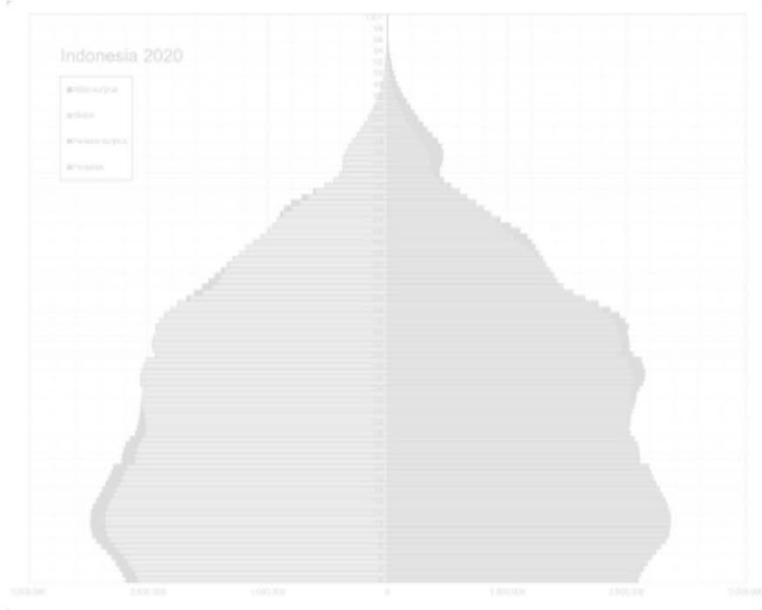
ISSN: 2424-8150 (Print)
ISSN: 2424-8606 (Online)
Volume 2 · Issue 1
June 2016

INTERNATIONAL JOURNAL OF POPULATION STUDIES



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Print ISSN: 2424-8150 Online ISSN: 2424-8606

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Volume 2 • Issue 1 • June 2016
ISSN 2424-8150 (print) ISSN 2424-8606 (online)

INTERNATIONAL JOURNAL OF POPULATION STUDIES

Editor-in-Chief
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International Journal of Population Studies

ISSN: 2424-8150 (print)

ISSN: 2424-8606 (online)

Editorial and Production Credits

Publisher: Whioce Publishing
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Volume 2 | Issue 1 | June 2016 | Page 1-116 |
International Journal of Population Studies

CONTENTS

1 **Nonparametric graduation techniques as a common framework for the description of demographic patterns** *RESEARCH ARTICLE*
Anastasia Kostaki, Javier M. Moguerza, Alberto Olivares and Stelios Psarakis

21 **Monitoring adult mortality by type of residence in the absence of death registration: a perspective from Burkina Faso** *RESEARCH ARTICLE*
Bruno Yempabou Lankoande

38 **Life expectancy at birth and life disparity: an assessment of sex differentials in mortality in India** *RESEARCH ARTICLE*
Akansha Singh and Laishram Ladusingh

53 **Correlates of parental satisfaction: a study of late life family relationships in a rural county in China** *RESEARCH ARTICLE*
Yiqing Yang,Ming Wen

65 **Towards a data users' framework to advance Sustainable Development Goal 2** *RESEARCH ARTICLE*
Sylvia Szabo, Sinead Mowlds, Joan Manuel Claros, Anuja Kar, William Knechtel, Mariella Di Ciommo, Ima Kashim, and the members of the ONE Campaign-facilitated data users accountability group

78 **"I came by the bicycle so we can avoid the police": factors shaping reproductive health decision-making on the Thailand-Burma border** *RESEARCH ARTICLE*
Jillian Gedeon, Saw Nanda Hsue, and Angel M Foster

89 **Cross-sectional study of child malnutrition and associated risk factors among children aged under five in West Bengal, India** *RESEARCH ARTICLE*
Sanjit Sarkar

103 **Dietary intake knowledge and reasons for food restriction during pregnancy among pregnant women attending primary health care centers in Ile-Ife, Nigeria** *RESEARCH ARTICLE*
Mattew O. Oluleke,Akintayo O. Ogunwale,Oyedunni S. Arulogun,Ademola L. Adelekan

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RESEARCH ARTICLE

Nonparametric graduation techniques as a common framework for the description of demographic patterns

Anastasia Kostaki[1], Javier M. Moguerza[2], Alberto Olivares[3] and Stelios Psarakis[1]

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Abstract: The graduation of age-specific demographic rates is a subject of special interest in many disciplines as demography, biostatistics, actuarial practice, and social planning. For estimating the unknown age-specific probabilities of the various demographic phenomena, some graduation technique must be applied to the corresponding empirical rates, under the assumption that the true probabilities follow a smooth pattern through age. The classical way for graduating demographic rates is parametric modelling. However, for graduation purposes, nonparametric techniques can also be adapted. This work provides an adaptation, and an evaluation of kernels and Support Vector Machines (SVM) in the context of graduation of demographic rates.

Keywords: graduation, mortality pattern, fertility pattern, kernels, Support Vector Machines

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Received: August 24, 2015; **Accepted:** October 4, 2015; **Published Online:** October 17, 2015

Citation: Kostaki A, Moguerza J M, Olivares A, *et al*. (2016). Nonparametric graduation techniques as a common framework for the description of demographic patterns. *International Journal of Population Studies*, vol.2(1): 1–20. http://dx.doi.org/10.18063/IJPS.2016.01.001.

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1. Introduction

The graduation of demographic rates is a subject of special interest in demographic analysis, biostatistics, actuarial practice, and social planning. The demographer needs to describe the age-specific patterns of the various demographic phenomena in a population for various purposes such as providing population projections, constructing life tables and multiple decrement tables, as well as for calculating reproduction rates. The actuary needs a mortality and fertility basis suitable for calculations in life insurance and in designing of social security systems. Social planning also requires estimations and projections of the age-specific demographic patterns for many purposes, e.g., for designing health care systems, as well as for analysing and projecting the labour force.

In order to estimate the unknown age-specific probabilities of the various demographic phenomena underlying the empirical age-specific rates which are affected by random fluctuations, the typical way is the utilization of some graduation techniques to be applied to the empirical age-specific rates, under the assumption that the true probabilities follow a smooth pattern through age. A graduation technique, focusing to eliminate random fluctuations affecting the empirical measures, can

therefore serve in order to provide a clear description of the real shape of the various age-specific patterns, and consequently provide a real basis for population analysis and projections. The classical way to graduate empirical demographic rates is to fit a model that presents these rates as a parametric function of age. For the graduation of the age-specific rates of each one of the three demographic phenomena, specific parametric models have been proposed.

Several parametric models have been proposed for the graduation of the age-specific mortality rates and many authors have contributed to the problem of estimating their parameters (Heligman and Pollard, 1980; Keyfitz, 1982; Forfar, McCutcheon, and Wilkie, 1988; Kostaki, 1992; Hannerz, 1999; Karlis and Kostaki, 2000). A variety of models presenting the empirical age-specific fertility rates as a parametric function of age have also been proposed for the graduation of the age-specific fertility rates. A thorough description of these models is provided by Kostaki and Peristera (2007). Finally, for the description of nuptiality patterns alternative parametric models have been proposed (Coale and McNeil, 1972; Liang, 2000). However, for graduation purposes, a possible way to smooth demographic rates is the utilization of non-parametric smoothing techniques. Kernels have already been used for graduating mortality patterns (Copas and Haberman, 1983; Gavin, Haberman, and Verrall, 1993; Gavin, Haberman, and Verrall, 1994; Felipe, Guillen, and Nielsen, 2000). An evaluation of kernels as tools for graduating mortality patterns is provided by Peristera and Kostaki (2005).

An alternative nonparametric way for graduating age-specific demographic rates would be the utilization of Support Vector Machines (SVM). These techniques appeared in 1995 in the framework of Vapnik's Statistical Learning Theory (Vapnik, 1995; Moguerza and Muñoz, 2006) for classification and regression purposes. In particular, SVM have been used in a number of applications (Chongfuangprinya, Kim, Park *et al*., 2011; Erdogan, 2013). They have been also used successfully for smoothing noisy data such as neighbourhood curves (Muñoz and Moguerza, 2005) and nonlinear profiles (Moguerza *et al*., 2007). Therefore, they can *a priori* be considered as a promising tool for demographic graduation tasks. In addition, the use of SVMs is affordable by practitioners with a lack of advanced statistical or computational skills. The reason is that documentation at all levels is available through the Internet and new libraries and easy-to-use software are continuously being developed (see Weka[1] or the software package known as "R"[2]).

The focus of this paper is to evaluate and compare the performance of kernels and SVMs for graduation purposes of demographic rates for each one of the three basic demographic phenomena. Both kernels and SVMs have been adjusted and applied to empirical data sets of mortality, fertility, and nuptiality rates of a variety of populations and years. In particular, a cross-validation approach has been conducted for the SVM models and a plug-in technique has been used for kernel models, in order to fit their corresponding parameters. For comparison purposes parametric models are also fitted to the same empirical data sets. In the next section, a short description of existing parametric models for fitting mortality, fertility, and nuptiality data is provided. Sections 3 and 4 are devoted to a presentation of kernels and SVMs, respectively. Then, Section 5 provides the results of our calculations in order to assess the utilization of kernels and SVM techniques as tools for estimating age-specific mortality, fertility, and nuptiality patterns. Some concluding remarks and some issues for further research are given in Section 6.

2 Parametric Models

2.1 Mortality Models

A wide variety of mortality laws has been presented in the literature (Brass, 1971; Mode and Busby, 1982) since the first attempt by de Moivre in 1725. Among all of these laws, the most successful attempt to describe the age-specific mortality pattern for the total life span through a parametric

1 https://weka.wikispaces.com/LibSVMor
2 https://en.wikibooks.org/wiki/Data_Mining_Algorithms_In_R/Classification/SVM

model and the most widely used since 1980 is the one proposed by Heligman and Pollard (1980). This model (hereafter HP) is described by the formula,

$$\frac{q_x}{p_x} = A^{(x+B)^C} + De^{-(E(\ln x - \ln F)^2} + GH^x,$$

where q_x is the probability of dying within a year, $p_x=1-q_x$, and A to H are parameters to be estimated.

2.2 Fertility Models

A variety of alternative have been proposed in the literature. In this section, a summary of parametric models for fitting the age-specific fertility curve is provided.

The Hadwiger function (Hadwiger, 1940; Gilje, 1969) takes the form:

$$f(x) = \frac{ab}{c}\left(\frac{c}{x}\right)^{\frac{3}{2}} \exp\left\{-b^2\left(\frac{c}{x} + \frac{x}{c} - 2\right)\right\},$$

where a, b, and c are parameters to be estimated and x is the age of the mother at birth.

The Gamma function (Hoem, Madsen, Nielsen *et al*., 1981) is expressed by:

$$f(x) = R\frac{1}{\Gamma(b)c^b}(x-d)^{b-1} \exp\{-((x-d/c))\}, \quad fo\ xr > d$$

where R, b, c, and d are parameters that should be estimated.

The Beta function by Hoem *et al*. (1981) is given by:

$$f(x) = R\frac{\Gamma(A+B)}{\Gamma(A)\Gamma(B)}(\beta-\alpha)^{-(A+B-1)}(x-\alpha)^{A-1}(\beta-x)^{B-1}, \quad for\ \alpha < x < \beta,$$

where R determines the level of fertility, and A, B, α, and β are calculated as:

$$B = \left\{\frac{(\nu-\alpha)(\beta-\nu)}{\tau^2} - 1\right\}\frac{\beta-\nu}{\beta-\alpha} \text{ and } A = B\frac{\nu-\alpha}{\beta-\nu},$$

v being the mean and τ^2 the variance.

The Schmertmann (2003) model for representing age-specific fertility schedules is obtained using a piecewise quadratic spline function by defining three index ages that describe the shape of the age-specific fertility:

$$f(x) = \begin{cases} R * \sum_{k=0}^{4} \theta_k (x-t_k)_+^2, & \alpha \leq x \leq \beta \\ 0, & otherwise, \end{cases}$$

with Knots $t_0 < t_1 < \ldots < t_4$ falling in the interval between ages α and β, where $t_0 = \alpha$, (the lowest age of childbearing) and $(t-t_k)_* \equiv MAX[0, x-t_k]$.

A deviation from its classical shape in terms of a bulge in fertility rates of younger women is exhibited by recent fertility patterns of some developed countries. Chandola *et al*. (1999) developed a two-component mixture model of the Hadwiger function for the description of distorted fertility patterns:

$$f(x) = am\left(\frac{b_1}{c_1}\right)\left(\frac{c_1}{x}\right)^{3/2} \exp\left\{-b_1^2\left(\frac{c_1}{x} + \frac{x}{c_1} - 2\right)\right\} + (1-m)\left(\frac{b_2}{c_2}\right)\left(\frac{c_2}{x}\right)^{3/2} \exp\left\{-b_2^2\left(\frac{c_2}{x} + \frac{x}{c_2} - 2\right)\right\},$$

Where x is the age of the mother at birth, and parameters m, α, b_1, c_1, b_2, and c_2 are to be estimated, resulting in a seven parameter model by the inclusion of an additional parameter (Ortega and Kohler, 2000).

A model with two versions capturing both the classical and the distorted fertility pattern was proposed by Kostaki and Peristera (2007). The simple version of the Peristera-Kostaki model (hereafter P-K model) takes the form:

$$f(x) = c_1 \exp\left[-\left(\frac{x-\mu}{\sigma(x)}\right)^2\right],$$

Where $f(x)$ is the age-specific fertility rate at age x, c_1, μ, and σ are parameters to be estimated, while $\sigma(x) = \sigma_{11}$ *if* $x \leqslant \mu$, and $\sigma(x) = \sigma_{12}$ *if* $x > \mu$.

The version capturing the distorted fertility pattern of the Peristera and Kostaki model (hereafter P-K mixture model) is a mixture model given by:

$$f(x) = c_1 \exp\left[-\left(\frac{x-\mu_1}{\sigma_1(x)}\right)^2\right] + c_2 \exp\left[-\left(\frac{x-\mu_2}{\sigma_2}\right)^2\right],$$

Where $f(x)$ is the age-specific fertility rate at mother age x, while $\sigma(x) = \sigma_{11}$ if $x \leqslant \mu$ and $\sigma(x) = \sigma_{12}$ *if* $x > \mu$ and c_1, c_2, μ_1, μ_2, σ_{11}, σ_{12}, σ_{11}, σ_2 are parameters to be estimated.

2.3 Nuptiality Models

Next, we provide a brief description of different parametric models proposed in literature for the fitting of empirical first-marriage rates.

Coale and McNeil (1972) defined the probability density function (hereafter C-M) for the age distribution of first-marriages as:

$$f(x) = \frac{\beta}{\Gamma(a/\beta)} \exp\left[-a\left(x-\mu-\exp\left\{-\beta(x-\mu)\right\}\right)\right],$$

where Γ denotes the gamma function, and α, β, μ are parameters to be estimated.

The generalized log gamma model (hereafter GLG) proposed by Kaneko (1991, 2003) is expressed by:

$$f(x;C,u,b,\lambda) = C\frac{|\lambda|}{b\Gamma(\lambda^{-2})}\left(\lambda^{-2}\right)^{\lambda^{-2}} \exp\left[\lambda^{-1}\left(\frac{x-u}{b}\right) - \lambda^{-2}\exp\left\{\lambda\left(\frac{x-u}{b}\right)\right\}\right],$$

where $f(x)$ is the age-specific first marriage rate at age x, C, λ, and u are parameters to be estimated and Γ denotes the gamma function.

Since in recent years a considerable variation is observed in the pattern of first-marriage in data sets of several populations, Liang (2000) built a mixture model using the double-exponential distribution. This model, denoted as the mixture Coale-McNeil model (hereafter MC-M), is described by:

$$f(x;m,\alpha_1,\lambda_1,\mu_1,\alpha_2,\lambda_2,\mu_2) = \frac{m\lambda_1}{\Gamma\left(\frac{\alpha_1}{\lambda_1}\right)}\exp(-\alpha_1(x-\mu_1) - e^{-\lambda_1(x-\mu_1)})$$

$$+\frac{(1-m)\lambda_2}{\Gamma\left(\frac{\alpha_2}{\lambda_2}\right)}\exp\left(-\alpha_2(x-\mu_2) - e^{-\lambda_2(x-\mu_2)}\right),$$

where m, α_1, λ_1, μ_1, α_2, λ_2, and μ_1 are parameters to be estimated.

3. Kernel Techniques

Let (x_i, y_i), $i = 1,\ldots,p$ be a set of observations of two variables X and Y whose relation is given by an unknown regression function $m(x)$:

$$y_i = m(x_i) + \varepsilon_i,\ i = 1,\cdots,p,$$

where ε_i are independent random variables with zero mean and constant variance. In order to estimate the unknown function m at a point x, an averaging of the values of the response variable is locally done. The smoothness of the resulting estimator is controlled by a bandwidth determining the width of the neighbourhood over which the averaging is performed. As a result, the estimator of the function m takes the form:

$$\hat{m}_h(x) = n^{-1} \sum W_h(x; X_1, X_2, \cdots, X_n) Y_i ,$$

where W_h is a weight function depending on the bandwidth parameter h and variables $X_1, X_2, \cdots, X_n$. The shape of the weight function W_h is represented by a so-called kernel function, which includes the bandwidth h that adjusts the size and the form of the weights around x, acting as a scale parameter. Hence, kernel regression estimators correspond to local weighted averages of the response variable, with weights determined by the kernel function K, depending on the size of the weights on the bandwidth parameter. Usually, for regression purposes, K performs and has the properties of a probability density function: it is generally a positive, smooth function, decreasing monotonically as the bandwidth parameter increases in size and peaking at zero.

A detailed review of the formulae proposed in the literature for the kernel estimator $\hat{m}$ of the regression mean function m can be consulted in Peristera and Kostaki (2005), where it is shown that the Gasser-Müller estimator (Gasser and Müller, 1979, 1984) is an adequate estimator for the graduation of mortality data, its formula being:

$$\hat{m}_{GM}(x) = \sum_{i=1}^{n} Y_{[i]} \int_{(x_{(i)}+x_{(i-1)})/2}^{(x_{(i+1)}+x_{(i)})/2} K_h(x - x_i) dx,$$

where $x_0 = -\infty$, $x_n = \infty$, x_i denotes the ith largest value of the observed covariate values and $Y_{[i]}$ the corresponding response value.

Regarding the selection of the bandwidth parameter, a description of techniques can be consulted in Hardle (1990, 1991), and Peristera and Kostaki (2005). A typical way to select the bandwidth parameter is to build a direct plug-in estimator of the optimal smoothing parameter h. Gasser *et al.* (1991) described how unknown quantities can be effectively estimated and explicit expressions for h appropriate to the Gasser-Müller estimator are provided. The selection of a global or a local bandwidth is another crucial decision. A local selection allows the use of a smaller bandwidth in areas of high density, while for areas of low density a larger bandwidth can be adopted (Brockmann *et al.*, 1993; and Hermann, 1997, for discussions on the advantages of using kernel regression estimators with a local bandwidth). The underlying idea of the plug-in method is to select the optimal bandwidths by estimating the asymptotically optimal mean integrated squared error bandwidths. Hermann (1997) developed a generalization of the global iterative plug-in algorithm of Gasser *et al.* (1991) for the selection of a local bandwidth, and the advantages of the local selection over the global plug-in rule and the cross-validation method are shown.

4. Support Vector Machines

The SVM technique is part of the regularisation methods (Moguerza and Muñoz, 2006). These methods also include Splines. In fact, there is a close relation between both methodologies — SVM and Splines (Pearce and Wand, 2006). Next, we provide a brief description of the regression version of SVM and its main features. SVM can be presented from its geometrical interpretation. Basically, the method works by solving an optimization problem of the form (Tikhonov and Arsenin, 1977):

$$\min_{f \in H_K} \frac{1}{p} \sum_{i=1}^{p} L\left(f(x_i) - y_i\right) + M \|f\|_K^2 ,$$

where (x_i, y_i), $i = 1, K$, and p are a set of data with $x_i \in \Re^n$ and $y_i \in \Re$, L is a loss function, $M > 0$ is a constant that penalizes non-smoothness, H_K is a space of functions known as Reproducing Kernel Hilbert Space (RKHS) (Aronszajn, 1950; Moguerza and Muñoz, 2006), and $\|f\|_K$ is the norm

of f in the RKHS. The loss function L measures the estimation error of the method and $\|f\|_K$ is a measure for non-smoothness. The smaller $\|f\|_K$ is, the smoother f becomes. This means that the function $f^* \in H_K$ obtained as the solution of this optimization problem will be the result of a compromise between accuracy and smoothness. As a consequence, this way to proceed seems to be a nice approximation for the graduation of demographic data. Moreover, the optimization problem to solve is convex and therefore, without local minima. This convex property is one of the main differences with other methods, avoiding the possible existence of local solutions.

Another key issue of SVM is its ability to map the data into a higher-dimensional space (known as "feature space"). To achieve this task, a kernel approach is used in order to operate in the feature space. A kernel K is a real-valued function $K(x,y) \in \Re$ where usually $x, y \in \Re^n$, which makes the role of a scalar product in the feature space. In this way, the explicit coordinates in this higher-dimensional space are never calculated, as only the inner products between the images of all pairs of data in the feature space are needed. Three of the most widely used kernels: the linear kernel $K(x,y) = x^T y$ which corresponds to the identity mapping; the polynomial kernel $K(x,y) = (c + x^T y)^d$, where c and d are constants, which maps the data into a finitely dimensional space; and the Gaussian kernel $K(x, y) = e^{-\frac{|x-y|^2}{\sigma}}$, where σ is a positive constant, which maps the data into an infinitely dimensional space. The Gaussian kernel, given its approximation capacity, is the most extensively used (Moguerza and Muñoz, 2006), and the one that we suggest for graduation purposes.

In practical implementations of the method, such as the one provided by the software R, the accuracy and smoothing properties are achieved by fixing a band determined by a constant $\varepsilon > 0$ around the solution $f^* \in H_K$. In order to penalize strong violations of the band, another constant $C > 0$ is used. The constant ε makes the role of the loss function and C performs the control of smoothness. As a consequence, three parameters are to be fixed when using SVM with the Gaussian kernel, namely: ε, σ, and C. In practice, a grid of parameters can be determined visually taking into account that the problem at hand is one-dimensional. Then, a so called cross-validation is performed, that is, a random search within the grid is done in order to find the best combination of the parameters.

5. Evaluation and Comparisons

5.1 Numerical Results for Mortality

In our calculations we used the empirical age-specific mortality rates of the male and female populations in Sweden, for the time periods of 1981–1985, 1984–1988, and 1991–1995, as well as those in France and Japan for the years of 1990, 1991, and 1995. The Swedish data sets were taken from Statistics Sweden while the French and Japanese ones were parts of the Berkeley mortality database (2005) available from the web.

For kernel applications, the subroutine "*lokerns*" of the library "*lokern*" for the R-package is used for the calculation of Gasser-Muller estimators with local bandwidth parameter. This is available from http://cran.r-project.org/web/packages/lokern/index.html. In order to select bandwidth for a local linear Gaussian kernel regression estimator, a direct plug-in technique (Ruppert, Sheather, and Wand *et al*., 1995) is used. The initial bandwidth parameter is derived using the KernSmooth library in R package. In particular, for this implementation we obtained an initial bandwidth $h = 2.3849$.

The parameters in the Heligman-Pollard model are estimated using an iterative routine of the Nag library that is based upon a modification of the Gauss-Newton algorithm, described by Gill and Murray (1978). The model was fitted using weighted non-linear least squares, minimizing the following sum of squares:

$$\sum_x w_x \left(\hat{q}_x - q_x\right)^2 \quad (4.1)$$

With weights w_x the reciprocals of the estimated variances of the age-specific mortality rates $w_x = E_x / q_x(1-q_x)$, where E_x is the exposed-to-risk population at age x and q_x is the mortality rate at age x.

For the SVM applications, the subroutine "*svm*" of the library *e*1071 for the *R*-package is used for the derivation of the SVM model parameters. This is available from http://cran.r-project.org/. In order to select the parameters ε, σ, and C for the ε-regression procedure, the previously tioned cross-validation technique was conducted. Since the search within the grid of parameters involves randomness, for the sake of replicability, we provided the final combination of parameters used in the experiments. In particular, the values $\varepsilon = 0.02$, $\sigma = 125$ and $C = 2200$ have been chosen for this SVM implementation.

Although the graphical representation of the observed and the graduated rates is a useful way for deriving conclusions, we also used a statistical criterion in order to evaluate the performance of the alternative estimators. To check the closeness of the graduated rates to the observed ones, we used the χ^2 criterion, (4.1) that was used as minimizing criterion for fitting HP model.

The values of the criterion (4.1) for all the data sets used, and all the graduation techniques applied, are presented in Table 1. Examining these values, one can easily observe that the SVM

Table 1. Values of (4.1) at the exit of the estimation procedure for HP, SVM, and Kernels

	HP	SVM	Kernels
Sweden			
Females			
1981–1985	950	725	2842
1984–1988	861	293	1817
1991–1995	1468	882	2507
Males			
1981–1985	180	717	3813
1984–1988	191	485	3125
1991–1995	268	490	3340
Japan			
Females			
1990	4370	453	1767
1991	3849	568	1859
1995	3516	320	1601
Males			
1990	1140	495	2219
1991	951	300	2047
1995	542	394	2023
France			
Females			
1990	2887	594	3508
1991	1995	639	2897
1995	879	366	1839
Males			
1990	983	786	4685
1991	687	999	4625
1995	987	1117	2697

graduation proves adequate in terms of goodness of fit. Considering the value of 4.1 quantities, these values are lower in all female cases for SVM than for the HP model and kernels for the Swedish and the Japanese data sets. In males, SVM are better than kernels in all cases, they are a bit higher compared to the HP model for the Swedish data and in comparable levels in the French and Japanese data sets.

Figures 1–6 illustrates the results of each technique separately for some chosen cases. It is clear in these figures that the results of SVM are closer to the empirical data than those of HP formula, the later exhibiting some systematic deviations in the early adult ages. It is also clear that SVM provides smoother results than kernels. In order to do that more clearly, we compared only kernels and SVMs (Figures 2A and 4A).

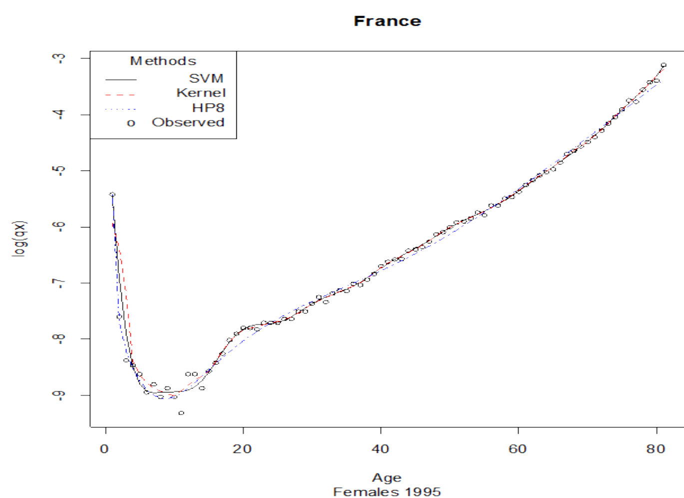

Figure 1. Empirical and graduated q_x-values, French females, 1995.

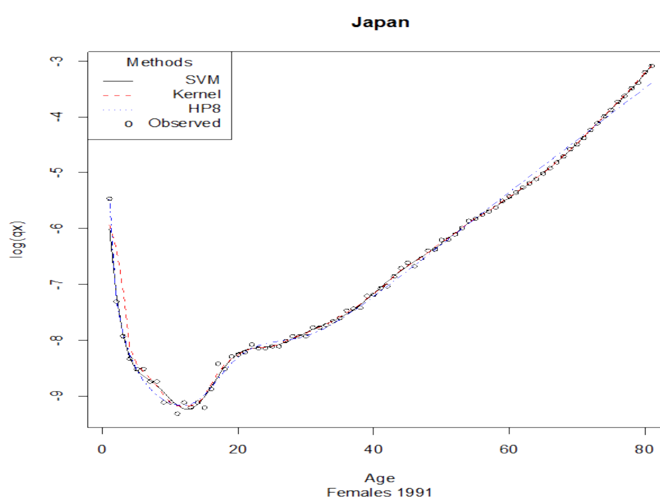

Figure 2. Empirical and graduated q_x-values, Japanese females, 1991.

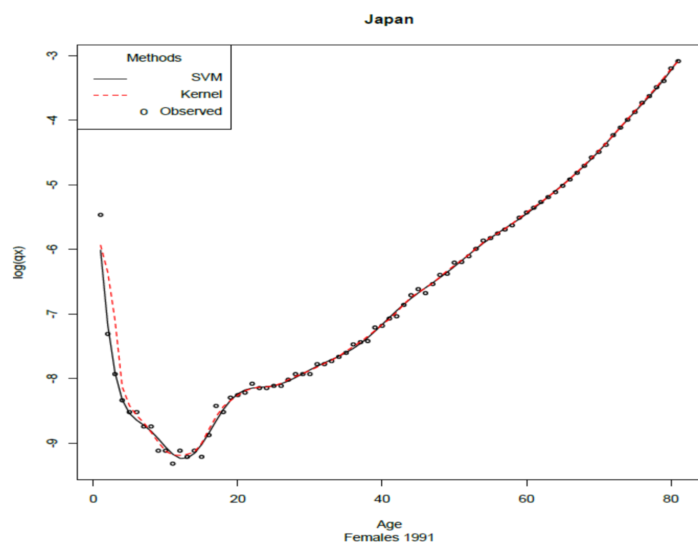

Figure 2A. Empirical and graduated q_x-values, Japanese females, 1991.

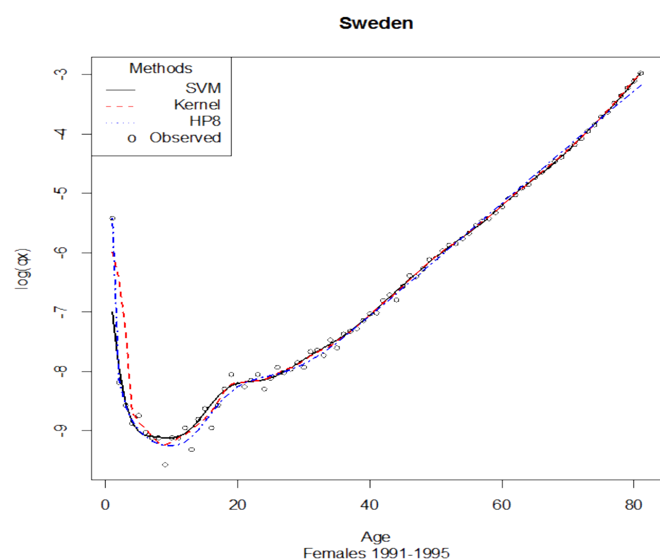

Figure 3. Empirical and graduated q_x-values, Swedish females, 1991–1995.

5.2 Numerical Results for Fertility

In order to evaluate SVM as a tool for graduating age-specific fertility patterns, we used period

age-specific fertility rates for the populations of Sweden, Norway, and Denmark (1996 and 2000); Belgium (1993 and 1995); Greece and Italy (1995 and 2000); UK (1992 and 2000); Ireland (1995 and 2000); the white and black populations of the USA (2003); and for Spain (1942 and 1963). The empirical data sets were obtained from Eurostat New Cronos database (http://www.eui.eu/Research/Library/ResearchGuides/Economics/Statistics/DataPortal/NewCronos.aspx). Additionally, single year age-specific fertility rates for the US were derived for the 2003 Natality Data Set, obtained after a request from the US National Center of Health Statistics (http://www.cdc.gov/nchs/). Cohort data are also used for Spain for the generations born in 1943 and 1962, obtained from the Eurostat New Cronos database. It should be noted that even for cohorts not yet completed, Eurostat provides estimates of the fertility rates for older women by using the rates observed for previous generations, without waiting for the cohort to reach the end of the reproductive period. Parity-specific birth rates were computed as occurrence exposure rates based on parity in marriage.

Then, we applied SVMs and kernels and also provided the fits of the alternative parametric models to these data sets, the latter initially calculated by Kostaki and Peristera (2007). In populations with no apparent early-age hump, except of kernels and SVMs, the fits of Hadwiger, Gamma, and Beta models (Chandola, Coleman, and Hiorns, 1999; Hoem, Madsen, Nielsen *et al*., 1981), P-K model (Kostaki

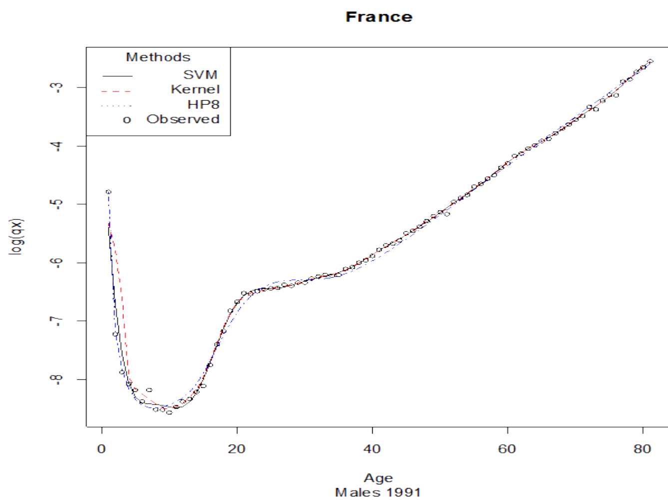

Figure 4. Empirical and graduated q_x-values, French males, 1991.

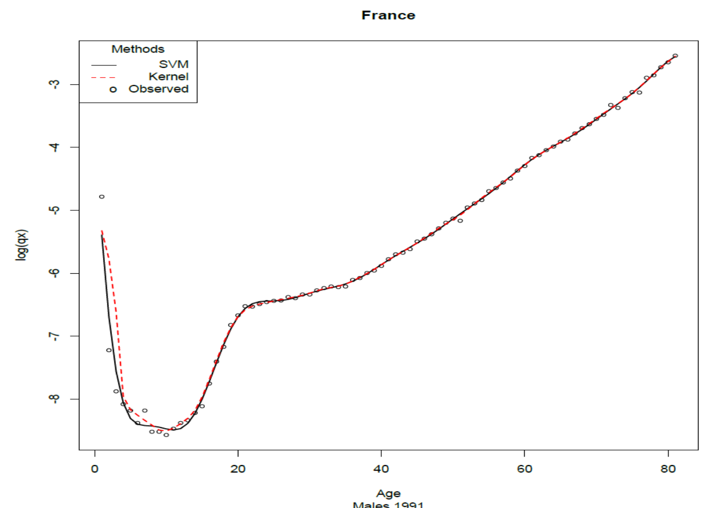

Figure 4A. Empirical and graduated q_x-values, French males, 1991.

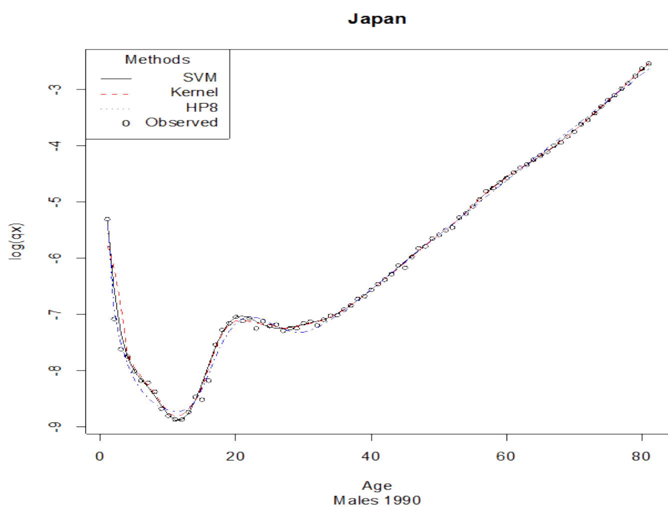

Figure 5. Empirical and graduated q_x-values, Japanese males, 1990.

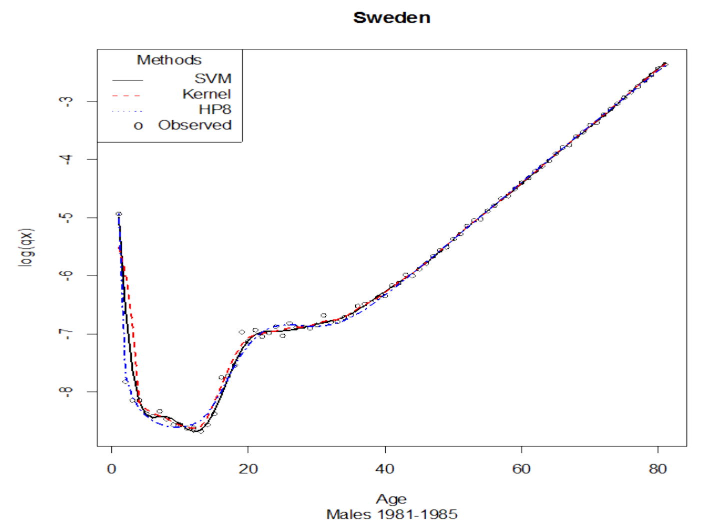

Figure 6. Empirical and graduated q_x-values, Swedish males, 1981–1985.

and Peristera, 2007), and the quadratic Spline model (Schmertmann, 2003) are provided, while in the cases of distorted fertility distributions, the Hadwiger mixture model (Chandola, Coleman, and Hiorns, 1999; 2002) and the P-K mixture model (Kostaki and Peristera, 2007) are provided.

In order to avoid heterogeneity, we also used data differentiated by order of birth from both cohort and period data sets. Finally, in the case of the USA, the fits of the alternative models are provided for the white and the black population separately. Details for fitting the alternative parametric models are given by Kostaki and Peristera (2007).

The parameters of the various models have been estimated by means of a non-weighted non-linear least-squares procedure, minimizing the following sum of squares:

$$\sum_x \left(\hat{f}_x - f_x \right)^2, \tag{4.2}$$

where $\hat{f}_x$ is the estimated marriage rate at age x and f_x is the corresponding empirical one. This minimizing criterion has been used as most appropriate for fertility graduation by Kostaki and Peristera (2007) and also suggested by Hoem *et al*. (1981) as providing equal good fits as the more complicated weighted one, with weights reciprocal to the estimated variances of the age-specific rates, the latter being most appropriate when fitting mortality rates.

For kernel applications, in the case of mortality data, the subroutine "*lokerns*" of the library "*lokern*" for the R-package was used for the calculation of Gasser-Muller estimators with local bandwidth parameter. In a similar way, the initial bandwidth parameter was derived using the KernSmooth library in R package. An initial bandwidth of h =1.9066 was obtained particularly for this implementation.

As in the case of mortality data, for the SVM techniques, the subroutine *svm* of the library *e*1071 for the R-package is used, and a similar two-step cross-validation technique is used to select the parameters ε, σ, and C of the ε-regression procedure. Parameters ε, σ, and C play the same role as explained in the mortality study. In particular, the values $\varepsilon = 0.0001$, $\sigma = 40$ and $C = 1.8$, have been obtained for this SVM implementation.

The values of (4.2) for all the data sets used, and all graduation techniques applied, are presented in Tables 2 and 3. The results of fitting the parametric models were first presented by Kostaki and Peristera (2007). Figures 7–12 provide illustrations for some chosen cases. In all cases, we used ages ranging from 15 to 48, so each schedule has 34 rates.

As stated in the tables and figures, the results of SVM prove superior to the corresponding ones of all the other models. SVM produced results that in the vast majority of cases are closer to the empirical rates, with a sole exception, the results for the USA data differentiated by order of birth and race, where the performance of the P-K mixture model were somewhat superior. Regarding the figures, one can easily observe that the results of SVM were closer to the empirical values especially for the ages in the tails and the peak of the fertility curve.

Table 2. Values of (4.2) multiplied by 100.000, at the exit of the estimation procedure for P-K model, Beta model, Gamma model, Hadwiger model, quadratic Spline model, kernels, and SVM

SSE*10^6	P-K Model	BetaModel	Gamma Model	Hadwiger Model	Quadratic Spline Model	Kernel	SVM
Period Data							
Sweden							
1996	115	108	132	326	174	67	72
2000	117	181	321	689	174	30	11
Norway							
1992	242	175	265	656	263	65	61
2000	233	225	640	329	287	40	10
Denmark							
1992	103	107	130	383	169	54	20

Continued table2

SSE*10^6	P-K Model	BetaModel	Gamma Model	Hadwiger Model	Quadratic Spline Model	Kernel	SVM
2000	225	363	575	1073	287	51	6
Belgium							
1993	401	396	380	540	462	68	15
1995	346	374	376	558	525	78	30
Greece							
1995	190	137	184	289	101	26	14
2000	34	114	491	617	55	14	13
Italy							
1995	20	58	139	352	49	18	11
2000	47	71	524	908	82	14	3
Cohort Data							
Spain							
1943	732	1005	1159	1547	5450	452	562
1962	295	259	1113	184	3720	69	67

Table 3. Values of (4.2), multiplied by 100.000, at the exit of the estimation procedure, for P-K mixture model, Hadwiger mixture, and SVM for the US data

SSE*10^6	P-K Mixture Model	Hadwiger Mixture Model	Kernel	SVM
Period Data Total Births				
UK				
1992	154	35	37	14
2000	99	22	40	14
Ireland				
1995	437	97	62	90
2000	78	177	65	43
Spain				
1999	29	17	30	12
2000	23	15	31	6
Cohort Data Total Births				
Spain				
1963	77	85	59	62
Period Data First Births				
UK				
2004	5	8	47	4
Ireland				
2000	73	53	61	62
Period Data Second Births				
UK				
2004	4	5	45	3
Ireland				
2000	31	31	25	28
USA 2003				
Total	150	28	63	58
White	28	156	63	51
Black	39	190	103	86

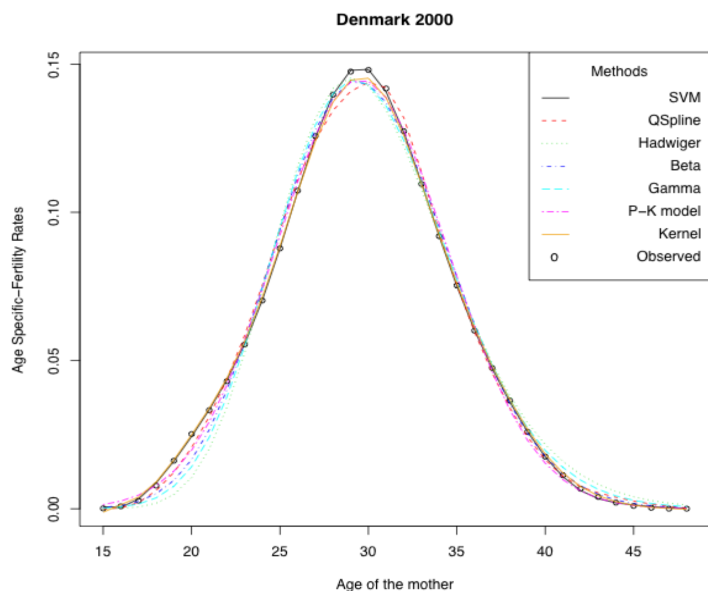

Figure 7. Observed and estimated period age-specific fertility rates for Denmark, 2000.

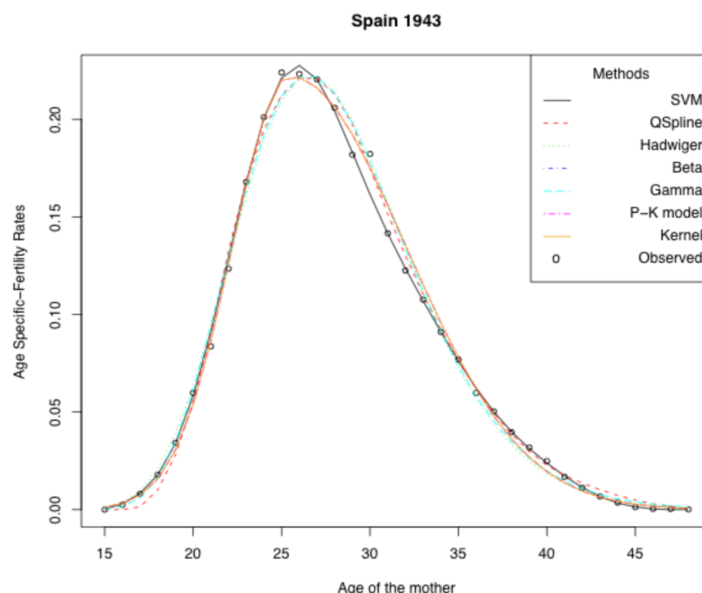

Figure 8. Observed and estimated cohort age-specific fertility rates for Spain, 1943.

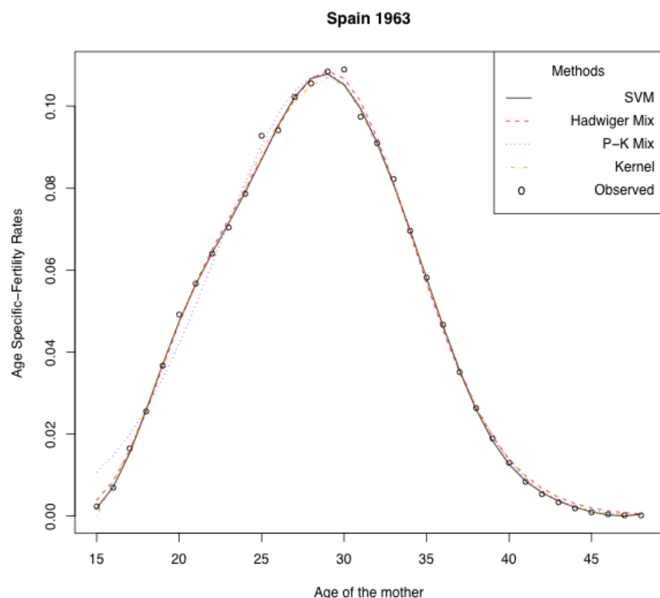

Figure 9. Observed and estimated cohort age-specific fertility rates for Spain, 1963.

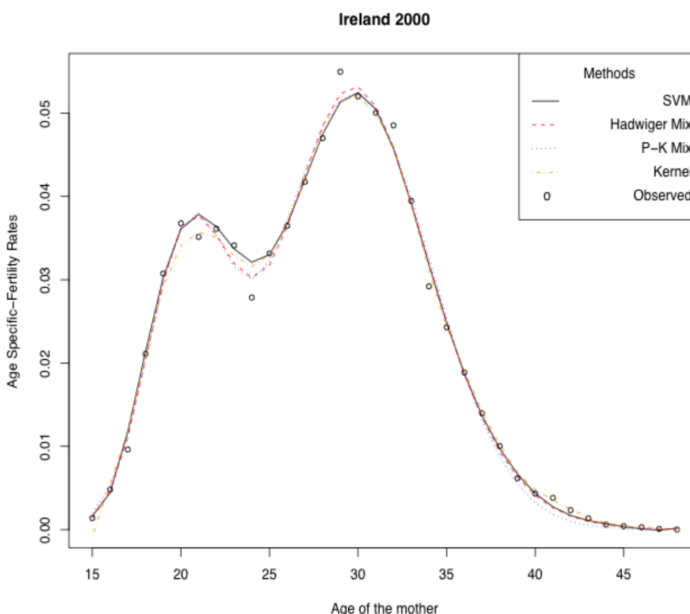

Figure 10. Observed and estimated age-specific fertility rates of Ireland, 2000. First births.

5.3 Numerical Results for Nuptiality

In order to evaluate the adequacy of SVM for nuptiality graduation purposes, we applied SVM to a variety of empirical data sets. For comparison reasons, we also fit the same data sets to the SC-M, C-M, and GLG models. In cases where these simple models fail to adequately estimate the nuptiality pattern in data sets expressing heterogeneity, we fitted the MC and the P-K mixture models.

Once again, for kernel techniques, in the case of mortality and fertility data, the subroutine "*lokerns*" of the library "*lokern*" for the R-package was used for the calculation of Gasser-Müller

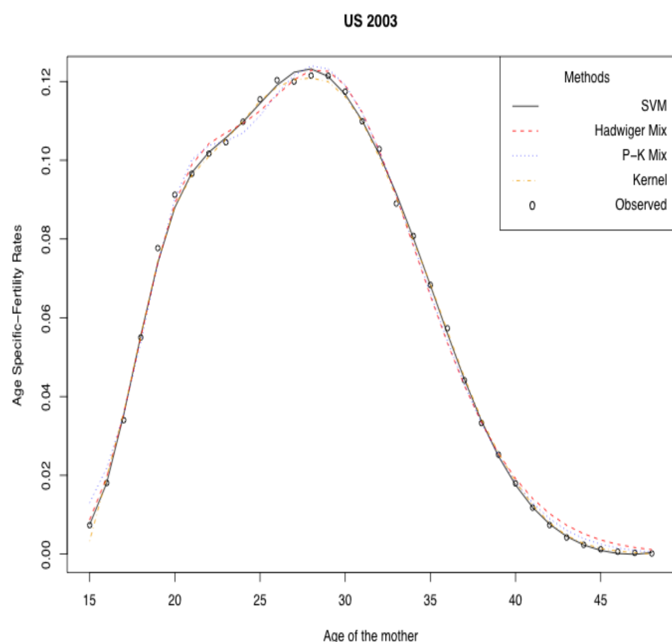

Figure 11. Observed and estimated age-specific fertility rates of US, 2003. 2003. White population.

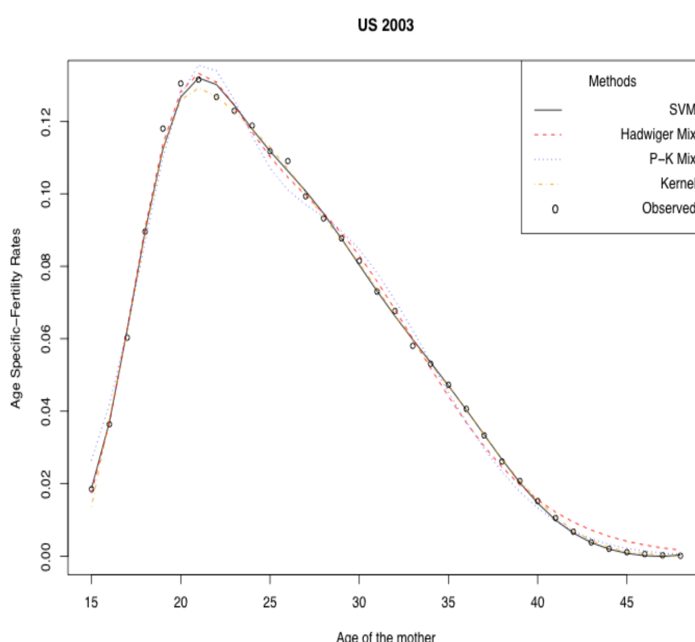

Figure 12. Observed and estimated age-specific fertility rates of US, 2003. Black population.

estimators with local bandwidth parameter. And in a similar way, the initial bandwidth parameter is derived using the KernSmooth library in R package. In particular, for this implementation, an initial bandwidth of h =1.3118 was obtained.

Also, in the case of mortality and fertility data for the SVM applications, the subroutine *svm* of the library *e*1071 for the R-package was used, and a similar two-step cross-validation technique was used to select the parameters ε, σ, and C of the ε-regression procedure. In particular, the values ε = 0.00008, σ = 0.0424, and C = 0.0662, have been obtained for this SVM implementation.

Single-year age-specific first-marriage rates for the female populations of Spain, Greece, Italy, Germany, the Netherlands, Norway, Sweden, Finland, Ireland, and the UK for the available years were used. These data were obtained from the Eurostat New Cronos database (http://www.eui.eu/ Research/Library/ResearchGuides/ Economics/Statistics/DataPortal/NewCronos.aspx).

The parameters of the parametric models are estimated, as in the case of fertility for the same reasons mentioned before, by means of a least-squares procedure by minimizing the following sum of squares.

$$\sum_x (\hat{f}_x - f_x)^2, \tag{4.3}$$

where $\hat{f}_x$ is the estimated first-marriage rate at age x and f_x is the empirical one.

All the parametric models are fitted by means of a non-linear least-squares procedure and a Gauss-Newton optimization scheme. The Matlab built-in routine for non-linear parameter estimation "*lsqnonlin*" was used in order to find the unconstrained minimum of the unweighted sum of squares.

The residual sums of squares are given in Table 4. Furthermore, the empirical and graduated age-specific first-marriage rates for selected years and countries are depicted in Figures 13–22.

The observed and estimated rates of GLG, C-M, and SC-M models as well as of SVM are depicted in Figures 13–19 for the populations of Germany, Greece, Italy, the Netherlands, Norway, Spain, and the UK.

The existence of a bulge at young ages and another one at the older ones becomes obvious in re-

cent Swedish data. The bulge during the young ages appears around age 20 and the older one around age 40. This phenomenon has also started to appear in the data sets of Finland and Ireland. In these cases, simple models fail to closely estimate the tails and the peak value of the marriage distribution. We thus fitted the mixture model MC-M to the data sets. Figures 20–22 provide illustrations of the results.

According to the values of the minimizing criterion, for the majority of the cases the C-M model provides the best fits among the parametric models. The second best fit is usually obtained by the GLG one.

As mentioned above, a variety of factors related to the socioeconomic and cultural background of male and female populations may contribute to the appearance of the heterogeneity in the first-marriage curve. However in order to be able to verify or reject all these hypotheses about heterogeneity in the first-marriage curve, further research based on empirical evidence is required.

Turning now to the SVM, we observed from the values of the residual sum of squares as well as from the graphical illustration, that their performance is superior in comparison to any other parametric approach. In the vast majority of the data sets, the values of the residual sum of squares were in significantly lower levels than those resulting by model fitting. It is probably worth mentioning that this technique works with high accuracy in both homogeneous and heterogeneous data sets, while for the later cases more complicated models are required. Taking a closer look at the figures, we observed that SVM performance is highly superior to parametric modelling, in the peaks and the tables of the marriage distributions where parametric modelling provides systematic deviations from the empirical rates.

Table 4. Values of (4.3), multiplied by 100.000, at the exit of the estimation procedure

FEMALES

SSE*10^6	Standard Coale-McNeil	GLG	Coale-McNeil	Kernel	SVM
Spain					
1995	62308	17358	14058	788	216
2002	46959	14321	12446	731	185
Greece					
2001	54891	8333	63228	331	214
2002	54891	8333	63228	289	329
Italy					
1990	38956	8654	8251	2431	2706
2000	47607	8605	6597	603	312
Germany					
1998	27263	4936	4761	786	517
2001	19583	3331	3137	279	195
Netherlands					
1996	19516	2661	2563	859	1144
2002	40108	8705	8171	372	201
Norway					
1996	29525	8001	7828	1746	3986
2002	20803	5770	5291	352	539
UK					
1996	12060	2271	2226	449	223
1999	214910	10280	10278	759	241

SSE*10^6	Standard Coale-McNeil	GLG	Coale-McNeil	Mixture Coale-McNeil	Kernel
Sweden					
1997	16568	8873	9152	8482	929
2002	32185	18168	17859	26983	327
Finland					
1993	29465	8252	8413	2251	935
1998	23595	8527	8436	6049	833
Ireland					
1993	31352	12977	12975	7389	2032
1998	62918	19153	17110	8563	886

MALES

SSE*10^6	Standard Coale-McNeil	GLG	Coale-McNeil	Kernel	SVM
Spain					
1990	52827	13188	1220	1198	496
2002	22002	9331	9261	656	250
Greece					
1998	22913	5541	5477	334	284
2002	18348	5543	5528	277	283
Italy					
1991	21338	5345	5334	829	240
2000	23853	7017	6624	360	181
Germany					
1993	13191	3127	3084	428	567
1998	21424	5043	4609	317	670
Netherlands					
1995	2350	15534	15534	603	783
2003	19898	6130	5924	195	327
Norway					
1997	13648	6041	6041	872	1744
2001	10697	4134	4138	171	228
UK					
1999	21491	3126	3088	281	288
2000	20437	2469	2460	215	223

SSE*10^6	Standard Coale-McNeil	GLG	Coale-McNeil	Mixture Coale-McNeil	Kernel	SVM
Sweden						
1997	4827	3904	3822	8482	519	1039
2001	7135	5411	5382	26983	211	273
Finland						
1995	8290	3377	4350	2251	398	453
2002	12020	7793	7791	6049	305	346
Ireland						
1996	13788	4468	4422	7389	242	317
1998	34290	12541	11680	8563	808	281

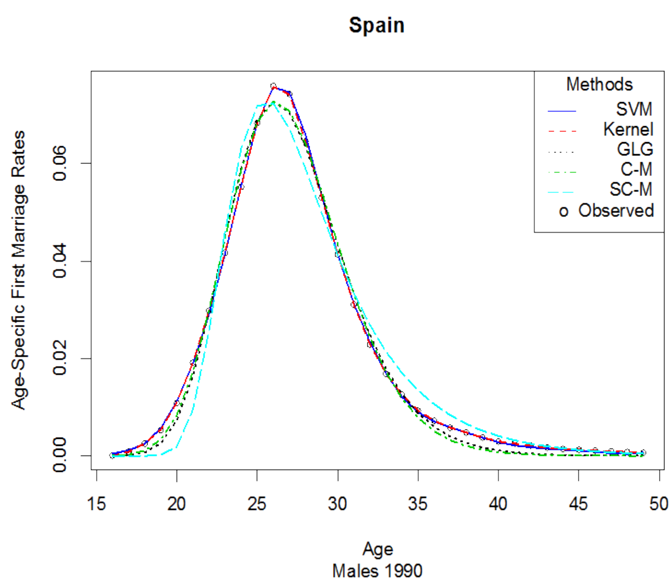

Figure 13. Observed and estimated age-specific nuptiality rates, Spain, males,

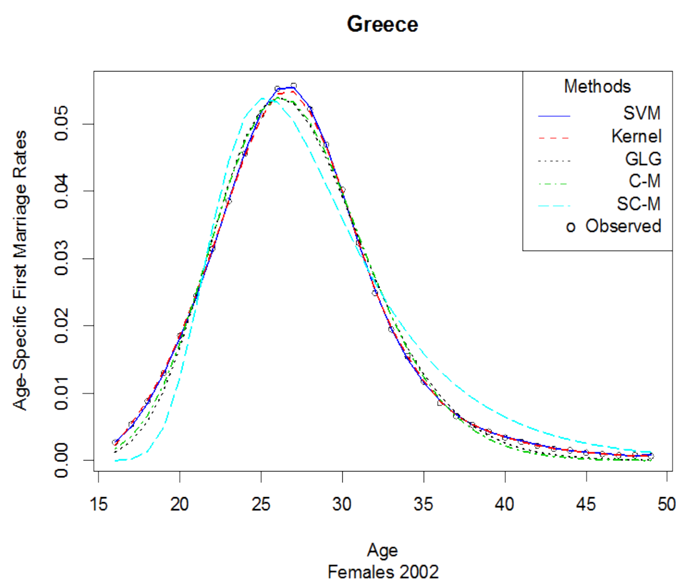

Figure 14. Observed and estimated age-specific nuptiality rates, 1990 Greece, females, 2002.

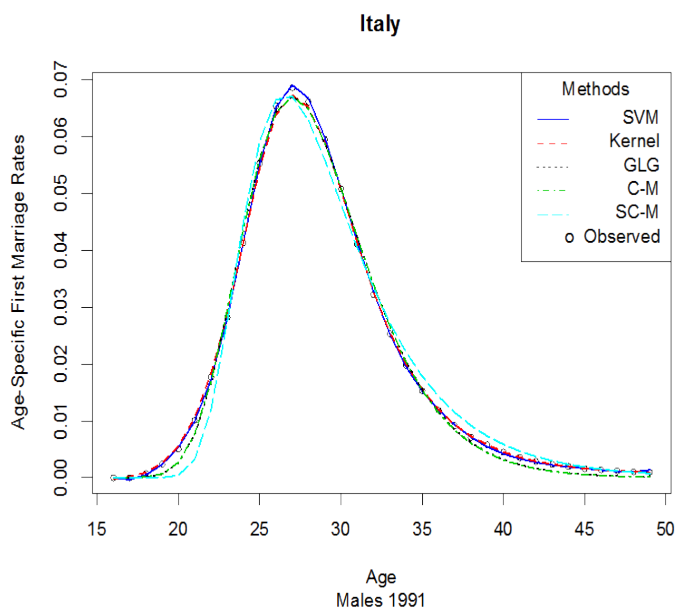

Figure 15. Observed and estimated period age-specific fertility rates, Italy, males, 1991.

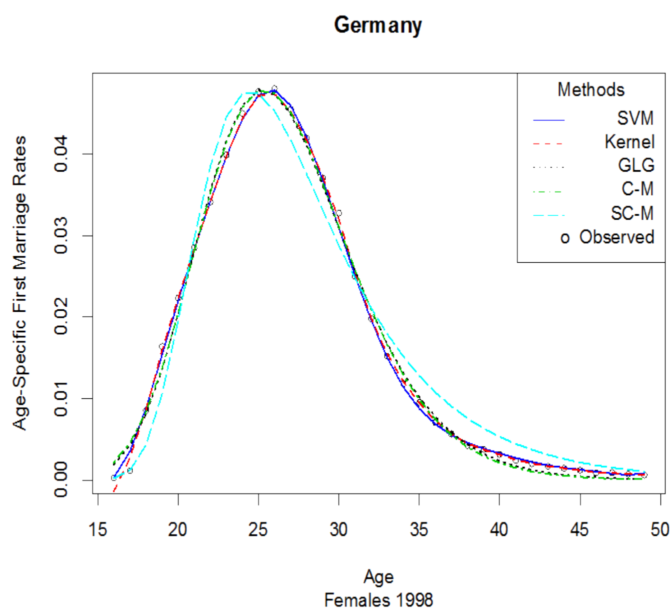

Figure 16. Observed and estimated age-specific nuptiality rates, Germany, females, 1998.

6. Conclusions

In this paper, we evaluated and compared SVMs and kernels for graduating age-specific demographic rates. The performance of these two nonparametric techniques has been evaluated by applying them to a set of empirical mortality, fertility, and nuptiality rates of different populations and time periods. Moreover, parametric models are fitted to these rates in order to compare their effectiveness. With regards to the values of the typical minimization criteria, the results for the two nonparametric techniques are apparently closer to the empirical values than those provided by the para-

metric models. This performance is probably due to the higher smoothness capacity of parametric models. A higher degree of smoothness may lead to larger distances between the graduated and the empirical values and, in many cases; it provides oversimplifications of the described patterns or systematic deviations between the empirical and the graduated values. Concerning the comparison between SVMs and kernels (the two nonparametric techniques), SVMs provided results, usually with lower values of the minimizing criteria.

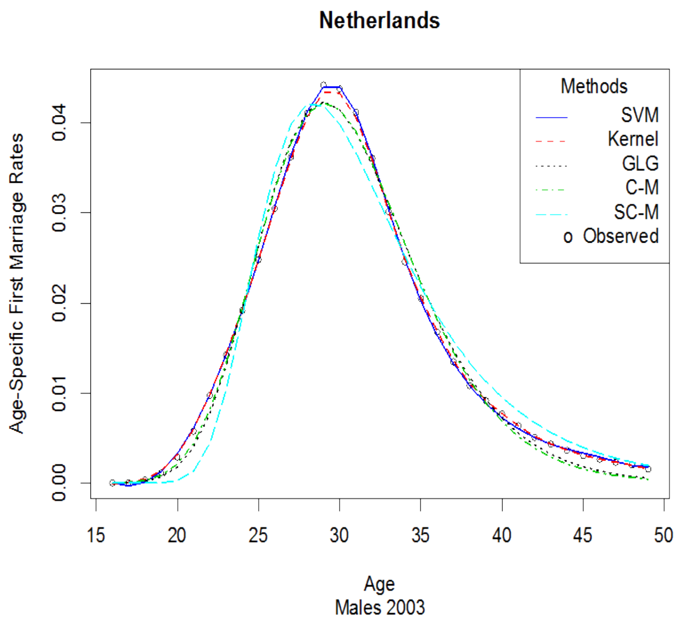

Figure 17. Observed and estimated age-specific nuptiality rates, the Netherlands, males, 2003.

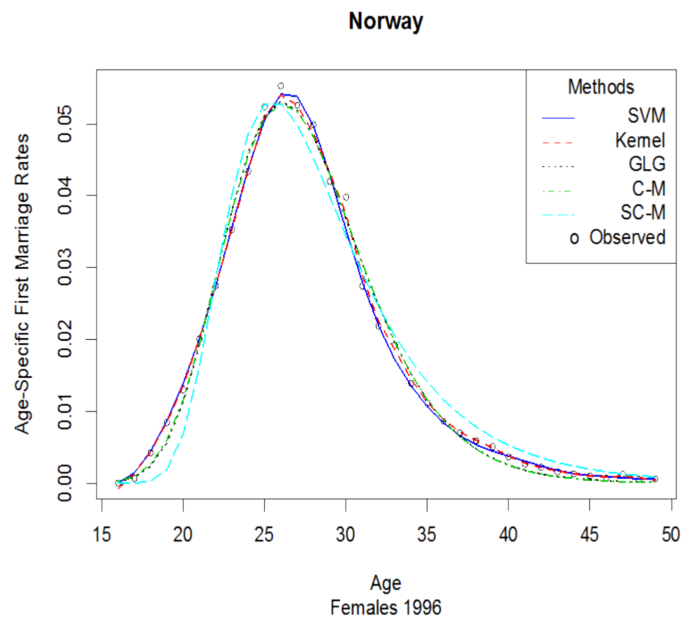

Figure 18. Observed and estimated age-specific nuptiality rates, Norway, females, 1996.

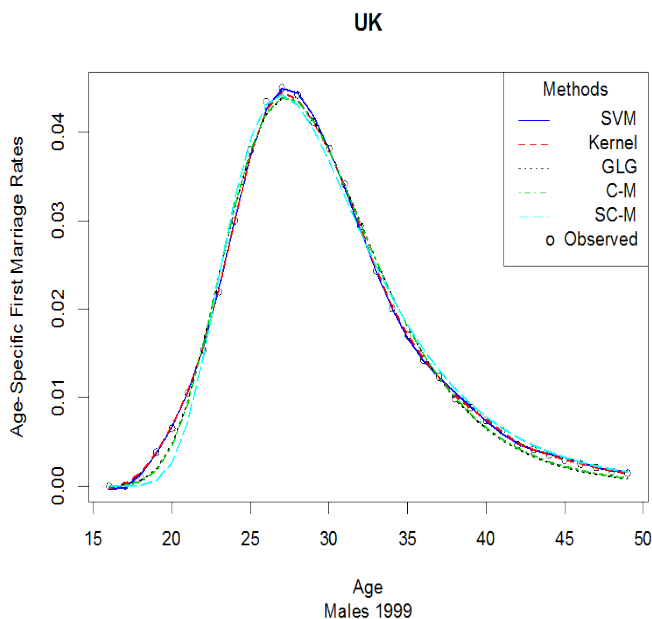

Figure 19. Observed and estimated age-specific nuptiality rates, the UK, males, 1999

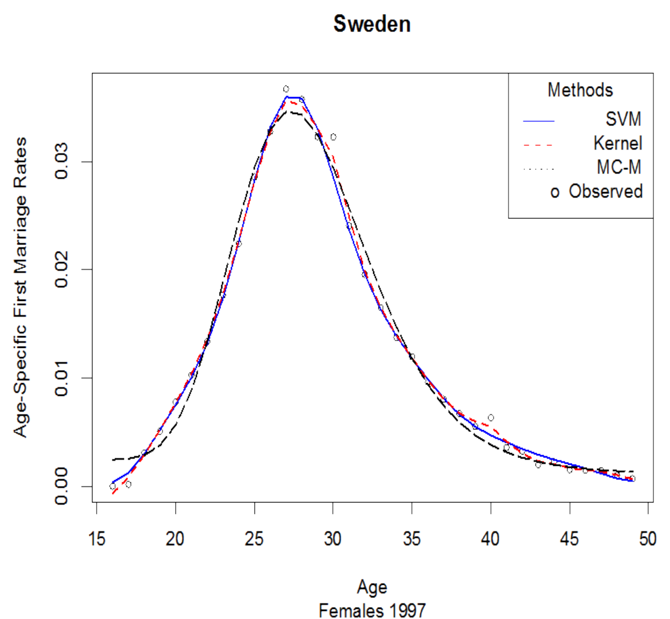

Figure 20. Observed and estimated age-specific nuptiality rates, Sweden, females, 1997.

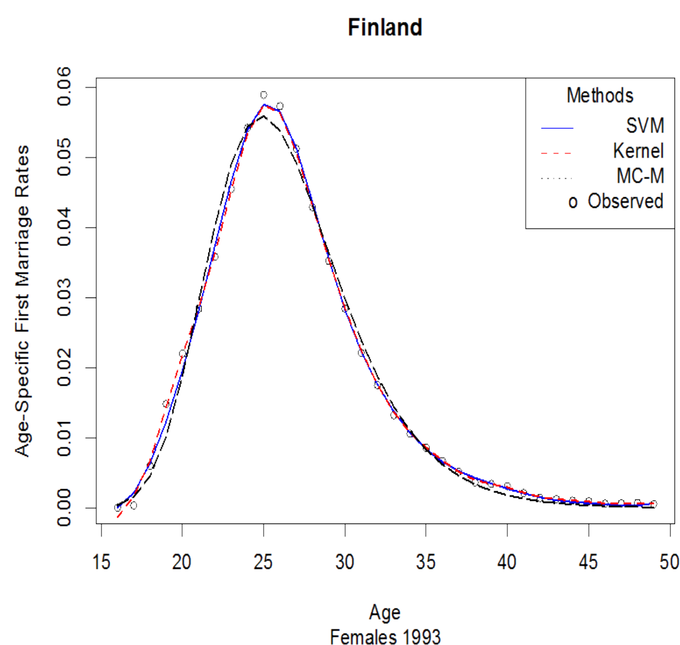

Figure 21. Observed and estimated age-specific fertility rates, Finland, females, 1993.

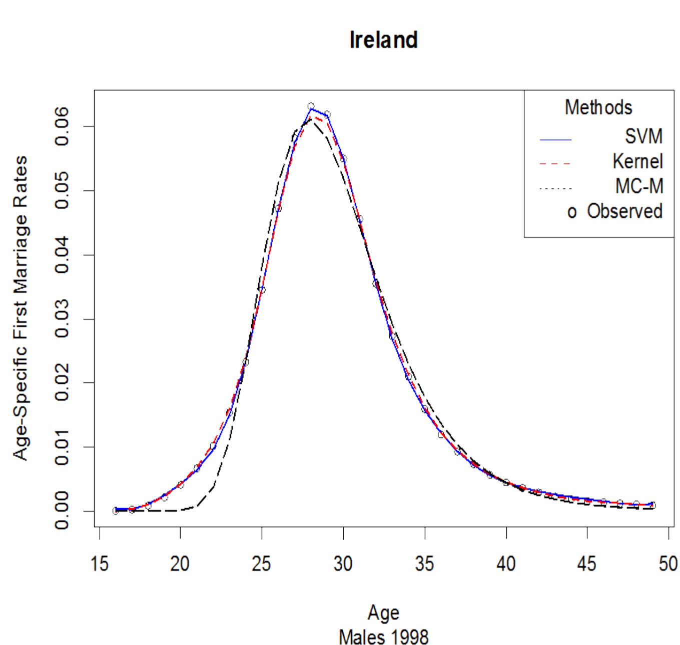

Figure 22. Observed and estimated age-specific nuptiality rates, Ireland, males, 1998.

In addition, the SVM method produces results closer to the empirical rates in most cases, showing a successful performance for the graduation of empirical rates in both simple and distorted data sets. It can be observed in the figures that the results provided by SVM were closer to the empirical data than those of most alternative methods, especially for ages in the peak and the tails of nuptiality and fertility.

Nonparametric graduation techniques have the advantage of being suitable to all data sets. This is an important remark, as for data sets with distorted patterns; the use of standard parametric models is inadequate. Another advantage of the nonparametric approach is that the user has the possibility of regulating the degree of smoothness and, as a consequence, choosing a degree adapted to the goal of the graduation framework, avoiding in many cases oversimplification of age patterns.

As a future extension of the current work, we propose the use of SVM as a multivariate model for demographic forecasting.

Conflict of Interest and Funding

No conflict of interest has been reported by the authors. This research is partially financed by the Research Centre of Athens University of Economics and Business, in the framework of the project entitled “Original Scientific Publications”; and projects GROMA (MTM2015-63710-P), PPI (RTC-2015-3580-7), and UNIKO (RTC-2015-3521-7), funded by the Ministry of Economy and Competitiveness (Spain).

Acknowledgements

We would like to thank the editor and the reviewers for their constructive comments and their valuable insight, which led to significant improvements.

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International Journal of Population Studies

RESEARCH ARTICLE

Monitoring adult mortality by type of residence in the absence of death registration: a perspective from Burkina Faso

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Abstract: In the context of the post 2015 agenda, disaggregation of mortality indicators is needed to assess health inequalities within populations. However, producing sub-national estimates of adult mortality is notably difficult in the absence of death registration. Using Burkina Faso as a case study, this paper revisits the main avenues to quantify differences in adult mortality between the ages of 15 and 60 according to urban/rural residence. Estimates are based on reports on the survival of parents and siblings collected in surveys and in the 2006 census, and compared to levels inferred from recent household deaths or inferences based on child mortality. Results indicate that in Burkina Faso, adults living in urban areas still benefit from a health advantage compared to their rural counterparts. Thus, efforts made in reducing adult mortality in rural settings should be intensified. In terms of methods, this analysis shows the value of asking additional questions about the place of residence of close relatives to avoid misclassification errors. The approach adopted here could be implemented in other countries to facilitate the measurement of spatial inequalities in health indicators for all ages when monitoring Sustainable Development Goals (SDGs).

Keywords: adult mortality, Burkina Faso, indirect techniques, urban, rural, SDGs

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Received: September 3, 2015; **Accepted:** October 16, 2015; **Published Online:** October 20, 2015

Citation: Lankoande Y B. (2016). Monitoring adult mortality by type of residence in the absence of death registration: a perspective from Burkina Faso. *International Journal of Population Studies*, vol.2(1): 21–37. http://dx.doi.org/10.18063/IJPS.2016.01.004.

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1 Introduction

Historically, European cities were long characterized by higher mortality rates, a phenomena referred to as the "urban penalty", while cities in Sub-Saharan Africa have long benefited from a comparative advantage, due to colonial health policies that were very favorable to large urban centers (Leon, 2008). As many health determinants (such as education, sanitation, access to health services, and wealth) are better on average in urban areas, it is generally assumed that urban residents in Sub-Saharan Africa benefit from better health conditions compared to their rural counterparts (Leon, 2008; Montgomery, 2009). Hence, mortality rates by urban/rural location are regularly monitored to track progress made in reducing the gap in mortality, initially with a focus on rural health, but with a particular attention on urban health in recent years (Fink, Günther, and Hill, 2014; Bocquier, Madise, and Zulu, 2011). Yet, most of these studies were limited on child survival and findings, mainly based

on the Demographic and Health Surveys (DHS), show that the urban advantage is weakening overtime. This is partly due to the development of slums associated with rapid and poorly managed urbanization in Sub-Saharan Africa (Kimani-Murage, Fotso, Egondi *et al.*, 2014). This particular focus on child survival fit well within the context of the Millennium Development Goals (MDGs), but adult health is now as important on the global health agenda. Coupled with the strong desire to place equity in a central role in the Sustainable Development Goal (SDG) framework ("no one should be left behind"), disaggregation of adult mortality indicators by urban/rural location is now imperative to track progress in a world that is becoming both older and more urban (United Nations, 2015).

A better monitoring of adult mortality by place of residence is more important than ever in Sub-Saharan Africa; available evidence shows that rapid urbanization could be a threat to adult health. In contrast to most rural areas where infectious and parasitic diseases remain the leading causes of deaths, urban settings of Sub-Saharan Africa are often characterized by a "double burden of diseases," particularly among urban poor (Ramroth, Lorenz, Rankin *et al.*, 2012; Awini, Sarpong, Adjei *et al.*, 2014; Agyei-Mensah and de-Graft Aikins, 2010). While wealthy adults are at higher risk of non-communicable diseases due to lifestyle (smoking, alcohol consumption, physical inactivity), and inadequate diet habits (diets too rich in sugar, salt, fat), the urban poor bear simultaneously the burden of infectious and non-communicable diseases (Soura, Lankoande, Millogo *et al.*, 2014; Mberu, Wamukoya, Oti *et al.*, 2015). For instance, slums are a favorable ground for some infectious diseases such as malaria and tuberculosis, and at the same time their inhabitants tend to consume cheaper energy dense food that promote obesity, a risk factor for non-communicable diseases (Neiderud, 2015; Zeba, 2012). Furthermore, mental disorders and injuries seem to be more prevalent in urban settings of Sub-Saharan Africa (Dyson, 2003; Kobusingye, Guwatudde, and Lett, 2001). In summary, it is simplistic to always consider the urban environment as a "safer place" for adults, compared to rural areas. Poor sanitary and living conditions experienced by rural dwellers may be offset by health problems related specifically to urban residence.

Despite its relevance for the global health agenda, research on urban/rural differentials in adult mortality in Sub-Saharan Africa is still largely limited by the scarcity of data. While much is known about child mortality, the measurement of adult mortality is hampered by the lack of reliable data and the absence of very robust estimation methods. In the absence of civil registration data, estimates derived from surveys and censuses are prone to recall errors and selection biases (Reniers, Masquelier, and Gerland, 2011). These problems are magnified when looking at differentials.

Census reports on the number of household members who died in the last 12 months are a common source of data on adult mortality by place of residence. However, these data are subject to many errors, including omissions of deaths due to recall errors and household dissolutions after a death of an adult, but also fieldworkers' related errors, coverage errors, and errors on the reference period (Timæus, 1991). Adult mortality rates published in census reports are sometimes also inferred from child mortality rates combined with model life tables, but this practice is not recommended because mortality in children and adult do not always evolve in the same direction (Masquelier, Reniers, and Pison, 2014). This approach is even more problematic when deriving estimates of adult mortality by place of residence, because nothing guarantees that urban/rural differentials are invariant by age. Child mortality rates are dominated by infectious diseases which are more prevalent in rural areas, while chronic conditions that disproportionately affect adults are typical of urban areas.

Apart from census estimates, it is possible to derive mortality rates from survey reports on the survival of close relatives, such as parents or siblings. Nevertheless, estimates based on these methods are also not exempt of problems (Helleringer, Pison, Kanté *et al.*, 2014; Reniers, Masquelier, and Gerland, 2011). Mortality rates obtained from the survival of parents are related to the past and dating estimates is only possible under some assumptions. Data on survival of siblings provide the opportunity to directly estimate adult mortality but estimates may be altered by underreporting of deaths. Nevertheless, beyond these general issues related to the estimation, deriving estimates of adult mortality by place of residence is even more challenging since information on the place of res-

idence of close relatives is not collected in surveys such as DHS. To the best of my knowledge, no attempt was made in the literature to estimate adult mortality by place of residence based on orphanhood data. However, few studies have used sibling survival data collected in the "maternal mortality module" of the Demographic and Health Surveys (DHS) to explore urban/rural differences in adult mortality in Sub-Saharan Africa. Their findings are not consistent, and this is likely due to the different approaches adopted to circumvent the issue raised by the lack of information on the place of residence or death of the siblings. De Walque and Filmer (2013) assumed that women and their siblings share the same place of residence and concluded to a slightly higher mortality in rural areas of Sub-Saharan Africa. It was an analysis of pooled data on sibling survival collected in 84 DHS surveys from 46 countries (33 of which were in Sub-Saharan Africa). The datasets covered the period of 1975–2004 and adult mortality was measured as the risk of dying between the ages of 15 and 55. In addition to the issue of the sibling's place of residence, the aggregated analysis conducted by the authors will hide cross-country variations in the urban/rural disparities in adult mortality. Also based on sibling survival data of the DHS datasets, Günther and Harttgen (2012) documented urban/rural mortality differences at the country level in 14 Sub-Saharan countries. The risk of dying between the ages of 15 and 45 was used as a measure of adult mortality. In complement to the approximation made by De Walque and Filmer (2013), their analysis was restricted to siblings reported by women who spent their entire life in an urban (rural) area. They found that in the 2000s, out of 14 countries, urban adult mortality rates were *higher* than rural mortality rates for 11 countries. For example, in Burkina Faso, urban/rural adult mortality ratio rose from 1.09 during the 10 years before the 1998 DHS to 1.33 also ten years before the 2003 DHS. These results were totally inconsistent with estimates published in Burkina Faso's census reports where an excess mortality in rural areas was documented in 1984, 1995, and 2006 (INSD, 1989; 2000a; 2009a).

Faced with these inconsistent results and limitations inherent in the different methods, this paper uses Burkina Faso as a case study to explore new strategies for providing better disaggregated mortality indicators in countries lacking vital registration. Existing research on differentials in adult mortality by urban/rural location are extended in two directions. First, I revisit together, the main estimation methods that were used in isolation in previous studies despite their limitations. This includes the application of the orphanhood method that has never been used to look at mortality differentials by urban/rural location. Second, the impact of limitations related to the different techniques on mortality differentials is assessed by further analysis and thanks to the use of a specific survey conducted in 2000 which included questions on the place of residence and deaths of parents. The study covers approximately the 1989–2006 period and starts with the presentation of the study setting. Adult mortality by urban/rural location is then computed using indirect methods and multiple data sources. The estimates are discussed and reconciled to offer a coherent picture of urban/rural adult mortality differences in Burkina Faso. Lastly, I discuss technical issues related to adult mortality estimation by place of residence in Sub-Saharan Africa in general, and draw conclusions for the measurement of differentials.

2 Data and Methods

2.1 Study Setting

Burkina Faso is one of the poorest countries in the world, with a population estimated at 14 million inhabitants in 2006 (INSD, 2009b). The population size has grown at an annual rate of 3.1% between the two last censuses (1996–2006), but the annual growth rate in the urban areas is as high as 7.1%, more than twice the national average (INSD, 2009b). In recent years, the country has experienced a rapid and poorly managed urbanization. As a result, a growing number of urban dwellers live in slum-like conditions. For example, the share of slum dwellers was estimated at 30% in Ouagadougou, the capital city (Boyer and Delaunay, 2009). The urbanization process is mainly driven by rural exodus, emergence of new cities, and spatial extension of large urban centers such as Ouagadougou

(INSD, 2009c). The capital is among the fastest-growing cities in the world. Even though the population is essentially rural (77% in 2006), it is expected that urban population will take over in 2050 (United Nations, 2014). However, the health indicators in Burkina Faso are not very encouraging. The under-five mortality rate is still high, reaching a level of 10.4% in urban areas and 15.6% in rural areas (INSD, 2012). Data on adult mortality are scarce, but the probability ${}_{45}q_{15}$, estimated at 30.4% in men and 26.8% in women in 2005, was higher than that observed in countries such as Senegal and Niger (IHME, 2014). According to IHME (2015), in 2013, communicable diseases were the leading causes of death in adults aged 15–49 while non-communicable diseases represented the major causes of death in adults aged 50–69.

2.2 Data

Adult mortality is measured as the probability of dying between 15 and 60 years of age (${}_{45}q_{15}$). Three types of data sources are used in this paper to estimate mortality levels. The corresponding sample sizes by urban/rural location are presented in the Appendix (Table A3). It is important to mention that the definition of urban and rural residence changes over time, from one census to another. An economic criteria was used in the 1996 census, but an economic and population size criteria was retained in 2006 (INSD, 2009c). The definition used in DHS is based on the definition adopted in the most recent census (INSD, 2004; INSD, 2012).

2.2.1 Census Reports on Recent Household Deaths

To date, four censuses have been conducted in Burkina Faso to monitor demographic trends (1975, 1985, 1996, and 2006). However, it is unclear whether data from the 1975 census have been properly archived. Samples of individual-level data from censuses conducted in 1985 and 1996 are freely available online through the Integrated Public Use Microdata Series (IPUMS), but the urban/rural status is missing. Thus, only the census of 2006 is used here to estimate adult mortality, based on data collected on the number of deaths in each household in the twelve months preceding the census.

2.2.2 Data on Sibling and Parental Survival from Demographic and Health Surveys (DHS)

Data from DHS conducted in Burkina Faso in 1993, 1998/1999, 2003, and 2010 are used in this study. Funded by the U.S. Agency for International Development (USAID), these surveys are a key data source to assess population dynamics and their health in countries lacking vital registration systems. The data are freely available online and are representative at the urban/rural level. In the 1993, 2003, and 2010 surveys, children aged less than 15 years were asked about the survival status of their parents (mothers and fathers). In surveys conducted in 1998/1999, 2003, and 2010, each woman interviewed was also asked to list all her siblings born to the same mother. For each sibling, information was collected on their date of birth, sex, survival status, current age for those who were alive, age at death, and number of years since death for those who had died prior to the survey.

2.2.3 Orphanhood Data from the Migration Dynamics, Urban Integration and Environment Survey (EMUIB)

Census and DHS data are complemented with a survey (EMUIB) conducted in Burkina Faso in 2000 by the Demography department of the University of Ouagadougou and has never been used so far to estimate mortality. This survey was representative at the national and urban/rural levels. In total, 9188 individuals aged between 15 and 64 years old were interviewed. The overall objective was to provide reliable and relevant information on urban planning in Burkina Faso and topics such as migration and employment were covered (for a full description of the survey design, see Poirier, Piché, Le Jeune *et al*. (2001)). The questionnaire included a set of questions on parental survival and, unlike in other surveys, the place of residence at the time of survey or at the time of death of parents was also collected. This is an added value compared with DHS data where information on parents'

place of residence at the time of the survey or at the time of death is usually not collected.

2.3 Methods

The different techniques used to estimate differences in urban/rural mortality levels in Burkina Faso are presented in this section. The choice of these methods was mainly guided by the availability of data. For each method, adult mortality rates, and confidence intervals around estimates (if relevant) were computed according to urban/rural residence for each sex. The datasets used in each estimation technique, the reference period for the estimates, the sample description, and the approximations of the place of residence are reported in Table 1.

Table 1. Datasets used, reference period, sample description and approximation of the place of residence for each estimation method

Estimation method	Datasets	Sample description	Approximation of the place of residence	Reference period for male mortality	Reference period for female mortality
Growth balance	Census 2006	Household heads reporting on deaths among adults aged 15–60 years old	Household's place of residence	2006	2006
Direct estimation from sibling survival data	DHS 1999	Women aged 15–49 years old reporting on the survival of their siblings	Women's place of residence	1992–1997	1992–1997
	DHS 2003			1998–2003	1998–2003
	DHS 2010			2004–2009	2004–2009
Orphanhood	DHS 1993	Children aged 5–9 years old and 10–14 years old, reporting on the survival of their parents	Children's place of residence	1988	1987,2; 1989,4
	DHS 2003			1998,5	1997,8;2000,0
	DHS 2010			2005,6	2004,8; 2007,0
	EMUIB 2000	Young adults aged 15–19 years old; 20–24 years old and 25–29 years old, reporting on the survival of their parents	Parent's place of residence	1989,8; 1991,4	1989,4; 1990,9;1992,6

2.3.1 Estimating Adult Mortality from the Growth Balance Method

Data collected on the number of deaths in each household were discarded by the National Institute of Statistics (INSD) when deriving mortality estimates from the 2006 census. The published estimates of adult mortality were obtained from child mortality rates combined with model life tables. Even though the estimation method is not entirely clear in the official report, it seems that child mortality rates were estimated indirectly from reports on the number of children ever born and still alive (INSD, 2009). This approach is inadequate because trends in child and adult mortality do not always evolve in the context of Sub-Saharan Africa. In Burkina Faso, DHS estimates indicate that child mortality rates have declined substantially in recent decades, while adult mortality rates have mostly stagnated, although the reason for these divergent trends is undetermined (Masquelier, Reniers, and Pison, 2014).

To move away from the child-mortality matching approach used by the INSD, I estimated for each place of residence, adult mortality using the Growth Balance Method (GBM) developed by Brass (1975). Its principle is to estimate the completeness of the reporting of deaths relative to an estimate of the population under the assumptions that the population is stable, is closed to migration and that the completeness of underreporting of deaths is constant above a certain age limit. This estimate which is an indicator of data quality, is then used to adjust mortality rates upward to account for incompleteness of death reporting (Moultrie, Dorrington, Hill *et al*., 2013). To reduce the sensitivity of the method to internal migration, which can be a great concern in a country such as Burkina Faso, the completeness estimates were obtained solely from reported deaths among adults aged 35 and above, because they are less likely to migrate (Beauchemin, 2011). With this method, there was no need to compute confidence intervals because estimates were derived from the census data.

2.3.2 Estimating Adult Mortality from Orphanhood Data

The rationale behind the orphanhood method is to convert proportions of respondents classified by

five-year age groups whose mother (father) is still alive into survivorship ratios using a set of coefficients (obtained from simulations). The mean age at childbearing of women (men) is used to control for variations in the fertility schedule, which affects the exposure time. Survivorship ratios are then converted into summary indices of adult mortality using one parameter of a relational logit model table (Moultrie, Dorrington, Hill *et al.*, 2013). Finally, estimates are located in time under the assumption that mortality trends have been linear. Coefficients used in this paper to convert proportions into survivorship ratios are those proposed by Timæus (1992), and the time location procedure is the method developed by Brass and Bamgboye (1981). In addition, since DHS and EMUIB data are samples of the entire population, confidence intervals are required to statistically compare levels of adult mortality between urban and rural areas. Orphanhood estimates are seldom presented with confidence intervals, and there is no standard way to obtain them. Here, I computed 95% bootstrap-based confidence intervals of estimates in each place of residence (2000 replicates). The bootstrap technique has proven useful over the years to estimate robust confidence interval without making strong assumptions about the distribution of estimates (Efron and Tibshirani, 1993). To the best of my knowledge, this method has never been used to compute confidence intervals based on orphanhood data.

The estimates derived from the DHS and EMUIB data were obtained from the survival of parents of young children (5–9, 10–14 years old), and young adults (15–19, 20–24, 25–29 years old) respectively. I also applied the orphanhood method on data collected during the 2006 census and the multiple indicator cluster survey (MICS) conducted in 2006. The corresponding results are not commented in the main text because there are in line with estimations derived from EMUIB and DHS data (Appendix, Table A1 and Figure A1).

The orphanhood method does not assume that the population is closed to migration, but a major issue in applying the method with data disaggregated by place of residence is the lack of information on the urban/rural status of parents. In DHS surveys, only the place of residence of children at the time of the survey is known. I used this information as a proxy for the parents' place of residence at the time of the survey or at the time of death. By contrast, in the EMUIB survey, it is possible to correct for this and assess the impact of misclassification of parent's place of residence on differences in urban/rural adult mortality. For this survey particularly, to investigate the variation in the quality of data by place of residence that may affect the estimates, I compared by urban/rural location and for each age group, the proportion of surviving parents, reported by men and women (Appendix, Table A2).

2.3.3 Estimating Adult Mortality from Sibling Survival Data

Unlike the two methods presented above, sibling survival data provide an opportunity to "directly" estimate adult mortality rates. With the information provided by each interviewed woman (15 to 49 years) on her siblings, it is possible to compute mortality rates by dividing the number of deaths by the population at risk for a given period and age group. However, because adult mortality is a relatively rare event, and sample sizes in DHS are too small to derive age- and period-specific estimates without introducing some smoothing, mortality rates were derived from a quasi-Poisson model for this analysis. The data file was reshaped in person-periods and the dependent variable was the number of deaths. The age group, sex, and place of residence (urban/rural) were used as explanatory variables. This approach, introduced by Timæus and Jassey (2004), also generates confidence intervals. As suggested by Masquelier (2013), no attempt was made to weigh the data to account for selection biases, and I assume that mortality does not vary with the number of adult siblings.

Although the sibling survival method does not rely on many assumptions, the quality of data is an issue, particularly the underreporting of deaths due to recall biases. Evidence abounds of decay in the completeness of death reporting among siblings when the time interval between the death and the survey increases (Masquelier, Reniers, and Pison, 2014; Obermeyer, Rajaratnam, Park *et al.*, 2010). To account for this, mortality estimates were restricted to the 6 years prior to each survey. The choice

of this cutoff point also helped to keep the sampling errors at an acceptable level for the analysis and to attenuate the effect of heaping for five years prior to the survey (Bicego, 1997).

A major drawback also related to the estimation of adult mortality by place of residence using sibling survival data is the difficulty to apprehend siblings' place of residence. The DHS surveys do not collect information on the place of residence of siblings at the time of survey or at the time of death. To address this issue, the place of residence of interviewed women was tested as proxy for the place of residence of their siblings. Misclassification of siblings' place of residence may thus lead to misinterpretation of differences in urban/rural mortality levels, particularly when migrations flows are important (Bicego, 1997).

3 Results

3.1 Growth Balance Method (GBM)

Estimates of adult mortality obtained by place of residence and by sex in 2006 from the GBM, and from the census official report are presented in Table 2. The completeness of death reporting was higher in urban areas compared to rural areas (80.5% and 73.5% respectively), suggesting that data quality issues are more prevalent in rural areas. The estimates were also higher than those published in the census report (except for women in rural areas). Disregarding these methodological differences, the value of the probability $_{45}q_{15}$ was higher in rural areas than urban areas according to both sources. In the estimates presented here, the urban-rural differentials in mortality were lower among men with a ratio of urban to rural mortality of 0.7. This ratio rose to 0.9 in women. As expected, the levels of male mortality were higher than those of female mortality.

Table 2. Estimates of $_{45}q_{15}$ (per 1000) from the GBM and results published in the census' official report by sex and according to urban/rural residence in Burkina Faso in 2006

	Men			Women		
	Urban	Rural	Urban/rural Ratio	Urban	Rural	Urban/rural Ratio
GBM	270.2	366.1	0.7	215.2	248.6	0.9
Census report	220.0	321.5	0.7	183.6	280.3	0.7

3.2 Orphanhood Method

Figure 1 presents trends in adult mortality obtained from orphanhood data collected in the 1993, 2003, and 2010 DHS according to place of residence and sex of parents. For men, only one estimate was obtained from each dataset (because the estimation of male mortality requires that reports from two adjacent age groups be combined). For women, two estimates were derived from each dataset (based on 5–9 and 10–14 year-olds).

Overall, in urban as well in rural areas, adult mortality rates seem to have fallen since 1988 to 2005 for men, and since 1987 to 2007 for women. Quite surprisingly, urban residents seem to have experienced a slight mortality increase in the late 1990s and the early 2000s. This counterintuitive result is likely due to the issue raised by the approximation of parents' place of residence (those who are at risk of dying) by their children's place of residence. Over the whole period considered, values of $_{45}q_{15}$ were on average higher in urban areas compared to rural areas. In men, these inequalities in mortality seem to have widened over time in favor of the rural settings. In women, the gap of urban/rural mortality was most pronounced in the first half of the 2000s.

By using parents' place of residence in the estimation, thanks to data collected in the EMUIB survey (Figure 2), the mortality differentials were reversed in favor of urban areas in men, and the gap widened in favor of urban areas in women. In men, when children's place of residence is used as proxy for their parent's place of residence, values of $_{45}q_{15}$ were far higher in urban areas than in rural areas. However, a lower mortality in urban areas was obtained when parents' place of residence at

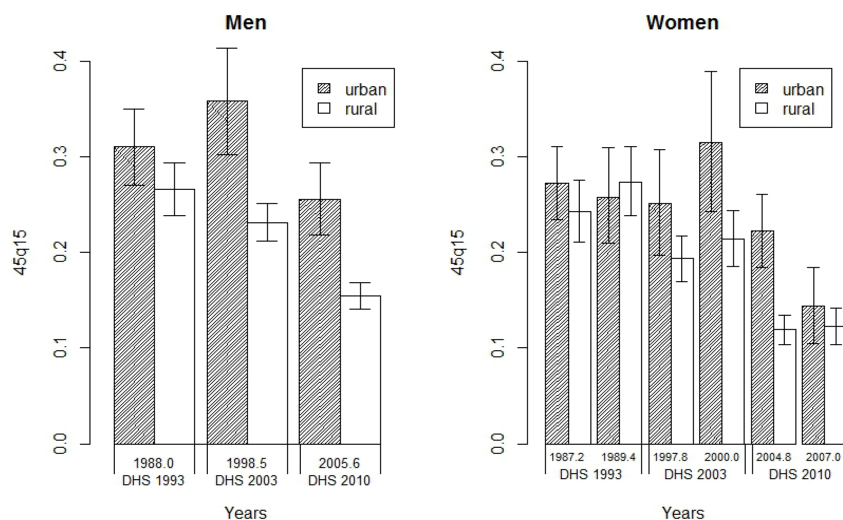

Figure 1. Estimates of adult mortality with bootstrap confidence intervals (95%), by sex and according to place of residence (DHS orphanhood data).

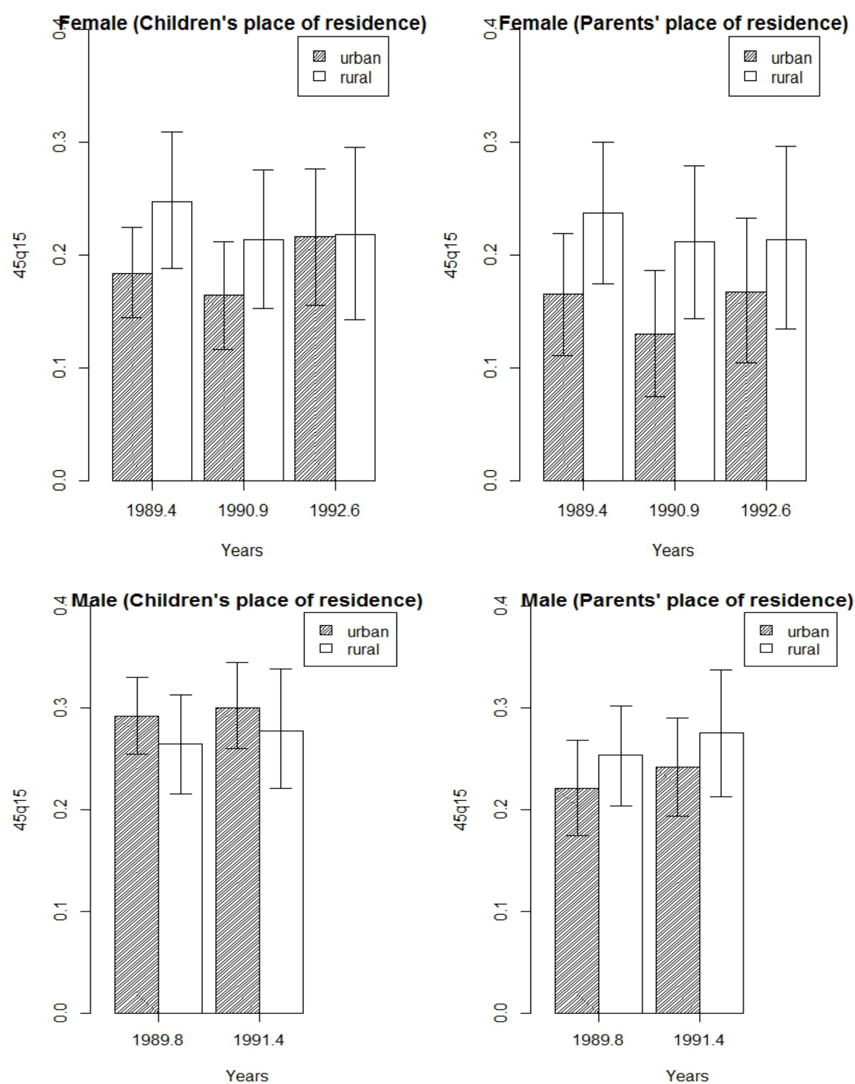

Figure 2. Estimates of adult mortality with bootstrap confidence intervals (95%), by sex and according to place of residence (EMUIB orphanhood data).

the time of the survey or at the time of death is used to assess the gap in mortality. In women, estimates obtained by using children's place of residence yielded an urban advantage. This advantage was reinforced when parent's place of residence were taken into account.

These results suggest that information on children's place of residence is not a good proxy for their parents' place of residence. In addition, misclassification errors seem to operate differentially according to the sex. Nevertheless, even if urban areas benefit from a slight advantage, this difference is not significant at the 0.05 level, because confidence intervals considerably overlap in each period.

3.3 Sibling Survival Histories

Estimates of adult mortality based on sibling histories are presented in Figure 3 for both types of residence. The dating procedure is more precise here (compared to orphanhood estimates) and the availability of three surveys provides a rough idea on the trend in mortality. On the one hand, adult mortality rates have decreased since 1990s to 2000s in urban areas. This mortality decline was more marked among men. On the other hand, rural areas experience stalls, sometimes reversals, in adult mortality. Rural areas tend to have an advantage in terms of adult mortality that fades over time. In the period of 1992–1997, for men as well as women, the value of ${}_{45}q_{15}$ in urban areas was around 0.4 while this value was less than 0.3 in rural areas. An inverse situation was observed in the period of 2004–2009, with higher mortality in rural areas. However, for each period, confidence intervals largely overlap, indicating that DHS sample sizes are too small to detect any significant difference. Again, I should reiterate that the place of residence of interviewed women was used as a proxy for their sibling's place of residence.

To assess the quality of sibling survival histories in the different DHS, Figure 4 shows the mean number of siblings reported by the five-year age group of respondents. This number is the average parity of the respondents' mother; it should be closed to the completed fertility in Burkina Faso, and should increase with the respondents' age since fertility has declined in recent decades. Two major observations stand out from these plots. First, the average parity is globally higher in urban

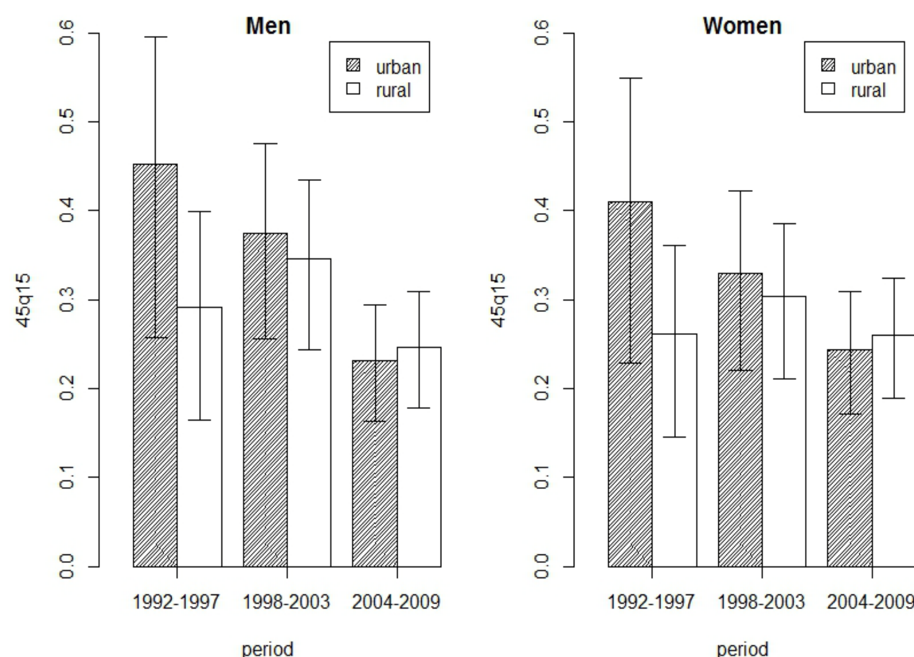

Figure 3. Estimates of adult mortality with 95% confidence interval, by sex and according to place of residence based on siblings survival data from 1992 to 2009 (DHS data).

areas compared to rural areas in 1999 and 2003. The same pattern is observed in the 2010 DHS among older respondents (30–49 year-olds). Second, the average number of siblings declines with the respondent's age in rural areas, and it remains stable in urban areas. These results are surprising, because fertility is higher in rural areas in Burkina Faso, and over the years, it has declined both in urban and rural areas (Shapiro and Gebreselassie, 2009). The patterns observed here are likely caused by rural exodus of women or a pronounced omission of women's siblings in rural areas. As reported by Stanton *et al*. (2000), as well as Masquelier and Dutreuilh (2014), it is likely that older respondents disproportionately omit to report all of their siblings. These omissions seem to be more marked in rural areas, and if related to adult death, it is likely that adult mortality will be underestimated, particularly in these settings. This could be explained by the low level of education among interviewed women and misunderstanding of local language by fieldworkers in rural areas (Johnson, Grant, and Khan, 2009).

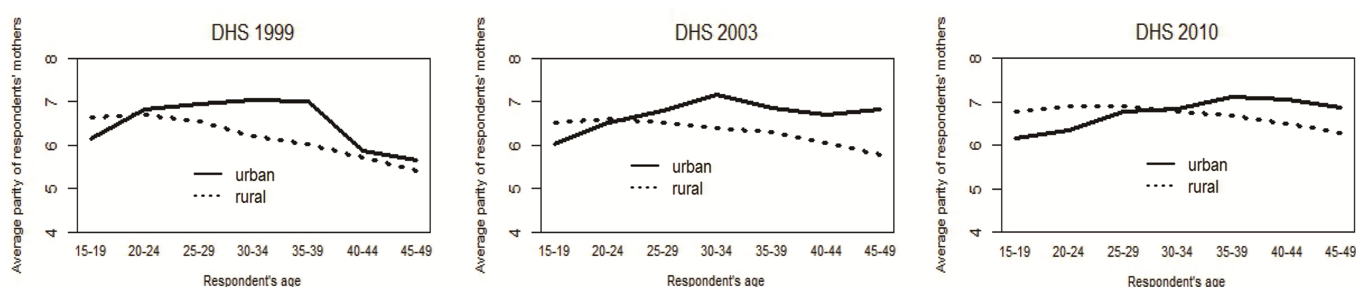

Figure 4. Average parity of respondents' mothers by respondents' age and place of residence according to each round of survey (DHS data).

3.4 Summary

Figure 5 presents estimates of differentials in urban/rural mortality derived from the different sources and methods. Estimates derived from the orphanhood method applied on DHS are discarded from this plot, since those obtained from the EMIUB survey are to be preferred.

Among men as well as women, an urban penalty is unlikely from 1989 to 2006, if one remembers that sibling survival data overestimate adult mortality in urban areas and underestimate adult mortality in rural areas. It is only since around 1994 that adult mortality appears to be particularly lower in rural areas. These estimates were derived from sibling survival data of the DHS conducted in 1998/1999. A cursory evaluation of data quality indicates that this survey is not as reliable as the others. For example, the percentage of deaths which were reported without any information on "age at death" and "years since death" was respectively 2.7% and 0.2% in 2003 and 2010 respectively, while it was as high as 8.5% in 1998/1999 (INSD, 2000b; 2004; 2012).

4 Discussion

At first glance, the picture of differentials in urban/rural mortality derived from the different methods is inconsistent. While the orphanhood method produced mixed results, the growth balance method tends to conclude to an urban advantage in the recent period, and sibling histories data suggest that urban areas suffer from a penalty that is vanishing overtime. This highlights the crucial need to restrain from drawing any firm conclusion on differentials based on a particular technique of estimation in isolation. The different estimates have to be screened in order to come up with a better measurement of urban/rural differentials in adult mortality. Despite technical issues related to the estimation (issues of assumptions, data quality, and selection effects), and the administrative problem in defining urban areas, a systematic analysis shows that an urban disadvantage in terms of mortality is unlikely in Burkina Faso.

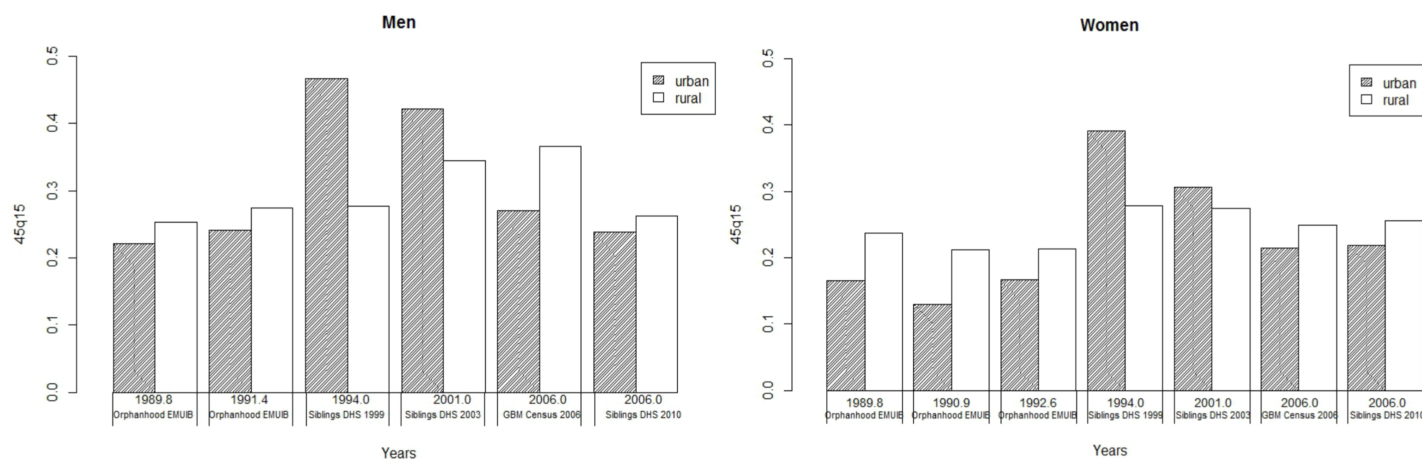

Figure 5. Estimates of adult mortality in Burkina Faso by place of residence and sex according to different sources and methods, from 1989 to 2006.

A common limitation of the application of the growth balance method to measure adult mortality in sub-geographical units is the issue of migration. The method could be adjusted to take into account internal migration flows between urban and rural areas, but such data are rarely available (Bhat, 2002; Hill and Queiroz, 2010). In the case of urban/rural differentials in mortality in Burkina Faso where migration flows are mainly from rural to urban areas, discarding migration effects will result in an underestimation of mortality in urban areas and an overestimation in rural areas (Moultrie, Dorrington, Hill *et al*., 2013). The approach adopted here by limiting the estimation of the completeness of the reporting of deaths on people aged 35 years and more, seems to yield consistent results. Estimates do not seem to be affected by migration since it is possible to get a straight line in each case by plotting the partial births against the partial deaths (Figures A2 and A3 in the Appendix). In addition, the completeness of death registration was high enough, both in urban (80.5%) and rural areas (73.5%). This limits the effect of adjusting for completeness on the final mortality estimates in the two settings (Moultrie, Dorrington, Hill *et al*., 2013). In summary, estimates derived from the growth balance method for each place of residence are acceptable.

The EMUIB survey allows bypassing a major problem encountered when applying the basic orphanhood method in sub-national geographic units using DHS data, as respondents and parents do not always share the same place of residence (Moultrie, Dorrington, Hill *et al*., 2013). Indeed, the urban disadvantage observed in orphanhood estimates in DHS data (based on reports from children), is likely due to the effect of the practice of child fostering in Burkina Faso. A common practice in the country is to move children from one family to another for schooling or housework (Dabiré, 2001; Serra, 2009). Based on the definition adopted by Grant and Yeatman (2012), the DHS data indicate that the prevalence of child fostering varies greatly with place of residence in Burkina Faso. For example, in 2010, only 7.6% of children under 15 were fostered in rural areas whereas this figure rose to 17.2% in urban settings. In addition, orphanhood prevalence was higher in fostered children compared to non-fostered ones in both urban and rural areas. By using children's place of residence as a proxy for their parent's place of residence, a fraction of deaths occurring in rural areas was therefore transferred to urban areas, and those of the urban areas were allocated to rural areas. The problem raised by the misclassification of parent's place of residence is likely to play against urban areas because flows from rural to urban areas are more important. A great share of urban growth in Burkina Faso is still explained by internal migration (Guengant, 2009). I can conclude that mortality levels based on DHS data are overestimated in urban areas, and underestimated in rural areas, yielding a spurious "urban penalty." When data on the survival of young adult's parents were used to estimate the difference in mortality between urban and rural areas, the urban disadvantages vanishes, as shown in Figure 2, even though the difference in favor of the urban advantage is

not significant. In addition, these estimates are not impacted by variation in the quality of data according to urban/rural location (Appendix, Table A2). Except, for the 20–24 year-old age groups in rural areas, proportions of surviving parents reported by men and women are not statistically different at the threshold of 5%. The urban/rural mortality differentials derived from data on young adults collected during the EMUIB survey are probably the most reliable, but they are only available for the late 80s and early 90s.

Estimates based on sibling histories present the advantage of depicting the trend in adult mortality by place of residence in a relatively long period. However, the major issue related to these estimates is the approximation of the place of residence of the siblings of interviewed women. In the absence of migration data, I made the assumption that siblings and interviewed women share the same place of residence. This approach has been adopted in previous studies (Bicego, 1997; De Walque and Filmer, 2013); however, it is problematic when migration flows are important. Another possibility was to limit the analysis to siblings of interviewed women who had never migrated before the survey as experimented by Günther and Harttgen (2012). This may lead to a selection bias if siblings of migrant women are affected by lower or higher mortality compared with siblings of non-migrant women. In contrast with previous research which ignored or did not quantify the impact of these approximations of sibling's place of residence on mortality differentials, further analysis shows that adult mortality is likely overestimated in urban areas and underestimated in rural areas. First, from the experience I have drawn from the orphanhood method applied on data collected during the EMUIB survey, it is clear that a large amount of deaths occurring in rural areas are transferred to urban areas and the opposite is done with deaths occurring in rural areas, but with a lesser magnitude. This suspicion is strengthened by the higher sibships reported in urban areas compared to rural areas on average. Second, from the analysis of the mean number of reported siblings, I saw that there is a more pronounced underreporting of siblings in rural areas and if related to adult deaths, it is likely that mortality is underestimated in rural areas. In summary, an urban disadvantage is not likely, what appeared in early periods is probably spurious and generated by the misclassification of sibling's place of residence, and by the poor data quality mainly in rural areas.

By carefully analyzing the case of Burkina Faso, the results presented in this paper showed that the urban disadvantage in adult mortality put forward by Günther and Harttgen (2012) is improbable, even though the differences in favor of the urban areas found here are not significant. Such a conclusion is reinforced by estimates derived from the different Health Demographic Surveillance Systems (HDSS) located in Burkina Faso. By taking the HDSS of Ouagadougou as a proxy for the urban areas and the other HDSS located in the country (Nouna, Nanoro, Kaya) as proxies for rural areas, one can again observe that adult mortality (45q15) is lower in urban areas (for the period of 2009–2011) (Sié, Soura, Derra *et al.*, 2015). Taken together, these results support the argument that urban adults in Burkina Faso still benefit from better health conditions. Although the dynamic of differentials in urban/rural mortality is still somewhat erratic and difficult to depict based on the available evidence, the urban environment continues to be negatively associated with adult mortality in Burkina Faso. Despite the global concern about the rising burden of non-communicable diseases in least developed countries associated with urbanization, urban dwellers still live longer than their rural counterparts in Burkina Faso. Efforts made in reducing adult mortality in rural settings should therefore not be abandoned.

Beyond the case of Burkina Faso, this paper highlighted the need for additional information on the type of residence of close relatives to obtain a better picture of adult mortality differences by urban/rural location in countries without death registration. Given that expansion of data collection in large programs such as DHS will not happen in a near future, the comparative approach taken here could be implemented in other countries when measuring spatial inequalities in health indicators for all ages in the context of the SDGs. The availability of untapped sources of data particularly on migration (e.g., EMUIB in Burkina Faso, the 2009 migration and remittances household surveys in Senegal), may help to correct data on the survival of siblings and parents for a better measurement of the levels and trends in spatial inequalities in mortality.

Conflict of Interest and Funding

No conflict of interest has been reported by the author

Acknowledgments

The author is particularly grateful to Bruno Masquelier who gave useful insights on indirect techniques of mortality estimation. I also thank Philippe Bocquier, Abdramane Soura and Andrea Verhulst for revising the first draft of this paper. Thanks are also given to researchers involved in EMUIB's project, who allowed me to have access to the data.

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Appendix

Table A1. Estimates of adult mortality (per 1000) by sex and according to place of residence (MICS orphanhood data)

Men			Women		
Date	Urban	Date	Urban	Date	Urban
2001.3	243.2	231.1	2002.7	206.4	133.1
			2000.6	149.0	141.7

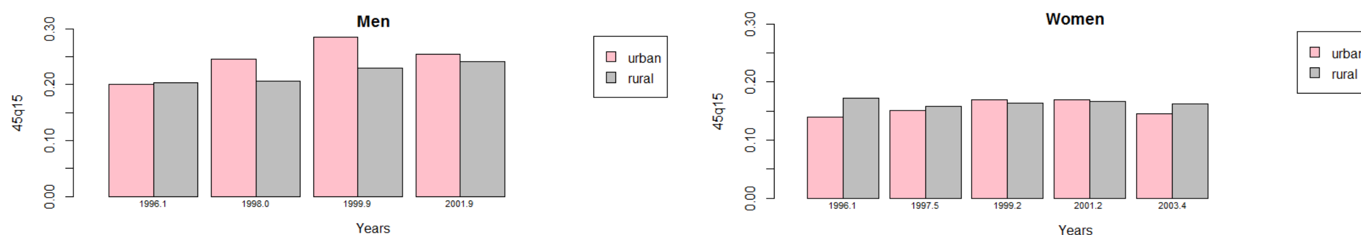

Figure A1. Estimates of adult mortality by sex and according to place of residence (Census Orphanhood data)

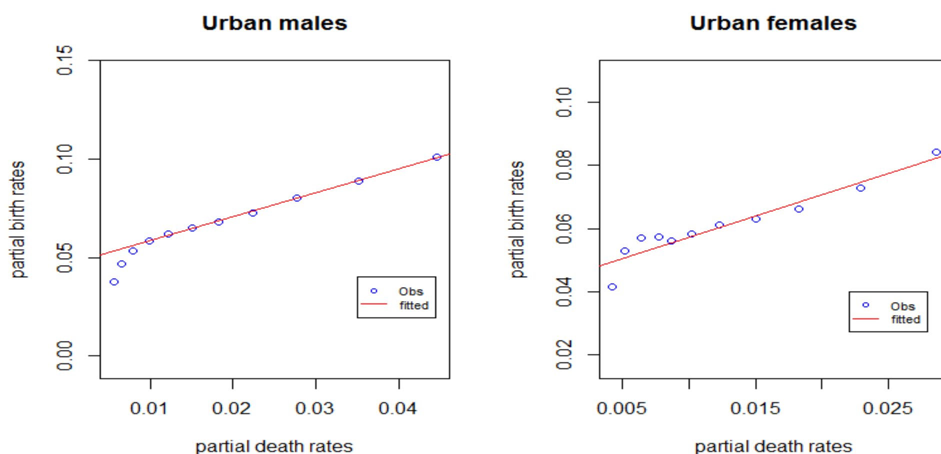

Figure A2. Diagnostic plots from GBM, by sex in urban areas, census 2006.

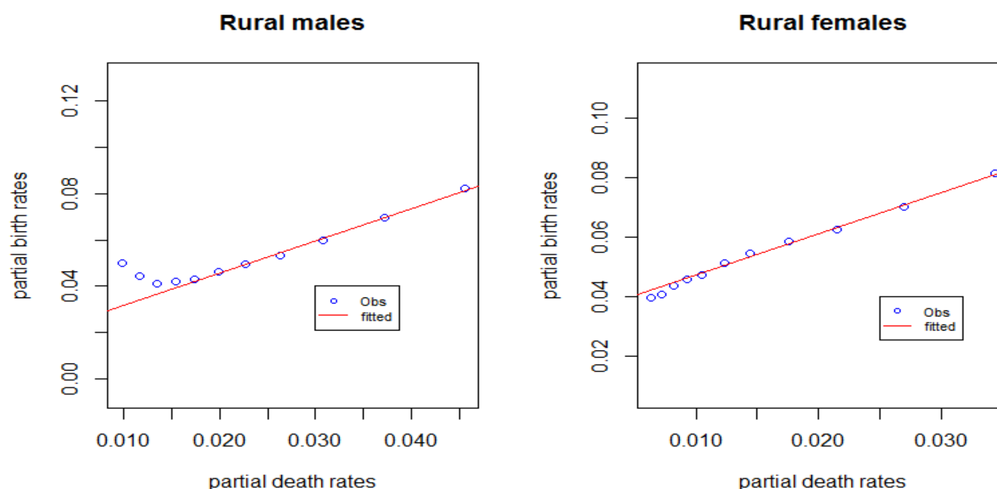

Figure A3. Diagnostic plots from GBM, by sex in rural areas, census 2006.

Table A2. Comparison of the proportion of surviving parents reported by men and women, according to urban/rural location

		Urban			Rural		
Sex (parents)	Age group	Male	Female	Proportion-test (P. values)	Male	Female	Proportion-test (P.values)
Male	15–19	0,8775	0,8475	0,5728	0,7957	0,8493	0,6095
	20–24	0,7384	0,813	0,3232	0,8082	0,742	0,0177
	25–29	0,7224	0,7347	0,7111	0,6632	0,6876	0,4166
Female	15–19	0,9567	0,9311	0,1371	0,9505	0,8948	0,2875
	20–24	0,9505	0,9257	0,1249	0,9056	0,8786	0,5382
	25–29	0,9202	0,843	0,1725	0,8717	0,7936	0,9615

Table A3. Sample size by sex and place of residence for each data set

Estimation method	Datasets	Sample description	Individuals reported in sample size	Number of individuals				Number of deaths			
				Men		Women		Men		Women	
				Urban	Rural	Urban	Rural	Urban	Rural	Urban	Rural
Growth balance method	Census 2006	Household heads reporting on deaths among adults aged 15–60	Individuals aged 15–60	936320	2173654	920183	2736823	3522	13595	2663	11039
Direct estimation from sibling survival data	DHS 1999	Women aged 15–49 reporting on the survival of their siblings	Siblings aged 15–60 (6 years prior the survey, persons years are reported)	9537	46146	9626	43430	74	221	58	189
	DHS 2003			24386	84901	23740	81228	114	485	143	336
	DHS 2010			47305	132551	46624	126872	169	511	173	509
Orphanhood method	DHS 1993	Children aged 5–9 and 10–14, reporting on the survival of their parents	Parents of the interviewed children	3683	6513	3683	6513	338	455	171	293
	DHS 2003			3249	14987	3249	14987	357	951	155	525
	DHS 2010			5840	19412	5840	19412	424	847	193	413
	EMUIB 2000	Young adults aged 15–19; 20–24 and 25–29, reporting on the survival of their parents	Parents of the interviewed adults	1261	2272	1261	2272	277	637	120	280

RESEARCH ARTICLE

Life expectancy at birth and life disparity: an assessment of sex differentials in mortality in India

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Abstract: This study aims to examine the sex differentials in life expectancy at birth and life disparity, and to estimate the age-specific contribution of the differences for India and its major states. Life disparity measures the variation in the distribution of deaths, and life expectancy at birth measures the average length of life. Complete life tables generated from death rates and abridged life tables of the Sample Registration System in India from 1970–1975 to 2006–2010 were used to fulfill the research goals. Stepwise replacement algorithm was used for the decomposition of sex differences in life expectancy at birth and in life disparity. The results indicate that the increase in life expectancy at birth and decline in life disparity was higher for females. The sex differential was more prominent in urban areas than in rural areas. A majority of the states in India experienced changes in the direction and magnitude of sex differentials in life expectancy at birth and life disparity from 1970–1975 to 2006–2010. The sex differentials in life expectancy at birth and life disparity in 1970–1975 were primarily attributed to child mortality, whereas the sex differentials in recent decades were attributed to adult mortality.

Keywords: adult mortality, child mortality, decomposition, India, life expectancy at birth, life disparity, life table, sex differential

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Received: September 10, 2015; **Accepted:** October 20, 2015; **Published Online:** October 27, 2015

Citation: Singh A and Ladusingh L. (2016). Life expectancy at birth and life disparity: an assessment of sex differentials in mortality in India. *International Journal of Population Studies*, vol.2(1): 38–52. http://dx.doi.org/10.18063/IJPS.2016.02.005.

1. Introduction

1.1 Rationale

Life expectancy at birth is not only a summary measure of mortality, but also an accepted indicator for the development of a country (UN/DESA, UNICEF, and WHO, 2016). The sex differential in life expectancy at birth has been the focus of research in both developed and developing countries. Mortality gains in men and women have not been uniform (Edwards and Tuljapurkar, 2005), with males having higher death rates at all ages in developed nations like Denmark, Japan, and the United States (Oksuzyan, Crimmins, Saito *et al.*, 2010), and in most developing countries (United Nations, Department of Economic and Social Affairs, and Population Division, 2015). In recent decades, the male–female gap in life expectancy at birth in some developed nations, like the United States, rapidly widened and then stabilized (Edwards and Tuljapurkar, 2005).

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Mortality research in several developed nations has not been restricted to differentials in life expectancy. The differentials in the distributions of deaths at different ages and dispersion measures of mortality have also been analyzed in recent studies. Various dispersion measures have been proposed and examined along with the life expectancy to show the sex, socio-economic, and educational differences (Edwards and Tuljapurkar, 2005; Shkolnikov, Andreev, Zhang *et al*., 2011). As with the declining mortality and improvement in life expectancy, deaths are postponed and concentrated at advanced ages. Studies indicate that there is a substantial negative correlation in life expectancy and dispersion measures across time in most countries (Shkolnikov, Andreev, Zhang *et al*., 2011; Singh and Ladusingh, 2013). The correlation is strong, but there are inconsistencies. Some countries, notably the United States, have a greater lifespan disparity than expected, even after achieving higher levels of life expectancy (Edwards and Tuljapurkar, 2005). At a similar level of remaining life expectancy, some population subgroups are experiencing lower levels of lifespan variation than others.

The sex differentials in dispersion measures of mortality have been observed in several countries. Most studies suggested that the female advantage is vigilant in the mean length of life and also observed in dispersion measures of age at death. The dispersion measure, standard deviation of age at death for ages 10 or older (S_{10}) among females is lower than that among males, which indicates a smaller uncertainty in female's life span (Edwards and Tuljapurkar, 2005). Female populations in developed countries, like France and the United States, have a higher mean and modal age at death, the age where most of the deaths are occurring (Kannisto, 2001). The measure of life disparity ($e^{\dagger}$) is also a dispersion measure based on the distribution of deaths at different ages and is defined as the average life years lost due to death. Females often have a lower life disparity than males in developed countries (Shkolnikov, Andreev, Zhang *et al*., 2011).

However, until now, studies focused on the difference in lifespan variation have been limited to cross-sectional analyses (Vaupel, Zhang, and van Raalte, 2011) or changes over time (Shkolnikov, Andreev, and Begun, 2003), as evident from the studies in the developed countries. These studies provide evidence that females from the developed countries usually have a higher life expectancy and a lower level of death dispersion than males, with some exceptions. No such studies are from developing countries, including India, either to support or negate the phenomenon of death dispersion found in the developed countries. The mortality differentials by sex, in India, are mostly analyzed for life expectancy at birth. Furthermore, the sex differentials in life expectancy at birth are often examined by mainly observing their time trends (Chaurasia, 2010). It is quite evident that the sex differentials in life expectancy at birth are widening over the period in India, with significant differentials by age as well (Canudas-Romo, Saikia, and Diamond-Smith, 2015).

With significant mortality decline in the past four decades, there is a need for a comprehensive study that looks into the sex differentials in life expectancy at birth and death dispersion in India. This study is an attempt to enrich research on the implication of enhancement in life expectancy on the dispersion of deaths over time, in India. This study would also examine the sex differentials in life expectancy at birth and dispersion measures of mortality for states of India to discover regional differentials in dispersion measures of mortality in India. Studies on dispersion of deaths are confined to examining the differences between countries and less focused on variations within the country (van Raalte, Martikainen, and Myrskyla, 2014). Hence, this study would provide an important contribution to understand the sex differentials in the dispersion of deaths for subpopulations within the country.

Before we describe our data sources, we first provide some brief information about India's life expectancy and distribution of deaths since the 1970s, relevant to this study.

1.2 Brief Background about Life Expectancy in India

The life expectancy at birth in India increased from 49.7 years in 1970–1975 (RGI, 1984) to 66.1 years in 2006–2010 (RGI, 2012). The increase was smaller for males than for females. The female life expectancy at birth was higher during the late 1990s to mid-2000s in all the states of India, whe-

reas the male life expectancy at birth was higher in the 1970s and 1980s (Dyson, 1984). However, in recent decades, in spite of higher child and maternal mortality, life expectancy at birth of females has surpassed that of males. The increase in life expectancy at birth was more rapid in rural than in urban areas. The increase in life expectancy at birth also varied across Indian states. There was a strong North-South gradient across the states, with great variations in the level and the pace of mortality reduction over time (Bhat, 1987; Saikia, Jasilionis, Ram *et al*., 2011). The pace of mortality decline was faster than international standard for males in Kerala and Tamil Nadu, and for females in Kerala, Tamil Nadu, Himachal Pradesh, and Uttar Pradesh (Chaurasia, 2010).

The sex differentials in mortality indicators also vary by age, in India. Research on infant and child mortality in India showed significant sex differentials (Subramanian, Nandy, Irving *et al*., 2006; Claeson, Bos, Mawji *et al*., 2000). Although the sex differential in adult mortality was not very high, it has been increasing continuously since the declining female mortality outpaced male mortality (Saikia and Ram, 2010). At older ages, the probability of survival is much higher among females than males in India in the recent decades (Chaurasia, 2010).

The distribution of deaths in 2013 by age showed that child (aged 0–4) deaths constituted 3% of the total deaths in Kerala compared with 25% in Uttar Pradesh, whereas adult (aged 15–59) deaths constituted almost 30% to 35% of the total deaths in all the major states of India (RGI, 2014). Saikia *et al.* (2013) further demonstrated that there was a substantial rural–urban difference in infant mortality at both national and state levels. Such a rural-urban difference in infant mortality was found in both socio-economically advanced states (e.g., Goa, Kerala) and disadvantaged states (e.g., Madhya Pradesh, Assam, and Orissa).

2. Data and Methods

2.1 Data

The Sample Registration System (SRS), under the auspices of the Office of the Registrar General of India (RGI), is the major source of mortality data and life tables in India (RGI, 2014). SRS is a dual record system with the continuous registration of birth and deaths in a nationally representative sample of villages and urban blocks in addition to a half-yearly survey for an independent count of events to update the demographics of the sample population. Events recorded in both the operations are matched to identify the unmatched and partially matched events, which can be referred to the field for verification. SRS provides information on age-specific death rates in different age groups and the abridged life tables starting 1970–1975. The data on death rates along with the abridged life tables from 1970–1975 till the recent time period (ORG 1984, 1985, 1989; RGI 1994, 1996–2010, 1998) were used in this study.

The quality of death statistics, in particular, uneven completeness of death registration by age, and systematic age misreporting can have an adverse impact on the accuracy of a life table and estimated life expectancy and life disparity. Nevertheless, SRS data are considered the most reliable of all death statistics in India (Roy and Lahiri, 1988; National Commission on Population, 2001; Mathers, Fat, Inoue *et al*., 2005). Definition of terms, administrative guidelines, and data collection methods of SRS are consistent over time, allowing for comparisons across time periods. An SRS representative character allows for estimation of vital statistics for India and the major states. The death registration completeness was about 95% for both males and females during 1971–1980. Evaluation for the recent time period 1990–1997 suggested no substantial changes in the completeness of reporting of either deaths or births in SRS (Bhat, 2002). With exceptions at the older ages, the registration of deaths at both childhood and adult ages was considered to be reliable because they were consistent with the SRS data (Saikia, Jasilionis, Ram *et al*., 2011).

2.2 Complete Life Table Construction

${}_nq_x$ (the probability of dying from age x to x+n) was segregated into ${}_1q_x$ (the probability of dying

from age x to x+1) using the parametric technique of Heligman and Pollard (1980) with the help of Mortpak developed by United Nations Population Division (2003), which provides smoothed values of $_1q_x$. The parametric model provides a smoothed curve, which reaches the whole age interval and provides flexible solutions in a set of parameters. This facilitates comparisons between and across time periods and spaces (Kostaki and Panousis, 2001). The procedure for constructing a life table in Mortpak from $_nm_x$ or $_nq_x$ is based on a method developed by Greville (1943). To construct a life table with the open age group at 100+, the $_nq_x$ values are extrapolated until no survivors remain, by fitting a Makeham function through the last six $_nq_x/(1 - _nq_x)$ values available (United Nations Population Division, 2003).

The conversion of age-specific death rates into age-specific probabilities of dying was consistent with the RGI abridged life tables from 1970–1975 to 1991–1995. However, previous studies reported problems in the conversion of age-specific death rates into age-specific probabilities of dying at early ages in the recent SRS abridged life tables from 1996–2000 to 2002–2006 (e.g., Saikia, Singh, and Ram, 2010). This conversion error further affects the estimates of infant, child mortality, and the life expectancy at birth. The purpose of our new life tables from 1996–2000 to 2006–2010 is to correct these errors. The $_nq_x$ values of the newly constructed abridged life tables from 1996–2000 to 2006–2010 were used as inputs in the Heligman–Pollard equation. The complete life tables were constructed according to $_1q_x$ values from age 0 to terminal age ω (100+).

2.3 Life Disparity

To measure dispersion of death, several measures such as S_{10}, interquartile range (Wilmoth and Horiuchi, 1999), the Gini coefficient (Shkolnikov, Andreev, and Begun, 2003), the Theil index of inequality (Smits and Monden, 2009), and average interindividual difference and the related measures of absolute inequality (Moser, Shkolnikov, and Leon, 2005; Shkolnikov, Andreev, and Begun, 2003) are often used extensively. S_{10} is defined as the standard deviation of the age at death for ages 10 or older (Edwards and Tuljapurkar, 2005). The distance between the lower and the upper quartile of the distribution of ages at death in a life table is called as interquartile range (Wilmoth and Horiuchi, 1999). The Gini coefficient is defined as the average of absolute differences in individual ages at death relative to the average length of life (Shkolnikov, Andreev, and Begun, 2003). The inequality in the distribution of age at death can be measured using the Theil index of inequality (Smits and Monden, 2009). Some formal properties of these measures are different from each other and the degree of their aversion to inequality. In this study, life disparity based on the distribution of death at different ages was used to measure the dispersion of deaths. The convergence of death rates in a narrow age interval can be observed from the decline in life disparity. The life disparity declines when saving lives occur at early ages, which compresses the distribution of deaths. The distribution of death expands when saving lives occur at late ages, which leads to increase in the average remaining life expectancy. Unlike life expectancy at birth, life disparity combines the age pattern of mortality and average mortality in a single measure (Singh and Ladusingh, 2013). The concept of this measure is in line with Keyfitz's idea that everybody dies prematurely, that is, every death deprives the individual concerned of his or her remaining life expectation (Keyfitz, 1977). Hence, life disparity occurs because of deprivation from death and inequality in the length of life. The measure of life disparity $e_x^\dagger$, appeared in several previous studies (Mitra, 1978; Zhang and Vaupel, 2009; Shkolnikov, Andreev, Zhang, *et al*., 2011).

Life expectancy at age x is measured using the following formula:

$$e_x^0 = \frac{T_x}{l_x} \tag{1}$$

Life disparity at age x is estimated using the following formula:

$$e_x^\dagger = \frac{1}{l_x}\sum_{y=x}^{\omega-1}\left[d_y\left(e_{y+1}+1-a_y\right)\right]+\frac{1}{l_\omega}d_\omega\left(\frac{1}{2}e_\omega\right) \tag{2}$$

where

l_x = Number of survivors at age x

d_y = Expected number of deaths in age interval $[y,y+1)$

T_x = Total number of person-years lived above age x

e_{y+1} = Life expectancy at age $y+1$

a_y = Average number of years lived in age interval $[y,y+1)$

$\omega = 100+$

2.4 Decomposition of Sex Differences in Life Expectancy and Life Disparity

The purpose of the decomposition is to estimate the contribution at each level of the underlying factor which can be added to the overall difference between values of the aggregated measure. A stepwise algorithm was developed for decomposing differences between aggregated demographic measures and applied it to analyzing the change in life expectancies, healthy life expectancies, parity-progression ratios, and total fertility rates (Andreev, Shkolnikov, and Begun, 2002). Using a stepwise algorithm programmed with VBA/Excel, Shkolnikov and Andreev (2010) generated a spreadsheet to decompose the age-specific difference in any life table indicator between two populations. With the help of a general stepwise replacement algorithm, age decompositions for different types of life-table based quantities can be executed. This Excel spreadsheet was used in this study to decompose the sex difference in life expectancy at birth or life disparity, that is, the difference between male and female life expectancy at birth or the life disparity. Decomposition was performed for all periods, yet we only presented the results for two periods (1970–1975 and 2006–2010) to show the transition in age-specific contributions of sex difference in both periods. Because the life tables for Bihar and West Bengal were available only from 1981–1985 onward, the figures for these two states are for the time period of 1981–1985, not 1970–1975.

3. Results

3.1 Male-female Differences in Life Expectancy and Life Disparity

Figure 1 shows that there was not much difference between the observed and fitted values of abridged $\ln({}_nq_x)$ for males and females in both periods. The $\ln({}_nq_x)$ values from the Heligman-Pollard model are also compared with the $\ln({}_nq_x)$ values of United Nations life tables and shown in Appendix 1. It is evident from the figures that there are no major differences in the values from the two sources in both periods, except some differences in the adult age group during 1970–1975. These comparisons indicate that the complete life table estimates based on the fitted ${}_nq_x$ values are good enough to be used for further comparison and decomposition analyses.

Figure 2 shows that over time, larger numbers of survivors (the l_x column of the complete life tables) had reached the older ages. Deaths are shifting to the older age, which leads to a compression of deaths. The difference in male and female survivors is evident in both 1970–1975 and 2006–2010 periods. In 1970–1975, as compared to that of females, a higher proportion of male survivors reached at age 50 from age 5. No significant sex difference was found in the older ages. In 2006–2010, the number of survivors in the initial ages was almost the same between males and females, but the gap became noticeable after age 40. The curves for males and females did not converge at any point after this age. The graph clearly shows a major transition in mortality in India: females, who were lagging behind males in the earlier decades, have outpaced males in survival in the recent years.

Figure 3A clearly shows that the sex difference in life expectancy at birth increased over the period. The male advantage in life expectancy at birth was mainly observed until 1981–1985. There is an apparent increasing trend in sex difference in life expectancy at birth in India, with females at the higher end. The female life expectancy at birth was 3.0 years higher than the male life expectancy

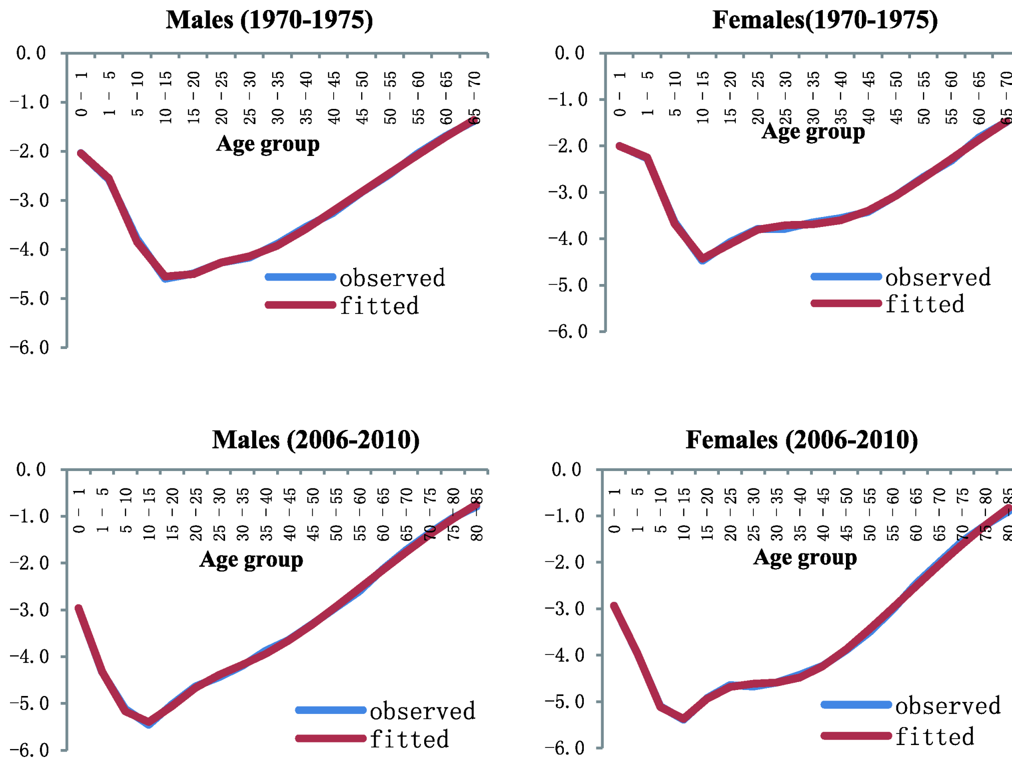

Figure 1. Fitting of $\ln({}_nq_x)$ values using the Heligman–Pollard equation on SRS Data for males and females in India, at two time periods.

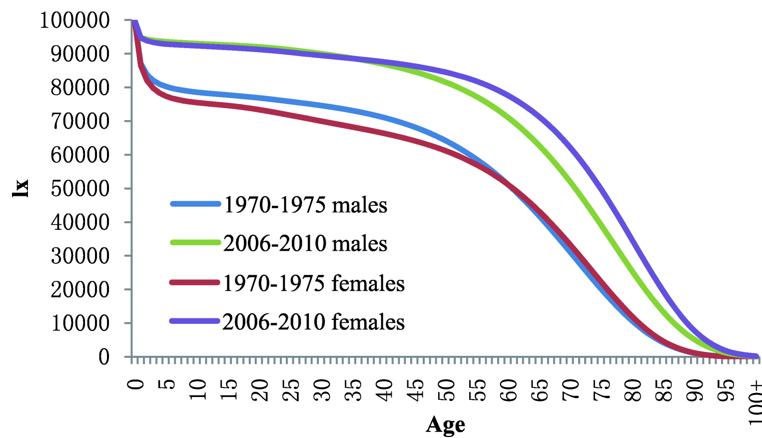

Figure 2. l_x values of the complete life tables at two time periods for males and females in India.

at birth in 2006–2010. The male–female difference in life expectancy at birth significantly varied by the place of residence. In the rural areas, because the female life expectancy at birth increased at a faster pace than the male life expectancy at birth, male advantage in the earlier periods was faded out in the recent period. In the urban areas, females were already in advantage in 1970–1975 and the gap has enlarged in the recent period.

Figure 3B reveals that over time, the male–female difference in life disparity was diminishing, from −1.5 years in 1970–1975 to 0.4 years in 2006–2010. Contrary to the male–female gap in life expectancy at birth by the place of residence, the male–female gap in life disparity has shown diverging trends by the place of residence. The urban–rural difference in the male–female gap of life disparity has increased significantly. The male–female gap in life disparity for urban areas was almost twice of that in the rural areas in 2006–2010.

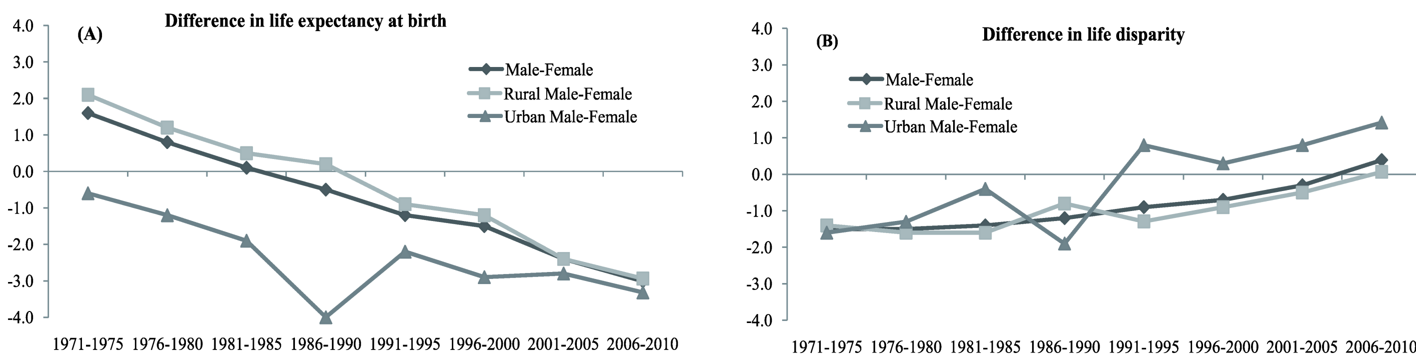

Figure 3. Sex difference in life expectancy at birth **(A)** and life disparity **(B)** by the place of residence, 1970–2010

3.2 Decomposition of Male–Female Difference in Life Expectancy and Life Disparity by the Place of Residence

Figures 4A and 4B present the age-specific contribution (in years) of the male–female difference in life expectancy at birth and life disparity in the two time periods by the place of residence. In 1970–1975, the male–female difference in life expectancy at birth was positive, and life disparity was negative. The decomposition result shows that in 1970–1975, a significant portion of the observed sex difference in life disparity and life expectancy at birth was explained by the higher female mortality under age 30 years, with infant (<1 year) and child age group (1–14 years) contributing most. In 2006–2010, the adult age group (30–59 years) contribution served to the widened female advantage in life expectancy by almost 2 years. The same age group contributed to the enlarged male life disparity by 1 year in 2006–2010. In the rural areas, the male advantage in both indicators of mortality was explained by the large contribution of child age group (1–14 years) in 1970–1975. The contribution of infant (<1 year) and child (1–14 years) age group in the rural areas was higher than in the urban areas. On the other hand, in 2006–2010, the negative sex difference in life expectancy was mainly attributed to the contribution of the age group 30–59 years (–2.0) and older age group 60+ (–1.4). The contributions of adult age group (30–59 years) and older age group (60+ years) increased over time. The sex difference in life expectancy at birth was negative in the urban areas for both time periods, with an increased intensity in 2006–2010. The negative difference in life disparity in 1970–1975 was mainly because of the higher female mortality in children (0–14 years) and the early adult age group (15–29 years). Higher male life disparity in 2006–2010 was because of the large contribution of the adult age group (30–59 years). The contribution of the adult age group (30–59 years) was higher in the urban (life expectancy at birth: –2.2 years; life disparity: 1.1 years) than in the rural areas (life expectancy at birth: –2.0 years; life disparity: 0.8 years).

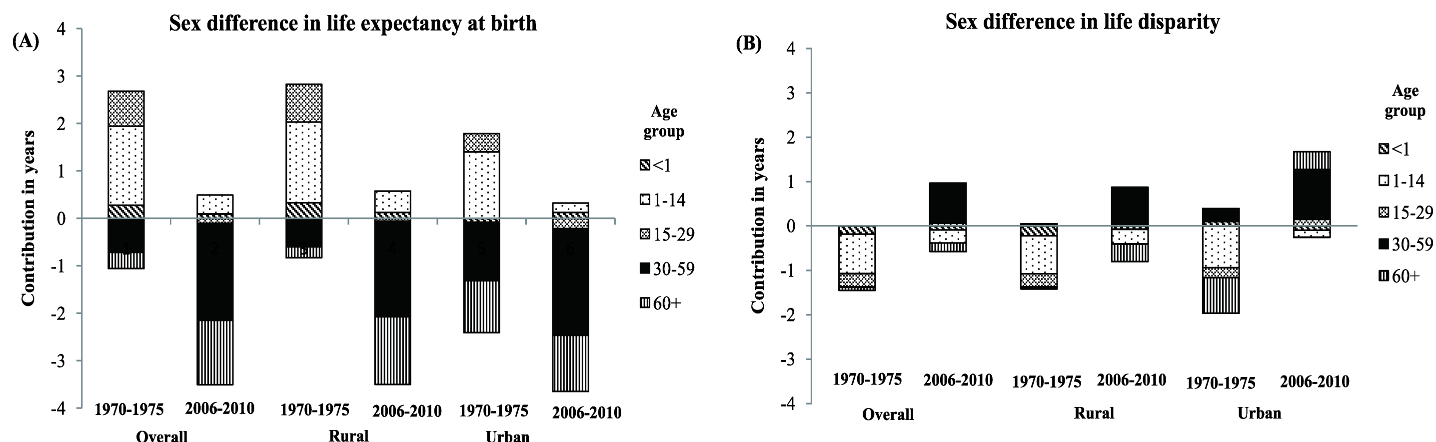

Figure 4. Age-specific contribution to sex differences in life expectancy at birth and life disparity in India at two time periods.

3.3 Male-Female Difference in Life Expectancy and Life Disparity by State Group

Figures 5A and 5B show the geographical pattern of the male–female difference in life expectancy and life disparity in 1970–1975 and 2006–2010. The increase in life expectancy at birth and the decline in life disparity were higher among females in the majority of the Indian states. The male–female difference in life expectancy at birth changed from positive to negative, whereas it was just opposite for life disparity. The change in terms of the number of years was more prominent for life expectancy at birth than for life disparity. The female life expectancy at birth in 2006–2010 was higher than the male life expectancy at birth in every major state of India. The female life expectancy at birth was more than 4 years higher than males for demographically advanced south Indian states such as Kerala, Karnataka, and Andhra Pradesh, and north Indian states such as Punjab, Haryana, and Himachal Pradesh. Along with life expectancy at birth, life disparity in Himachal Pradesh and Kerala was in favor of females in 1970–1975. Most of the states had higher female's life disparity in 1970–1975, that is, negative sex difference, with the maximum gap found in Uttar Pradesh and West Bengal. This negative sex difference in life disparity changed to positive in two-thirds of Indian states in 2006–2010. The female life disparity in 2006–2010 was higher than the male life disparity in states such as Assam, Bihar, and Uttar Pradesh.

The states are classified into two groups based on the transition of sex differentials in life expectancy, as observed in Figure 5A and 5B. This approach was adopted to present the decomposition results for the major states in Figures 6 and 7 more systematically. Group 1 includes the states where the male–female difference in life expectancy or life disparity changed the sign either from positive to negative or from negative to positive, and Group 2 includes the states that have not undergone a

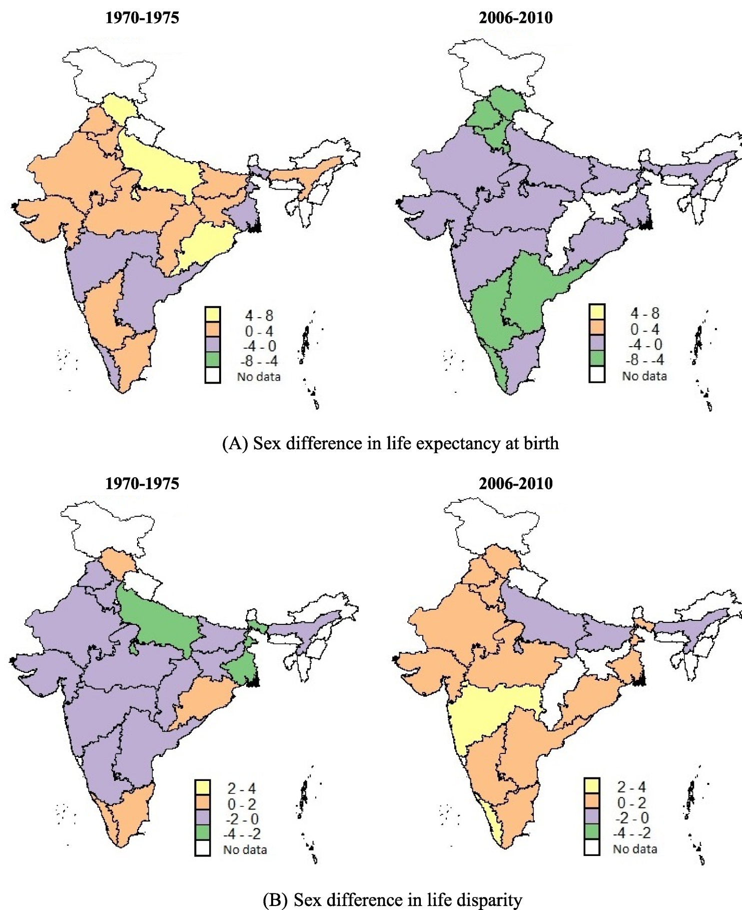

Figure 5. Sex difference in life expectancy at birth and life disparity in major states of India at two time periods 1970–1975 and 2006–2010.

transition, that is, the male–female difference in life expectancy or life disparity did not change the sign over the periods.

3.4 Decomposition of Male–Female Difference in Life Expectancy and Life Disparity by State

Figure 6 shows the decomposition of sex difference in life expectancy at birth results for each major state in India during 1970–1975 and 2006–2010. The states in Group 1 of life expectancy analysis comprise states with a positive sex differential in life expectancy at birth in 1970–1975 and a negative one in 2006–2010. Group 2 consists of four states (Andhra Pradesh, Kerala, Maharashtra, and West Bengal), which had negative male–female difference in life expectancy in both periods. In 1970–1975, all the states had higher male life expectancy at birth and only a few states with higher female life expectancy. The sex differentials in mortality were largely influenced by the difference in death rate under the age of 15 in 1970–1975. A major shift in age-specific contribution toward these sex differentials was observed in 2006–2010. The contribution of the two age groups 0 and 1–14 years was replaced by the age groups of 30–59 years and 60+ years. The contributions of age groups of 30–59 years and 60+ years in 1970–1975 were already higher in the Group 2 states, which were further enlarged in 2006–2010, leading to a larger negative male–female difference. The maximum contributions of adult and old age mortality toward the sex differential in life expectancy at birth were observed in Himachal Pradesh in Group 1 and Kerala in Group 2. In Bihar, the positive contribution of child age group (1–14 years) was negated by the negative contribution of the adult age group (30–59 years) in 2006–2010. The states in Group 2 had a negative male–female difference in life expectancy at birth in 1970–1975, which suggests that females in these states were in a much better situation at that time period than those in the other states.

Figure 7 presents the decomposition of sex differentials in life disparity in the major states in India. Compared to life expectancy at birth, transition in sex differences in life disparity occurred in a lesser number of states. Nearly half of the states fell in Group 1 and the remaining were in Group 2. Group 1 states had a negative male–female difference in life disparity in 1970–1975 and a positive value in 2006–2010; while in Group 2 states such as Assam, Bihar, and Uttar Pradesh had a negative

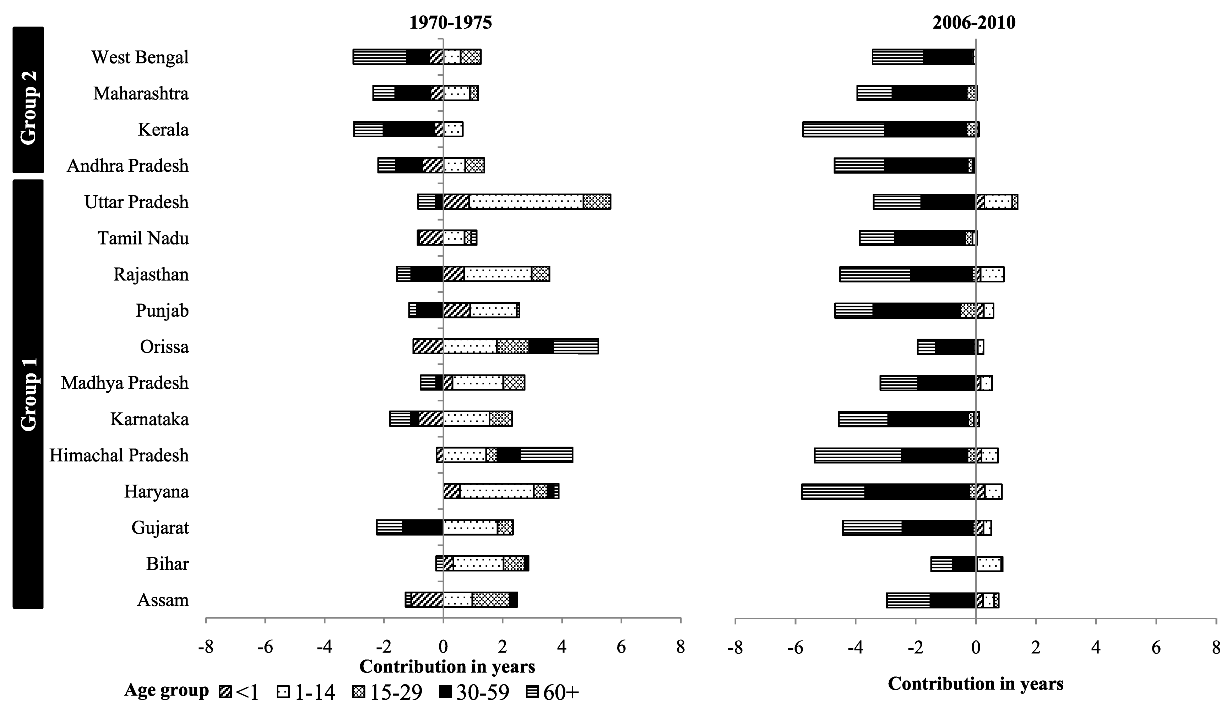

Figure 6. Age-specific contribution to sex differences in life expectancy at birth at two time periods, in major states of India.

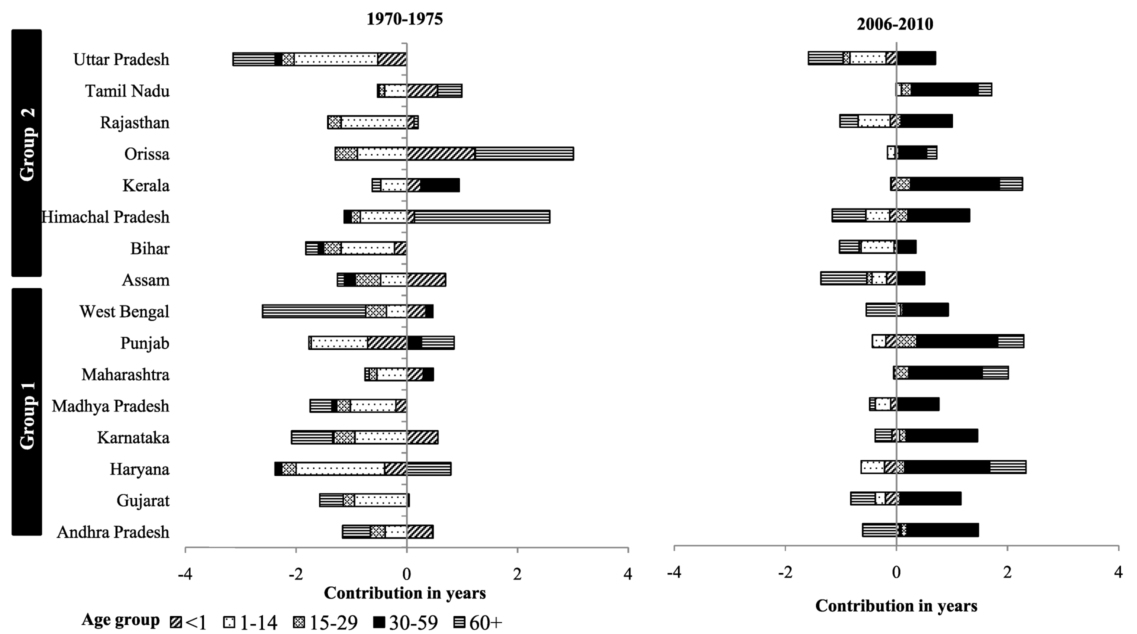

Figure 7. Age-specific contribution to sex differences in life disparity at two time periods, in major states of India.

male–female difference in life disparity in both 1970–1975 and 2006–2010, and states such as Himachal Pradesh, Kerala, Orissa, and Tamil Nadu had a positive difference for both the time periods. In 1970–1975, the sex differential in life disparity was negative for most of the states, suggesting a higher female life disparity than male. In 1970–1975, in states with poor mortality indicators like Uttar Pradesh, Rajasthan and Bihar as well as states with better mortality indicators like Punjab, Haryana and Karnataka, the negative difference in life disparity was largely due to higher female mortality at or below 14 years. The female life disparity in Kerala was lower than males in both periods, with increasing contribution of adult and older age groups to this gap in 2006–2010. The transition in the role of age-specific mortality toward sex difference in both periods is evident in the Group 1 states. The analysis shows that in all the states, the positive sex difference in life disparity in 2006–2010 was mainly attributed to the higher male mortality in the adult age group (30–59 years) and the older age group (60+ years). This contribution was larger in states like Maharashtra and Punjab, which are in the advanced stages of mortality transition in India. The states in Group 2 also experienced a similar change. However, the contributions of child age group (0–14 years) and younger adult age group (15–29 years) was also significant for the states in Group 2.

4. Discussion and Conclusions

Essentially, life disparity measures the dispersion of deaths, whereas life expectancy is a measure of the average length of life. An important factor in increased life expectancy in India is the contribution of infant and child mortality (Singh and Ladusingh, 2016). While trends in infant mortality are important, a small change in early ages of mortality would have a significant effect on the momentum of age distribution at death (Edwards and Tuljapurkar, 2005). Unlike S_{10}, life disparity covers the child, adult and old age group and holds an important public health interpretation. For a developing country like India, where the infant and child mortality are still high as compared with those in developed countries, using life disparity to study the dispersion of deaths is most suitable. Life disparity at specific age can be easily compared to the life expectancy at specific ages.

This study is distinctive in the sense that it analyzed the sex differentials in life expectancy at birth and life disparity at the same time. Furthermore, the study demonstrated the changing dynamics of different age groups and their contribution to the differences between the male and female life ex-

pectancy and life disparity, and their variation over time. The sex differentials in life expectancy at birth and life disparity were measured at the state and urban–rural level. Such dispersion measures have not been in much use in developing countries like India. In this study, we made such an attempt using the most reliable data source of mortality – from the SRS.

Our results showed that the sex gap in life expectancy at birth and life disparity widened over time, in India. The study suggested a shift in the role of age-specific mortality to the sex differentials in life expectancy and disparity, with adult ages contributing more significantly unlike in the past, younger ages contributing more to the differentials. The female advantage in life expectancy in 2006–2010 was mainly attributable to the low level of female adult and older age mortality than males in India, and the low life disparity is because of the contribution at the adult ages. This finding indicates that the female advantage in life expectancy and life disparity is occurring in India as what have been found in the developed countries (Shkolnikov, Andreev, Zhang, *et al*., 2011; Edwards and Tuljapurkar, 2005). However, in comparison to the international levels, there is a scope for further reduction, especially in the rural areas and high mortality states. Large decline in adult mortality among females is because of a significant decline in maternal mortality. Under the Reproductive and Child Health Programme started in 1997 and the National Rural Health Mission started in 2005, the government has started several new initiatives to address the problem of maternal deaths and to speed up the rate of decline of maternal mortality across all states (RGI, 2006, 2013).

In India, it has been observed that sex of the person is one of the important and significant determinants of adult mortality in India (Saikia and Ram, 2010). The mortality risk in middle-aged female people in India is lower than males (Subramanian, Nandy, Irving *et al*., 2006). Adult mortality in the age group 15–59 has declined to a large extent among females from 358 per 1000 in 1970 to 145 per 1000 in 2010 (Rajaratnam, Marcus, Levin-Rector *et al*., 2010). The decline among males has not been at the same rate as it has been for females. Studies in developed countries mostly attribute such differences to the behavioral risk factors (Edwards and Tuljapurkar, 2005). The grandness of health risk and behavioral factors is increasing in India due to the changing pattern in the cause of death (Krishnan, Nawi, Kapoor, *et al*., 2012). In India, the level of risk factors among the males is more marked than among the females (Wu, Guo, Chatterji *et al.,* 2015). Behavioral risk factors, such as smoking, little physical activity, poor diet, and other unhealthy practices, have a significant role to play in adult mortality in India (Jha, Gajalakshmi, Gupta *et al*., 2006).

This study also showed that sex differential in life expectancy and life disparity existed in the rural and urban areas, with larger gap in the urban areas. The major reason of this large gap in the urban areas is the significant contribution of both older age group 60+ years and adult age group 30–59 years. The older age mortality decline for females was more pronounced than males in the urban areas (Yamunadevi and Sulaja, 2016). The difference in health behavior of older males and females can be associated with the significant decline in female older age mortality (RGI and CGHR, 2015). Furthermore, higher infant and child mortality among females in the rural areas (RGI, 2014) negated the advantage females gain from the mortality decline in the adult age group, and resulted in a higher life disparity. Discriminatory treatment of females over males with respect to food allocation and healthcare is associated with the excess female mortality (Arokiasamy, 2004).

This study found significant regional differentials in sex gap for both life expectancy and life disparity. Many studies have found that Maharashtra, Punjab, Haryana, and Kerala have much better mortality measures than the national level (Chaurasia, 2010; Saikia, Jasilionis, Ram *et al*., 2011), but the sex gap in life expectancy and life disparity is increasing over time because of the increasing contribution of adult age group. This suggests that the sex differences in mortality rates for the adult age group is widening over time. In Kerala, females were in an advantageous position from the 1970s onward. The slow reduction in the mortality rates among adults and elderly males in Kerala was related with the ongoing epidemiological transition and misalliances in health policies (Thomas and James, 2014).

Compared to the life expectancy at birth, the transition in sex differentials in life disparity has oc-

curred in a lesser number of states. Even though the life expectancy at birth of females was higher than that of males in Assam, Bihar, and Uttar Pradesh, the life disparity of females was higher than that of males. This indicates that a strong negative correlation between the life expectancy and life disparity does not assure that higher life expectancy population would also have a lower life disparity. A higher female life disparity in these states was mainly because of the higher female child mortality (RGI, 2012), and negated the large gain of females in the adult age group.

Analyzing differentials in life disparity and life expectancy at birth simultaneously by sex in this study has provided a new perspective on mortality differentials. This study has shown that with the rapid increase in the average length of life of females, life disparity is also converging faster for females than for males in India, leading to enlarged sex differentials for the life expectancy and disparity, with the highest differences in low mortality states. To diminish the lifespan variability among males in India, among its states, and ultimately, to close the sex gap in lifespan variability, policies should focus on averting premature and young adult deaths among males in India. This aversion would simultaneously increase life expectancy and decrease life disparity, whereas strategies aiming at extending the length of life among the oldest-old would increase life expectancy of a population, but at the expense of increasing lifespan variability (Kannisto, 2001). As adult deaths have severe economic and social consequences, more and effective health policy interventions in India are clearly needed to prevent such deaths.

Conflict of Interest and Funding

No conflict of interest was reported by all authors.

Acknowledgements

We express thanks to the editor and the two anonymous reviewers for their very detailed helpful and constructive comments that greatly improve the quality of the paper.

Ethics Statement

The analysis described in this paper was performed using secondary data obtained from publicly available sources as outlined in the Data and Methods section.

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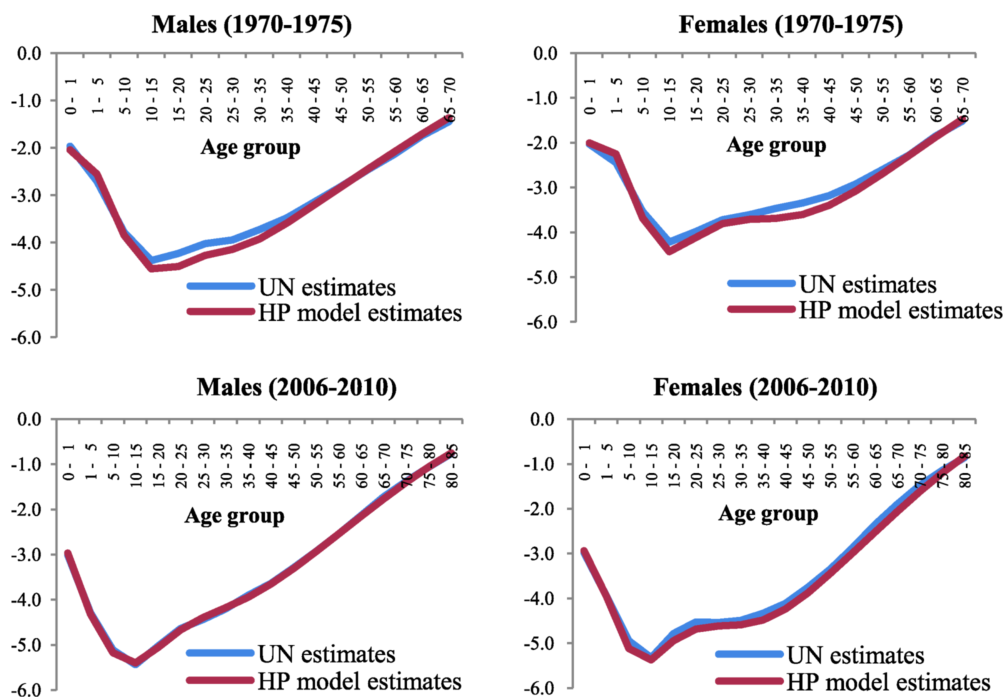

Appendix 1. Comparison of ln(nqx) values of United Nations (UN) and Heligman–Pollard (HP) model estimates.

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RESEARCH ARTICLE

Correlates of parental satisfaction: a study of late life family relationships in a rural county in China

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Abstract: This study aims to identify correlates of satisfaction in late life parental role, using a sample of 432 older parents (not couples) aged 60 to 79 with 1,223 adult children living in one of the least developed counties of northern China. Drawing upon the symbolic interactionism perspective and Chinese cultural emphasis on filial piety, we tested a parental satisfaction model including a set of variables capturing parental perceptions of relationship quality with *each of their grown children* (hereafter offspring), expectations of various forms of support from offspring, and evaluations of offspring's filial piety (being *filial*). Most parents in our sample were satisfied with their parental role. Logistic regression analysis indicated that getting along with offspring, offspring met parental expectations in terms of providing emotional, practical, and financial support, and offspring being filial were significantly associated with parental satisfaction, respectively, net of parent and offspring characteristics. When simultaneously examined in the full model, however, only two correlates remained significant: getting along with offspring and offspring being filial. Offspring's filial piety was associated with parental satisfaction in a dose-response manner, indicating the importance of considering multiple children in a family on parental well-being. Findings underscore the significance of parental perceptions of relationship quality with offspring and offspring's filial piety for parental satisfaction. Findings suggest that filial piety, a multifaceted concept deeply rooted in Confucianism, continues to exert a strong influence today on Chinese family relationships despite the dramatic socioeconomic and cultural transformation China has been experiencing in the past three decades.

Keywords: relationship quality with offspring, child-to-parent support, filial piety, filial discrepancy, multiple children, counties below poverty level

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Received: October 12, 2015; **Accepted:** November 28, 2015; **Published Online:** December 3, 2015

Citation: Yang Y and Wen M. (2016). Correlates of parental satisfaction: a study of late life family relationships in a rural county in China. *International Journal of Population Studies*, vol.2(1): 53–64. http://dx.doi.org/10.18063/IJPS.2016.01.007.

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1. Introduction

Parental satisfaction has been identified to be positively related to health and well-being in late life (Reczek and Zhang, 2015; Umberson, 1992). Much less is known, however, about the factors associated with parental satisfaction, which may operate differently at the various stages of the parental life course and across a variety of cultural contexts. In a review of parental satisfaction research focusing mainly on parenting young children, Goetting (1986) concluded that "very little can be stated

with any degree of certainty regarding satisfaction in the parental role" due largely to "the paucity of research efforts expended in this direction". Twenty-four years after Goetting's review, Mitchell (2010) extended this work to further explore components of midlife parental satisfaction using the parent-focal child information. She found that income satisfaction, emotional closeness to the study child, parents' main activity (e.g., paid work, retired, or other), health, age, ethnic background, and perceptions of how children "turn out" influence midlife Canadian parents' subjective levels of satisfaction. In light of these developments, which aspects of the parent-adult child ties account for parental satisfaction in late adulthood remain to date unstudied.

Identifying correlates of satisfaction in parental role is particularly important for older adults because intergenerational relations (and parent – adult child ties in particular) become increasingly important in old age (Bengtson, 2001). Longer life expectancy of both parents and their children is enabling parent and adult children today to share extended "linked lives," a span of time commonly lasting as long as 50 years for the first time in human history (Umberson, 1992). Such extendedly shared lifespans make it possible for longer periods of interactions and increased exchanges of support between generations, as aging parents across the world all rely on family members taking primary responsibility to provide support and care (Angel, 2011). Indeed, empirical studies on parenting adult children have documented that the interdependent life course trajectories of parents and adult children remain an important influence on parental wellbeing across the life course (Umberson, Crosnoe, and Reczek, 2010). A better understanding of correlates of parental satisfaction in late life would help the development of evidence-based strategies to reduce parental dissatisfaction among older adults and in turn enhance their odds of experiencing healthy aging.

Similarly, little evidence is available on correlates of parental satisfaction in late life in a Chinese setting. A China-based study examining this issue is of great significance for several reasons. First, China is experiencing rapid population aging, with more than 110 million people aged 65 or older in 2010, more than 240 million in 2030, and 370 million in 2050 according to projections (United Nations, 2015). Second, family support from adult children remains a primary source of support for older adults in China (Shen and Yeatts, 2013), where social welfare and health insurance systems are quite limited and are still being developed. Third, traditionally in Chinese culture, filial piety — the virtue of respect for, taking care of, and obeying one's parents — has shaped the expectations and behaviors of Chinese families for thousands of years as a central value of family life (Ikels, 2004). Older Chinese adults under the regulation and guidance of filial piety beliefs may have different expectations for the parental role in late life as well as for the interaction and exchange with offspring relative to their counterparts in other cultural contexts. They may thus likely be more sensitive to adult children's non-filial behaviors compared to those living in other cultures. Yet, little attention has been paid in previous studies to the cultural context in which parental roles are experienced (Mitchell, 2010). The current study aims to address these gaps in the literature by identifying factors associated with parental satisfaction in late adulthood using a sample of 432 older Chinese parents with 1,223 grown children living in a "below poverty level" county in northern China. Taking advantage of a rich and recent data set self-collected in 2014, information from *each of the grown children* in a family (hereafter *offspring* is used to represent *each of the grown children*) are utilized when measuring variables of interest (see Section 2.3.2 for details), as research indicated that it was important to consider multiple children when examining parent-adult child relationships (e.g., Fingerman, Cheng, Birditt *et al*., 2012).

We identified relevant variables that might explain and contribute to parental satisfaction in the context of China and formulate our hypotheses by drawing upon the symbolic interactionism perspectives and Chinese cultural emphasis on filial piety and reviewing previous studies of parenting. According to the symbolic interactionism perspective, social roles such as being a parent, a worker, or a friend, are positions or statuses in the social structure regulated by a set of normative rights and obligations, which give identity, guidance, purpose and sense of meaning to life through role involvements (Berkman, 2000; Thoits, 1983, 2011). The parental role is ranked at the top of most par-

ents' identity salience hierarchies, higher than their worker role (Thoits, 1992), accounting for a prominent source of identity. Unlike most other social roles that have specified durations and clear boundaries, the parental role never ends. It may become even more important in late life because old age is a life phase that frequently brings in negative changes in social roles (Pudrovska, 2009). Older adults, for instance, often face the loss of some salient roles (e.g., the worker role, and possibly, the spouse role) undertaken in earlier adulthood (Orth, Maes, and Schmitt, 2015).

It is the quality of experiences in social roles, however, rather than role occupancy *per se*, the number of roles, or the amount of time spent in a particular role, is more important to psychological outcomes (Barnett and Hyde, 2001; Thoits, 1992). Krause (1995; 2005) found, for example, that negative dimensions of social ties were a particular source of unhappiness and distress. Ryan and Willits (2007) further indicated that having a satisfying relationship with adult children, rather than the frequency of parent-child interactions, was significantly associated with older people's personal feelings of well-being. These findings suggest that parent-perceived quality of relationship with offspring should be associated with parental satisfaction in later life. We thus formulated:

Hypothesis 1: Relationship quality with offspring is positively associated with parental satisfaction.

Furthermore, parental expectations of offspring's various types of support may be related to parental satisfaction in late life in the context of China. Despite filial obligation to one's parents being a moral imperative found in almost all societies (Silverstein, Conroy, and Gans, 2012), the norms governing parental support differ between Western and Chinese cultures, with the former preferring independence and the latter valuing interdependence (Markus and Kitayama, 1991). Unlike in Western cultures where filial duty is often viewed as the practice of caring for aging parents "at times of need" (Gans and Silverstein, 2006), filial duty in the form of filial piety within Confucian culture requires offspring providing sufficient emotional, physical, and financial support to older parents (Johnson, 1983; Wang, Laidlaw, Power *et al*., 2010) regardless of parental needs (Kim, Cheng, Zarit *et al*., 2015). It is likely that such differential cultural norms can affect role quality by way of affecting role practices (Barnett and Hyde, 2001), given that social integration and support may be conditioned upon cultural context (Thoits, 2011). Therefore, we theorized our second hypothesis:

Hypothesis 2a: Offspring's emotional support is positively associated with parental satisfaction.

Hypothesis 2b: Offspring's practical/instrumental support is positively associated with parental satisfaction.

Hypothesis 2c: Offspring's financial support is positively associated with parental satisfaction.

Moreover, filial piety, as a multifaceted concept, is a much broader belief system (Li, Pang, Chen *et al*., 2010) beyond providing emotional, practical, and financial support. It also prescribes, for instance, a set of behaviors and attitudes requires a child showing love and respect towards one's parents. In contemporary Chinese, (being) *filial* is used to indicate that a child has successfully behaved in ways consistent with the parents' cultural expectations of filial piety. Accordingly, learning to be a filial child is "the essential first step toward being socialized to be an acceptable adult member of society" (Ho, Xie, Liang *et al*., 2012). An adult child who fails to meet the parent's expectations of filial piety thus exhibits filial discrepancy (Cheng and Chan, 2006) and is considered *unfilial* or *less than filial*. Consequently, offspring's filial discrepancy may heighten parental feelings of social stigma and make parents view their parental role as a failure — self-critical thoughts that are detri-

mental to parental wellbeing (Knoester, 2003; Milkie, Bierman, and Schieman, 2008). A study, for instance, indicated that *unfilial* offspring was a risk factor for depression among older Chinese parents (Li, Pang, Chen *et al.*, 2010). Given the significance of filial piety as an overarching family value in Chinese family and society, we formulated our last hypothesis:

Hypothesis 3: Offspring's filial piety is positively associated with parental satisfaction.

Briefly, the present study tests a late life parental satisfaction model in China including variables tapping relationship quality with offspring, expectation of various forms of support from offspring, and offspring's filial piety. The key purpose is to identify important correlates of parental satisfaction for older Chinese adults to provide evidence informing intervention design and policy formulation in order to promote healthy aging in China more efficiently.

2. Methods

2.1 Data

Data were collected between June and August 2014 employing face-to-face interviews with a sample of 432 older parents in Linxi County, a traditionally agricultural county located in the Inner Mongolia Autonomous Region of northern China. Linxi County is one of 592 "below poverty level" counties nationwide as measured by the average annual disposable income of its residents (Central People's Government, 2012), with 28% and 24% of its urban and rural residents living "below poverty level" as of 2012, respectively, according to the documents from the county government. Survey data collection at this level is rare.

2.2 Procedures

The sample were drawn from forty-five neighborhoods within seven community centers of the two subdistricts of the county seat and a township (a subdistrict is the equivalent of a township). The source of the sample was the electronic resident roster kept in the computer system of each community center that records itemized demographic information of all household members in each household within all neighborhoods under its governance. The selection criteria included residents who were 60 to 79 years old at time of survey, apparently cognitively capable of answering questions, from different households (not couples), and had at least one living child.

A convenience sample method was employed to reach participants. At each participating community center, a staff member first screened residents on the roster according to the selection criteria to make a list of eligible residents. Then the staff member contacted eligible respondents and scheduled interviews for those who were willing to take the survey. All face-to-face interviews were conducted by a team of three interviewers (none of them were community staff and all were recruited and trained by the first author) and the first author. Interviews were conducted mostly at community centers, without the presence of persons other than the respondent and the interviewer. The duration of each interview varied from one hour and a half to two hours and a half. Participants received ¥50 ($7.60) on completion of the interview. Of the 464 eligible respondents that were contacted, 432 completed the face-to-face interview, yielding a response rate of 93%.

2.3 Measures

2.3.1 Dependent Variable

Parental satisfaction is the dependent variable based on a single-item question. Before asking this question, interviewers read the following sentences to each interviewee, "Next we'll move into the *Relationship and Exchange with Children* section. Questions in this section are to ask your relation-

ship with your children." Then the interviewers paused a second and asked, "All in all, on a scale of 1–6 with 1 being '*not at all satisfied*' and 6 being '*extremely satisfied,*' how satisfied are you with being a parent?" Similar one-item measurement was used in previous studies (Mitchell, 2010). Responses were highly skewed to "*5 very*" or "*6 extremely*" satisfied (n=280, 64.81%), with the rest of responses containing less satisfactory options ranging from "*1 not at all satisfied*", *"2 not too satisfied", "3 somewhat satisfied"* to "*4 fairly satisfied*". As such, parental satisfaction is dichotomized into "*satisfied*=1 (categories 5 and 6)" and "*not satisfied*=0 (categories 1 to 4)". Skewed distribution aside, the following two perspectives help theoretically justify the use of parental satisfaction as a binary measure: First, social desirability bias explains that people have a tendency to overreport positive feelings about their family life rather than their real sentiments. Second, from the perspective of dissonance theory (Secord and Backman, 1974), parents report high satisfaction in the parental role in spite of the presence of deleterious relationships with children because they respond to an attitude adjustment consistent with their earlier decision to have children. Dichotomizing this variable thus will help reduce the measurement error incurred by such tendencies. Moreover, ordinal logit models were fitted with the original categories of parental satisfaction maintained as sensitivity test and the results are comparable to those reported here (results available upon request).

2.3.2 Independent Variables

We tested five independent variables representing relationship quality with offspring, expectation of various forms of support from offspring, and evaluation of offspring's filial piety, based on ratings by respondents of *each of their grown children*, respectively. Overall, the sample had 1,223 grown children (range 1–8, mean=2.83, *SD*=1.17). About 9.26% had one child, a little more than one-third (35.19%) had two children, almost another one-third (31.02%) had three children, and the rest had four or more. For each variable, responses of the parent's evaluation to each child were combined across multiple children and organized into three categories: 1=*all children met expectation*, 2=*at least one but not all met expectation*, and 3=*none met expectation*. *Relationship quality* was measured by a single question that asked, "Overall, how well do you and each of your children get along together at this point in your life using a 4-point scale ranging from 1 (*not at all well*) to 4 (*pretty well*)?" *Offspring's support* was measured by asking respondents to rate to what extent each of their children's behaviors and activities met their expectations in terms of three types of support: emotional support ("listening to your problems"), practical/instrumental support ("providing practical assistance"), and financial support ("providing financial assistance"), respectively. *Offspring's filial piety* was assessed by a question that asked, "How *filial* is each of your children rated using a 7-point scale ranging from 1 (*not filial at all*) to 7 (*extremely filial*)?"

2.3.3 Parent and Offspring Characteristics as Controls

Measures of parental characteristics reflect late life variations in resources, which in turn, can create opportunities and constraints for the parent-adult child relations to influence the risk of parental satisfaction(Mitchell, 2010).Therefore, we included parental age (entered as a continuous variable), gender (1=*female*, 0=*male*), marital status (1=*married*, 0=*widowed/divorced*), financial strain (1=*yes* — family income barely took care of family needs, 0=*no*), and self-rated health as parental characteristics controls. Self-rated health was assessed using a single item asking respondents, "How do you rate your overall physical health on a 5-point scale ranging from 1 (*poor*) to 5 (*excellent*) these days?" A higher score indicated better parental health.

Research indicated that parents' perceptions of adult children's problems (e.g., marital or partner relationship problems and lack of career success) were associated with poorer parental well-being (Cichy, Lefkowitz, Davis *et al*., 2013; Greenfield and Marks, 2006; Mitchell, 2010). We thus also controlled for two offspring characteristics in the analyses, which reflected older parents' evaluations regarding how their adult children "turned out". Offspring's marital status was measured by asking, "How satisfied are you with each of your children's marital status rated using a 7-point scale

ranging from 1 (*extremely dissatisfied*) to 7 (*extremely satisfied*)?" Offspring's socioeconomic status (SES) was measured in the same manner. Like the independent variables previously mentioned, responses to each question were combined across multiple children and organized into three categories, respectively: 1=*all children met expectation*, 2=*at least one but not all met expectation*, and 3=*none met expectation*.

2.4 Analyses

We first calculated descriptive statistics and checked intercorrelations for measures employed. Next, we ran logistic regression models to examine the influence of the hypothesized correlates on parental satisfaction in late life, starting from relationship quality (Model 1), followed by emotional support (Model 2), practical support (Model 3), financial support (Model 4), and then offspring's filial piety (Model 5). Parent and offspring characteristics such as age, gender, marital status, financial strain, self-rated health, offspring's marital status, and offspring's socioeconomic status were controlled for in each model. Model 6 represented the full model including all variables tested in previous models. The analyses were performed using Stata/MP 13.1.

3. Results

3.1 Sample Description

Table 1 presents sample descriptive statistics. The sample was composed of 432 older adults with a mean age of 66.24 years (range 60–79; *SD*=5.00). The majority of the respondents were women (55.32%), married (77.08%), experiencing no financial strain (60.42%), satisfied with offspring's marital status (67.36%), and satisfied with being a parent (64.81%). Less than half of the sample was satisfied (48.15%) with each of the grown children's SES while near a third (27.08%) was satisfied with none of the grown children's SES, though.

3.2 Correlates of Parental Satisfaction

Table 2 summarizes bivariate correlations among all variables included in the analyses. All independent variables correlated significantly to parental satisfaction in expected directions and ranged from 0.13 (practical support from offspring) to 0.32 (getting along with offspring). We assessed variance inflation factors (VIFs) for multicollinearity diagnostics. All calculated VIFs (1.08–1.50) fell well below 4.00, the suggested threshold of multicollinearity (Cohen, Cohen, West *et al.*, 2003).

Table 3 displays the results from logistic regression models. In the first five models, the five tested variables – getting along with offspring, offspring's emotional support, offspring's practical support, offspring's financial support, and offspring being filial — each exhibited a statistically significant and positive association with parental satisfaction, respectively. Specifically, compared with respondents who got along with all children, respondents who got along with none of his/her children were considerably less likely to report being satisfied with the parental role (odds ratio=0.19, $p<0.001$). Similarly, parents who reported being satisfied with none of his/her children's emotional, practical, or financial support, respectively, were markedly less likely to be satisfied with their parental role relative to those who reported all their children met expectations in terms of providing for them emotional, practical, or financial support, respectively. In the fifth and the sixth model, a dose-response relation between offspring's filial piety and parental satisfaction was revealed. Older parents who were satisfied with none of their children's filial piety were remarkably less likely to be satisfied with their parental role compared with those who were satisfied with at least one child's filial piety, while the latter were less likely to be satisfied with their parental role relative to those who were satisfied with all children's filial piety. The sixth model represents the full model in which only relationship quality with offspring and offspring's filial piety remained significant. The overall model was statistically significant ($\chi^2 = 101.19$, $p<0.001$).

Table 1. Sample descriptive statistics (N=432)

Variables	Range	M (SD)	%
Parental satisfaction (ref.= dissatisfaction)	0–1		64.81
Relationship quality with offspring	1–3		
All children met expectation			70.60
At least one but not all met expectation			18.98
None met expectation			10.42
Emotional support from offspring	1–3		
All children met expectation			69.91
At least one but not all met expectation			17.59
None met expectation			12.50
Practical support from offspring	1–3		
All children met expectation			59.26
At least one but not all met expectation			17.59
None met expectation			23.15
Financial support from offspring	1–3		
All children met expectation			72.69
At least one but not all met expectation			13.89
None met expectation			13.43
Offspring's filial piety	1–3		
All children met expectation			80.56
At least one but not all met expectation			14.35
None met expectation			5.09
Controls			
Age	60–79	66.24 (5.00)	
Female (ref.=male)	0–1		55.32
Married (ref.= widowed/divorced)	0–1		77.08
Financial strain (ref. = no)	0–1		39.59
Self-rated health [a]	1–5	2.31 (0.91)	
Offspring's marriage			
All children met expectation			67.36
At least one but not all met expectation			25.46
None met expectation			7.18
Offspring's SES			
All children met expectation			48.15
At least one but not all met expectation			24.77
None met expectation			27.08

[a] Higher scores indicate better health.
ref. = reference group.

4. Discussion

This study identifies correlates of parental satisfaction in late life in a sample of 432 older parents aged 60 to 79 with 1,223 adult children from one of the least developed counties in China. Results indicated that most parents reported being satisfied with their parental roles, and we found support to our three hypotheses. Specifically, relationship quality with offspring, offspring's emotional support, offspring's practical support, offspring's financial support, and offspring's filial piety were positive correlates

Table 2. Bivariate correlations matrix (N=432)

	1	2	3	4	5	6	7	8	9	10	11	12	13
1	1.00												
2	0.06	1.00											
3	–0.02	–0.17***	1.00										
4	0.00	–0.20***	–0.37**	1.00									
5	–0.15**	0.00	0.10*	–0.07	1.00								
6	0.23***	0.07	–0.19**	0.09*	–0.23***	1.00							
7	0.23***	0.08	–0.05	0.09	–0.20***	0.22***	1.00						
8	0.32***	–0.11*	–0.03	0.04	–0.06	0.14**	0.26***	1.00					
9	0.23***	–0.13**	–0.01	0.10*	–0.07	0.14**	0.13**	0.38***	1.00				
10	0.13**	–0.16***	–0.02	0.01	–0.08	0.03	–0.01	0.20***	0.15**	1.00			
11	0.21***	–0.13**	–0.05	0.03	–0.13**	0.13**	0.17***	0.36***	0.51***	0.12**	1.00		
12	0.30***	–0.16***	–0.00	0.05	–0.05	0.11*	0.16***	0.50***	0.39***	0.20***	0.34***	1.00	
13	0.16***	–0.09	–0.02	–0.00	–0.04	0.07	0.19***	0.29***	0.24***	0.15**	0.23***	0.26***	1.00

* *P*<.05; ***P*<.01; ****P*<.001; two-tailed

Note:

1=Parental satisfaction,2=Age, 3=Female, 4=Married, 5=Financial strain, 6=Self-rated health, 7=Offspring's SES, 8=Getting along with offspring, 9=Emotional support from offspring, 10=Practical support from offspring, 11=Financial support from offspring, 12=Offspring's filial piety, 13=Offspring's marriage.

of parental satisfaction in this sample, respectively; net of parent and offspring characteristics.

The finding regarding the association between offspring's emotional support and parental satisfaction is in line with Western research that indicated older parents' satisfaction improved when children gave emotional support (Lang and Schütze, 2002). Our findings that offspring's practical support and financial support were positively associated with parental satisfaction, respectively, are consistent with Chinese cultural emphasis on filial piety. Filial piety in Confucian culture represents "a life-long responsibility" for offspring to demonstrate their dedication and efforts to their parents' wellbeing by making parents free from worry (Kim, Cheng, Fringeman *et al.*, 2015). In contrast, filial obligation required in Western cultures is primarily need-driven as older parents expect adult children to step in to help only when they are "at times of need" (Gans and Silverstein, 2006). Previous work documented no or only weak associations between exchanges of assistance and parental well-being in some Western settings (Lowenstein, Katz, and Gur-Yaish, 2007; Umberson, 1992). This contrast may help understand our study findings of why expectation of practical and financial support from offspring plays a significant role, respectively, in deciding parental satisfaction in late life in a sample of able-bodied older Chinese parents.

Meanwhile, we found that the significant effects of parental satisfaction with offspring's emotional, practical, and financial support disappeared in the full model when examining relationship quality with offspring and offspring's filial piety simultaneously. This result indicates that child-to-parent support, in general, plays a less salient role than better relationship quality with offspring and offspring being filial among older adults who were satisfied with their parental role, suggesting specific forms of support from offspring in these dimensions may become less important even in one of the least developed counties in contemporary China. Contrary to this finding, the significant dose-response relation between offspring's filial piety and parental satisfaction detected in the current study indicates that filial piety is a multidimensional concept. Its meanings go above and beyond various forms of support and this complicated and all-embracing concept remains influential in terms of affecting older Chinese adults' wellbeing, manifesting that the parental role in late life is embedded in the cultural context in which the parent-adult child interaction and exchange occurs. These findings are consistent with the symbolic interactionism perspective underscoring role and relationship quality and the Chinese cultural norms emphasizing filial piety. In addition, the

Table 3. Odds ratio estimates from logistic regression of parental satisfaction (N=432)

Variables	Parental Satisfaction					
	Model 1	Model 2	Model 3	Model 4	Model 5	Model 6
Relationship quality with offspring						
All children met expectation (ref.)	1.00					1.00
At least one but not all met expectation	0.39**					0.61
None met expectation	0.19***					0.30**
Emotional support from offspring						
All children met expectation (ref.)		1.00				1.01
At least one but not all met expectation		0.58				0.71
None met expectation		0.31***				0.68
Practical support from offspring						
All children met expectation (ref.)			1.00			1.00
At least one but not all met expectation			0.77			1.03
None met expectation			0.49**			0.66
Financial support from offspring						
All children met expectation (ref.)				1.00		1.00
At least one but not all met expectation				0.74		1.35
None met expectation				0.35***		0.61
Offspring's filial piety						
All children met expectation (ref.)					1.00	1.00
At least one but not all met expectation					0.31***	0.46*
None met expectation					0.10***	0.15**
Controls						
Age	1.04	1.03	1.03	1.03	1.04	1.06*
Female (ref.=male)	1.25	1.15	1.27	1.26	1.18	1.21
Married (ref.= widowed/divorced)	1.02	0.89	1.03	1.00	0.95	0.92
Financial strain (ref. = no)	0.66	0.69	0.72	0.71	0.69	0.65
Self-rated health [a]	1.52**	1.52**	1.62***	1.57***	1.54**	1.45**
Offspring's marriage						
All children met expectation (ref.)	1.00	1.00	1.00	1.00	1.00	1.00
At least one but not all met expectation	0.83	0.75	0.72	0.71	0.90	0.90
None met expectation	0.44	0.45	0.34*	0.37*	0.40*	0.49
Offspring's SES						
All children met expectation (ref.)	1.00	1.00	1.00	1.00	1.00	1.00
At least one but not all met expectation	0.72	0.58*	0.55*	0.59	0.62	0.65
None met expectation	0.62	0.50*	0.46**	0.53*	0.54*	0.65
Overall model χ^2	76.89***	64.05***	57.81***	61.76***	79.56***	101.19***
df	11	11	11	11	11	19

[a] Higher scores indicate better health. ref. = reference group.
*P<. 05; **P<. 01; ***P<. 001; two-tailed

dose-response association of filial piety and parental satisfaction pinpoints the importance of considering the effects of all children, rather than the focal child or children as a composite, on parental wellbeing when examining parent-adult child relationships, echoing previous research that called for such investigation (Fingerman, Cheng, Birditt *et al*., 2012).

This study has limitations that provide directions for future research. First, this study is a locally conducted small-scale study. Although our sample fit the profile of Chinese aged 60 to 79 living in townships in terms of sex and education composition according to the 2010 Census (National Bureau of Statistics, 2012, Forms 3-1b and 4-1b), future studies with nationally representative data or large-scale sample are needed to ascertain our study findings' generalizability. Future research could also explore the definition of "a *filial* child" among older Chinese adults to ascertain its various dimensions. Second, longitudinal analyses are warranted to provide more rigorous hypothesis testing on directionality of the associations, as components of parental satisfaction may change over time even in late adulthood, and longitudinal studies can help detect whether reciprocal effects exist. Third, we measured parental satisfaction using a single item. Research has indicated that single-item measures can be almost as effective, especially when the construct is unambiguous, as multiple items (e.g., Cheung and Lucas, 2014). For a complex rather than straightforward construct like parental satisfaction, however, multiple-item scales if constructed appropriately might be better than a single-item measure.

5. Conclusions

Despite the limitations, this study is the first to identify correlates of parental satisfaction in late life and in a Chinese setting. It examines a range of relationship quality, interaction and exchange with offspring variables regarding parent – adult child ties across multiple children in the context of China, along with offspring's filial piety. A particular strength of this study is the use of a rich data set recently collected from one of the least developed counties in China, which offers unusually rich information about relationship quality, interaction, and exchange with each adult child in a family. The data set provides us a rare opportunity to go beyond the commonly used parent – *focal* child information or aggregated measures viewing children as a composite to study parent-child relationship and exchange. The key take-home message from this study is that relationship quality and offspring's filial piety are the most essential positive factors promoting parental satisfaction among older Chinese parents in our sample whereas specific forms of support and exchange are less important. Moreover, offspring's filial piety was associated with parental satisfaction in a dose-response manner. That is, having none of the children meeting parents' filial piety expectations was more detrimental on parental satisfaction than having at least one but not all children meeting expectations. Future work using data from different regions in China and different countries is needed to further test these hypotheses.

Overall, findings of this study have implications for the development and implementation of appropriate interventions aimed to reduce parental dissatisfaction. For example, we might extend government funded family-strengthening programs aiming to enhance the quality and stability of the relationships with children (mainly focusing on parents with a young child with behavioral problems, though; e.g., Kumpfer, Pinyuchon, de Melo *et al*., 2008) to help improve parent-adult child ties in late life. Such programs might be especially useful among older Chinese adults as getting along with all adult children apparently reduces parental dissatisfaction. Moreover, for Chinese practitioners, such educational intervention programs should pay particular attention to understanding the life histories, filial piety expectations, and values of both generations, considering that offspring's filial piety in the family can clearly enhance parental satisfaction among older Chinese parents as evidenced in this study.

Conflict of Interest and Funding

No conflict of interest was reported by all authors.

Acknowledgements

The data collection was supported by the University of Utah Center on Aging Pilot Grant issued to Ming Wen in 2014. We are grateful to Shujun Tian, Xia Sun, Wen Li, and Yang Yang for their valuable

assistance with data collection. We thank Michael F. Timberlake and Sonia Salari for their helpful comments on the original draft. We also thank both anonymous reviewers and the editor for their insightful comments that help improve the manuscript.

Ethics Approval

The Institutional Review Board at the University of Utah approved the project in May 2014 (IRB: 00067618).

Author Contributions

Yiqing Yang and Ming Wen jointly designed the survey. Yiqing Yang played a leading role in the fieldwork of data collection and cleaned the data. In this article, Yiqing Yang proposed the specific research questions, conducted the analyses, drafted the first version, and revised the manuscript. Ming Wen participated in the writing and further revision of the manuscript.

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International Journal of Population Studies

RESEARCH ARTICLE

Towards a data users' framework to advance Sustainable Development Goal 2

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Abstract: Ensuring effective accountability mechanisms will be a pre-requisite for achieving food and nutrition security and thus, advancing the progress towards Sustainable Development Goal 2 (SDG2). Here we discuss and summarise the findings of the ONE Campaign-facilitated accountability working group for data users, which deliberated between November 2015 and February 2016, and involved expert consultations from civil society organisations, research institutions, and academia. We provide an overview of the key challenges identified by data users in relation to nutrition and food security, propose a novel conceptual framework within which these challenges should be analysed, and offer a set of concrete policy and programmatic recommendations to address the recurrent bottlenecks. The paper concludes by providing a summary of key findings within the larger context of relevant global initiatives and processes, such as Nutrition for Growth Summit, the Global Open Data for Agriculture and Nutrition network, and the United Nations General Assembly.

Keywords: food security, nutrition, SDG2, accountability, data use

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Received: November 14, 2015; **Accepted:** December 26, 2015; **Published Online:** January 2, 2016

Citation: Szabo S, Mowlds S, Claros J M, *et al.* (2016). Towards a data users' framework to advance Sustainable Development Goal 2. *International Journal of Population Studies*, vol.2(1): 65–77. http://dx.doi.org/10.18063/IJPS.2016.01.008.

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1. Introduction

Addressing accountability will be a pre-requisite for the achievement of the Sustainable Development Goals (SDGs). Accountability constitutes a critical part of effective governance, and as such it has been placed at the centre of the new development agenda (United Nations, 2014; United Nations, 2015a, United Nations, 2015b). It can be defined as "the obligation of power-holders to take responsibility for their actions" (UNDP, 2010: 8) and refers to the rights and responsibilities between

the citizens and the institutions which have an impact on their lives and well-being. Accountability is strongly associated with good governance (Bovens, 2007). An effective accountability framework will therefore need to consider and address multifaceted challenges that are linked to data collection and data use, legal and regulatory frameworks, policy tools, social participation at different levels, including of the youth, and monitoring and evaluation frameworks which would allow tracking progress against specific commitments (Potts, 2008; Potts and Hunt, 2008). Accountability mechanisms are also critical in ensuring that human rights of individuals are met (Potts, 2008). As a cross-cutting and multi-scale issue, accountability will need to translate into incorporating specific mechanisms within the thematic policy areas at regional, national, and global levels. While tailored to different geographic contexts, universal accountability principles and mechanisms are required as guiding principles.

More specifically, effective accountability mechanisms will also be critical to ensuring progress towards the achievement of SDG2 — "End hunger, achieve food security and improved nutrition, and promote sustainable agriculture" (United Nations, 2015a). Accountability can and should be part of the projects, programmes and policies aiming at eliminating hunger, reducing malnutrition and promoting food security. As with health and education, the right to food has been recognised to be a basic human right (Osmani, 2000; Szabo, 2016), and as such, access to safe and nutritious food should be guaranteed by the state. While hunger and famines have been proven to be associated with unfair distributional policies and lack of social protection (Devereux, 2009; Sen, 2009), increasingly obesity prevention has become a key public health priority in many developed and developing countries (Popkin, Adair, and Ng, 2012; Swinburn, Caterson, Seidell *et al*., 2004). The economic power of food industry and its influence on market dynamics and public policy has meant less accountability towards consumers and governments (Swinburn, Kraak, Rutter *et al*., 2015). It has been recognised that strengthening the accountability mechanisms is a precondition for achieving progress in reducing obesity rates and the prevalence of non-communicable diseases (NDCs) (Swinburn, Kraak, Rutter, *et al*., 2015).

Accountability and data revolution are intrinsically linked. As part of the pre-SDG agenda setting, policy makers and citizens called for a data revolution which would involve making data more available, accessible and disaggregated (IEAG, 2014). Data standardisation and disaggregation will become increasingly critical with the ever greatest focus on socio-economic inequalities (United Nations, 2015a; United Nations, 2015b). The implications of the availability or lack of quality data on inequalities and wider human development can be twofold. First, poor data hinder evidence generation; thus, preventing effective policy design and decision making. Second, unequal access to data can prevent citizens from access to information, thus limiting their engagement in social actions and political processes (IEAG, 2014). These barriers in access to data are also linked to inability of the poor to purchase or use ITC services, because of lack of resources, remote location or lack of education (IEAG, 2014).

This paper summarises the results of the discussion and analysis undertaken by ONE Campaign-facilitated working group on accountability for SDG2, and in particular the data users sub-groups. ONE Campaign is an international campaigning organisation which aims to fight extreme poverty and preventable diseases, mainly in Africa. The paper's key objective is to contribute to the current debate on SDG2-related accountability mechanisms, by providing a novel conceptual framework and a set of concrete policy recommendations on how to overcome data challenges in nutrition, agriculture, and food security. The paper starts by highlighting key accountability challenges for data collectors and data users with references to specific programmatic examples. We then propose a new accountability framework for data users and collectors. Finally, we provide a set of operational and policy solutions to address accountability obstacles for data users and collectors by applying a chart of principles approach.

2. Data User Experiences and Challenges

Quality data are the necessary foundation for strategic decision-making amongst governments,

donors, and private sector investors alike (IEAG, 2014). Yet the extent and quality of data for analysis and progress tracking require significant improvement. As part of the ONE Campaign-facilitated accountability working group's mandate, the authors undertook extensive analysis and expert consultations in order to identify specific challenges faced by data users, which are likely to hamper accountability and thus, progress towards the achievement of the SDGs. Here, we provide specific examples of data challenges identified within selected global and national projects and activities related to monitoring progress in commitments to improve food and nutrition security. A table summarising key challenges is provided as supplementary material.

2.1 Ending Rural Hunger Project

The Ending Rural Hunger project is a first attempt at providing a tool to review and follow-up on Sustainable Development Goal 2: end hunger, achieve food security and improved nutrition and promote sustainable agriculture. The Ending Rural Hunger project was created by the Global Economy and Development division of the Brookings Institution in 2015. The project was a collaborative effort benefiting from the input of over 120 experts. The project gathers and curates the data necessary to review and follow-up on a key aspect of SDG2: Ending Rural Hunger. In the developing countries' needs assessment, the analysis is directly tied to the specific targets of SDG2 (2.1, 2.2, 2.3, 2.4). Before arriving at the database with 106 indicators for 145 countries, an assiduous review of available sources was undertaken, to exclude data deemed inaccurate or unreliable. Three over- arching challenges were encountered: availability, reliability, and difficulty in measurement.

First, some crucial food and nutrition security (FNS) indicators are not measured and available (see Table 1). While the SDGs explicitly call for doubling the productivity of small-scale farms, at present there are no comparable, cross-country data specifically on the productivity of small-scale farms. Similarly, very little country-specific data are available on how much food is lost or wasted (post-harvest or post-market) in developing countries, although rough regional estimates have been compiled. Systematic data on domestic private investment in agriculture, a key driver of progress, are not available. Very few agricultural indicators are disaggregated by gender, even though many key FNS indicators may vary systematically between men and women. An initial database on access to rural insurance has been discontinued on the grounds that it did not adequately reflect ground realities. Other variables are available for certain countries or regions but have limited coverage. Of the 80 indicators used, 15 were available for fewer than half of developing countries.

Second, even where data are available, reliability is an issue in terms of quality and comparability. The statistics collected and published by the Food and Agricultural Organization (FAO) are based on reporting from national statistical agencies. But due to a lack of reliable reporting from member countries, FAO data experts have had to generate their own estimates of basic production data for nearly 70 percent of African countries (FAO, 2008). This means that even straightforward production data for most African countries could be unreliable. This presents a challenge to strengthen national statistical offices, something that the Paris 211 initiative and the new Global Partnership for Sustainable Development Data are responding to.

Data on more complex or nuanced issues such as under nutrition, the capital stock in agriculture, or the environmental impact of agricultural production are often derived from modelling and extrapolation rather than real data collection. Data on governments' domestic public spending on agriculture are also out of date and of questionable comparability because the various statistical agencies take different approaches to include or exclude line items like "rural roads" that serve multiple purposes (FAO, 2008, pp.8,36). According to the Partnership in Statistics for Development in the 21st Century, a number of issues and priorities are important for FNS but are inherently difficult to measure and quantify. For example, strong leadership — among politicians, government bureaucrats, and entrepreneurs in the private sector — is a crucial ingredient in designing and implementing a successful national strategy for ending hunger, but good metrics for capturing leadership are hard to find. And when it comes to trying to estimate the effects of climate change on agricultural productivity, so many factors and assumptions must be built into agro-climatic models that ultimately we must accept that there will always be high levels of uncertainty in such projections.

Table 1. Global FNS Data Gaps

Indicator	% of countries missing data
Developing Countries	
Cold Storage	78%
Food Consumption Score	73%
Percent of Area Devoted to Modern Varieties	72%
Official Flows to FNS-Brazil	66%
Relative Rate of Assistance	65%
Trade Bias Index	62%
Access to Agricultural Extension Services	61%
Time-Bound Nutrition Targets	61%
Governments Promote Complementary Feeding	61%
Nominal Rate of Assistance	60%
Family Farm Prevalence	59%
Consumer Tax Equivalent of Farmer Support	59%
Welfare Reduction Index	59%
Trade Reduction Index	59%
NGO	58%
Share of Female Researchers	54%
Agricultural R&D as Percent of Agricultural GDP	53%
Share of Researchers with PHD	53%
Developed Countries	
Indicator	**% of countries missing data**
Support to Biofuel Production	31%
Simple Average Applied MFN Tariff, Biofuels	31%
Support to the Marine Sector	24%
Support to the Marine Marketing and Processing Sector	24%
Support to the Aquaculture Sector	21%

Source: End Rural Hunger project

There are reasons to hope that agricultural data will improve in the future. For example, new technologies such as cell phones may decrease data collection costs. More rigorously designed and implemented household and agricultural surveys have potential for better measuring the production and consumption of small-scale farms (Carletto, Jolliffe, and Banerjee, 2015). Satellite imaging can potentially provide cheaper, more accurate, and more regionally disaggregated data on physical and environmental issues. There are efforts to create agreed protocols for how to measure food loss and waste. Increasing political attention is being devoted to the issue. For instance, the United Nations (UN) has recently launched an Inter-Agency and Expert Group on Food Security, Agricultural and Rural Statistics to document good practices and guidelines on concepts, methods, and statistical standards. A Global Open Data for Agriculture and Nutrition program (GODAN) has brought together 100 partners to improve data (GODAN, 2016). The open data successes of the GODAN efforts will be shared during the GODAN summit during this year's United National General Assembly (UNGA) in New York.

2.2 The Global Agriculture and Food Security Program

The Global Agriculture and Food Security Program's (GAFSP) Monitoring and Evaluation (M&E) framework is designed to strengthen the partnership for sustainable development, with an overarching program goal (Tier – I) to focus on improvement of incomes and food security of a significant number of rural communities in the world's poorest countries, in support of the SDGs to end hunger and poverty. As a part of the M&E process — and while awaiting for the final SDG indicators agreed by the UN Statistical Commission — the GAFSP team has performed extensive analytical exercise to validate indicators for food security/nutrition measurement at a country/national level using standardised scores derived from experience-based methods. As data users, accountability for measurement of results in nutrition remains challenging for multiple reasons.

First, data coverage for some of the key nutrition-specific indicators is sparse. Indicators central to SDG2 theory of change, such as minimum dietary diversity (proxy indicators of diet quality/access), need to be tested for cross-country comparisons. For the purpose of monitoring, evaluation, and targeting, careful validation of these indicators must be undertaken, which remains challenging. Second, food consumption scores, diet quality, and diversity merit more comprehensive and standardised measurement across all developing countries. This will also help and expedite the process of external validation. This also includes standardisation of recall approach for better comparison. Finally, a transparent and credible tracking and disclosure of financial resource requirements for monitoring of nutrition indicators must be in place. Currently, identifying the cost implications of implementing and advocating certain indicators at project level, where a stand-alone DHS, LSMS, MICS surveys are not available (or possible), remains a challenge.

2.3 Budget Analysis to Track Commitments to Nutrition

Budget analysis has been increasingly undertaken as a means to monitor nutrition commitments at national and local levels. The Scaling up for Nutrition (SUN) Secretariat works with SUN countries and technical partners to perform financial tracking by relying on a standard methodological framework for routinely and systematically collecting country budgetary data relevant to nutrition known as the Three-Step Approach (SUN, 2015). The three phases of the approach include: (i) identification of relevant budget-line items through a strategically created key word search; where possible, the initial search should be related to relevant outcomes and actions as presented in national plans for nutrition, (ii) categorisation assessing whether the identified budget-line items correspond to nutrition-specific or nutrition-sensitive programs and excluding those that are found not to be relevant (after further consultations), and (iii) weighting or applying an attributed percentage of the allocated budget-line item to nutrition where the percentage is based on the step-two categorisation as well as consultation with national experts. This Three-Step Approach allows countries to view changes in budgetary allocations (and actual expenditures when possible) over time. While the results do not directly allow for comparisons across countries, the Three-Step Approach is designed to identify the gaps between cost estimations for reaching World Health Assembly (WHA) nutrition global targets and future financing (SUN, 2015b).

In 2015, 30 out of 56 SUN Countries have applied this "three-step" approach to analyse nutrition related expenditures within their national budgetary systems (SUN, 2015b). 16 countries identified more than ten budget line items (averaging 23 items), while 6 countries reported more than 80 budget line items. 22 countries were able to identify integrated health programmes and categorized them as nutrition-specific budget allocations. 25 countries were able to identify nutrition-sensitive budget allocations across more than four of the key sectors (health, agriculture, education, social protection, and Water, Sanitation and Hygiene (WASH). 10 countries were able to identify allocations for nutrition governance, covering costs for coordination, research, and nutrition information systems. Lastly, 7 countries were able to provide sufficient detail to review funding sources permitting a better understanding of who is investing where.

As a result of these analyses, four challenges were identified. First, a key difficulty in conducting a budget analysis that seeks to account for nutrition-related expenditures is how to identify and assess personnel costs such as salaries, benefits, and overheads. Second, there is often misalignment or variance between plans and budgets which inhibits the development of a comprehensive framework for financial tracking. Third, the fact that addressing malnutrition requires multi-sectoral and multi-stakeholder actions (SUN, 2015b) effectively blurs the boundaries of what and what not to include for nutrition relevant budget-line items. Fourth, and following from the third challenge, it is crucial for financial tracking to identify the levels of government in order to be clear on who is responsible for public spending. Allocation and spending data at lower government levels are normally not included in the national budget. If transfers from the national government are in the form of block grants or similar, the budget data will not provide details on sector or program spending. This is especially troubling given that many countries are undergoing a process of devolution where service delivery is being transferred to regional and/or local governments.

Similar analyses were undertaken by Save the Children. The challenges encountered throughout the process included access to data and data alignment. Access to digital data can be particularly difficult and hence manual data entry is often required, which tends to be a resource intensive exercise. Organisation of the data across countries is also a challenge in terms of alignment and comparability. For example, Niger's budget proposal (*Plan d'Action Annuel*) is structured differently to Zambia's budget.

2.4 Tracking ODA to Nutrition Using OECD DAC Data

The principal and most comprehensive source of nutrition official development assistance (ODA) data is the Development Assistance Committee's Creditor Reporting System (DAC CRS). This reporting is compulsory for DAC members. Donors report each project under the purpose code that best represents the main objective or sector of their initiative. This approach avoids double-counting, but limits the ability to further breakdown projects with multiple objectives. Only a sub-set of development assistance is reported to the CRS as only DAC members have obligation to report. Countries that report voluntarily do not necessarily provide enough details. Other countries do not report to the DAC CRS at all. In addition, ODA is an essential resource available to developing countries, but the development finance landscape has become more complex and varied, including other resources, national and international, public and private. How these resources contribute to improved nutrition and how ODA works in complementarity with them is difficult to ascertain as data on this wider landscape are scant or difficult to access.

More detailed analysis based on project descriptions in the CRS and on project documents can provide a clear picture on nutrition ODA. Development Initiatives (DI) used this approach to track nutrition spending using the SUN Donors Network methodology and to assess the reach, coordination and coherence of DFID`s nutrition portfolio. The study found that, while some assessment was possible, future exercises would benefit by better data quality and coverage in the CRS and in project documents. The report presented some sub-national data on the location of DFID's activities using data published by the International Aid Transparency Initiative (IATI) registry (IATI, 2015). IATI data provided insights on projects location, proximity, and reach. But coverage was limited to a sub-set of projects and quality of information reported to the IATI standard was quite varied.

Similar challenges have been identified in the work carried out by Thousand Days. The main issues are pertaining to lack of easy access and standardisation. For example, when analysing DAC data for nutrition commitments and disbursements (code 12240), users found that the webpage was not user friendly, difficult to find and locating information on nutrition investments was challenging. Lack of standardisation is related to how such DAC data are produced. Reporting periods are not always the same for all donors, so what is reported might not be the actual amount disbursed. The United States Agency for International Development (USAID), for example, has very different re-

porting timelines than those of UK, and they only report funds as disbursed when projects end. As could be observed by some users, real amounts invested according to some donors did not match with those we found in DAC data files. Specific codes for nutrition-sensitive and nutrition-specific investments were also lacking.

3. Towards Evidence-based Accountability: A Framework

As one of the outcomes of the review of challenges pertaining to data use and data standard setting, the working group suggested a new conceptual framework which illustrates a data centred accountability process. The four main pillars of the framework are data standard setting, data collection, data use, and policy and practice. The framework draws from the work by Kraak *et al*. (2011) and Swinburn *et al*. (2015), which focuses on the agreed objectives, processes and outcomes, and accounts for the key role of legal accountability framework and communication with different stakeholder groups (Swinburn, Kraak, Rutter *et al*., 2015).

The very initial step in this accountability approach is the assessment step — where evidence is being generated, including through primary data collection, common measures, such as Body Mass Index (BMI) and the WHO's Non-communicable diseases (NCDs) Global Monitoring Framework. The second step involves communication with key stakeholders, including beneficiaries, which can happen through formal and informal process. Swinburn *et al*. (2015) provide an example of the European Union's (EU) consultation process on the EU-USA trade agreement and the recommendation of evidence-based interventions, such as tax on sugar-sweetened beverages. Legal mechanisms constitute an integral part of an efficient accountability framework because by definition they imply enforcement of agreed rules and principles, and as such, can act as incentives and disincentives for individual and group behaviour. Finally, continuous improvements of accountability mechanisms are keys to ensure specific accountability approaches and tools that respond to the changing realities. In our proposed framework (Figure 1), we adapt the four principles of the discussed above framework, but focus on the fundamental role of data for accountability.

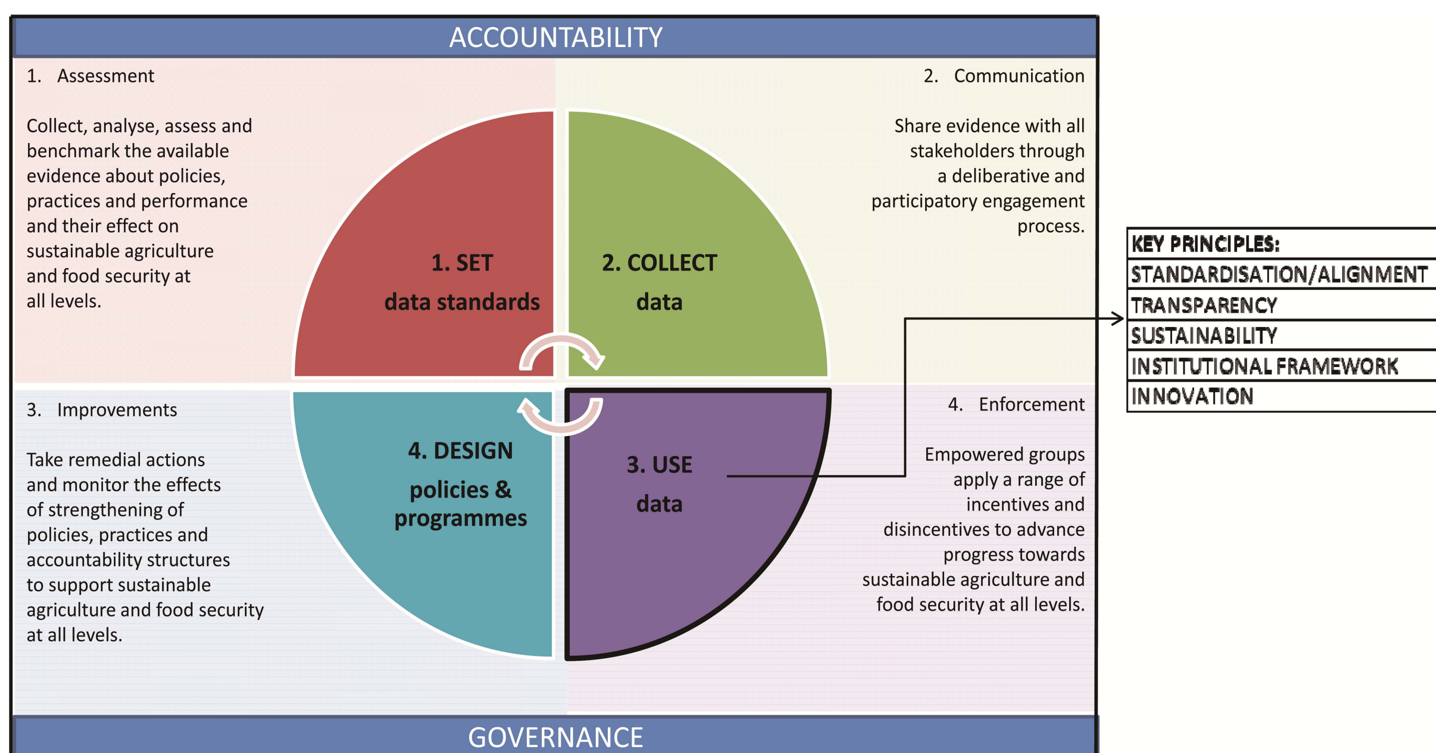

Figure 1. Data centred accountability framework for SDG2. Source: Adapted from Swinburn *et al*. (2015).

The framework draws from the working group's key assumption that achieving accountability for SDG2 is not possible without scaling up efforts in investments throughout the full data cycle, including from standard setting to designing evidence based policies. While the assessment part seems intuitively the most critical element of the data centred framework, other aspects are also dependent on the availability of quality data. Both communication and enforcement mechanisms can operate effectively only if there is reliable evidence supported by data at the different levels. Communicating about local and national budget allocations for nutrition specific and nutrition sensitive interventions can only happen if supported by validated results. Improvements to policies and practices pertaining to nutrition and food security and sustainable agriculture require regular monitoring and evaluating, and best practices can be developed and applied if relevant empirical evidence is available. Global nutrition related indices, such as the Access to Nutrition Index and Hunger and Nutrition Commitment Index, tend to be regularly re-evaluated and re-calculated, and methodological improvements can be made based on new data, tools, and methodological advances.

4 Towards Evidence-based Accountability: A Charter of Principles

We find that the following principles are most relevant from the data users' perspective: standardisation/alignment, transparency, innovation, institutional framework, and the overarching principle of sustainability. Summary of suggested policy solutions for data users is provided in Table 2. In terms of standardisation/alignment, the key questions are around best legal and regulatory practice and licensing agreements which should be put in place for data collectors, data users, and data standard setters to adhere to. Here, it is critical to develop a detailed set of standard food security and nutrition (FSN) related indicators and innovative measurement tools. Creation of the UN Inter-Agency and Expert Group on Food Security, Agricultural and Rural Statistics to document best practices and create guidelines, concepts, and methods constitutes a positive example of tackling challenges related to gaps in standardisation. Another relevant example is FAO's work on developing new guidelines for the 2020 World Programme for the Census of Agriculture for the Period of 2016–2025 (UNSC, 2015). From an IT perspective, a unified application program interface (API), such as onedata.org, could act as a mediator and façade between the users of the API (decision makers, civil society organisations and researchers) and changes to the core source systems (various AgFSN reports and datasets provided by sectoral experts, NGOs) that provide the data. This would shield users of an API from changes to those source systems as an API could implement logic to maintain the structures and methods that applications have been developed against. For example, JavaScript Object Notation (JSON) is a schema-less standard which is particularly suited to allowing new data to be incorporated without impacting previously developed solutions.

Second, transparency involves open data formats used by all organisations providing data. The reports and datasets must be available in open data formats in real-time, or at least as close to real-time as possible, to allow for the latest data to be extracted from all reports. PDF reports and other closed datasets limit the use of data, and the common tried and tested formats for such data are in XML and JSON formats. JSON is quickly becoming the *de facto* data format for web and mobile applications, due to its ease of integration into both browser- and server technologies that support JavaScript. JSON also allows for an easier integration with web-based mapping technologies such as Google Maps and Open Street Map, which is particularly important, giving the data users' aim to geolocate the information within the accountability framework. The data that are made available and used within the accountability framework must be designed with customer-facing (local community, decision maker) applications in mind and the data's output is designed to be easily understandable, and supportive of common customer-facing application use cases.

Implementing effective solutions would not be possible without innovative approaches and technologies. Hence, the third suggested principle is around innovation, in particular the innovative use

of technologies. Continuous innovations in both data collection and data use are critical to ensure efficiency gains. Innovative data use techniques include the use of mobile applications for progress monitoring. An example of such an initiative developed by the Myanmar Nutrition Technical Network which uses mobile applications to monitor the status of implementing of the code for marketing breast milk substitutes in the country. Another example is the development of a micro-tasking platform run by volunteer scientists to monitor the state of tropical forests. This project combines innovative approaches for data collection, dissemination, and data use by combining science, volunteering, and advocacy. It proposes a new approach for conservation by allowing larger public to gain access to data on deforestation of tropical forests, including high resolution satellite images of forested regions and the levels of deforestation (Civicus, 2016).

Fourth, institution framework constitutes an underlying principle for accountability, including in relation to data use. Two terms define the concept of institutional accountability in the health and social sectors, i.e., answerability and enforceability (George, 2003). They are equally relevant when considering FNS data. Answerability refers to information that should be provided to various stakeholders to keep them abreast of issues, while enforcement involves the mechanisms that are needed when there is lack of or ineffective action. This concept adopts a human rights based approach that directly links providers and users (through dialogue and negotiation) and can be effective if improved transparency is promoted as a crucial mechanism to improve services (McNeil and Mumvuma, 2006; Joshi, 2013).

For example, in 2014, Nigeria created an independent body to help track progress towards achieving the goals of the maternal, newborn, and child health (MNCH) roadmap. The modality the Nigeria Independent Accountability Mechanism (NIAM) adopted was to use a scorecard and directly interface with the government led steering Committee on MNCH. NIAM comprised of representatives from the media, civil society, and health professionals have begun to appraise government's efforts to achieve its commitments and goals (Garba and Bandali, 2014). While NIAM is facing a daunting task, one key recommendation being made is for the current administration of Muhammad Buhari; to set up a Presidential Taskforce on Data for Accountability and Development as part of his change mantra. Until and unless information and data can be generated before and after the variables, the attempts to evaluate change would be whimsical and transient. Based on the work undertaken in the area of MNCH, policy makers should draw from NIAM to advance accountability in nutrition, food security, and agriculture. Linking the data and accountability mechanisms across nutrition, health, and agriculture would allow data users to conduct more integrated analyses; thus, leading to further advancing evidence for both nutrition and MNCH.

Finally, as data users' experience has shown, better data on financial resources for improved nutrition and more details on how these resources reach people on the ground would advance both accountability and evidence-based decision-making. Data production and reporting practices affect the availability and quality of data; therefore, affecting the ability to conduct meaningful analysis. While progress occurred in recent years, data gaps still exist. Substantial improvements can result from increased granularity. Reporting by activity rather than by project and geo-coded information would allow a more accurate tracking at national and sub-national level. More granular information on beneficiaries would increase knowledge on who can be reached by which interventions, supporting better targeting to the people most in need. Disaggregation should be done by gender, age, income, disability, geography (including sub-national) and displacement status. Financial information reporting should favour disbursements as they represent how much each donor has actually spent in a given year. While commitments are useful information, they represent just how much a country agreed to spend in a given year, often over a given period of time. A timelier reporting system would allow a more rapid assessment of resources allocation and improve the effectiveness of accountability mechanisms.

Table 2. Summary of solutions for data users to ensure accountability and achieve SDG2

Examples of challenges	Proposed solution	Related principle
Unavailable or unmeasured indicators Small scale farms: No comparable, cross-country data specifically on their productivity. Little or no country specific data on Food Loss and Waste (FLW), post-harvest or post-market, but rough regional estimates exist. Systematic data on domestic private investment in agriculture. Agricultural indicators are not disaggregated by gender. Access to rural insurance indicators has been discontinued. Poor data availability, e.g., out of 80 indicators in the Ending Rural Hunger (ERH) developing country database, 15 are available for fewer than half of developing countries.	More rigorously designed and implemented household and agricultural surveys have potential for better measuring the production and consumption of small-scale farms. Efforts to create agreed protocols on how to measure food loss and waste. Increasing political attention is being devoted to the issue. For example, the UN has recently launched an Inter-Agency and Expert Group on Food Security, Agricultural and Rural Statistics to document good practices and guidelines on concepts, methods, and statistical standards.	I. Standardisation/ alignment II. Institutional framework III. Sustainability
Reliability is a challenge in terms of quality and comparability The nature of self-reported data, e.g., due to a lack of reliable reporting from member countries. FAO data experts have had to generate their own estimates of basic production data for nearly 70 percent of African countries. Presents a challenge to strengthen national statistical offices.	Paris 21 initiative and the new Global Partnership for Sustainable Development Data are responding to the need to strengthen national statistical offices. New technologies such as cellphones may decrease data collection costs.	I. Standardisation/ alignment II. Institutional framework III. Sustainability
Data on more complex or nuanced issues such as undernourishment, the capital stock in agriculture, or the environmental impact of agricultural production are often derived from modelling and extrapolation rather than real data collection. Data on governments' domestic public spending on agriculture are also out of date and of questionable comparability because the various statistical agencies take different approaches to include or exclude line items like "rural roads" that serve multiple purposes.		
Inherent difficulty of measurement and quantification Strong leadership is a crucial ingredient in designing and implementing a successful national strategy for ending hunger, but good metrics for capturing leadership are hard to find. Effects of climate change on agricultural productivity; because many factors and assumptions must be built into agro-climatic models that ultimately there will always be high levels of uncertainty in such projections.	Satellite imaging can potentially provide cheaper, more accurate, and more regionally disaggregated data on physical and environmental issues.	Institutional framework Innovation
Data are not open In some countries, data of budgetary allocations and spending are not publicly available and difficult to obtain.	GODAN is promoting opening data sets for transparency	Transparency Institutional framework

5 Conclusions

This paper summarises the findings of the data user working group on the accountability framework for SDG2 facilitated by the ONE Campaign. The paper describes key accountability challenges with specific programmatic examples and proposes a novel framework for professionals working with data. Finally, the paper provides concrete operational and policy solutions to address accountability obstacles by applying a chart of principles approach. Accountability constitutes a critical part of ef-

fective governance, and as such, it has been placed at the centre of the new development agenda (United Nations 2015a; United Nations 2015b). Effective accountability mechanisms will ensure progress towards achieving SDG2. To achieve these goals, the development agenda calls for a data revolution with increased availability, accessibility, and disaggregation of data.

We conducted expert consultations to identify specific challenges faced by data users, which are likely to hamper accountability and thus, progress towards the achievement of the SDGs. Specific bottlenecks were identified within selected global and national projects, including activities related to monitoring progress towards commitments made. Most challenges are due to a lack of availability, reliability, and transparency of data. Cross country comparison, validation, and difficulty in measuring (e.g. leadership) of some indicators remain a challenge. Availability and accessibility to data are the bottlenecks that have been identified when tracking commitments to nutrition using budget analyses. Reporting investments in the OECD DAC is also challenging due to a lack of standardisation for data reporting, timing of disbursements, lack of specific codes for nutrition-sensitive and nutrition-specific investments, and poor project data. Tracking OECD investments is also challenging for users because the website is not user friendly.

In response to the challenges, a four-pillar accountability framework is suggested. The main pillars are data standard setting (involves assessment), data collection (requires communication), data use (requires enforcement), and policy and practice (involves improvement). This framework (see Figure 1) focuses on the fundamental role of data use for accountability with the assumption that achieving accountability for SDG2 is not possible without scaling up investments throughout the full data cycle. For data users, key principles for a common accountability framework include: standardisation, consistency and alignment, transparency, sustainability, institutional framework, and innovation. A clear accountability framework helps to conceptualise the inter-linkages between different accountability mechanisms as related to data use. Failure to apply a robust accountability framework for SDG2 may trigger risks related to the progress towards this goal and hampers wider sustainable development agenda.

Availability of quality data is critical to ensuing and measuring accountability, and the lack of data and robust evidence is likely to prevent effective policy design and decision making. Accessibility to data is also important for citizen engagement in social actions and political processes, since the lack of it can prevent or limit citizen engagement in social and political change. Disaggregation of data is crucial for understanding and addressing socio-economic inequalities. Ongoing global processes such as GODAN, the Nutrition for Growth Compact (UK Gov., 2013), and the United Nations General Assembly in September 2016 present important engagement opportunities for improving accountability. Additionally, the SUN Movement is strengthening accountability at country level (IFPRI, 2015), GODAN is progressing on filling existing gaps in open data, and ONE Campaign is developing an accountability framework for SDG2. To firmly measure progress and for long-lasting sustainable accountability, more work is needed. Data use plays a cornerstone role requiring more institutional frameworks, improved standardisation, consistency/alignment, transparency, and innovation. All these are possible with the proposed framework.

Conflict of Interest and Funding

No conflict of interest was reported by all authors.

Acknowledgements

The authors wish to thank David McNair, Katherine Van Waes, Alexander Schmid and Sophie Taylor of the ONE Campaign for their useful comments and discussions which contributed to this paper. The authors also thank two anonymous reviewers for their valuable comments on an earlier version of this manuscript.

Author Contributions

Sylvia Szabo designed the study and contributed the most of the first draft of the manuscript. Sinead Mowlds, Joan Manuel Claros, Anuja Kar, William Knechtel, Mariella di Ciommo, and Ima Kashim contributed in the writing of the initial draft and subsequent revisions.

Ethics Statement

No ethics approval was required for this study.

Disclaimer

The views expressed in this work are those of the authors and do not necessarily represent those of the Save the Children UK, Scaling- Up Nutrition (SUN) Movement Secretariat, Global Agriculture and Food Security, Brookings Institution, Development Initiatives or Thousand Days, and are not necessarily attributable to their organisations.

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RESEARCH ARTICLE

"I came by the bicycle so we can avoid the police": factors shaping reproductive health decision-making on the Thailand-Burma border

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Abstract: For over half a century, political conflict combined with an overall lack of economic development has resulted in the displacement of millions of people both within Eastern Burma and to neighbouring Thailand. Given the overarching context, in conflict-affected regions of Burma, women face tremendous challenges in trying to obtain high quality, comprehensive reproductive health services. Drawing from interviews we conducted in Tak province, Thailand with 31 migrant and refugee women from Burma, this article explores women's lived experiences along the border and focuses on the ways that complex, overlapping barriers impact women's reproductive health decision-making at different points in their reproductive lives. Our results show that reproductive experiences are highly dependent on the woman's place of living mixed with her legal status and financial resources. Combined with socio-cultural taboos and externalized and internalized stigma, these dynamics blend to place constraints on women's autonomy and self-actualization. The way in which women's experiences are shaped by these barriers offers insights into priorities for education and programming to help improve reproductive health services in this protracted conflict setting.

Keywords: abortion, ethnic minorities, family planning, migrants, Myanmar, refugees

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Received: December 11, 2015; **Accepted:** January 19, 2016; **Published Online:** January 26, 2016

Citation: Gedeon J, Hsue S N and Foster A M. (2016). "I came by the bicycle so we can avoid the police": factors shaping reproductive health decision-making on the Thailand-Burma border. *International Journal of Population Studies*, vol.2(1): 78–88. http://dx.doi.org/10.18063/IJPS.2016.01.002.

1. Introduction

Eastern Burma represents one of the longest conflict-affected regions in the world.[1] Infrastructure and services in Eastern Burma have been neglected, impeding movement, and creating enormous disparities in education, healthcare, and income generating opportunities (Sietstra, 2012; Mullany, Lee, Yone *et al.*, 2008; Crawford, 2005). These overall dynamics combined with an overarching lack

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[1] In 1989, the military junta officially renamed the country of Burma as Myanmar. However, there continues to be significant debate as to the legitimacy of this name change. Our study team has chosen to use the name "Burma" as this respects the language used by our study participants and the stakeholders that we work with on the Thailand side of the border. We will use Burma to refer to the country throughout this article. This is a decision made solely by the authors and does not reflect the views of the editors, the journal, or the publisher.

of economic development have resulted in the displacement of millions of people both within Eastern Burma and to neighbouring Thailand (Sietstra, 2012; New Internationalist, 1996). Those who have been internally displaced and those living in conflict-affected areas of Eastern Burma are commonly referred to as "cross-border populations" as they are often provided with services and support from organizations operating in Thailand (Hobstetter, Walsh, Leigh, *et al.*, 2012). Populations from Burma residing in Thailand are comprised of two primary groups — refugees who reside in one of the nine "unofficial" refugee camps in Northern Thailand and migrants, most of whom are undocumented and do not have legal status.[2]

Consistent with conflict-affected populations around the world, the overall situation has impacted women's reproductive health. Cross-border populations are at significant risk of dying during pregnancy and childbirth, lack consistent access to contraception, and face high rates of unintended pregnancy (Burma Medical Association, National Health and Education Committee, Back Pack Health Worker Team, 2010; Back Pack Health Worker Team, 2006). Burma's abortion law is one of the most restrictive in the world and is narrowly interpreted. As a consequence, unsafe abortion is common and is a leading cause of maternal mortality in Eastern states (Ba-Thike, 1997). Women in Burma residing in Thailand — as either refugees or migrants — also face tremendous challenges to obtaining high quality, comprehensive reproductive health services and are at heightened risk of sexual exploitation and violence (Mullany, Lee, Yone *et al.*, 2008; Crawford, 2005; Maung and Belton, 2005; Belton and Maung, 2004). The efforts of a large number of international non-governmental organizations (NGOs) and community based organizations (CBOs) have not been sufficient to meet the overwhelming needs of women on both sides of the border (Hobstetter, Sietstra, Walsh, *et al.*, 2015; Gedeon, Hsue, Walsh, *et al.*, 2015; Sietstra, 2012; Hobstetter, Walsh, Leigh *et al.*, 2012; Lee, Mullany, Richards *et al.*, 2006).

That women in this context face structural, systems, legal, policy, and socio-cultural barriers to accessing desired health services has been well documented (Hobstetter, Sietstra, Walsh *et al.*, 2015; Sietstra, 2012; Hobstetter, Walsh, Leigh *et al*, 2012; Mullany, Lee, Yone *et al.*, 2008; Maung and Belton, 2005; Belton and Maung, 2004). However, far less research has been dedicated to exploring how women experience those barriers and identifying ways that women navigate these multi-faceted constraints. Drawing from interviews we conducted in Tak province, Thailand with migrant and refugee women from Burma, this article explores women's lived experiences and the ways that complex, overlapping barriers impact women's reproductive health decision-making at different points in their reproductive lives.

2. Methods

In the summer of 2013, we conducted a qualitative study dedicated to understanding women's experiences with the intrauterine device (IUD) on the Thailand-Burma border, a rarely used technology in this setting at the time. This effort was part of a larger project focused on identifying and addressing barriers to expanding access to long-acting reversible contraception and involved a multi-stage, multi-year collaboration between researchers and service providers in the US, Canada, and Thailand. We have reported on the IUD-related findings elsewhere (Gedeon, Hsue, Walsh *et al.*, 2015).

However, our semi-structured interviews with 31 women from Burma explored a range of issues beyond the IUD and our initial study questions. Participants provided extraordinarily detailed accounts of their lives, including reflections on major reproductive health-related decisions and events. In this article, we use the same dataset to delve into women's experiences along the border and focus on the structural, systems, financial, and socio-cultural factors that influence decision-making and access to services.

[2] Thailand is not a signatory to the 1951 Refugee Convention nor to the 1967 Protocol Relating to the Status of Refugees, and thus does not officially recognize the camps (Women's Commission for Refugee Women and Children, 2006).

2.1 Study Sites

Our data collection took place between June and August of 2013 in two cities located along the Thailand-Burma border: Mae Sot, Thailand, and Mae La, Thailand. Located only 5 km from the Burmese border, Mae Sot includes a large population of individuals who fled Burma during the civil strife as well as people who have crossed the border in search of economic opportunities and served as our primary base throughout the project. Mae Sot is home to the Mae Tao Clinic, an independent facility that provides comprehensive care to cross-border, migrant, and refugee populations and serves a catchment area of more than 200,000 people. Our second study site was the Mae La refugee camp, one of the largest unofficial refugee camps located along the border with over 40,000 inhabitants (AMI, 2012), otherwise known as "persons of concern" or as displaced populations (UNHCR, 2005).

2.2 Recruitment and Data Collection

We used a multi-modal, multi-lingual recruitment strategy to identify participants. Because the study was designed to explore women's experiences with and perceptions of the IUD, women were eligible to participate in the study if they were over 18 years of age, had used an IUD for at least six months, and were living along the Thailand-Burma border as a refugee, migrant, or cross-border individual. Women also needed to be sufficiently fluent in English, Burmese, or Karen in order to participate. Women who were interested in speaking with us first contacted our local Study Coordinator (Saw Nanda Hsue) who provided additional information about the study, confirmed eligibility, and scheduled the interview at a mutually convenient time and location. A local member of our team helped advertise the study in the Mae La refugee camp through her networks which helped recruit the majority of our participants for this study.

We obtained informed consent before commencing and audio-recording each interview. Using an interview guide developed specifically for this study, Jillian Gedeon conducted the interviews with the aid of an interpreter when necessary. We asked women to share with us information about their sexual and reproductive health history, experiences with the IUD, and thoughts on the ways that services along the border could be improved. Due to the sensitivity of the research topics, participants were given the option of having either a male or a female interpreter. Interviews in Mae Sot were conducted in a private room at Mae Tao Clinic and interviews in Mae La refugee camp took place either in a private room courtesy of a local organization or in the woman's house, per her preference. Women were repeatedly assured that participation and their responses to our questions would have no impact on the health services they received. All participants received the Thai Baht equivalent of USD10 as a thank you for participating, as well as refreshments during the interview itself. The Health Sciences and Sciences Research Ethics Board at the University of Ottawa approved this study (File #H02-13-08), as did the research committee at Mae Tao Clinic, Mae Sot, Thailand.

2.3 Data Management and Analysis

Our analytic plan was iterative, meaning that we reviewed data as they were collected to reflect on categories of content, adapt the interview guide, and identify thematic saturation. Jillian Gedeon also made detailed field notes before and after the interview and formally memoed throughout the project in order to reflect on emerging themes and the ways in which her positionality influenced the process. We transcribed and translated the interviews and used ATLAS.ti to manage our data (Friese, 2014). Using a sequenced approach to coding and interpretation, we conducted content and thematic analyses of the data through employing both *a priori* (pre-determined) codes and categories based on our study questions and the interview guide as well as inductive techniques to identify emergent themes (Gibbs, 2008). Regular study team meetings guided our interpretation.

In the results section we begin with a brief description of our participants. We then turn to the findings related to women's perceptions of the factors that impact reproductive health decision-making

and access along the border. We use quotations throughout the article to illustrate key findings and have removed or masked all identifying information by using pseudonyms throughout. We also include a series of narrative vignettes that showcase the ways in which participants revealed their experiences, perceptions, and opinions.

3. Findings

3.1 Participant Characteristics

Over the course of the study we conducted in-depth interviews with 31 women. At the time of the interview, participants' ages ranged from 21 to 55, with an average of 32. All of our participants were married and all but one of the women we spoke with had at least one child. Our participants included women who identified as cross-border (n = 2), migrants (n = 8), and refugees (n = 21).[3] Consistent with the population of women from Burma residing on the border in general, our participants identified with a range of religious and belief systems including Buddhism (n = 14), Christianity (n = 11), and Islam (n = 6).

3.2 Precarious Legal Status and Restrictions on Freedom of Movement

"If we go to the Mae Tao Clinic, the way to go there, there is no police. But sometimes when we come back…there is a police officer there and we have to pay 100 baht [USD3] to the police"
- *Thanda, age 32, migrant*

The harsh realities of life in Burma influenced all of the participants in our study. All of the women we spoke with talked at least briefly about the circumstances surrounding their "escape" or departure from their communities of origin. Whether or not our participants had sought formal asylum in Thailand, all of our participants has crossed the border in search of safety, economic security, and/or services for themselves or members of their family. For many, the move was also aspirational, based on hope that life in Thailand would bring additional freedom and opportunities.

However, all of the women in our study also discussed the challenges associated with having a precarious legal status in Thailand, as captured in Lwin's experience (Box 1).

Box 1: Lwin's story

Lwin fled from Burma with her mother and her younger sister in her early teens. As the oldest child, she has been responsible for providing for her family since they arrived in Mae Sot. Since moving to Thailand, she has worked several odd jobs, including construction work, caregiving, and factory labour, in order to help make ends meet. At a young age, Lwin accepted the reality that she would not be able to continue her education due to financial and legal barriers.

Now 22 years old, Lwin is married to a man that she met at the sewing factory where she currently works. They both work 16-hour days, six days a week and only have Sundays off to spend together and with other family members. Lwin and her husband decided to wait to have children until their financial situation was more stable; their long hours at the factory coupled with their duties to provide for family members prevent them from being able to raise a child comfortably.

Lwin gained her contraceptive knowledge from the married women at the factory and learned both

[3] There is considerable fluidity in the way in which women living on at the border identify their residence. For example, a woman may typically reside on the Burma side of the border but may engage in seasonal labour as an undocumented worker and reside in Thailand for several months of each year. Whether this woman identifies as "cross-border" or "migrant" is conditioned upon a number of factors, including the time of the year, the duration of current residence, the site of her primary income generating activities, and the location of family members. We acknowledge this fluidity and report women's residence as determined by individual participants.

accurate and inaccurate information about the oral contraceptive pill, the Depo-Provera shot, and the IUD. She explained that trying to seek medical care for her sexual health is challenging both because of the lack of time in her daily schedule and the risk of being stopped by the police on the way to the clinic. She is now an IUD user and hopes to one day be in a position where she can afford to grow her family.

Undocumented migrants like Lwin and cross-border residents "visiting" Thailand are at risk of deportation and are vulnerable to the demands of Thai police who may levy onerous "fines." Women's legal status (or lack thereof) becomes an important part of the calculus of where to go and when and how to travel, thus impacting freedom of movement. Women explained that these dynamics shape their decisions about whether and when to seek reproductive health services.

"On the way [to the clinic] we have to worry about the police, so if I take the pill, I will forget to take it regularly and for the depo [injection] I would have to [try to] come to the clinic quarterly. But if I insert the IUD, then I don't need to worry about anything for 5 years"

- *Khin, age 33, migrant*

Women are aware of these risks and some developed strategies to navigate them. As Lwin explained, "It's not hard to get to the Mae Tao Clinic. In the past, I used to come by car. But later on I came by the bicycle so we can avoid the police." Other participants reported, traveling to Mae Tao Clinic at times of the day when encounters with police would be less likely.

The issue of freedom of movement also emerged in our interviews with refugee women. Women living in the Mae La camp are generally able to move freely within the designated borders of the camp itself. However, in the absence of an identification card or travel papers, movement outside of the camp is severely limited and women who leave the confines of the camp without authorization risk confrontation with Thai authorities. Most of the refugee women we spoke with reported that learning about, let alone accessing, reproductive health services outside of the refugee camp was challenging. As Bway Paw, age 47, explained, "It's difficult to survive in this camp because we cannot go out. And we don't have any ID, including UN ID, Thai ID, and Burma ID." Although many women in our study had positive experiences with clinics in the camp, women who require or desire reproductive health services that are not available within the camp borders and those who would prefer to access services outside of the gaze of their immediate community are severely restricted in being able to do so.

3.3 Availability and Accessibility of Services

"…some of the women are far away from the hospital and they believe that they can rely on [child] delivery by their own [peers] in their village at home. However, when they get a serious condition and they go to the hospital, it is [often] too late."

- *May Ta, age 28, refugee*

The lack of availability of comprehensive services, particularly for those women who live in rural and more remote areas, was consistently raised by our participants as a major factor in their reproductive health decision-making. Beyond the legal risks undocumented women incur in traveling long distances, many women reported that the costs associated with travel shaped their options and influenced decision-making. The Mae Tao Clinic has established accommodations for women and their families who require multiple days of treatment or who have travelled extensively. However, some of our respondents explained that space was limited and often filled to capacity. Women in Mae La camp generally had ready access to primary reproductive health services in the camp itself, but tertiary services (for high risk pregnancies or complicated deliveries, for example) require transfer to

hospital facilities hours away.

The challenges associated with getting to a facility heavily influenced the timing and types of services women sought. Many of the women in our study had worked with a traditional birth attendant or a traditional healer at some point in their reproductive lives. Although some women reported having positive experiences with traditional and lay providers, most described use of these systems as being forged out of necessity. For example, Myia, a 54-year-old who resided in Eastern Burma at the time of interview, delivered her son in her village in Mon State, Burma in the early 2000s. She believes that his death was directly tied to her inability to travel to an affordable clinic:

"I delivered my son [in the village] and after 5 days, he was not healthy...And then we tried to get him some medicine and we also asked some other people to come and check but they could not help us. They gave us traditional medicine but it wasn't helpful for my son. He continued to feel better for 7 days but then after 12 days, he died."

- *Myia, age 54, cross-border*

A number of our participants reported that the availability of health facilities also directly influenced their contraceptive decision-making. Our participants who lived in Mae Sot or in the Mae La camp were overwhelmingly positive about the contraceptive method mix available to them. However, women who resided in communities outside of Mae Sot or the Mae La camp at some point in their reproductive lives described significant challenges in accessing ongoing contraceptive methods and lacked access to long term reversible contraceptive methods. Women explained that even if they had information about more effective methods, their choices were constrained. Indeed, almost all of the participants in our study adopted the IUD after having experienced challenges in accessing or using hormonal contraception consistently and/or having had unintended pregnancies, as showcased in Khin's story (Box 2).

Box 2: Khin's story

Khin got married at the age of 16 when she was still living in Pago, Burma. She became pregnant with her first child a few months after being married to her husband; she explains that they were young and did not know about sexual and reproductive health. She later tried to use contraception to plan her family, but could not afford to take contraception consistently. Reflecting on her experience, she reports:

"I got pregnant with my young daughter because I could not really afford to buy the pill. When I had the money, I would use the pill, but when I didn't have the money, I didn't use anything. That is when I became pregnant with her."

Living in Burma presented many financial hardships and after the birth of her second child, Khin tried to use oral contraceptive pills again, but they made her dizzy. She sought contraceptive counseling and experimented with a variety of methods, all of which came at a cost, while trying to help her husband support their family. The financial constraints that her family was experiencing motivated their move to Mae Sot, Thailand. Since then, Khin experienced contraceptive failure with the pill and had a miscarriage. Her migrant status led her to seek medical advice from a doctor at the Mae Tao Clinic. Now in her mid-30s, Khin eventually opted for the IUD and explained that it was particularly useful when living in Thailand because it reduces the need for many clinic visits, which in turn reduces the risk of getting caught by the police and getting fined as an undocumented migrant.

3.4 Direct and Indirect Financial Costs of Obtaining Services

Fines or bribes to ensure safe passage to or from a clinic and the costs associated with traveling long

distances to clinics are but a few of the financial considerations that our respondents described as shaping their reproductive health decision-making. Most of our participants described the costs of obtaining reproductive health services — particularly contraceptive supplies and delivery care — as prohibitively expensive. This was especially true for cross-border women, as family planning services are often not subsidized and facility-based deliveries often require payment in Burma. In comparing services in Thailand to those in Burma, Lwin explained, “Here, [in Thailand] even if you have no money, they just provide a free service for us.”

Many women in our study explained that financial costs not only influenced their decision to consistently use a particular method of contraception but also served as a major factor in the decision to adopt any method of contraception. Women who engaged in small-scale income generating activities, owned small shops and businesses, and worked in factories along the border, all struggle to make ends meet. Women explained that having (in all but one case) additional children would impede their ability to give their existing children as many opportunities as possible. Further, many women in our study described demanding workloads and daily exhaustion that influenced their decisions about the timing of pregnancies and parenting. As one 30-year-old factory worker explained, “[Each week I have one] day off, on Sunday. We usually start at 8 am and [go] until 10 pm or sometimes…they keep us working until 12 midnight.” Sie Sie’s story (Box 3) reflects this dynamic.

Box 3: Sie Sie’s story

Sie Sie is a 27 year old married woman with one child. She currently works in Mae Sot in a cotton factory with her husband. During her late teens, she found out she was pregnant after having unprotected sexual intercourse with her partner. Sie Sie struggled to find abortion services in Mae Sot and she eventually travelled across the friendship bridge to Myawaddy, Burma to consult with a traditional birth attendant. She was initially given a red powder to ingest and later endured a pummel massage, both of which made her feel very sick and uncomfortable.

“I deliberately aborted my pregnancy because I didn’t want it and I [didn’t] want to get married. When I tried to abort my pregnancy [myself] it didn’t work...So I went to a woman in Myawaddy and she treated me with a medicine...After 15 and 20 days the foetus was not totally aborted and it really hurt me. She pressed and squeezed my stomach with her body and treated me with herbal medicine but I was still really hurt and uncomfortable. I was scared and became thinner. I couldn’t eat any more and then I worried that something would happen [to me]”

Sie Sie and her partner were not convinced that the abortion had worked. Thus they decided to get married immediately because of the cultural stigma associated with pre-marital sex. They found out a couple of days after the wedding that the unsafe abortion had been successful.

After a few years of using the oral contraceptive pill provided to her by her employer, Sie Sie and her husband decided to have a child. But after their daughter was born it became clear that the long and exhausting hours at the factory and the costs associated with caring for a child made raising her in Thailand impossible. Sie Sie ultimately sent her daughter to Yangon to be cared for by extended family members. Sie Sie and her husband continue to live and work in Mae Sot; they hope to eventually be able to obtain enough financial security to be reunited with their child.

3.5 Socio-cultural Stigma Associated with Sex Before Marriage

Irrespective of women’s ethnic or religious identification, the majority of participants in our study referenced that sex before marriage was considered a major social taboo. The stigma associated with premarital sexual activity was cited as a major factor influencing women’s reproductive health knowledge and decision-making by cross-border, migrant, and refugee participants. These women

reported that broader social stigma restricted information and service delivery to adolescent populations and added to community pressure towards early marriage. Internalized stigma impacted the ability of unmarried women to ask questions or seek services when needed; a cultural construct often described as "shyness." Thus, the majority of women in our study reported that they only learned about reproductive health issues — including reproductive anatomy and physiology, contraception, and pregnancy — after getting married, even if they themselves were sexually active before marriage.

Two of our participants shared their abortion experiences during the interviews. In both cases, as illustrated in Sie Sie's story (Box 3), the women were unmarried at the time of the pregnancy and first attempted to terminate the pregnancy through self-induction practices. Both women then went to a traditional birth attendant and had an unsafe abortion and their stories showcase legal status, service availability, financial and socio-cultural dynamics shaping reproductive health decision-making along the border.

4. Discussion

Women's reproductive health decision-making along the Thailand-Burma border is shaped and influenced by a multitude of structural, systems, financial, and socio-cultural factors. Our results are consistent with a larger body of literature that explores reproductive health in crisis, conflict, emergency, and refugee settings in general, and on the Thailand-Burma border in particular. Migrant women's health is affected by pre-departure events (war, trauma, natural disaster, poverty, etc.), the mode and duration of travel to the new destination, the availability of resources in the host community, and discrimination and exploitation associated with relocation (International Organization for Migration, 2013; López-Acuña, 2008). Along the Thailand-Burma border, access to healthcare services such as hospitals or clinics is highly dependent on the person's place of living combined with her legal status and financial resources. Combined with socio-cultural taboos and externalized and internalized stigma, these dynamics blend together to place constraints on women's autonomy and self-actualization. The experiences of women in our study make evident the claim that reproductive health and rights are intertwined with the broader issue of human rights and social justice.

However, in addition to the barriers that women experience, our results also showcase the resilience of women in this protracted conflict setting and suggest that there are a number of ways that women navigate existing challenges. In order to reduce the chance of being stopped by Thai authorities, women use their bicycles to travel to and from different health services. If and when a clinic is not nearby, women ask friends and family members for reproductive health advice and support which often leads them to a traditional birth attendant near their village or community. In desperate situations, women will find themselves inducing their own abortions, if legal, structural, and/or socio-cultural barriers stand in the way of much needed abortion care.

That women's lives are complex and that reproductive health is affected by a range of factors is hardly surprising. However, the ways in which women in this context experience structural barriers offers insights into priorities for programming and service delivery. Many of our participants suggested that one of the most important avenues for improving reproductive health along the border is to increase multi-lingual educational efforts. Our participants' own lack of knowledge of reproductive health issues — especially in the period before marriage — certainly signals this need. This finding is consistent with a larger body of research with women on the border that has documented the social taboos surrounding sexual and reproductive health among adolescents and unmarried youth (Oh and van der Stouwe, 2008; Women's Commission for Refugee Women and Children, 2006).

Yet as is evidenced from the experiences of our participants, increasing awareness, at the individual, community, and/or health service provider levels, is not a panacea as education alone will not address the larger structural and systems constraints that women face. Rather, culturally-and con-

text-specific educational programs that explicitly acknowledge the confluence of forces shaping decisions and access are likely to have more resonance. Further, identifying and expanding initiatives, such as the accommodations program at the Mae Tao Clinic, that address the complex challenges women experience in seeking health services appears warranted.

Finally, our findings showcase that the totality of women's reproductive health experiences shape future decisions. A woman's decision to use contraception is not only made in the context of structural, economic, and social forces but is also influenced by her earlier reproductive health experiences and those of women in her community. Our findings support an emerging effort to reconceptualise women's reproductive histories as "reproductive careers," a sociological construct that recognizes the inter-relatedness of the reproductive health events in an individual woman's life (Nash, 2014; Bessett, 2010). This can include the utilization of contraception, abortion care, and delivery services as well as engagement with reproductive health issues such as infertility and sexually transmitted infections. The woman who has an abortion, the woman who delivers a healthy infant and parents, the woman who actively prevents pregnancy for a decade, and the woman who experiences perinatal loss, are one and the same. The siloing that has often characterized both rhetoric and policy in the reproductive health field belies women's lived experiences.

Because of the qualitative nature of this study, this study is not meant to be representative or generalizable. Rather this research provides insight into the reproductive decisions and experiences of migrant, refugee, and cross-border women living in the Mae Sot and Mae La areas of Tak Province. It is worth noting that this particular region stands out along the entire Thailand-Burma border as it is home to the Mae Tao Clinic, a well established not-for-profit clinic that provides services free-of-charge to Burmese migrants and refugees. In conducting a rigorous and credible qualitative study, we believe that our results have import beyond the small number of women who participated in the project. However, our participants are also exceptional within this region as all had used an IUD at some point in their reproductive lives and almost all were current users of the device. Use of the IUD is rare along the border and, until recently, few health care facilities have offered this modality of contraception (Hobstetter, Walsh, Leigh *et al.*, 2012). Thus this sub-set of women had all been able to successfully navigate the myriad barriers to obtain a desired reproductive health service from a trained provider. The experiences of women living along the border who are unable to navigate these barriers or choose not to contracept are not reflected in our study. Additionally, by recruiting women who are (or were) users of the IUD, our study is limited to the experiences of married women. Although women in our study reflected on their previous experiences as unmarried women, rigorous qualitative research with adolescents and unmarried young adults may reveal different perspectives.

5. Conclusions

Women's experiences with health services along the Thailand-Burma border suggest that legal, structural, financial, and socio-cultural barriers play a role in shaping a women's reproductive health decision-making and overall health. Educational services and resources that are culturally and context specific can help mitigate these barriers and improving the availability and accessibility of much needed reproductive health services appears warranted. This study sheds light on the complex, intertwining factors that can shape women's reproductive health and careers along the Thailand-Burma border and may provide health care providers with more insight into women's health in a protracted conflict and refugee setting. In the last several years, Burma has experienced tremendous political and economic reform and in 2016 elected its first civilian President in more than five decades. This transition to democracy opens the way for improved human rights conditions and may also create an opportunity to improve health services in the eastern part of the country. Understanding and recognizing the importance of women's lived experiences may help inform these efforts.

Conflict of Interest and Funding

The authors have no conflict of interest. This work was supported by an Ontario Women's Health Scholars Award (JG); a research travel grant from the Faculty of Graduate and Post-Graduate Studies at the University of Ottawa (JG); and funding from an anonymous individual donor. AF's Endowed Chair is funded by the Ministry of Health and Long-Term Care in Ontario.

Acknowledgements

The study team thanks all of the women who shared their stories and experiences with us. We would like to thank Meredith Walsh, NP, MPH and Cari Sietstra, JD for their input in the conceptualization and implementation of this project. Additional thanks goes to the leaders and staff of the Mae Tao Clinic, especially Dr. Cynthia Maung. We are also grateful to Hay Mar San, Naw Ree and Naw Hser Gay Moo for their help with recruiting participants and translating/interpreting, and to Drs. Raywat Deonandan and Shoshana Magnet for their feedback on the overall project.

Author Contributions

Jillian Gedeon led the overall project, collected and analyzed the data, and drafted the manuscript. Saw Nanda Hsue coordinated recruitment and data collection, translated and transcribed interviews, and contributed to drafting and revising the article. Dr. Angel M. Foster supervised the overarching project, contributed to data analysis, and contributed to drafting and revising the article.

Ethics Statement

The Health Sciences and Sciences Research Ethics Board at the University of Ottawa (File #H02-13-08) and the research committee at Mae Tao Clinic, Mae Sot, Thailand approved this study.

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WHIOCE PUBLISHING PTE. LTD.
International Journal of Population Studies

RESEARCH ARTICLE

Cross-sectional study of child malnutrition and associated risk factors among children aged under five in West Bengal, India

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Abstract: Using a cross-sectional study of 485 sample households in 2013, the present paper examines the prevalence and risk factors of child malnutrition among children under the age of five in West Bengal, India. As a part of this investigation, children's underweight status, wasting, and stunting were examined in order to determine child nutritional status using the WHO growth standard. We performed bivariate analyses in order to elucidate differentials in nutritional indices and fitted multinomial logistic regression models to examine the net effect of different socio-economic factors on the likelihood of child malnutrition. Analysis results revealed stunting (51%) as the most common form of malnutrition among children aged under five, followed by underweight status (41%), and wasting (22%).Gender discrimination among children increases with age, whereby girls are more deprived (as measured by nutritional indices) compared to boys later in childhood relative to younger ages. Results from multinomial analyses reveal age, religion, caste, and birth-order of the child as significant predictors of child's nutritional status.

Keywords: underweight, wasting, stunting, WHO Growth Standard, gender discrimination

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Received: January 27, 2016; **Accepted:** March 5, 2016; **Published Online:** March 11, 2016

Citation: Sarkar S. (2016). Cross-sectional study of child malnutrition and associated risk factors among children aged under five in West Bengal, India, *International Journal of Population Studies*, vol.2(1): 89–102. http://dx.doi.org/10.18063/IJPS.2016.01.003.

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1. Introduction

Malnutrition, which is one of the global culprits, resists the optimal health achievement among children and has serious implications, including death, especially in the low- and middle-income countries. Although prevalence of underweight status among under-five children has decreased since 1990, 99 million children under five years of age are underweight around the globe (UNICEF, WHO and World Bank, 2014). UNICEF estimates that nearly 2.6 million children, who die each year due to malnutrition, are equivalent to one-third of all registered child deaths globally (UN Inter-agency Group for Child Mortality Estimation, 2011). However, the contribution made by under-nutrition towards child mortality varies by disease, and is the highest for diarrheal diseases (73%), with much

lower mortality rates associated with pneumonia, measles, and severe neonatal infections (Mathers, Stevens and Mascarenhas, 2009). In addition, malnutrition in early childhood prevents overall physical, mental, and psychological growth of the children (Victora, Adair, Fall *et al*., 2008; Victora, Onis, Hallal *et al.,* 2010). Previously, the term 'malnutrition' has been often incorrectly associated solely with under-nutrition only, whereas it now refers to both excess and deficiency in nutrition confined to a specific population (Shrimpton and Rokx, 2012). The co-existence of under-nutrition and obesity in a population has been popularly referred to as 'The Double Burden of Malnutrition'. This concept first emerged at the International Conference on Nutrition (ICN) in 1992, held by the Food and Agriculture Organization of the United Nations (FAO) and World Health Organization (WHO, 1995). Moreover, the WHO has used the term 'malnutrition' to imply all of its forms, namely under-nutrition, growth faltering, micronutrient deficiency, over-nutrition, and obesity.

A wide range of socio-demographic and economic factors are associated with the child malnutrition, including mother's nutrition, poverty, food security, healthcare practices, environment, hygiene, and sanitation (Islam, Rahaman and Mahalanabis, 1994). Low birth weight is another factor that increases the risk of malnutrition among children and makes them vulnerable to serious negative consequences later in life, such as adulthood diabetes and cardiovascular disease (Fall, 2009). Childhood malnutrition predisposes affected individuals to numerous long-lasting negative effects, including physiologic dysfunctions and impaired cognitive development (Martins, Florencio, Grillo *et al*., 2011). Owing to the high incidence of child malnutrition, an extensive body of research has been conducted in India, focusing on its contextual determinants including child's demographic characteristics (Talapalliwar and Garg, 2014), household level variables (Som, Pal and Bharati, 2007), mother's characteristics (Imai, Annim, Kulkarni *et al*., 2014), community level factors, and environmental factors (Aneja, Singh, Tandon *et al*., 2001) at both regional and national levels (Bharati and Bharati, 2008; Bisai, Bose and Ghosh, 2008; Biswas, Bose, Bisai *et al*., 2009; Biswas, Bose and Mukhopadhyay, 2009; Debnath and Bhattacharjee, 2014; Dey and Chaudhari, 2008; Khokhar, Singh, Talwar *et al*., 2003; Kumar, Mohanan, Kotian *et al*., 2008; Kumari, 2005; Meshram, Laxmaiah, Reddy *et al*., 2011; Rao, Yadav, Dolla *et al.,*2005; Talapalliwar and Garg, 2014).

The relationship between a child's nutritional status and feeding practices (complementary vs breast feeding) has been established through various studies conducted in India (Banapurmath, Nagarajand Banapurmath, 1996; Bhandari, Mazumder, Bahl *et al*., 2004; Kumar, Goel, Mittal *et al.*, 2006; Sreedhara and Banapurmath, 2014). Recently, Khan and Raza (2014) demonstrated that the probability of anthropometric failure increases with age, birth-order, and breastfeeding duration. In contrast, a longer birth interval, childbirth in hospital, the wealth index of the household, and mother's BMI and education reduce the prevalence of child malnutrition in both rural and urban India (Gribble, Murray and Menotti, 2008; Kumar and Singh, 2013; Mandal, Prabhakar, Pal *et al*., 2014). The present study aims to describe the prevalence of child malnutrition in terms of stunting, wasting, and underweight status. Its further aim is to capture social and demographic differentials of children's anthropometric indices, by utilizing the individual- and household-level risk factors in determining the nutritional status of children residing in West Bengal, India.

2. Data and Methodology

2.1 Data Sources

The present study is based on a cross-sectional survey that was conducted in Bankura district of West Bengal, India in 2013. The study participants were selected via a multi-stage sampling procedure, resulting in 485 households with children aged under five. Semi-structured household questionnaire and child questionnaire served as data collection instruments. The household questionnaire comprised basic household-level social and economic information, and was completed by any adult household member. The children's questionnaire aimed to elicit information on childcare practice, child health, and nutrition. In case of more than one eligible child (under the age of five) in the

household, only the youngest child was included in the survey. We also collected anthropometry data, whereby we measured the height and weight of the children and mothers along with their age. For measuring weight, digital scales were employed, ensuring requisite accuracy. Both mother and child were weighed twice and the average weight was recorded, in order to minimize measurement error. Children aged <24 months were weighed while being held by their mothers, after which the mother's weight was subtracted to derive the weight of the child. When measuring height, mother sand children aged >24 months were asked to stand against straight a wall, whereby an inch tape was utilized to record their height. Children aged <24 months were measured while lying down.

2.2 Child Anthropometry

The outcome of interest for the present study is child malnutrition, classified as either underweight status, wasting, or stunting. The corresponding scores, i.e., weight-for-age Z-score (WAZ), weight-for-height Z-score (WHZ), and height-for-age Z-score (HAZ) were calculated based on the WHO new growth standard(WHO, 2006) using the WHO-Anthro software. For the purpose of the present investigation, underweight status, wasting, and stunting were defined by WAZ, WHZ, and HAZ scores that were more than –2*Standard Deviation (–2SD) away from the WHO standard reference for the general population, respectively.

2.3 Independent Variables

Key independent variables that influence the child's nutritional outcomes included age,gender, religion, caste, and monthly per capita consumer expenditure (MPCE)status of the children, mother's body mass index (BMI), and birth order of the child. The inclusion of these variables was guided by approaches adopted in extant studies (Bisai, Bose and Ghosh, 2008; Debnath and Bhattacharjee, 2014; Khan and Raza, 2014; Talapalliwar and Garg, 2014). The age of the child was recorded in completed months based on the mother's report and was categorized as16, 12−23, 24−35, 36−47, and 48−59 months. We treated the child's gender as a dichotomous variable (male vs female). The child's religion was categorized into Hindu and Muslim, whereas their caste was categorized into four groups: scheduled caste (SC), scheduled tribe (ST), other backward classes (OBC), and general; based on the household head's report. We measured the household's economic status using the MPCE—classified into five quintiles. The MPCE was constructed using the household consumer expenditure schedule adopted by the National Sample Survey (NSS, 2010). Expenditure items included food, fuel, conveyance, medicinal, beverages, clothing, and other non-food daily items. For most of the items, the reference period was the preceding 30 days; however, for some less frequent purchases, such as clothing, education, or medicines, the last 365 days served as the reference period. Expenditure on domestic consumption incurred by households was standardized based on the pertinent reference period and was divided by the family size to arrive at the MPCE. We measured the mother's nutritional status using the BMI, which is the recommended measure for assessing adult malnutrition. The World Health Organization (WHO) defined BMI as "weight in kilograms divided by height in meters squared (kg/m^2)". Based on their BMI, mothers were classified as thin (<18.5), normal (18.5–24.9), and obese (>25). Birth order refers to the order in which the child included in the study was born,i.e., 1st, 2nd, 3rd, or greater.

2.4 Statistical Analyses

First, we carried out bivariate analyses to elucidate the differentials in child nutritional indices (i.e., underweight status, wasting, and stunting) with respect to the child's demographic and socio- economic background characteristics. To test the significance of associations between child nutritional indices and the examined background characteristics, we applied χ^2tests for variables with two categories. One-way analysis of variance (ANOVA) and '*t*-test' were also employed to test the statistical significance of the difference in mean scores pertaining to the three nutritional indices for variables

with three or more categories. Multivariate binary logistic regression models were subsequently performed in order to identify the significant risk predictors of underweight status, wasting, and stunting among the studied children. We coded all outcome variables used in this study as binary responses,whereas independent variables were presented in categorical or dichotomous forms. We presented the results of the logit models in terms of odds ratios (OR) with 95% confidence interval (CI). Furthermore, to evaluate the multiple occurrences of child malnutrition, the children were categorized into three groups: non-malnourished (coded as 0), single-state malnourished (i.e., malnourished in terms of either underweight status, stunting, or wasting, coded as 1), and multi-state malnourished (i.e., malnourished in any two or all three forms, coded as 2). We applied multinomial regression model to estimate the regression coefficients for all three malnutrition forms.

The interpretation of coefficients in multinomial models is not as straightforward as in the binary logistic regressions. In order to simplify the interpretation of results, we converted multinomial regression coefficients into adjusted percentage by using multiple classification analysis (MCA) conversion tables. First, we computed the predicted probabilities by using regression coefficients for the independent variables, mean values, and regression coefficients for other independent variables and constant coefficient which were then converted to percentages.

3. Results

3.1 Summary of Child Anthropometric Indices

Table 1 shows a summary of nutritional outcomes among the studied children (*N*=485). As can be seen from the reported data, majority of the children exhibited stunted growth. More specifically, 51% of children under the age of five were classified as stunted (<2S D) and 25%were severely stunted(<−3SD). Nearly 41%of children were categorized as underweight (<−2SD) and 13% were severely underweight. Finally, 20% of children were classified as wasting (<2SD) and almost 8% were categorized as severely wasting. A small proportion of sampled children (4%) were classified as overweight.

Kernel density plots indicate that the Z-scores of the three anthropometric indices were distributed normally for both genders. It is also evident that the Z-score distribution pertaining to weight-for-height data resembles that of the reference population more closely compared to the weight-for-age and height-for-age distributions, which shifted downward. This observation was also confirmed by the data provided in Table 1, which indicates that the mean Z-score of weight-for-height was close to zero (M =−0.86) compared to weight-for-age (M = −1.70) and height-for-age (M = −1.92). Although the curve distributions were fairly symmetrical, their degree of flatness differs significantly for different indices. For example, Figure 1A shows that the Z-score distribution for female weight-for-age was more symmetrical than that corresponding to males. It is also evident that the mean Z-score value for females shifted slightly to the left relative to that pertaining to males, whereas the curves were nearly *mesokurtic* for both genders. On the other hand, the Z-score distribution for height-for-age reveals that, while the mean score values were nearly identical for both genders;

Table 1. Summary of nutritional indices among children aged 6−59 months in West Bengal, India

Nutritional Indices	Percent			Mean Z score	SD
	< −2SD	< −3SD	> +2SD		
Underweight	41.44	13.4	–	–1.70	1.19
Stunted	51.34	25.57	–	–1.92	1.96
Wasted	22.47	7.84	4.12	–0.86	1.75

Note: >+2SD refers high weight-for-height or overweight status among the children.
Underweight = Weight-for-Age; Stunting = Height-for-Age; Wasting = Weight-for-Height;
<−2SD = moderately malnourished; <−3SD = severely malnourished

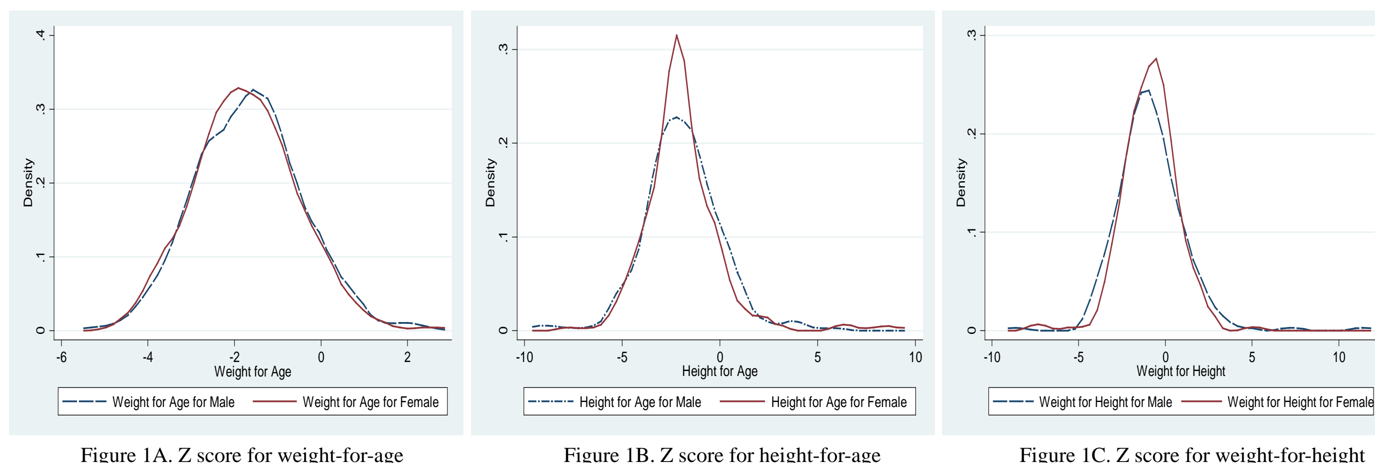

Figure 1A. Z score for weight-for-age

Figure 1B. Z score for height-for-age

Figure 1C. Z score for weight-for-height

Figure 1. Kernel density for plots showing distribution of Z scores for weight-for-age, height-for-age, and weight- for-height.

they differed in their peaked (Figure 1B). More specifically, female Z-score curve distribution was *leptokurtic*, while that pertaining to males was *mesokurtic*. Finally, as can be seen in Figure 1C, the mean Z-score of female weight-for-height data was positioned slightly to the right relative to that pertaining to males, while the distribution was nearly *leptokurtic* in both cases.

3.2 Age and Gender Differentials of Malnutrition

Data shown in Table 2 indicate that the child's age was significantly associated with his/her potential to be diagnosed as being underweight (χ^2 = 14.19; p = 0.007), having stunted growth (χ^2 = 49.04; $p <$ 0.001), and wasting (χ^2 =18.14; p = 0.001). We identified that the highest percentage of under-weight children was in the 24–35 months age group (56%), followed by 47% and 39% in the 36–37 months and 6–11 months age groups, respectively. The mean Z-score of weight-for-age was higher for children under 24 months of age compared to the older group. We observed a significant negative

Table 2. Age and gender differentials of incidences of underweight status, stunting, and wasting among children aged 6−59 months, West Bengal

Demographic Characteristics	Underweight		Stunting		Wasting	
	<−2SD	Mean Z score	<−2SD	Mean Z score	<−2SD	Mean Z score
Age in Months						
06−11	38.89	−1.4	79.17	−2.6	6.94	0.4
12−23	31.85	−1.5	60.74	−2.1	19.26	−0.6
24−35	55.56	−1.9	50.00	−2.1	23.33	−1.1
36−47	47.13	−1.9	37.93	−1.8	27.59	−1.3
48−59	38.61	−1.7	31.68	−1.2	32.67	−1.5
	χ^2 = 14.1882	F = 3.11	χ^2 =49.0398	F = 6.51	χ^2 = 18.1400	F = 17.87
	p = 0.007	p = 0.0152	p = 0.000	p = 0.000	p = 0.001	p = 0.000
Gender						
Male	39.36	−1.7	48.19	−1.9	25.3	−0.9
Female	43.64	−1.7	54.66	−1.9	19.49	−0.9
	χ^2 = 0.9174	t = 0.6355	χ^2 = 2.0292	t = 0.0456	χ^2 = 2.3472	t = 0.0820
	p = 0.338	p = 0.5254	p = 0.154	p = 0.9637	p =0.126	p = 0.9346

Note: One-way analysis of variance (ANOVA) is applied (F test) to test the differences in the mean Z scores of more than two categorical independent variables;

t-test is applied to test the differences in the mean Z scores of two categorical independent variables;

Underweight = Weight-for-Age; Stunting = Height-for-Age; Wasting = Weight-for-Height

relationship between stunted growth and child's age, whereas the proportion of those diagnosed as 'wasting' increased as the age increased. We also observed gender differentials in the prevalence of malnutrition, with the greater percentage of female children diagnosed as underweight (44%), stunted (55%), and wasting (19%) relative to their male counterparts.

3.3 Socio-economic Differentials in Malnutrition

While the prevalence of malnutrition (classified as underweight status, stunting, and wasting) among children that were under five years of age did not vary significantly with the religious status, significant differences across the castes were noted (Table 3). The proportion of underweight children was the highest (48%)in SC and ST. Similarly, the highest proportion of stunted children was found among ST (67%), followed by SC (57%). Prevalence of wasting was also the highest (32%) among children from OBC. The mean Z-scores for weight-for-age (F = 7.98; p <0.001), height-for-age (F = 3.76; p = 0.011) and weight-for height (F = 1.22; p = 0.30) also varied significantly across different caste groups. Household's MPCE quintile status was marginally correlated with the child being underweight (χ^2 = 8.71; p = 0.069), and exhibiting stunted growth (χ^2 = 14.14; p = 0.007). More specifically, the prevalence of underweight and stunted children was significantly higher in the lower MPCE quintile households compared to the upper MPCE quintiles. We observed that almost 51% and 63% of the children in the 1st MPCE quintile households were underweight and stunted. A significant difference in the mean Z-score for weight-for-age (F = 4.95; p<0.001) and height-for-age (F = 2.65; p = 0.032) was also observed when the data was analyzed with respect to the household MPCE quintile status.

Table 3. Socio-economic differentials of children bellow −2SD and mean Z scores pertaining to various nutritional indices

Social and Economic Variables	Underweight		Stunting		Wasting	
	<−2SD	Mean Z score	<−2SD	Mean Z score	<−2SD	Mean Z score
Religion						
Hindu	41.60	–1.7	52.89	–2.0	23.69	–0.8
Muslim	40.98	–1.6	46.72	–1.8	18.85	–0.9
	χ^2 = 0.0142	t = -0.6643	χ^2 = 1.3920	t = -0.8307	χ^2 = 1.2272	t = 0.4840
	p = 0.905	p = 0.5068	p = 0.238	p = 0.4065	p = 0.268	p = 0.6286
Caste						
SC	48.20	–1.9	56.83	–2.2	28.06	–1.0
ST	48.00	–2.0	67.00	–2.3	20.00	–0.9
OBC	38.00	–1.6	42.00	–1.5	32.00	–1.1
General	34.18	–1.4	41.84	–1.7	17.35	–0.7
	χ^2 = 8.8883	F=7.98	χ^2 = 20.3278	F= 3.76	χ^2 = 8.3997	F= 1.22
	p = 0.031	p = 0.000	p = 0.000	p = 0.0108	p = 0.038	p = 0.3023
MPCE Groups						
1st Quintile	50.52	–2.0	62.89	–2.4	21.65	–0.8
2nd Quintile	44.33	–1.9	53.61	–2.0	22.68	–1.1
3rd Quintile	44.33	–1.7	56.70	–1.9	21.65	–0.9
4th Quintile	31.96	–1.4	39.18	–1.6	21.65	–0.9
5th Quintile	36.08	–1.4	44.33	–1.7	24.74	–0.6
	χ^2 = 8.7002	F = 4.95	χ^2 =14.1462	F = 2.65	χ^2 = 0.4024	F = 1.09
	p = 0.069	p = 0.0006	p = 0.007	p = 0.0326	p =0.982	p = 0.3626

Note: One-way analysis of variance (ANOVA) is applied (F test) to test the differences in the mean Z scores of more than two categorical independent variables; t-test is applied to test the differences in the mean Z scores of two categorical independent variables; Underweight = Weight-for-Age; Stunting = Height-for-Age; Wasting = Weight-for-Height

3.4 Mother's BMI and Child's Malnutrition

Another important factor influencing child malnutrition or anthropometric outcomes is the mother's BMI, which was calculated as the ratio of weight (kg) relative to squared height (m^2). Figure 2 shows the relationships between mother's BMI and a child's malnutrition status in terms of the three anthropometric indices analyzed in this work. As can be seen, the prevalence of underweight status, stunted growth, and wasting among children was much higher among children whose mothers have a low BMI or were categorized as 'thin'. More specifically, 63% of the children whose mother's BMI was low exhibited stunted growth, whereas these percentages declined to 43% and 15% for children whose mothers had a normal BMI or were classified as obese, respectively. We observed a similar pattern for underweight children.

3.5 Factors Associated with Underweight Status, Wasting, and Stunted Growth

To gain a better understanding of the significance of risk factors that may result in child malnutrition (based on the examined nutritional indicators);we employed multivariate logistic regression models. We analyzedseparate models for underweight status, wasting, and stunting(Table 4). The choice of independent variables included in these models was guided by the extant literature. These variables included age, gender of the child, religion, caste, MPCE of the child's household, and birth order of the child. The table represents the significant predictors for underweight status, wasting, and stunting. We found that achild's age was a strong predictor of wasting and stunting, but not of underweight status. Odds ratio for wasting increased as a child'sage increased, whereas that for stunting decreased linearly with the child's age. Religious status was found to be significant only for underweight status. More specifically, Muslim children were found to be more likely to be underweight than were Hindu children (OR=1.884; $p<0.05$). Children raised in a household belonging to the general caste were less likely to be underweight (OR=0.446; $p<0.05$), wasting (OR=0.483; $p<0.05$), and have stunted growth (OR=0.535; $p<0.05$) compared to the SC children. Higher birth order was inversely related to the underweight status and stunted growth ,whereas no significant association was found with wasting.

Table 5 represents the adjusted percentages of non-malnourished, single-state malnourished, and multi-state malnourished children estimated using multinomial regression models and the MCA table. The results indicate that the children in the '6 to 11 months' age group were more likely to be single-state malnourished (47%),whereas those aged24–35 months were more likely to be classified as multi-state malnourished (52%). In addition, 42% female children were classified as multi-state malnourished, whereas 39% of males were in the same category. Both single-state malnourishment

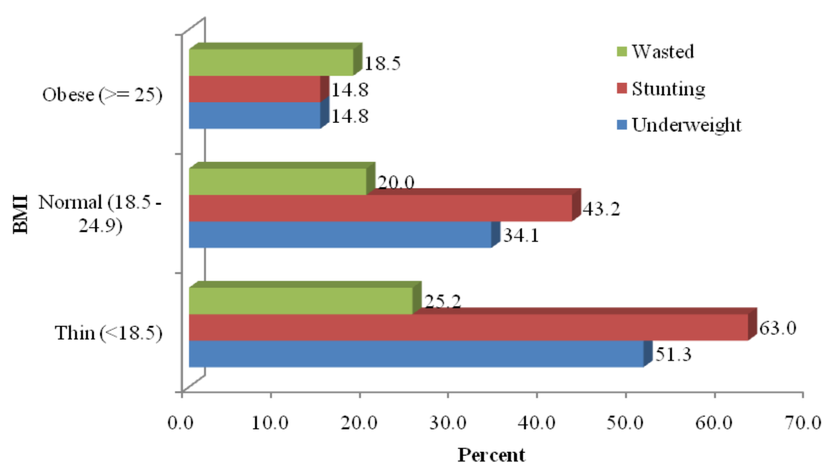

Figure 2. Relationship between mother's BMI and children's anthropometric indices
Underweight = Weight-for-Age; Stunting = Height-for-Age; Wasting = Weight-for-height

Table 4. Multivariate logistic regression models predicting the likelihood of incidences of underweight status, wasting and stunting among children (6−59 months) in West Bengal, India

Covariates	Underweight	Wasting	Stunting
	OR (95% CI)	OR (95% CI)	OR (95% CI)
Age in Months			
06−11®			
12−23	0.795 (0.428−1.476)	3.427 (1.240−9.471)*	0.426 (0.212−0.855)*
24−35	2.285 (1.181−4.421)*	4.338 (1.524−12.347)*	0.256 (0.123−0.535)**
36−47	1.901 (0.964−3.750)	5.803 (2.028−16.607)*	0.178 (0.083−0.380)**
48−59	1.175 (0.614−2.248)	7.764 (2.807−21.477)**	0.120 (0.057−0.253)**
Gender			
Male®			
Female	1.214 (0.827−1.782)	0.702 (0.448−1.099)	1.339 (0.900−1.993)
Religion			
Hindu®			
Muslim	1.884 (1.048−3.385)*	1.007 (0.512−1.981)	1.583 (0.882−2.841)
Caste			
SC®			
ST	0.944 (0.548−1.625)	0.663 (0.348−1.262)	1.371 (0.762−2.466)
OBC	0.562 (0.258−1.226)	1.037 (0.456−1.262)	0.658 (0.303−1.427)
General	0.446 (0.243−0.817)*	0.483 (0.243−0.958)*	0.535 (0.292−0.980)*
MPCE Groups			
1st Quintile®			
2nd Quintile	0.967 (0.533−1.754)	1.08 (0.527−2.210)	0.896 (0.477−1.685)
3rd Quintile	1.005 (0.555−1.820)	1.045 (0.510−2.144)	0.922 (0.487−1.744)
4th Quintile	0.765 (0.404−1.451)	1.20 (0.562−2.560)	0.561 (0.287−1.098)
5th Quintile	1.127 (0.577−2.199)	1.642 (0.755−3.572)	0.859 (0.430−1.718)
Birth Order			
1			
2	0.483 (0.322−0.725)**	0.665 (0.414−1.068)	0.526 (0.348−0.793)*
3+	0.185 (0.060−0.572)*	0.511 (0.117−1.068)	0.155 (0.048−0.505)*
Constant	0.970	0.119**	6.400**
Pseudo R2	0.0781**	0.071*	0.1449**

Note: ® = reference category; ** $p < 0.01$, * $p < 0.05$; SC = scheduled caste, ST = scheduled tribe; OBC = other backward classes

(33%) and multi-state malnourishment (45%) were found to be more prevalent among Muslim children compared to Hindus. The proportion of children who were classified as single-state malnourished was greater among ST children (37%), children from the highest MPCE household (35%), and children with 3+ birth order (47%). On the other hand, SC children (48%), children from the lowest MPCE household (49%), and firstborn children were more likely to be multi-state malnourished.

4. Discussion

In this study, we analyzed child malnutrition in terms of underweight status, stunting, and wasting, aiming to link these indicators with the household characteristics . The study findings revealed that the prevalence of underweight status, stunting, and wasting among children was 41%, 51%, and 22% in 2013, respectively, which exceeded the national average (i.e., 42%, 48% and 20%) established by

Table 5. Multinomial logistic regression results showing adjusted percentage of non-malnourished, single-state malnourished and multi-state malnourished children in West Bengal, India

Covariates	Non-Malnourished		Single-State Malnourished		Multi-State Malnourished	
	Adjusted percent(95% CI)	*p*-value	Adjusted percent(95% CI)	*p*-value	Adjusted percent(95% CI)	*p*-value
Age in Months						
06–11	16.4 (7.63–25.27)	$p < 0.001$	46.9 (34.99–58.87)	$p < 0.001$	36.6 (25.21–48.02)	$p < 0.001$
12–23	27.2 (19.37–34.94)	$p < 0.001$	41.7 (32.55–49.87)	$p < 0.001$	31.7 (23.54–39.81)	$p < 0.001$
24–35	29.8 (19.93–39.74)	$p < 0.001$	18.4 (10.11–26.69)	$p < 0.001$	51.7 (40.96–62.55)	$p < 0.001$
36–47	34.8 (24.27–45.42)	$p < 0.001$	20.3 (11.44–29.21)	$p < 0.001$	44.8 (33.68–55.97)	$p < 0.001$
48–59	41.8 (31.58–52.11)	$p < 0.001$	22.9 (14.49–31.45)	$p < 0.001$	35.2 (25.32–45.02)	$p < 0.001$
Gender						
Male	31.8 (25.60–38.03)	$p < 0.001$	29.4 (23.40–35.52)	$p < 0.001$	38.7 (32.26–45.17)	$p < 0.001$
Female	29.2 (22.99–35.42)	$p < 0.001$	29.9 (22.99–35.38)	$p < 0.001$	41.6 (34.90–48.30)	$p < 0.001$
Religion						
Hindu	34.2 (28.58–39.87)	$p < 0.001$	27.7 (22.24–33.24)	$p < 0.001$	38.0 (32.09–43.97)	$p < 0.001$
Muslim	21.0 (12.96–29.08)	$p < 0.001$	33.5 (22.07–44.96)	$p < 0.001$	45.5 (33.51–57.40)	$p < 0.001$
Caste					0	
SC	21.6 (14.26–29.03)	$p < 0.001$	29.8 (20.91–38.73)	$p < 0.001$	48.5 (38.83–58.22)	$p < 0.001$
ST	17.4 (9.35–25.53)	$p < 0.001$	37.5 (25.65–49.28)	$p < 0.001$	45.1 (33.26–56.92)	$p < 0.001$
OBC	34.2 (20.02–48.47)	$p < 0.001$	27.6 (13.80–40.30)	$p < 0.001$	38.7 (23.84–53.54)	$p < 0.001$
General	45.9 (37.05 - 54.66)	$p < 0.001$	23.8 (16.34–31.26)	$p < 0.001$	30.3 (22.35–38.32)	$p < 0.001$
MPCE Groups						
1st Quintile	27.3 (17.17–37.46)	$p < 0.001$	23.9 (14.88–32.99)	$p < 0.001$	48.7 (37.66–59.81)	$p < 0.001$
2nd Quintile	33.5 (23.21–43.82)	$p < 0.001$	22.8 (13.50–31.05)	$p < 0.001$	44.2 (33.59–54.81)	$p < 0.001$
3rd Quintile	26.8 (17.30–36.28)	$p < 0.001$	33.6 (23.45–43.45)	$p < 0.001$	39.7 (29.51–49.99)	$p < 0.001$
4th Quintile	37.1 (26.82–47.46)	$p < 0.001$	32.7 (22.53–42.94)	$p < 0.001$	30.1 (20.33–39.91)	$p < 0.001$
5th Quintile	27.3 (17.53–37.11)	$p < 0.001$	34.9 (23.67–46.16)	$p < 0.001$	37.7 (26.65–48.86)	$p < 0.001$
Birth Order					0	
1	31.6 (24.93–38.31)	$p < 0.001$	24.8 (18.21–30.34)	$p < 0.001$	44.1 (36.99–51.20)	$p < 0.001$
2	29.8 (22.78–36.82)	$p < 0.001$	30.8 (23.21–37.34)	$p < 0.001$	39.9 (32.44–47.39)	$p < 0.001$
3+	26.2 (14.75–37.68)	$p < 0.001$	47.4 (33.9–60.84)	$p < 0.001$	26.4 (15.17–37.57)	$p < 0.001$
Log likelihood			–489.02173			
LR χ^2			80.73			
Pr > χ^2			0.000			

The NFHS-3 (IIPS, 2005–2007). In line with the results yielded by existing research conducted in India, this study also revealed that stunting is the most common form of malnutrition among children under the age of five, followed by underweight status and wasting (Bhadoria, Sareen and Kapil, 2013; IIPS, 2005–2007; Ratnu, 2013; Singh, Foteder, Lakshminayarana *et al*., 2006). Higher prevalence of stunting supports the inference that child malnutrition in this population occurs probably due to past or chronic inadequacy of nutrition or due to long-term growth faltering. In contrast, underweight status indicates disturbances in the combination of linear growth and body proportion,

whereas wasting indicates acute or recent growth disturbance. The results obtained in the present study indicate a significant age differential in the prevalence of underweight status, stunting, and wasting among children. Underweight status was the highest (56%) in the '24−35 months' age group and the lowest among children aged 12–23 mo nths. On the other hand, stunting was inversely associated with child's age, while the association with wasting was positive.Similar associations have been reported in other studies conducted in India (Bharti, Chakrabarty, Som *et al*., 2010; Kamiya, 2011).

In contrast to the findings reported by other authors (Dasgupta, 1987; Habyarimana, Zewotir and Ramroop, 2014; Payandeh, Saki, Safarian *et al*., 2013), the present study failed to reveal any significant gender and religion differentials in the prevalence of underweight status, stunting, and wasting among children. Nonetheless, we observed clear gender discrimination in nutritional status, which increases with the child's age. While no gender differences were found in the lowest age group (6−23 months), the gender gap in the prevalence of these three nutritional indices widened as children matured (24−59 months). We found similar gender patterns for stunting as well as wasting. Our findings strengthen the argument that the gender-related difference in malnutrition found in younger children is a biological phenomenon rather than a social one. Biologically, female children are stronger than male children, and are found to be more resistant to infectious agents (Gangadharan and Maitra, 2000; Hill and Upchurch, 1995; Singh, Hazra and Ram, 2007), which is why female children are less malnourished than their male counterparts in the lower age group, when gender discrimination is supposed to be absent. At younger ages, children are heavily dependent on breast milk for their nutrition and are thus unlikely to be competing with other family members for food resources (Griffith, Matthews and Hinde, 2002). Consequently, due to their adequate nutrition and biological advantage, very young female children remain healthier relative to their male counterparts. However, gender discrimination starts to play a significant role once the child is no longer breastfed and has to compete for a share of family resources (Griffith, Matthews and Hinde, 2002). Thus, while gender discrimination is absent in infancy, it gradually emerges in childhood because of social discrimination, rather than biological factors. Female children experience multifaceted discrimination, including lack of adequate nutrition, inappropriate healthcare practices, and inconsistent treatment seeking, among others, causing numerous health consequences, such as malnutrition, illness, morbidity, and mortality (Dasgupta, 1987; Kishor, 1993; Miller, 1981; Sen, 1988). The higher prevalence of malnutrition among female children observed in the older ages in this study indicates that female children become victims of greater gender discrimination as they mature, when their biological advantage diminishes.

Multivariate analyses revealed that religion and caste play an important role in determining child malnutrition. Muslim children were more likely to be underweight compared to Hindu children. Similarly, scheduled caste children were more likely to be malnourished compared to general caste children. Religion and caste are important means of social stratification in India. Cultural activities, rituals and practices are determined by religion and caste stratification. In terms of caste, SC is a more disadvantaged group compared to the general caste and faces discrimination in accessing many services, such as income, education, hygiene, sanitation, and public health utilization. Existing research has revealed that Muslim and SC children are more vulnerable compared to Hindu and general caste children, respectively, due to inadequate immunization, lack of nutrient-rich diet, inappropriate hygiene and sanitation, etc. (Kumar and Mohanty, 2011; Sabharwal, 2011). Utilization of antenatal care and nutritional status among Muslim and SC women is also found to be poor compared to Hindu and general caste women, which adversely affects children's nutritional outcomes. Perhaps higher malnourishment among Muslims and SC children is due to the differentials in childcare practices, poor utilization of healthcare services and inadequate child feeding behavior.

The study revealed that more than half of the children experienced stunted growth. It may be the result of long-term interactions of a complex set of factors like inadequate nutrition, poor feeding

practices, and infections. Integrated Child Development Scheme (ICDS), a government launched nutrition program, if strengthened through effective implementations and proper strategies, could itself play a vital role in improving the child nutrition status in their early ages. Dissemination of knowledge among mothers on infant and child feeding practices, hygiene and sanitation, and home-based treatment management during infectious disease among children is crucial in improving the childcare practice behavior. Community-based platforms like Self-Help Group (SHG) may be used as important platforms to implement interventions for improved exclusive breastfeeding and complementary feeding practices. Maternal nutrition and health also seem to be associated with child malnutrition. Nutrition status of the children is poor for mothers having lower BMI, indicating a positive association between maternal health and child nutrition status. Thus, integrating the maternal health components with a nutrition program is highly recommended for improving both maternal and infant health. Although the ICDS has addressed maternal health, the policy is needed to strengthen and focus more on implementation perspectives.

Several limitations needed to be acknowledged to interpret the results. Firstly, this is a cross- sectional study, which did not track the event history of a child's malnutrition across their ages. In order to understand the potential temporal association and dynamics of malnutrition, a cohort prospective study is more appropriate than a cross-sectional study. Secondly, there is likely a recall bias among the respondents answering the questions relating to the events that happened in the past such as the dates of birth of the mother and child. Thirdly, the study could not assess the contribution of exposure to hygiene and sanitation while there is evidence to show that it is an important contributing factor in the malnutrition of children in their younger age (Rah, Cronin, Badgaiyan *et al*., 2015). Fourthly, the results interpreted in this study based on sample data cannot be generalized for the whole geographical area due to diverse socio-cultural and geographical parameters.

Conflict of Interest and Funding

No conflict of interest has been reported.

Acknowledgements

The author would like express his sincere thanks to the anonymous reviewers for their critical and beneficial comments, and suggestions for improving the paper. The author is thankful to the editor of this journal for considering this paper for critical review. The author is also thankful to the respondents from Bankura district in West Bengal, India for their cooperation and support during the field survey.

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International Journal of Population Studies

RESEARCH ARTICLE

Dietary intake knowledge and reasons for food restriction during pregnancy among pregnant women attending primary health care centers in Ile-Ife, Nigeria

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Abstract: The study investigated dietary intake knowledge and reasons for food restriction during pregnancy among pregnant women attending antenatal clinics in Ile-Ife, Nigeria. This cross-sectional survey involved 530 pregnant women visiting 35 primary health care (PHC) centers in Ile-Ife. Interviewer-administered questionnaire used to collect data included a 30-point knowledge scale and food restriction related questions. Data were analyzed using descriptive statistics and chi-square at $P = 0.05$. Mean age was 27.0 ± 5.3 years, 44.5% had tertiary education and 11.1% earned above ₦50,000 monthly (approximately US$315). Mean knowledge score was 23.6 ± 4.2 and 75.5% had good knowledge. Higher education was significantly associated with good knowledge of dietary intake. Reasons for food restriction during pregnancy included cultural taboos (36.5%) and religious beliefs (12.1%). Major foods that were restricted or avoided for cultural reasons were protein and vitamin-rich foods such as snail (97.5%) and walnut (84.0%). Foods avoided based on religious beliefs included pork (87.4%) and dog (76.9%). A higher proportion (94.8%) of respondents who earn more than ₦50,000 avoided foods due to cultural taboos (94.8%) compared with those without monthly income (58.3%) ($P \leqslant 0.05$). The proportions of respondents who avoided foods due to cultural taboos with no formal, primary, secondary, and tertiary education were 95.5%, 93.8%, 79.8%, and 86.4% respectively ($P \leqslant 0.05$). Overall, respondents were knowledgeable about dietary intake. However, cultural taboos and religious beliefs were major reasons for food restriction among pregnant women and were more pronounced among women with low education and low monthly income. Nutrition education interventions are needed to address the phenomenon.

Keywords: pregnant women, food restriction, dietary intake, cultural taboos

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Received: February 24, 2016; **Accepted:** April 3, 2016; **Published Online:** April 9, 2016

Citation: Oluleke M O, Ogunwale A O, Arulogun O S, *et al*. (2016). Dietary intake knowledge and reasons for food restriction during pregnancy among pregnant women attending primary health care centers in Ile-Ife, Nigeria. *International Journal of Population Studies*, vol.2(1): 103–116. http://dx.doi.org/10.18063/IJPS.2016.01.006.

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1. Introduction

The problem of malnutrition among women is of serious public health concern (Maduforo, 2010). The well-being of mother and the newborn infant is greatly determined by the nutrition of the expectant mother during pregnancy and it further influences the health of the child during childhood and adulthood (Bhargava, 2000; Scholl and Johnson, 2000). According to a previous study (Harding, 2001), spontaneous abortion, impaired fetal growth, poor pregnancy weight gain, learning impairment, and behavioral problems of the offspring are caused by inadequate nutrition during pregnancy. According to Ramakrishnan (2004), a majority of low birth weight (LBW) infants in developing countries are due to intrauterine growth retardation (i.e., less than the 10th percentile weight for gestational age). In developing countries, the most important determinants of intrauterine growth retardation stem primarily from the mother's poor health and nutritional status (Wardlaw, Blanc, Zupan *et al*., 2004).

Malnutrition is ranked as one of the major causes of maternal mortality and it is a major determinant of a successful pregnancy and a healthy well-nourished baby (Sholeye, Badejo, and Jeminusi, 2014; Maduforo, 2010). Developing nations account for 99% of all maternal deaths in the world (World Health Organization, 2015). Nigeria has one of the highest maternal death rates in the world with the current rate of 576 deaths per 100,000 live births (National Population Commission, 2013). These staggering statistics show that while it is important that the major avoidable causes of maternal mortality and adverse pregnancy outcome are eliminated by looking into the feeding practices of women due to their traditional beliefs and taboos, and also to determine its effect on their nutritional status.

In Nigeria, improper dietary practices of pregnant women have apparently led to increased rates of stillbirths, premature births, low birth weight, maternal and prenatal deaths (Bhargava, 2000; Ramakrishnan, 2004). Food consumption practices of pregnant women in Nigeria are highly influenced by many socio-cultural factors such as food taboos, family food distribution, food beliefs, and food restriction practices (Sholeye, Badejo, and Jeminusi, 2014; Ojofeitimi, Ogunjuyigbe, Sanusi *et al*., 2008; Ogunjuyigbe and Maduforo, 2010). In a study conducted by Maduforo (2010) in Nwangele Local Government Area (LGA) of Imo State, southeastern Nigeria, it revealed that 15.0% of the respondents mentioned some foods as taboos in the study area and 38.0% of the pregnant women were malnourished. Maduforo (2010) observed that pregnant women held onto the food taboos handed down from generation to generation, including prohibition of grasscutter meat, cassava meals (*fufu*), spaghetti (pasta), noodles, cocoa beverages, eggs, and snails. Some of the prohibited or avoided foods are common sources of essential nutrients that are essential for improving maternal and child health (Ojofeitimi, Ogunjuyigbe, Sanusi *et al*., 2008).

As a result of the well-entrenched traditional food taboos and socio-cultural beliefs relating to dietary intake during pregnancy, many pregnant women have misinformation about the harmful effects of these taboo foods (Kavle, Mehanna, Saleh *et al*., 2014). In some sub-Saharan African countries including Nigeria, it is commonly believed that sexually transmitted diseases or complications during childbirth are the result of the violation of food taboos (King, 2000; Maimbolwa, Yamba, Diwan *et al*., 2003; Maduforo, 2010). An earlier study conducted in Nigeria by Odebiyi (1989) observed that Yoruba traditional healers in Nigeria often interpreted the occurrence or persistence of illness as a punishment for the violation of food taboos. It will therefore not be surprising if some pregnant Yoruba women have inadequate knowledge and misperceptions relating to necessary diets. Issues relating to knowledge and socio-cultural factors influencing dietary intake among pregnant women especially in south-western parts of Nigeria have not been well documented. These issues have the potential of facilitating the design and implementation of interventions and polices that would address the problem of malnutrition among pregnant women. This study therefore investigates dietary intake knowledge and reasons for food restriction during pregnancy among pregnant women attending antenatal clinics in Ile-Ife, Nigeria.

2. Data AND Methods

2.1 Study Area

The study investigated dietary intake knowledge and reasons for food restriction during pregnancy among pregnant women attending antenatal clinics in Ile-Ife, Nigeria based on a cross-sectional survey. Ile-Ife is the headquarters of the ancient Ife Kingdom situated in the southwest of Nigeria stretching over 200 km from the Niger River in the north to the borders of Benin in the west. It is believed to be the cradle of modern civilization and has a special place in the Yoruba culture. Major religions in Ile-Ife are Christianity, Islam, and Traditional African Religion (TAR). Ile-Ife is well-known for several TAR practices, doctrines, cultural beliefs, and festivals. Apart from the Yoruba language, the native language and widely spoken in Ile-Ife, many residents of Ile-Ife, especially the literate population, can communicate in English. Ile-Ife is made up of Ife Central LGA, Ife East LGA, and Ife East Area Office Modakeke Ife. Ile-Ife has many government-owned and private educational institutions including Obafemi Awolowo University, one of the foremost and first-generation universities in Nigeria, and Ododuwa University (a private-owned university). Ile-Ife has a teaching hospital named Obafemi Awolowo University Teaching Hospital Complex with an arm as Comprehensive Health Centre at Eleyele area of the town, a General Hospital at Oke-Ogbo, and thirty-five primary health care (PHC) facilities in the LGAs. Ife Central LGA, Ife East, and Ife East Area Office Modakeke Ife have 10, 15, and 10 primary health care facilities respectively. The study was carried out at 35 PHC facilities in the three LGAs in Ile-Ife.

2.2 Study Population and Sample Size

The study population comprised of pregnant women attending antenatal clinics in the PHC facilities in the three (Ife Central, Ife East, and Ife East Area Office) LGAs of Ile-Ife.

Records reviewed showed that there were 557 pregnant women attending antenatal clinics at PHC centers in the three LGAs in Ile-Ife at the time the study was conducted. The study therefore employed the use of total sampling so as to get optimal insight into the study, make wide coverage of population of interest, and increase the chances of harvesting potential insight from all eligible respondents. However, only 530 pregnant women who consented to participate in all the PHC facilities in the local government areas of Ile-Ife were involved in the study.

2.3 Instrumentation

A semi-structured questionnaire was used for data collection. The design of the questionnaire was based on the research objectives and review of related literatures. The instrument was also guided by relevant conceptual frameworks and benefited from the scrutiny and constructive criticism of five experienced researchers in the fields of public health and nutrition. A pre-testing of the instrument was carried out among 59 pregnant women (10% of the study sample) attending the antenatal clinic at Okoko PHC in Ipetumodu, which shares similar characteristics with the study area. This was necessary to determine length of time required to administer the questionnaire, check logical sequence of questions, and to ascertain whether the questions were clear and simple enough for respondents to understand. The internal consistency of the instrument was evaluated with the use of measures of Cronbach's alpha coefficient technique with the Statistical Package for Social Sciences (SPSS) that yielded a coefficient value of 0.6. Few revisions were made on the instrument before it was finally used. Revisions made included use of simpler and local terms for food items and some variables to improve respondents' understanding of questions, the inclusion of some pertinent variables such as respondents' average monthly income as well as skipping mechanism in the questionnaire.

The pre-tested semi-structured questionnaire captured respondents' socio-demographic characte-

ristics which included respondents' age, marital status, level of education, occupation, family structure (whether monogamy or polygamy), average monthly income (given in naira [₦], which is the Nigerian currency), and number of children. The instrument contained a 30-point knowledge scale that covered 10 knowledge items, focusing on various dietary related issues that included how to eat during pregnancy, classes of food (with examples) supposed to be taken during pregnancy, and the roles of each of the classes of food. The instrument also contained items or questions relating to reasons or factors responsible for food avoidance or restriction during pregnancy as well as lists of foods that were restricted or avoided based on each specific factor or reason. The questionnaire was constructed in the English language and translated into Yoruba by a linguistic expert who was vast in both languages for easy communication with respondents consisting of illiterate and semi-illiterate population. The Yoruba version of the instrument was back-translated into English by another language expert to ascertain the accuracy of the translation.

2.4 Data Collection Process

Copies of the semi-structured questionnaire were administered with the help of four female research assistants who were trained thoroughly to ensure that they had adequate understanding of the instrument prior to commencement of data collection. Permission was sought from appropriate authorities including PHC coordinators and heads of health facilities. Pregnant women attending the clinics were approached and their consents were sought prior to the commencement of the interviews. The respondents were interviewed with copies of the questionnaire either in Yoruba or English, depending on respondents' preference and language spoken or understood.

All copies of the questionnaires were checked for completeness and a serial number was given to each for easy identification and recall. A coding guide was developed based on the variables and responses teased out from the questionnaires. This coding code was used to facilitate data entry into a computer. Based on the 30-point knowledge scale, scores of ≤10, >10–20, and >20 were categorized as poor, fair, and good knowledge respectively. Data collection was carried out in all the 35 PHC centers in the study sites over a period of eight weeks.

2.5 Analytical Strategies

SPSS software version 20 was used to facilitate data analysis. Descriptive statistics, frequency counts, and percentages were used for analysis of univariate data. Bivariate analyses of test of associations between independent and dependent variables were subjected to chi-square tests at 0.05 level of significance. For this purpose, dependent and independent variables were presented as categorical data. Dependent variables that were considered were dietary intake knowledge and practice of restriction or avoidance of food based on cultural taboos. Each of these dependent variables was calculated and tabulated by relevant independent variables such as respondents' age, level of education, occupation, monthly income, religion, and number of children. Results obtained from the data were summarized in text and where necessary, tables and charts were also presented.

3. Results

3.1 Socio-demographic Characteristics of Respondents

The socio-demographic characteristics of the respondents are presented in Table 1. The respondents' ages ranged from 14–53 years old with a mean of 27 ± 5.3 years. The respondents also had a mean of 2.0 ± 1.3 children. Most (90.8%) women were married and 91.1% of them have a monogamous family. A large proportion (44.5%) of the respondents had tertiary education. Three-quarter (75.0%) of the respondents' were Christians and 88.0% were Yorubas. Very few (4.6%) of the respondents' had no income and only 11.1% earned above ₦50,000 (approximately US$315).

Table 1. Socio-demographic characteristics of respondents (N = 530)

Characteristics	Frequency	Percentage (%)
Age[+]		
14–24 years	160	30.2
25–34 years	333	62.8
⩾35 years	37	7.0
Marital status (N = 521)*		
Married	474	90.8
Single	41	7.9
Widowed	6	1.1
Divorced	1	0.2
Level of education (N = 521)*		
No formal education	22	4.2
Primary	48	9.1
Secondary	223	42.2
Tertiary	235	44.5
Occupation (N = 523)*		
Civil servant	164	31.4
Petty trader	146	27.9
Artisans	90	17.2
Housewife	45	8.6
Student	44	8.4
Unemployed	34	6.5
Monthly income (N = 523) *		
None	24	4.6
<10,000 Naira	146	28.8
11,000–20,000 Naira	157	30.1
21,000–30,000 Naira	66	12.6
31,000–40,000 Naira	23	4.4
41,000–50,000 Naira	48	9.2
>50,000 Naira	58	11.1
Number of children[++]		
0	106	20.0
1–2	275	51.9
3–4	136	25.7
⩾5	13	2.4
Religion (N = 528)*		
Christianity	396	75.0
Islam	127	24.0
Traditional	4	0.8
Others	1	0.2
Ethnicity (N = 527)*		
Yoruba	464	88.0
Igbo	53	10.1
Hausa	10	1.9
Family structure		
Monogamy	483	91.1
Polygamy	47	8.9

**Non responses were excluded*
[+]Mean age of respondents = 27 ± 5.3 years
[++]Mean number of children=2 ± 1.3 years

3.2 Dietary Knowledge of Respondents

Respondents' level of knowledge relating to dietary intake in pregnancy is shown in Figure 1. Participants had a mean knowledge score of 23.6 ± 4.2 years and about three-quarter (75.5%) of them had good knowledge of dietary intake during pregnancy. Respondents with fair and poor knowledge of dietary intake were 21.5% and 3.0%, respectively.

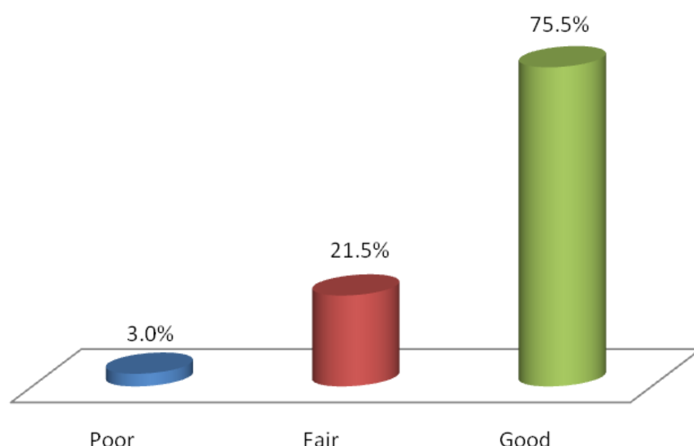

Figure 1. Dietary intake knowledge of respondents during pregnancy
Note: Mean knowledge score = 23.6 ± 4.2.

The proportions of respondents with correct responses about statements relating to food issues during pregnancy are presented in Table 2. Majority (88.3%) of the respondents were knowledgeable about the fact that food intake is supposed to increase during pregnancy. Almost three-quarter (73.4%) of the respondents understood that there is a need to take more protein during pregnancy. Nearly all (96.2%) respondents had the knowledge that food rich in proteins such as beef, fish, egg, and beans are essential for body growth and repair. Majority (88.5%) of the respondents were knowledgeable about the fact that food rich in fat and oil such as palm oil, groundnut oil, butter, and margarine are essential for tissues and organ protection. A large proportion of the respondents (87.7%) had a good understanding that food rich in vitamins and minerals such as fruits and vegetables are essential for good health. Many (44.7%) respondents incorrectly mentioned specifically that carbohydrate should be taken more during pregnancy. Slightly above one-third (36.0%) of the respondents mentioned specifically that there is a need to take more minerals and vitamins during pregnancy. Only 28.9% of the respondents mentioned fats and oil as a type of essential food that should be taken during pregnancy.

Table 2. Proportion with correct responses about statements relating to food issues during pregnancy

Statement	No. responded	% correct
Food intake is supposed to increase during pregnancy	468	88.3
There is a need to take more protein during pregnancy	389	73.4
Food rich in proteins such as beef, fish, egg, and beans are essential for body growth and repair	510	96.2
Food rich in fat and oil such as palm oil, groundnut oil, butter, margarine are essential for tissues and organ protection	469	88.5
Food rich in vitamin and minerals such as fruits and vegetables are essential for good health	465	87.7
Carbohydrate should be taken more during pregnancy	293	55.3
There is a need to take more minerals and vitamins during pregnancy	191	36.0
Food rich in fat and oil such as palm oil, groundnut oil, butter, margarine are essential during pregnancy for tissue and organ protection, and conservation of body heat	153	28.9

Table 3 shows the association between dietary intake knowledge and socio-demographic characteristics of the pregnant women. A higher proportion (86.5%) of respondents aged 35 years or older had good knowledge of dietary intake when compared to those aged 25–34 years old (77.5%) and 14–24 years old (68.8%) and this association was significant at P = 0.012. The proportion of respondents who had good knowledge of dietary intake was highest among those with tertiary education (81.7%), followed by primary (70.8%), secondary (70.4%), and those with no formal education (68.2%). Overall, there was a significant relationship between the level of education and knowledge of dietary intake (P = 0.002). The proportions of respondents who had good knowledge of dietary intake were lower among the unemployed women and petty traders compared with other categories of women including those who were civil servants and students.

Table 3. Association between dietary intake knowledge of respondent and socio demographic characteristics

Characteristics	Knowledge of dietary intake				Chi-square, P value
	Poor (%)	Fair (%)	Good (%)	Total (%)	
Age					
14–24	9 (5.6)	41 (25.6)	110 (68.8)	160 (100.0)	$\chi^2 = 12.95$
25–34	5 (1.5)	70 (21.0)	258 (77.5)	333 (100.0)	P = 0.012
⩾35	2 (5.4)	3 (8.1)	32 (86.5)	37 (100.0)	
Level of education					
No formal	2 (9.1)	5 (22.7)	15 (68.2)	22 (100.0)	
Primary	5 (10.4)	9 (18.8)	34 (70.8)	48 (100.0)	$\chi^2 = 21.42$
Secondary	6 (2.7)	60 (26.9)	157 (70.4)	223 (100.0)	P = 0.002
Tertiary	3 (1.3)	40 (17.0)	192 (81.7)	235 (100.0)	
Occupation					
Unemployed	3 (8.8)	9 (26.5)	22 (64.7)	34 (100.0)	$\chi^2 = 5.08$
Housewife	2 (4.4)	6 (13.3)	37 (82.2)	45 (100.0)	P = 0.024
Student	2 (4.5)	9 (20.5)	33 (75.0)	44 (100.0)	
Petty trader	7 (4.8)	38 (26.0)	101 (69.2)	146 (100.0)	
Artisan	0 (0)	20 (22.2)	70 (77.8)	90 (100.0)	
Civil servant	2 (1.2)	30 (18.3)	132 (80.5)	164 (100.0)	
Monthly income					
None	3 (12.5)	2 (8.3)	19 (79.2)	24 (100.0)	$\chi^2 = 7.415$
<10,000	4 (2.7)	38 (26.0)	104 (71.2)	146 (100.0)	P = 0.006
11,000–20,000	4 (2.5)	43 (27.4)	110 (70.1)	157 (100.0)	
21,000–30,000	2 (3.0)	12 (18.2)	52 (78.8)	66 (100.0)	
31,000–40,000	0 (0)	9 (39.1)	14 (60.9)	23 (100.0)	
41,000–50,000	0 (0)	6 (12.5)	42 (87.5)	48 (100.0)	
>50,000>50,000	1 (1.7)	3 (5.2)	54 (93.1)	58 (100.0)	
Ethnicity					
Yoruba	14 (3.0)	101 (21.8)	394 (75.2)	464 (100.0)	$\chi^2 = 2.17$
Igbo	1 (1.9)	10 (18.9)	42 (79.2)	53 (100.0)	P = 0.705
Hausa	1 (10)	2 (20.0)	7 (70.0)	10 (100.0)	
Number of children					
0	3 (2.8)	23 (21.7)	80 (75.5)	106 (100.0)	$\chi^2 = 0.027$
1–2	6 (2.2)	62 (22.5)	207 (75.3)	275 (100.0)	P = 0.869
3–4	7 (5.1)	29 (0)	100 (73.5)	136 (100.0)	
⩾5	0 (0)	0 (0)	13 (100)	13 (100.0)	

Overall, there was a significant relationship between the level of education and occupations of respondents (P = 0.024). The proportions of respondents with poor knowledge of dietary intake were lower among the respondents with higher monthly income compared with those with no monthly income and this association was found to be significant (P = 0.006). However, no significant association was found between knowledge of dietary intake and other socio-demographic variables such as marital status, parity, religion, ethnicity, and number of children.

Reasons for food restriction or avoidance during pregnancy were presented in Table 4. Cultural taboos (36.5%) topped the list of the factors influencing diet during pregnancy mentioned by the respondents, followed by restriction of some food because they cause big babies or make labor and delivery difficult (25.6%), belief relating to negative health effects of foods (13.7%), dislike of food taste during pregnancy (12.1%), and food forbidden on religious grounds (12.1%).

Table 4. Foods avoided by respondents during pregnancy based on cultural taboos/beliefs (N = 530)

*Cultural belief	Food avoided	N	%
***Depressed fontanelle^**	Pumpkin	241	45.5
	Banana	154	29.1
	Plantain	102	19.2
***Belching during delivery**	*Crasscephalum crepidoides*+	331	62.5
	Dioscorea dumetorum++	278	52.5
	Walnut	14	2.6
	Odu	13	2.5
***Animalistic behavior**	Snake	187	35.3
	Antelope	89	16.8
	Wild rat	68	12.8
	Dog	13	2.5
	Donkey	8	1.5
***Diet against family rites**	Okro	102	19.3
	Pork	56	10.6
	Dog	53	10.0
	Antelope	35	6.6
	Snake	13	2.5
	Wild rat	12	2.3
	Bat	4	0.8
	Snail	1	0.2
***Salivate excessively**	Snail	269	50.8
	Pork	4	0.8
	Dog	3	0.6
***Animalistic resemblance**	Snake	94	17.7
	Wild rat	8	1.5
	Pork	7	1.3
	Snail	6	1.1
	Dog	5	0.9
	Antelope	1	0.2
***Reduced contraction strength**	Walnut	315	59.4
	Dioscorea dumetorum	35	6.6
	Crasscephalum crepidoides	20	3.8
	Mushroom	5	0.9
***Slit on new born**	Pumpkin	3	0.6

*Multiple responses
^Depressed fontanelle – a soft spot on a babyft skull with noticeable inward curve
+Referred to as Thickhead, Fireweed (English) and Ebolo (Yoruba).
++Referred to as Bitter Yam (English), Esuru (Yoruba).

Table 4 presents the details of the food avoided by the respondents based on cultural taboos/beliefs. Pumpkin (45.5%), banana (29.1%), and plantain (19.2%) were avoided because they were believed to cause depressed fontanelle in babies. *Crasscephalum crepidoides* (62.5%) and *Dioscorea dumetorum* (52.5%) were mentioned as major foods believed to cause belching during delivery. Diets believed to reduce contraction strength during labor included walnut (59.4%), *Dioscorea dumetorum* (6.6%), and *Crasscephalum crepidoides* (3.8%). Pumpkin (0.6%) was believed to cause slits on newborns.

Table 5 highlights other reasons for avoiding food. Food avoided based on religious beliefs were pork (87.4%), dogs (76.9%), and snakes (66.5%) while beverages including '*bournvita*' — a brand of tea (91.3%), and '*milo*' beverage (67.5%) were avoided mainly because it causes pregnant women to have big fetuses causing difficulty during delivery. Food avoided based on health reasons included

Table 5. Foods avoided by respondents during pregnancy based on reasons other than cultural beliefs

Reasons Avoiding Food	Food Type	N	%
Religious beliefs*	Pork	159	87.4
	Dog	140	76.9
	Snake	121	66.5
	Snail	24	13.2
	Bush meat	23	12.6
	Crayfish	9	4.9
	Fish	5	2.7
Causing fetus to be too big*	Bournvita	306	91.3
	Milo	226	67.5
	Ovaltine	205	61.2
	Coke	110	32.8
	Fanta	72	21.5
	Wine	50'	14.9
Health reasons*	Sugary foods	44	32.1
	Salted food	32	23.4
	Eba	15	7.3
	Egg	10	5.8
	Bitter leaf	8	3.6
	Spices	7	5.1
	Yam	5	3.6
	Okro	5	3.6
	Crayfish	4	2.9
	Ugu	4	2.9
	Meat	3	2.2
+Cannot afford the food*	Fruits	142	35.0
	Protein	122	30.0
	Beverages	61	15.0
	Carbohydrates	52	12.8
	Vegetables	29	7.2

*Multiple responses

+Protein (egg, bushmeat, crayfish, milk, chicken)

Vegetables (Spinach- commonly called 'Green vegetable' or 'Tete' in Yoruba Language and Fluted Pumpkin- popularly known as 'Ugu' in Igbo Language), Fruits (apple, tangerine, pineapple, pawpaw)

Carbohydrates (pounded yam, rice, bread)

Beverages (bournvita, milo, juices)

sugary food (32.1%), salted food (23.4%), and '*eba*' — a staple Nigerian food made from cassava flour (10.9%). Another major reason for avoiding food was because some of the pregnant women could not afford some food due to high costs. These foods were fruits (35.0%); 'proteinous' foods (30.0%) including eggs, '*bushmeat*' (refers to meats from non-domestic or wild animals), crayfish, chicken; vegetables (7.2%); beverages (15.0%); and carbohydrates (12.8%).

In Table 6, the association between cultural taboos and socio-demographic characteristics of the respondents was assessed. A higher proportion of respondents with no formal education (95.5%)

Table 6. Association between avoidance of food based on cultural taboos and socio demographic characteristics of respondents

Characteristics	Avoidance of food based on cultural taboos			Chi-square P value
	Yes (%)	No (%)	Total (%)	
Age				
14–24	130 (81.3)	30 (18.8)	160 (100.0)	$\chi^2 = 3.151$
25–34	285 (85.6)	48 (14.4)	333 (100.0)	P = 0.207
⩾45	34 (91.9)	3 (8.1)	37 (100.0)	
Marital status				
Married	402 (84.8)	72 (15.2)	474 (100.0)	$\chi^2 = 0.249$
Single	34 (82.9)	7 (17.1)	41 (100.0)	P = 0.969
Widowed	6 (100)	0 (0)	6 (100.0)	
Divorced	1 (100)	0 (0)	6 (100.0)	
Education				
No formal	21 (95.5)	1 (4.5)	22 (100.0)	$\chi^2 = 9.59$
Primary	45 (93.8)	3 (6.3)	48 (100.0)	P = 0.022
Secondary	178 (79.8)	45 (20.2)	223 (100.0)	
Tertiary	203 (86.4)	32 (13.6)	235 (100.0)	
Occupation				
Unemployed	33 (97.1)	1 (2.9)	34 (100.0)	$\chi^2 = 16.28$
Housewife	37 (82.2)	8 (17.8)	45 (100.0)	P = 0.006
Student	31 (70.5)	13 (29.5)	44 (100.0)	
Petty trader	119 (81.5)	27 (18.5)	146 (100.0)	
Artisan	75 (83.3)	15 (16.7)	90 (100.0)	
Civil servant	148 (90.2)	16 (9.8)	164 (100.0)	
Monthly income				
None	14 (58.3)	10 (41.7)	24 (100.0)	$\chi^2 = 19.87$
<10,000	124 (84.9)	22 (15.1)	146 (100.0)	P = 0.003
11,000–20,000	133 (84.7)	24 (15.3)	157 (100.0)	
21,000–30,000	58 (87.9)	8 (12.1)	66 (100.0)	
31,000–40,000	17 (73.9)	6 (26.1)	23 (100.0)	
41,000–50,000	40 (83.3)	8 (16.7)	48 (100.0)	
>50,000	55 (94.8)	3 (5.2)	58 (100.0)	
Religion				
Christianity	336 (84.8)	60 (15.2)	396 (100.0)	$\chi^2 = 0.055$
Islam	107 (84.3)	20 (15.7)	127 (100.0)	P = 0.996
Traditional	4 (100.0)	0 (0)	4 (100.0)	
Others	1 (100.0)	0 (0)	1 (100.0)	
Number of children				
0	85 (80.2)	21 (19.8)	106 (100.0)	$\chi^2 = 3.58$
1–2	232 (84.4)	43 (15.6)	275 (100.0)	P = 0.310
3–4	120 (88.2)	16 (11.8)	136 (100.0)	
⩾5	12 (92.3)	1 (7.7)	13 (100.0)	

compared to those with primary education (93.8%), secondary education (79.8%), and tertiary education (86.4%) had food restriction or avoidance behavior due to cultural taboos. Overall, there was a statistically significant association between education and cultural taboo at P = 0.002. Respondents' occupation was significantly associated with food restriction or avoidance behavior associated with cultural taboos at P = 0.006. A higher proportion (97.1%) of unemployed respondents had food restriction or avoidance behavior due to cultural taboos compared to civil servants (90.2%), artisans (83.3%), petty traders (81.5%), and students (70.5%). A significantly higher proportion (94.8%) of respondents who earned ₦50,000 (approximately US$315) when compared to those who earn less had cultural taboo-induced food restriction or avoidance behavior. Overall, there was a statistically significant association between respondents' income and food restriction or avoidance behavior because of cultural taboos at P = 0.003. However, no significant association was observed between food restriction or avoidance behavior associated with cultural taboos and other variables such as age, marital status, religion, and parity.

4. Discussion

Ages of pregnant women ranged between 14–53 years old and a majority of the respondents were within the age group of 25–34 years old. This age group is similar to that of a previous study conducted among pregnant women visiting PHC centers for antenatal care in Ile-Ife which revealed a mean age of 26 years old (Adeleye, Akoria, Shuaib *et al*., 2010). This study revealed that a majority of the respondents had good knowledge of dietary intake during pregnancy. However, a few women lacked knowledge about the specific food that should be taken more during pregnancy. Previous studies have indicated a similar trend among pregnant women (Dyer, Fearon, Buckner *et al*., 2004; Kalesanwo, 2005). From this study, it was discovered that older women had better knowledge of dietary intake during pregnancy compared with younger women. This may be because older women are more experienced over time. It is not surprising that the more educated respondents had good knowledge of dietary intake. This may not be unconnected with the fact that education exposes people to different sources of information which makes them more enlightened (Global Campaign for Education, 2005). Income and occupation were not found to significantly influence knowledge of dietary intake. This underscores the need to provide nutritional education on dietary issues for all categories of women irrespective of their income level and occupations. Although it is interesting to observe that many pregnant women had good knowledge of dietary intake, good knowledge of dietary intake may not necessarily translate into good dietary practices among pregnant women. This concern has been observed in a study in Osun state that assessed food aversion during pregnancy (Ogunjuyigbe, Ojofeitimi, Sanusi *et al*., 2008). This implies that nutrition knowledge alone may not necessarily be sufficient to initiate behavioral application of healthy diets (Ozdoğan and Ozferzcelik, 2011).

A surprising finding in this study is the avoidance of foods because of the perceived adverse health effect of some healthy foods. This erroneous belief emphasizes the need for intensive nutrition education for pregnant women that could further upgrade their knowledge on dietary related issues during pregnancy. It is also unfortunate that many respondents avoided some body building food based on religious beliefs. This poses more concern as a result of the fact that the women involved were attending antenatal clinics and should be more informed than their counterpart who did not patronize orthodox health facilities. Dietary avoidance of fruits and other proteinous animal sources may result in maternal malnutrition and also deprive the child of sufficient nutrition (Ogunjuyigbe, 2004).

This finding revealed that a low level of education was a predictor of food restriction due to cultural taboos. This shows that women who are well educated are considered to reflect this knowledge to their behaviors/beliefs (Ozdoğan and Ozferzcelik, 2011). Understanding this inter-relationship may provide good information for designing more efficient and effective public policies, and mod-

ification of educational interventions. This study also revealed that earning more income is a determinant of food restriction due to cultural taboos. This finding can be explained by the fact that a higher income subsequently result in access to a variety of food (Ozdoğan and Ozferzcelik, 2011). Pregnant women of low socioeconomic status in developing countries are noted for insufficient protein and energy food intake (Wright, Hoffman, and Savitz, 2010; Beydoun and Wang, 2008; ADA, 2005). It is quite obvious that most of the items that would have provided all the key nutrients were primarily excluded on the basis that food might be hazardous to the health of the mothers. Contrary to the findings of other investigators (Gittelsohn, Anliker, Sharma *et al*., 2006; ESFA Panel on Dietetic Products, Nutrition, and Allergies [NDA], 2010), the result of this study indicated that milk, bournvita, and cowpea seeds were exclusively avoided on health grounds and particularly to prevent the development of big babies. The idea of big babies among the women signified referral for cesarean section and also implied difficult labor. Similar findings were reported in literature (Oboro, Tabowei, Jemikolajah *et al*., 2003). While poverty cannot be totally ruled out as one of the contributing factors to food restriction as a result of cultural taboos in developing countries, food taboos based on health or tradition are a potent factor that demands close attention of obstetricians, nutritionist and other health workers.

4.1 Implications for Nutrition Education

The findings of this study have several implications for nutrition-related health education interventions on the dietary intake of pregnant women. Several combination of health education strategies which include public enlightenment, training, and counseling of pregnant women as well as advocacy to religious and community leaders have huge potentials in addressing the phenomenon.

Public enlightenment campaigns can be used to create awareness and influence knowledge, behaviors, and cultural beliefs relating to dietary intake. It has the potential to reach large numbers of people including pregnant women and significant others such as spouses and relatives that can influence the dietary intake of pregnant women. Public enlightenment techniques that can be used include handbills, documentaries, and jingles.

Training as well as counseling of pregnant women during antenatal care visits on healthy diet and nutrition-related issues could serve as effective strategies for addressing food restriction practices during pregnancy. Emphasis should be placed on various maternal nutrition-related issues including healthy food selection and the importance of fruits and vegetables consumption for the supply of nutrients and fibers to the body. More attention should be given to young women who have less knowledge of dietary issues during pregnancy. This could be achieved, in part, by increasing their access to relevant youth-friendly training programs and providing opportunities for them to gain experiences from older pregnant women. Older pregnant women who are experienced and knowledgeable could be trained to provide peer-led training and support for young pregnant women on dietary issues during pregnancy. In addition, educational interventions on dietary issues during pregnancy using social media strategies or methods such as text messages can be implemented to target a large population of pregnant women especially the young pregnant women and provide them with robust learning opportunities.

Mobilizing communities to promote a healthy diet may also be very useful in addressing the problem of food restriction or avoidance associated with cultural taboos and religious beliefs facing pregnant women. Community involvement in community nutritional interventions for pregnant women is particularly appealing and holds the potential for success because it is based on the principle that it provides opportunities for community members to participate in the design, implementation, and evaluation of nutritional interventions.

Advocacy interventions that target religious leaders and custodians of tradition and customs have the potential of effectively addressing cultural beliefs and taboos that favor avoidance of healthy foods that could benefit pregnant women. Advocacy interventions can be made more effective when supported with locally generated data from systematically conducted studies.

4.2 Limitations of the Study

Although the study achieved its aims, there were some unavoidable limitations. First, this research was conducted on a small size of pregnant women population who were attending antenatal care in public or government-owned primary health centers. Therefore, to generalize the results for a larger population or all pregnant women in the study area, the study should have included pregnant women who registered with private clinics or hospitals as well as those who did not attend antenatal clinics. However, taking into consideration the scientific steps taken to carry out the study, it could be concluded that the results constitute a fair reflection of the phenomenon among pregnant women in the study area. Second, the simplicity of statistical analyses used in the study may also be considered as a form of limitation of this study. Inclusion of advanced statistical analyses such as multivariate logistic regression would have yielded more robust results relevant to the study. Finally, sole reliance on the information given by the respondents might have created some degree of subjectivity. In order to reduce biases and incorrect responses, trained research assistants were used to interview the research participants. Participants were provided with all the information related to the study and were encouraged to give honest information.

5. Conclusions

Most respondents had good knowledge of dietary intake. However, cultural taboos and religious beliefs were major reasons for food restrictions or avoidance during pregnancy, and were more pronounced among pregnant women with low education and low monthly income. The findings suggest a need for several nutrition education interventions for pregnant women. During antenatal visits, nutrition education should be intensified and emphasis should be placed on healthy eating patterns, healthy food selection, and the importance of fruits and vegetables consumption for the supply of nutrients and fibers to the body. Restriction of some healthy food during pregnancy can also be positively modified by nutritional counseling during antenatal visits. Efforts should be made to design community health education interventions that can target cultural taboos and religious beliefs affecting the dietary intake of pregnant women.

Conflict of Interest and Funding

The authors declared no potential conflicts of interest with respect to the research, authorship, and/or publication of this article. The authors received no financial support for the research, authorship, and/or publication of this article.

Ethical Consideration

Ethical approval to conduct this study was obtained from Obafemi Awolowo University Teaching Hospital Ethical Review Committee. Letters of permission to conduct the study in the PHC centers within the LGAs were received from the Director of PHC in each of the LGAs. The study participants were given adequate information on the study and they were told that their participation in the study was voluntary. They were assured of utmost confidentiality of their responses. There was no identifier on the questionnaire; participants who did not want to take part in the study were excused to observe the principle of autonomy. Only participants who signed or filled the informed consent were interviewed.

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