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Does Having Children Influence Female Lifespan in Mauritius?

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ABSTRACT

This paper investigates the potential relationship between longevity and parity among women. Mortality records from 2005 to 2014 were retrieved from the Health Statistics Unit of the Ministry of Health, Mauritius. Descriptive statistics and graphics were used to explain this relationship. A survival analysis was performed to investigate the risks of dying with respect to parity. While causality cannot be established due to the lack of potential confounding variables for mortality, the fitted Weighted Cox Regression model revealed a positive relationship between parity (above two children) and female lifespan. On the other hand, mothers having between one and two children were found to have lower survival probabilities compared with nulliparous females.

Keywords: Longevity, Parity, Survival analysis, Weighted Cox Regression

INTRODUCTION

Reproductive factors, such as parity and fertility are considered to have an effect on women's health. The capacity to reproduce is often measured by the Total Fertility Rate which represents the number of children a woman would bear if she was to live to the end of her childbearing years and bear children in accordance with current age-specific fertility rates (Martin, Hamilton, Ventura, Osterman, Kirmeyer, Mathews, & Wilson, 2011). While the inverse relationship in the direction in which fertility figures and life expectancy numbers move might suggest a negative correlation between parity and longevity, it should be appreciated that both decline in fertility and increase in longevity are linked to improved social and economic status in countries around the world and across time (Mondal & Shitan, 2014). The trade-off between reproduction and longevity has provide evidence on the type of

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relationship that might exist between these two variables (Gavrilov & Gavrilova, 1999).

Few studies have dealt with the association between mortality and parity among women and these results have been debated. Little has been studied about childbearing and its impact on women's health. Some of the studies have found a statistically significant positive association between mortality and the number of children conceived and the results have also been extended to cardiovascular and cerebrovascular diseases (Beral, 1985; Green, Beral, & Moser, 1988; Hinkula, Kauppila, Näyhä & Pukkala, 2006). However, the inverse relationship between parity and mortality has also been studied by Kvale, Heuch, & Nilssen (1994). To date, no studies have looked at the link between parity and mortality in developing countries such as Mauritius. Hence, this aim of this paper is to examine the effect of parity on female longevity.

METHODOLOGY

Data Sources

Mortality data between January 2005 and July 2014 was obtained from the Health Statistics Unit of the Local Ministry of Health which is responsible for collecting, analysing and disseminating heath statistics data in Mauritius. Initially, the data set consisted of 40,214 records. Missing values were deleted and the final dataset consisted of 34,794 female death records with limited variables such as cause of death, age at death, number of live births, marital status and occupation at death. Around 950 records were deleted since the belonged to those below the age of 15. Occupation as a variable was not used given that at death, most of the individuals were retired and it was not possible to obtain data pertaining to the occupation of the women. For the purpose of this study, we define nulliparous women as those who had no live births recorded in the database. Consequently, the variable 'number of live birth' corresponds to the number recorded of live births.

Statistical Analysis

A data-cleaning step was performed to identify imperfect data such as missing values and outliers. Female records below the age of 15 were not considered. Records with missing values (number of live birth, year at death and age at death) were removed from the original dataset. Exploratory analysis was performed by constructing Trellis boxplots using the 'lattice' package (Sarkar, 2015) in R for, first of all, various causes of mortality separately and second for all-cause mortality, to investigate the distribution of age at death by parity, measured by the 'number of live births' variable.

Survival analysis, used to model time to an event (in this case death) was identified as the appropriate method to investigate the potential effect of having more children on female lifespan. The final data did not contain any censored information and only consisted of death (observed cases). Using

all-cause mortality data, Super-Imposed Kaplan Meier curves were constructed after categorising the females as 'nulliparous', "two live births" and "more than two live births". The latter categorisation was based on the initial exploratory trellis boxplots. The Kaplan Meier curves were estimated as follows:

Suppose that there are observations on N females and that there are $(k<N)$ distinct times $t_1<t_2<\ldots<$ at which events of interest occur. Suppose furthermore that, at these times, d_1, d_2, …,d_k events of interest (or "deaths") occur respectively and that between times t_j and $t_{(j+1)}$, there are c_j censored observations, Then the number of females at risk at time t_j (see Equation 1) will be:

$$n_j = N - \sum_{i=1}^{j-1} c_i - \sum_{i=1}^{j-1} d_i \quad for\, j = 1, 2, \ldots., k \tag{1}$$

Therefore, the Kaplan-Meier estimator of S(t) is given by:

$$\hat{S}(t_k) = \prod_{j=1}^{k} \left[1 - \frac{d_j}{n_j} \right] \tag{2}$$

Initially, proportional hazards model (Cox, 1972) was fitted to model the 'time to death' using 'parity' and 'year of death' as explanatory variables using the 'survival' package (Therneau, 2015) in R. The variable 'year of death' was included as an additional explanatory term to control for the potential evolution in quality of life across time. The tenability of the proportional hazards assumption was investigated first, using plot of the estimated log cumulative hazard function (with 'number of live births' as explanatory variable) versus log time for each subject group on the same graph. The proportionality of all the predictors in the model was also tested. Since the latter assumption appears to be violated, Weighted Cox Regression, as proposed by (Schemper, Wakounig & Heinze, 2009) was fitted using the 'coxphw" package (Ploner, Heinze & Dunkler 2015). The estimates of the coefficients from separate models fitted by disease were also provided for further insight. The weighted estimation within the Cox's model is explained as follows:

In a sample of n females, we observe m distinct and uncensored survival times t_j $(1 \le j \le m)$ among the n possibly censored survival times t_i $(1 \le i \le n)$. A covariate vector $x_i = (x_{i1},...,x_{ir},...,x_{ik})$ is related to each individual as is a censoring indicator η_i (1 for censored, 0 for dead). The set of individuals alive and uncensored prior to t_j, the risk set is denoted by R_j, as is also the size of this set. A vector β of k regression parameters is to be estimated. Then the log partial likelihood for Cox's model is defined as:

$$\log L(\beta) = \sum_{j=1}^{m} \left[x_j \beta - \log \left\{ \sum_{h \in R_j} \exp(x_h \beta) \right\} \right] = \sum_{j=1}^{m} l_j \tag{3}$$

Where l_j is the contribution to the log likelihood at failure time t_j.

RESULTS

The boxplot showed a lower lifespan for female with one or two children compared with nulliparous women. However, lifespan appears to experience a 'boost' and longevity seems to be higher for women who have more than two children. Based on these findings, Kaplan Meier curves were constructed after categorising women into three groups; nulliparous, with one or two children, and more than two children. The Kaplan Meier curves, which show the survival probability (with 95% Confidence Limits) of living beyond a certain age was found to be higher for women with more than two children (compared with the other groups). Furthermore, trellis plots were created to visually assess the effect of parity on longevity for each cause of mortality separately (Classified according to the International Classification of Diseases). The resulting plot reveals the same trend as observed for all-cause mortality in terms of age at death, i.e. a decrease in lifespan before a general increase.

To investigate the tenability of the Cox Proportional Hazards Model, the estimated log cumulative hazard function is plotted against log time for each subject group, with the plots being superimposed on a single graph (refer to Figure 1). If the proportional hazards assumption is valid, then the resulting plots should be parallel to each other. From the plot below (Figure 1), the proportional hazards assumptions seem to have been violated. An assessment of Weibull or exponential models did not produce satisfactory diagnostic plots either, thus calling for the use of Weighted Cox Regression as proposed by Schemper et al. (2009).

Table 1 displays the results for fitting the various Cox Proportional Hazards (CPH) models: first, a Proportional Cox Regression model was fitted to compare women with more than two children with nulliparous women; Second, it was fitted to compare women with one or two children versus nulliparous women. The two models mentioned were again fitted, but this time using a Weighted Cox Regression as proposed by Schemper et al. (2009). Given the violation of the proportional hazards assumption (see Figure 1), only the results of the Weighted Cox Regression were interpreted.

Table 1 shows that the hazards of dying among women having more than two children was 0.816 times less than that of nulliparous women. Moreover, for women having 1 or 2 children, the hazard of dying was 1.310 times higher compared with nulliparous women.

In other words, the yearly probability of dying is reduced by approximately 19% for women with more than 2 children compared with those who have not given birth to any children. Turning to year of death, for a one-unit increase in year of death, the hazard of dying for women having greater than 2 children was 0.987. Similar results were demonstrated for those women having only 1 or 2 children (Hazard of dying = 0.999). It was worth noting that the covariate 'Year of death' was insignificant for women having 1 or 2 children (p-value = 0.787).

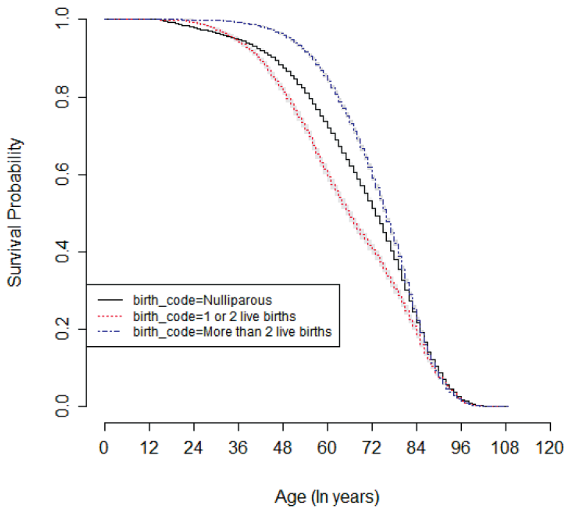

Figure 1. Superimposed Kaplan Meier curves for various groups of women

Table 1
CPH and Weighted CPH Regression Models

Model	n	Variables	*exp*(coef)	*se*(coef)	*p*-value
CPH	29906	> 2 children	0.950	0.012	<0.001*
		Year of death	0.984	0.002	<0.001*
	20703	1 or 2 children	1.181	0.016	<0.001*
		Year of death	0.993	0.003	0.011*
Weighted CPH	29906	> 2 children	0.816	0.013	<0.001*
		Year of death	0.987	0.003	<0.001*
	20703	1 or 2 children	1.310	0.019	<0.001*
		Year of death	0.999	0.003	0.787

Note: * Statistically significant (*p*-values less than 0.05)

Results from Table 2 displays CPH models for women suffering from different diseases. Six types of diseases including neoplasm; endocrine, nutritional and metabolic; circulatory; respiratory; digestive and genito-urinary were considered. The hazard of dying for women suffering from any of the abovementioned diseases and at the same time having 1 or 2 children and those having greater than 2 children were examined by the CPH models against nulliparous women. Results indicated that the hazard of dying for women suffering from neoplasm and who had 1 or 2 children was 1.551 times the hazard of dying for nulliparous women. It was observed that across all the diseases, the hazard of dying decreased for women having greater than 2

children in comparison to those having 1 or 2 children against the nulliparous ones. The highest hazard (exp(coef) = 1.551) of dying for those having 1 or 2 children were women suffering from any form of neoplasm and the lowest hazard (exp(coef) = 1.019) was noted for those suffering from respiratory problems.

Table 2
CPH Models by Diseases

Disease	Variables	n	*exp*(coef)	*se*(coef)	*p*-value
Neoplasm	1 or 2 children	4639	1.551	0.041	< 0.001*
	> 2 children		0.863	0.033	< 0.001*
	Year of death		0.987	0.006	0.025*
Endocrine, nutritional & metabolic	1 or 2 children	9843	1.216	0.033	< 0.001*
	> 2 children		0.941	0.022	0.005*
	Year of death		0.977	0.004	< 0.001*
Circulatory	1 or 2 children	12614	1.141	0.028	< 0.001*
	> 2 children		1.035	0.019	0.074
	Year of death		0.986	0.003	< 0.001*
Respiratory	1 or 2 children	2447	1.019	0.065	0.780
	> 2 children		0.895	0.044	0.011*
	Year of death		0.980	0.008	0.010*
Digestive	1 or 2 children	883	1.434	0.095	0.000*
	> 2 children		0.919	0.077	0.270
	Year of death		0.949	0.013	< 0.001*
Genito-urinary	1 or 2 children	657	1.190	0.112	0.120
	> 2 children		0.955	0.087	0.590
	Year of death		1.010	0.014	0.500

Note: * indicates *p*-values less than 0.001

DISCUSSION

The main finding of this study was that the hazard of mortality was lowest among women with more than 2 children compared with nulliparous women (see Figure 2). Additionally, low parity with 1 or 2 children was associated with an increased hazard of dying from neoplasm. Data was drawn from a cohort, which was representative of the general population, consisting of records of mortality and parity of all women between 2005 to

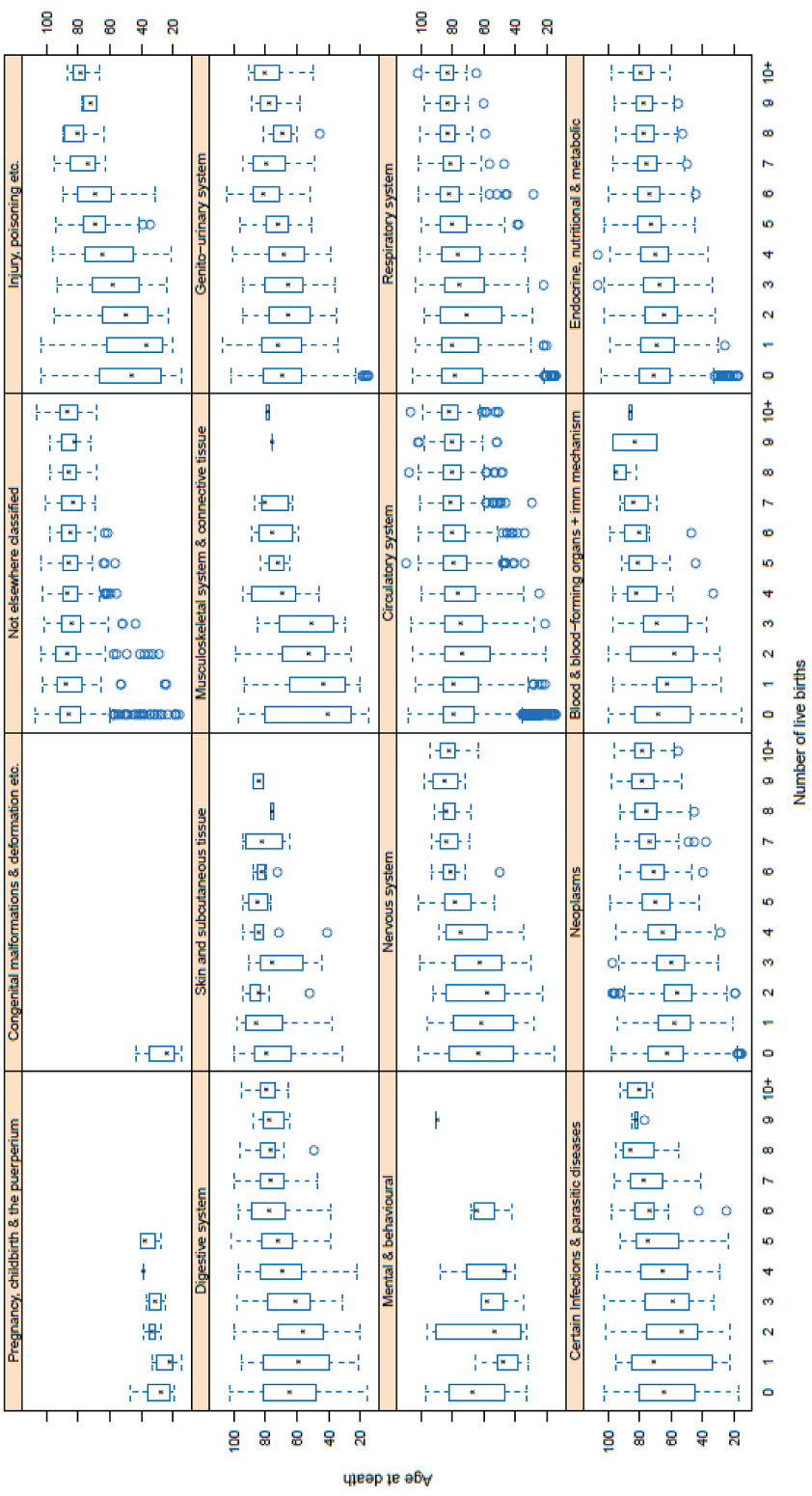

Figure 2. Trellis boxplot for age at death, by number of live births and disease

2014 in Mauritius. The study confirmed the findings of previous studies, which compared mortality between nulliparous and parous women.

However, recently, a handful of studies have suggested a different type of relationship between parity and lifespan. One of the recent studies by Simons, Simons, Friedlander & McCallum (2012) conducted on Australian women revealed that "all-cause mortality fell progressively with increasing parity in women". Muller, Chiou, Carey, & Wang (2002) used a historical French-Canadian cohort who lived beyond the age of 50 and concluded that increased fertility was linked to increased, rather than decreased, post-reproductive survival. In another study, the positive relationship between (not causation) late fertility, particularly between 33 and 37 years of age and survival time was established. Women who lived longer were found to be those who had children after the age of 33, the odds of living up to the older group increasing by 5% for every additional year added to the cut-off point.

Van den Berg, Gupta & Portrait (2010) concluded that "fertility has a protective causal effect on female mortality in post-reproductive years". Moreover, Gagnon, Smith, Tremblay, Vézina, Paré, & Desjardins (2009) used three historical databases (Québec in Canada and Utah in United States) and concluded that higher parity was associated with increased mortality rate but that late fertility was associated with increased survival rate. McArdle, Pollin, O'Connell, Sorkin, Agarwala, Schaffer, King, Shuldiner, & Mitchell (2006) found that that lifespan increased in a linear fashion with increased number of children for both mothers and fathers from an Amish community in Pennsylvania. Total mortality was found to be lowest among women with 2-4 livebirths in Finland but high parity was associated with increased risk of mortality from vascular complications after adjusting for confounding factors such as age, age at menarche and background factors (Koski-Rahikkala, Pouta, Pietiläinen & Hartikainen, 2006).

CONCLUSION

The main finding of this study was that women with more than 2 children compared with those without any children had a lower mortality hazard. One of the limitations of this study was that it failed to adjust for any confounders since limited demographic data was available. The study put forward the association between parity and female lifespan given the inconsistency of results from previous studies. Future studies can look into the effect of confounders, which past studies had not been able to adjust for.

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REFERENCES

Beral, V. (1985). Long term effects of childbearing on health. *Journal of epidemiology and community health, 39*(4), 343-346.

Cox, D. (1972). Regression Models and Life-Tables. *Journal of the Royal Statistical Society, Series B, 34*(2), 187-220.

Gagnon, A., Smith, K. R., Tremblay, M., Vézina, H., Paré, P. P., & Desjardins, B. (2009). Is there a trade-off between fertility and longevity? A comparative study of women from three large historical databases accounting for mortality selection. *American Journal of Human Biology, 21*(4), 533-540.

Gavrilov, L. A., & Gavrilova, N. S. (1999). Is there a reproductive cost for human longevity? *Journal of Anti-Aging Medicine, 2*(2), 121-123.

Green, A., Beral, V., & Moser, K. (1988). Mortality in women in relation to their childbearing history. *BMJ, 297*(6645), 391-395.

Hinkula, M., Kauppila, A., Näyhä, S., & Pukkala, E. (2006). Cause-specific mortality of grand multiparous women in Finland. *American Journal of Epidemiology, 163*(4), 367-373.

Koski-Rahikkala, H., Pouta, A., Pietiläinen, K., & Hartikainen, A. L. (2006). Does parity affect mortality among parous women? *Journal of epidemiology and community health, 60*(11), 968-973.

Kvale, G., Heuch, I., & Nilssen, S. (1994). Parity in relation to mortality and cancer incidence: A prospective study of Norwegian women. *International Journal of Epidemiology, 23*(4), 691-699.

Martin, J. A., Hamilton, B. E., Ventura, S. J., Osterman, M. J., Kirmeyer, S., Mathews, T. J., & Wilson, E. C. (2011). Births: final data for 2009. *National vital statistics reports, 60*(1), 1-72.

McArdle, P. F., Pollin, T. I., O'Connell, J. R., Sorkin, J. D., Agarwala, R., Schaffer, King, T., Shuldiner, A. & Mitchell, B. D. (2006). Does having children extend life span? A genealogical study of parity and longevity in the Amish. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 61*(2), 190-195.

Mondal, M. N. I., & Shitan, M. (2014). Relative importance of demographic, socioeconomic and health factors on life expectancy in low- and lower-middle-income countries. *Journal of Epidemiology, 24*(2), 117-124.

Muller, H. G., Chiou, J. M., Carey, J. R., & Wang, J. L. (2002). Fertility and Life Span Late Children Enhance Female Longevity. *The Journals of Gerontology Series A: Biological Sciences and Medical Sciences, 57*(5), 202-206.

Ploner, M., Heinze, G., & Dunkler, D. (2015). *Coxphw: Weighted Estimation in Cox Regression*. R package version 3.0.0. Retrieved April 30, 2015, from https://rdrr.io/cran/coxphw/man/coxphw.html

Sarkar, D. (2015). *Lattice: Lattice Graphics*. R package version 0.20. Retrieved April 30, 2015, from https://cran.r-project.org/web/packages/lattice/lattice.pdf

Schemper, M., Wakounig, S., & Heinze, G. (2009). The estimation of average hazard ratios by weighted Cox regression. *Statistics in medicine, 28*(19), 2473-2489.

Simons, L. A., Simons, J., Friedlander, Y., & McCallum, J. (2012). Childbearing history and late-life mortality: the Dubbo study of Australian elderly. *Age and ageing, 0*, 1-6.

Therneau, T. (2015). *Survival: Survival analysis*. R package version 2.38. Retrieved April 30, 2015, from https://cran.r-project.org/web/packages/survival/survival.pdf

Van den Berg, G. J., Gupta, S., & Portrait, F. (2010). *Do Children Affect Life Expectancy? A Joint Study of Early life Conditions, Fertility and Mortality*. (Master dissertation). University of Princeton, United States of America.