The Estimation of Contraception Rate: An Application of the Two-Sex Age-Dependent Simulation Model to Bangladeshi DHS Data

Jun HAGIHARA and Ryutaro OHTSUKA

It has been pointed out that desired family size and contraceptive prevalence are most important in considering proximate determinants of fertility. The former was much reported from many surveys, but the later was little reported. This study attempted to estimate the parameter in relation to contraceptive prevalence in Bangladesh, using the simulation model developed in the previous study. The parameters in the model were estimated from abridged life table and DHS (Demographic and Health Survey) in 1993. The parameter settings estimated from the empirical data were divided into two groups by the area of residence, i.e. rural and urban. Results showed that the simulation model developed in the previous study closely matched observed data in Bangladesh in rural and urban area. From the results of comparing the simulation-generated data with empirical data, it was shown that the model could estimate the unknown rate of contraception practice when married couple reached the desired family size.

Key words: proximate determinants, fertility, simulation, Bangladesh, desired family size, contraceptive prevalence

I Introduction

The changes in population size and population structure are one of the most critical global issues in terms of not only politics and economics but also human health and survival. There are many developed counties, in which the aging of population has progressed and the number of population has tended to decrease or will decrease. On the other hand, rapid population growth has been prevailing in the bulk of developing countries (Kirk, 1996). It is widely recognized that many developing countries whose population rapidly increases are under fertility transition, which is the process of change from high fertility to low fertility in the later phase of demographic transition (Kirk, 1996).

Factors which determine fertility are diversified and changeable from population to population and from time to time. Proximate determinants of fertility differ not only in magnitude but also in direction according to socioeconomic settings (Bongaarts, 1978), implying that it is necessary to construct a framework for analysis of relative effects of the proximate determinants on fertility. It has been pointed out that desired family size and contraceptive prevalence are most important in considering proximate determi-
nants. Pritchett (1994) reported that there was a negative correlation between contraceptive prevalence and total fertility rate and positive correlation between desired family size and total fertility rate. In order to directly evaluate effects of each factor on fertility, the authors formulated an age-dependent two-sex simulation model which makes it possible to compare between simulation-generated data and empirical data (Hagihara and Ohtsuka, 2001). Using this model, the present study attempted to evaluate relative effects of proximate determinants of fertility on Bangladesh, one of high-fertility developing countries.

In this study, data of Demographic and Health Survey (DHS) in Bangladesh in 1993 were used. Bangladesh was selected since this country is characterized by an extremely high population density, about 900 persons per km², and has kept a high population increase rate; an intercensal growth rate of population estimated from adjusted population in the 1991 census was 2.1 per annum (Bangladesh Bureau of Statistics, 1995). The program of countrywide intensive family planning has been conducted for aiming at reducing the population growth. However, its effects on fertility have not been estimated, based on a cohort data, largely because of unknown parity-based rate of contraceptive use.

DHS has been conducted for more than 100 times in various developing countries in Africa, Asia, Middle East and Latin America. The DHS data have been analyzed in many studies, using multivariate regression (e.g. Curtis, Diamond, and McDonald, 1993), but have scarcely been compared with the simulation-generated data.

The aim of this study is to estimate the contraception rate comparing between age-specific marital fertility rate generated by simulation and that of DHS data, while exploring unknown parameter in empirical data using sensitivity analysis. It is thus expected to estimate the parity-based rate of contraceptive practice, which was not involved in Bangladesh DHS data, using a simulation model developed by the authors, and to investigate effects of family planning in Bangladesh.

II Materials and Methods

1. Demographic and Health Survey Data

In Bangladesh, the DHS started in 1984. The DHS data in 1993, which were analyzed in this study, were collected from November

<p>| Table 1 Parameters of the regression equation from life tables in Bangladesh |
|-----------------|---------------|----------------|----------------|-----------------|----------------|</p>
<table>
<thead>
<tr>
<th>Area of Residence</th>
<th>Year</th>
<th>Sex</th>
<th>$e_0^*$</th>
<th>Expected Values $^2$</th>
<th>Mean Square Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>Urban</td>
<td>1993</td>
<td>Male</td>
<td>60.4</td>
<td>0.11922, 0.10276, 0.06304</td>
<td>0.000254</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>61.3</td>
<td>0.10215, 0.05919, 0.09821</td>
<td>0.00201</td>
</tr>
<tr>
<td>Rural</td>
<td>1993</td>
<td>Male</td>
<td>57.7</td>
<td>0.10740, 0.12926, 0.11468</td>
<td>0.00004</td>
</tr>
<tr>
<td></td>
<td></td>
<td>Female</td>
<td>57.4</td>
<td>0.10033, 0.16698, 0.09240</td>
<td>0.00001</td>
</tr>
</tbody>
</table>

$^1$ : $e_0$ means the expectancy of life at birth.

$^2$ : Expected Values were estimated, by using non-liner regression.
1993 to March 1994. The subjects of the investigation were ever-married women aged 10 to 49, 9640 in number. Basic and demographic information, including age at marriage, reproduction histories and desired family size, was used in this study. In order to reduce truncation biases and problems associated with periodical changes in fertility, this study treated the data of the birth cohort whose age ranged from 40 to 49 at the investigation. The subject women were divided into two groups by the area of residence, i.e. rural and urban, according to definition of Bangladesh government. The total number of subjects in the rural and urban areas were 1279 and 233, respectively.

2. Parameters and Variables Using Simulation Model

In the simulation model developed in the authors' previous study, it was necessary to determine parameters and variables in three components, which were death, marriage, and birth; detailed description of this simulation model was made elsewhere (Hagihara and Ohtsuka, 2001).

Parameters in the death component in rural and urban areas were estimated by abridged life table in 1993 (Bangladesh Bureau of Statistics, 1995). The results of estimation are shown in Table 1, and Figures 1 and 2 graphically depict the results of the observed and expected values of the survivorship function. Parameters, which are denoted
Fig. 2 The observed and expected values of parameters in the death component for urban Bangladeshi life table in 1993.

Table 2 Estimated parameters in the marriage function in Bangladesh

<table>
<thead>
<tr>
<th>Year</th>
<th>Area of Residence</th>
<th>a₀</th>
<th>μ</th>
<th>σ</th>
<th>Mean Square Error</th>
</tr>
</thead>
<tbody>
<tr>
<td>1993</td>
<td>Rural</td>
<td>1.473</td>
<td>0.424</td>
<td>0.00899</td>
<td></td>
</tr>
<tr>
<td>1993</td>
<td>Urban</td>
<td>1.662</td>
<td>0.560</td>
<td>0.00946</td>
<td></td>
</tr>
</tbody>
</table>

*1: Expected values were estimated by using nonlinear regression.

Table 2 Estimated parameters in the marriage function in Bangladesh

as a, b, and c in Table 1, were indicators of mortality on the late, middle, and early of the life span, respectively (Denny, 1997).

Parameters in marriage function were estimated by the variable of “age at first marriage” in DHS. The results of estimation were shown in Table 2, and Figure 3 graphically depicts the results. Parameters, which are denoted as a₀, μ and σ² in Table 2, were youngest age at marriage, the mean and variance of log normal distribution, respectively.

The parameters and variables used in the birth component are shown in Table 3. Figure 4 shows the desired family size from DHS, broken down by rural and urban area; a reply of “up to god” was involved in “others”. The mean value was 2.68 in the rural area and 2.70 in the urban area, when “others” were omitted. Based on this result, a variable of desired family size was fixed at 3 in the simulation analysis. From the report that the age when Bangladeshi women became menopause was earlier than most Western populations, about 43 years (Holman, 1996), the parameters of sterility func-
Fig. 3 The observed and expected values of marriage function for Bangladeshi data

<table>
<thead>
<tr>
<th>Parameters</th>
<th>Meaning</th>
<th>Value</th>
</tr>
</thead>
<tbody>
<tr>
<td>$a, b^1$ in beta distribution</td>
<td>Parameters determining the shape of fecundability.</td>
<td>2, 8</td>
</tr>
<tr>
<td>$k^2, r^3$ in sterility function</td>
<td>Parameters determining the age-specific sterility rate.</td>
<td>0.0002, 1.335</td>
</tr>
<tr>
<td>Desired family size $^4$</td>
<td>The number of children that a woman desires to have.</td>
<td>3</td>
</tr>
<tr>
<td>Effectiveness of contraception $^5$</td>
<td>The rate of reducing the fecundability.</td>
<td>0.93</td>
</tr>
<tr>
<td>Contraceptive rate</td>
<td>The rate of using contraception when a woman achieves her desired family size.</td>
<td>0.5, 0.7, 0.9</td>
</tr>
</tbody>
</table>

$^1$Source: Okun (1994)

$^2$Source: Trussell and Olsen (1983)

$^3$This value was determined by the test simulation.

$^4$This value was determined from distribution of desired family size in Demographic and Health Survey in Bangladesh (1993)

$^5$This value was assumed as the rate of condoms use (Okun, 1994).

Fig. 4 Distribution of the desired family size from Bangladesh DHS data. “Others” include reply of “up to god”. The mean value was 2.68 in rural area and 2.70 in urban area, when “others” were excluded.
tion, which are denoted as $k$ and $r$ in Table 3, were determined at 0.0002 and 1.335, using the test simulation. Other parameters and variables shown in Table 3 were referred to previous studies (Okun, 1994; Trussell and Olsen, 1983).

The simulation was conducted for the population whose initial number was 1000. The simulation was conducted 100-year duration in each run, and repeated 100 times for one parameter set.

### III Results

Since the DHS data revealed only age-specific marital fertility rates, the same rates were calculated in the simulation. For the birth component, three rates of contraceptive practice, i.e. 0.9, 0.7, and 0.5, were applied. These values were the proportions of women who began contraceptive practice at the time when they reached desired family size.

The results of the analysis are shown in Figures 5 and 6, separately by the residential areas of the respondents in the DHS survey. The plotted values are the average of 100 runs for each parameter set in the simulation-generated data and empirical data from DHS. It was observed that age-specific marital fertility rates were similar among younger women, aged about 20 or less, in all parameter sets of the simulation. After that, age-specific marital fertility rate tended to differ according to parity-based rate of contraceptive use. When the value of contraception rate was high, age-specific marital fertility rate was low.

For the DHS-based data, especially in older ages, differences were found between the rural and urban areas. For the rural area, age-specific marital fertility rate fluctuated along the line in the case that contraception rate was 0.5 in the simulation (Figure 5). For the urban area of the DHS-based data, age-specific marital fertility rate fluctuated almost same as the condition that contraception rate was 0.7 in the simulation (Figure 6).

### IV Discussion

In this analysis, the parameters of the sim-
Parameters of death and marriage components were estimated from 
Bangladeshi data. Then, sensitivity
analysis was conducted to estimate contraception rate, comparing between the simulation-generated data and the empirical data. As the results, age-specific marital fertility rates drawn from both data were similar, suggesting that the simulation model developed by the authors can be applied to the empirical data in Bangladesh.

It was thought that there were several reasons for the fit between age-specific marital fertility rate from the simulation-generated data and that from DHS data. The first reason was that the subjects were restricted to the birth cohort whose ages were 40—49 at the survey. Due to this restriction, this study was able to analyze the data without consideration of the differences between the birth cohorts. Second, the parameter in the sterility function was determined by means of test simulation to meet age-specific marital fertility rate at the end of birth history in the simulation data and DHS data.

From the results of comparing the simulation-generated data with empirical data separately by the residential area, this study was possible to estimate the unknown rate of contraception practice when married couple reached the desired family size. There was difference in contraception rates estimated by simulation between the rural and urban areas; the contraception rate was higher in the latter. Since the rate of contraception is assumed to reflect accessibility of contraceptive devices, this result suggests that the accessibility of contraceptive methods differed between the residential areas in Bangladesh.

Among variables incorporated in the model, the variable of desired family size may fluctuate during couple's birth history. The DHS data about desired family size were corrected at the end of birth history of the subjects. It is likely that desired family size changes throughout birth history. Furthermore, periodical changes in socioeconomic conditions relevant to contraception uses might affect couple's contraceptive behavior.

In this simulation, the demographic processes, which included birth, marriage
and death, were analyzed in relation to population size. The methods in which all of these components were incorporated to the simulation program and data generated from simulation were compared with empirical data make it possible to estimate unknown factor (s), that was proportion of contraceptive use in this study. This kind of simulation analysis is called “respectable use” in the simulation analysis (Dyke, 1981). As seen in other “respectable use” study by Nakazawa and Ohtsuka (1997), who developed individual based microsimulation model to evaluate effects of the inter-individual relationship on reproduction, and compare simulation-generated data with empirical data from Papua New Guinea, it is judged meaningful to estimate unknown demographic factors in simulation analysis.

V Conclusion

While several problems have been remained, the comparison of the simulation data with empirical data in Bangladesh supported basic applicability of this model to both rural and urban settings. From the comparison between the simulation-generated data and DHS data, this study made it possible to estimate the rate of contraceptive use after married couples reached the desired family size. In addition, different patterns of age-specific marital fertility rate were observed between the rural and urban areas presumably owing to different accessibility to contraception.

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References


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