007	16.022	8.698	3.014	86.846
MEN ALONE OTHER	17.867	15.443	12.536	9.013	4.364	3.212	1.656	530	116	64.737
MEN IN MARRIED COUPLE	65.472	108.260	135.319	140.985	82.943	66.790	31.944	9.327	1.507	642.547
MEN LIVING WITH OTHERS	172.649	134.009	92.214	59.193	27.280	20.756	12.089	5.854	2.351	526.395
MEN IN OTHER COLLECTIVE HH	790	996	1.295	1.611	1.431	2.418	3.044	2.478	1.237	15.300
TOTAL	544.390	563.635	552.302	515.310	314.205	304.266	208.758	102.772	37.136	3.142.774

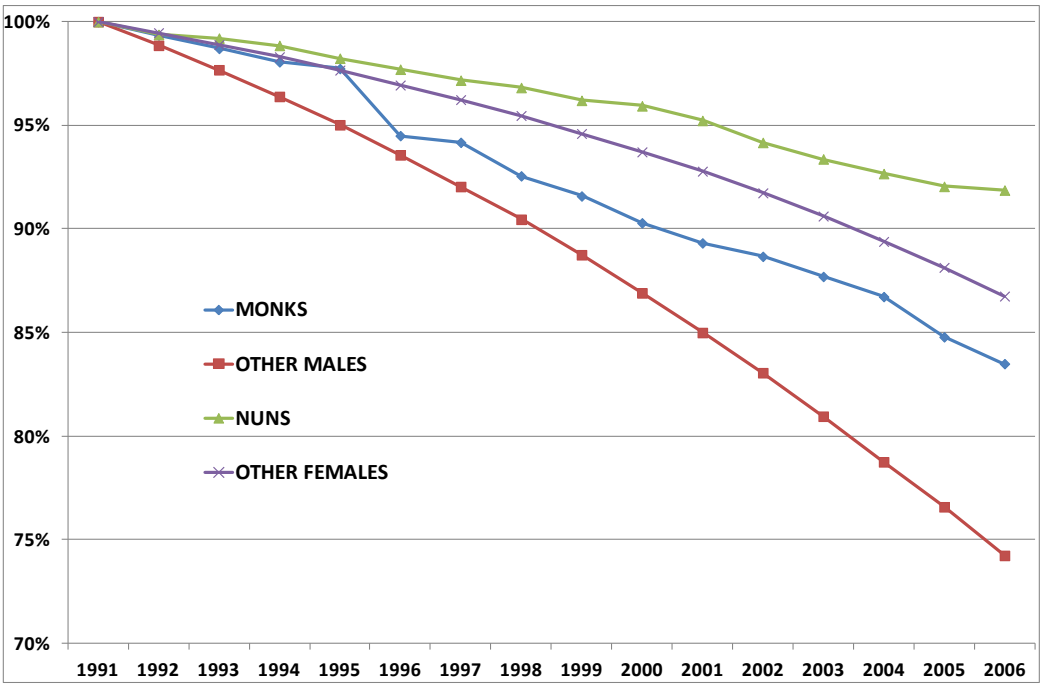
Results

Table 2 summarizes the results for the follow up of the survival on 1st January of the years 1991, 1996, 2001 and 2006 for the nuns and monks and for the total male and female populations (monks and nuns excluded). Figure 1 compares the different survival curves year by year for those aged 55-59 in 1991. These preliminary results confirm the existence of a survival advantage for nuns and monks compared to the total population, an advantage that is more evident if the survival is considered on a longer period. This advantage is generally larger for monks compared to nuns.

Table 2. The survival of nuns and monks per age groups in 1991 for an initial cohort equal to 1000. Ratio between the survival of nuns and monks and the total population.

PROPORTION SURVIVING IN		1991	1996	2001	2006	1991	1996	2001	2006	1991	1996	2001	2006
		MONKS & NUNS (1)				REST OF THE POPULATION (2)				RATIO (2/1)			
MALES	50	100,0%	98,3%	96,2%	88,6%	100,0%	96,1%	90,6%	83,5%	100,0%	102,3%	106,1%	106,2%
	55	100,0%	94,5%	89,3%	83,5%	100,0%	93,6%	85,0%	74,2%	100,0%	101,0%	105,1%	112,5%
	60	100,0%	93,1%	83,1%	69,0%	100,0%	89,6%	76,3%	60,8%	100,0%	103,9%	108,8%	113,5%
	65	100,0%	87,2%	71,3%	54,3%	100,0%	83,7%	64,5%	43,9%	100,0%	104,2%	110,4%	123,6%
	70	100,0%	77,9%	52,4%	27,9%	100,0%	75,4%	49,5%	26,0%	100,0%	103,3%	105,9%	107,0%
	75	100,0%	65,6%	38,0%	13,7%	100,0%	62,2%	30,5%	10,2%	100,0%	105,5%	124,6%	134,0%
	80	100,0%	50,0%	14,0%	3,4%	100,0%	46,8%	15,1%	2,7%	100,0%	106,8%		
	85	100,0%	37,9%	7,8%	0,9%	100,0%	31,7%	6,0%	0,5%				
	90	100,0%	17,5%	0,0%	0,0%	100,0%	16,7%	1,4%	0,0%				
FEMALES	50	100,0%	98,2%	95,7%	93,4%	100,0%	98,0%	95,2%	91,4%	100,0%	100,3%	100,5%	102,2%
	55	100,0%	97,7%	95,2%	91,9%	100,0%	96,9%	92,8%	86,8%	100,0%	100,8%	102,6%	105,9%
	60	100,0%	96,3%	91,4%	84,7%	100,0%	95,2%	88,4%	78,5%	100,0%	101,2%	103,4%	107,9%
	65	100,0%	93,3%	84,0%	69,9%	100,0%	92,1%	80,6%	64,1%	100,0%	101,3%	104,2%	109,0%
	70	100,0%	90,2%	73,0%	50,7%	100,0%	86,5%	67,8%	43,9%	100,0%	104,2%	107,7%	115,6%
	75	100,0%	78,7%	51,1%	24,0%	100,0%	76,2%	47,2%	20,7%	100,0%	103,4%	108,3%	116,3%
	80	100,0%	65,5%	29,9%	7,9%	100,0%	60,4%	26,1%	6,6%	100,0%	108,5%	114,6%	118,8%
	85	100,0%	45,3%	13,2%	2,2%	100,0%	42,0%	10,8%	1,4%				
	90	100,0%	23,5%	4,6%	0,5%	100,0%	22,3%	2,7%	0,1%				

Figure 1. Survival curves from 1991 to 2006 for nuns and monks aged 55-59 in 1991 and the same cohort in the total population of Belgium.



The survival of monks and nuns compared to persons in other living arrangement has been thereafter investigated by using the Cox PH method. For all models the age has been introduced as a continuous variable (50 years = 0) while sex is a binary variable (reference = men). In all models except in model 1, we introduced education as binary variable (reference = high educated). The different living arrangements are considered as a multi-categorical variable with being member of a religious community (monks and nuns) are reference group. Models 3 and 4 were run separately for men and women allowing the mortality relative risks to be different for age and education between men and women. For model 5, we consider the interaction between sex and living arrangement and the mortality relative risks are presented in parallels for comparing men and women with monks and nuns showing a relative risk equal to 1. Considering the large dataset, all coefficients are found significant with $p < 0.001$.

Table 3. Mortality relative risks obtained by applying the Cox PH method to several models (all coefficients are significant with p < 0.001).

COVARIATES	MODEL 1 WITHOUT EDUCATION	MODEL 2 WITH EDUCATION	MODEL 3 MEN ONLY	MODEL 4 WOMEN ONLY	MODEL 5 INCLUDING INTERACTION BETWEEN SEX AND LIVING ARRANGEMENT	
SEXE (reference : male)	0.5646	0.5550	-	-	1.651	
AGE1991 (continuous)	1.1129	1.1120	1.1020	1.1210	1.112	
EDUC91 (reference high education)	-	1.2970	1.3140	1.2640	1.294	
LIVING ARRANGEMENTS					***MEN***	***WOMEN***
MONKS / NUNS	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1.0000**	**1,0000**
ALONE SINGLE	1.3042	1.2300	1.3910	1.1150	1.4557	1,0973
ALONE WIDOWED	1.1767	1.0770	1.1440	1.0690	1.1251	1,0648
ALONE OTHER	1.4059	1.3050	1.4280	1.2190	1.5197	1,1588
MARRIED COUPLE	1.0371	0.9520	0.9960	0.9760	1.0286	0.9206
LIVING WITH OTHERS	1.1141	1.0270	1.0000	1.0960	1.0665	1.0430
OTHER COLLECTIVE HH	1.8821	1.7380	1.8270	1.6980	1.7870	1.7293
PSEUDO R2	3.65%***	3.68%***	3.04%***	4.58%***	3.68%***	

Discussion and further works

Our investigations support previous finding by showing that living in religious community results in a better survival above 50 years compared to all other types of private or collective living arrangement.

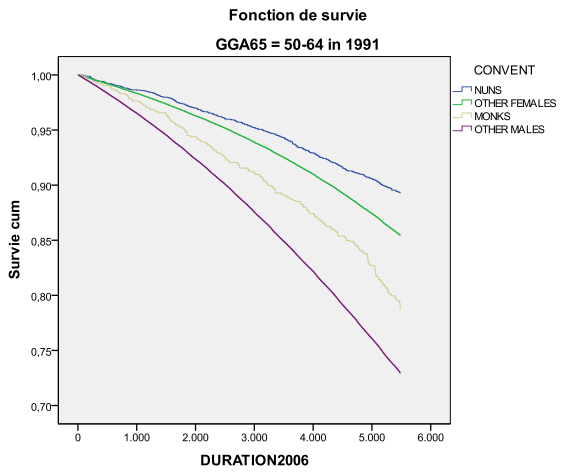
As monks and nuns are relatively better educated compared to the total population and keeping in mind that the longevity increases with the level of education we introduced the level of education in Model 2. The Mortality Relative Risks shown in Table 3 are less favorable to monks and nuns and those living in married couple present a lower mortality risk (about 5% lower). The same observation is valid when we run separately the male and female population. For both 'living in religious community' is ranked second following 'living in married couple'.

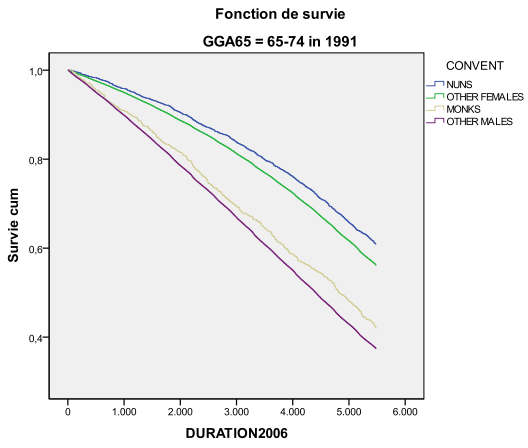
In order to compare the survival between monks and other men and between nuns and other women we run Model 5 where the interaction between sex and living arrangement is introduced. In this model, the difference between monks and nuns appears as monks show the best survival compared to other male living arrangements while for women living in married couple appears to result in 8% lower relative mortality risk compared to nuns.

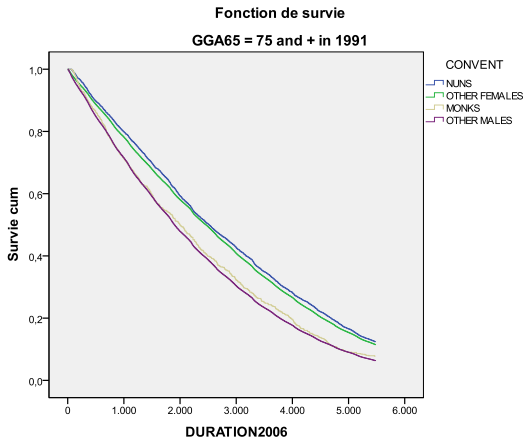
By comparing the relative mortality risks by gender we can see in Table 4 that the relative gender gap in mortality is lower for those living in religious community; that confirms Luy's findings.

In order to analyze such result more in detail we applied the KM survival method for three age groups 50-64, 65-74 and 75+ in 1991 and we opposed nuns and monks to other men and women. The figures hereunder confirm the advantage of nuns and monks compared to the whole population. However by comparing the three figures we observe that this advantage mostly concerns younger generations (aged 50-64 in 1991). Accordingly the advantage of being monk or nun seems to be more concentrated between 50 and 80 and is less apparent above 80 years of age.

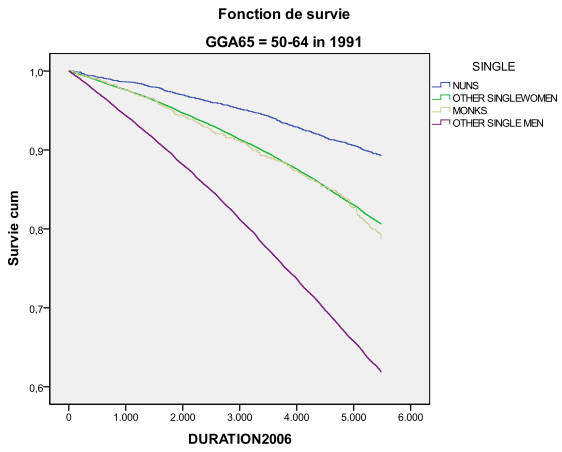
The first figure (50-64) also confirmed the advantage of monks compared to nuns.

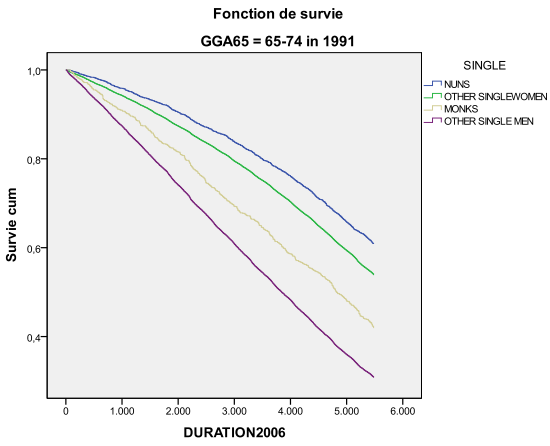


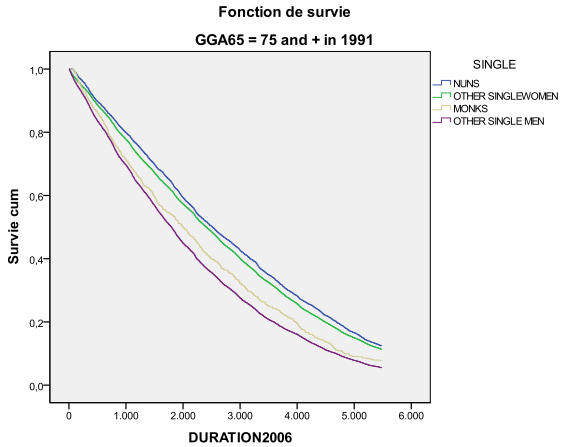




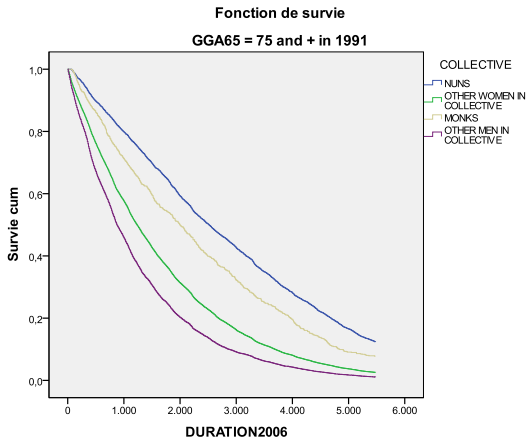
We applied also KM method to compare monks and nuns with other never married men and women respectively. The three figures hereunder show higher advantage compared to the previous situation. For the generation aged 50-64 in 1991, the survival curve for monks is even very close to the one of never married women.







Finally we applied the KM method for the oldest olds only in order to compare the survival of the oldest nuns and monks with the one of the oldest men and women living in nursing homes. Here also the advantage to live in religious collective household emerges compared to those living in nursing homes.



For future works several directions are planned. First it could be possible to extent the period of observation starting with the 1970 census. Therefore several linkage problems have to be solved but, even if we cannot achieve the complete linkage of data, the number of nuns and monks involved would be doubled as well as the duration of the period of observation. Secondly, there exists also the possibility to analyze the causes of death in order to investigate more in detail the reasons why monks and nuns present lower mortality risks. Thirdly, we intend to develop some international comparisons to confront our findings with the ones obtained in other populations.

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