Age-specific Maternal Mortality Ratio

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1. Introduction

Despite an estimated decline in the number of maternal deaths by approximately 35% since 1990, maternal mortality remains one of the most intractable public health problems today [1]. Strategies to reduce maternal death in developed countries have resulted in reductions in risk of 90-99%, however these same declines have not been replicated in developing nations [2]. An estimated 358,000 maternal deaths occurred globally in 2008 and with over 99% of these deaths occurring in developing countries [3], maternal mortality remains the most disparate public health problem between developed and developing nations.

Discrepancies between developed and developing countries extend into maternal mortality estimation procedures as well. Although efforts have been made to implement and improve surveillance and registration systems in developing countries, maternal death data remain difficult to obtain [4]. Special DHS surveys, focusing specifically on maternal health, have been conducted in Ghana and Bangladesh and increasingly, direct sisterhood and verbal autopsy data are included in DHS surveys to estimate maternal mortality rates.

The Maternal Mortality Ratio (MMR) is the most common indicator of maternal risk. It is defined as the number of maternal deaths in a specified period per 100,000 live births. MMR is not directly affected by fertility levels in a population, but is an estimate of obstetric risk per birth. Additionally, MMR uses live births only in the denominator and does not include stillbirths or abortions. In general, MMR is estimated as a summary measure across all ages and parities, and efforts are not made to estimate differences in obstetric risk across ages and parities.

The objective of this paper is to estimate age-specific MMRs using age-specific fertility rates and age-specific maternal mortality rates. The estimation of age-specific MMRs potentially allows for identification of age groups where obstetric risk is disproportionately high. Strategies to reduce MMR can be learned from the age-patterns of age-specific MMRs, e.g. prevention of pregnancy in high-risk groups would result in an overall reduction of the number of women facing high obstetric risk, MMR.

2. Data

Data for this paper comes from the Bangladesh Maternal Health Services and Maternal Mortality Survey 2001, which was a nationally representative survey carried out in 2001. Three questionnaires were used: a Household Questionnaire which identified deaths in the household over the past three years, a Women's Questionnaire which collected reproductive history and other reproductive health information, and a Verbal Autopsy Questionnaire which collected information on cause of death for all female (13-49) adult deaths in the household and was used to differentiate pregnancy-related deaths from true maternal deaths. A total of 99,202 households were successfully surveyed which resulted in the identification of 106,789 eligible women, of whom 103,796 (97%) completed the survey.

Verbal autopsy interviews collected the age of the woman at her death so deaths were tabulated by age and year to calculate age specific death counts. Age of the woman at birth was not calculated. However, age of the mother in 2001 and the year of birth allowed us to estimate the age of the mother at each birth. Women counts by age and parity were straightforward for the year 2001 as it was the age and parity specific population size at time *t*. However, for each year n prior to time (*t*), it was necessary to estimate the age and parity specific population. Age at time (*t-n*) was estimated by simply subtracting *n* years from age at time (*t*). Parity at time (*t-n*) was calculated by subtracting the number of births that occurred between time (*t-n*) and time (*t*) from the total live births at time t to estimate the parity at time (*t-n*).

3. Methods.

3.1 Age-specific Maternal Mortality Ratios

Let the Maternal Mortality Ratio at time *t*, *MMR(t)*, be defined as the ratio of maternal mortality deaths in year *t*, $D_o(t)$, divided by the births, $B(t)$, in that year as:

$$MMR(t) = \frac{D_o(t)}{B(t)}. \quad (1)$$

Similarly, let the age-specific MMRs be defined as the ratio of maternal mortality deaths in year t at age x, $D_o(x,t)$, divided by the births from women of age x, $B(x,t)$, in the same year t,

$$MMR(x,t) = \frac{D_o(x,t)}{B(x,t)}. \quad (2)$$

The relation between total MMR and age-specific MMRs is obtained by looking at the proportion of births of mothers of age x over the total number of births, denoted as $C_B(x,t)$ and calculated as:

$$C_B(x,t) = \frac{B(x,t)}{B(t)}. \quad (3)$$

It can readily be seen that the addition over all ages of the product of age-specific MMRs and C_B is equal to the MMR as

$$\sum_x MMR(x,t) C_B(x,t) = \sum_x \frac{D_o(x,t)}{B(t)} = \frac{D_o(t)}{B(t)} = MMR(t). \quad (4)$$

Furthermore, if both terms of the ratio on the right hand side of equation (2) are divided by the number of women of specific age x, $w(x,t)$, a commonly used proxy to person-years, we obtain a ratio of age-specific death rates for obstetric causes, $m_o(x,t)$, divided by the age-specific fertility rates $f(x,t)$, as :

$$MMR(x,t) = \frac{D_o(x,t)}{B(x,t)} = \frac{D_o(x,t) / w(x,t)}{B(x,t) / w(x,t)} = \frac{m_o(x,t)}{f(x,t)}. \quad (5)$$

Using equation (5) in the above equation (4) of MMR and age-specific MMRs we get

$$MMR(t) = \sum_x C_B(x,t)\frac{m_o(x,t)}{f(x,t)}. \tag{6}$$

3.2 Age- and Parity-Specific Maternal Mortality Ratios

A similar procedure can be used to work with age- and parity-specific MMRs. Let the age- and parity-specific MMRs be defined as the ratio of maternal mortality deaths in year *t* at age *x* for parity *i*, $D_o(i,x,t)$, divided by the births from women of age *x* and parity *i*, $B(i,x,t)$, in the same year *t*,

$$MMR(i,x,t) = \frac{D_o(i,x,t)}{B(i,x,t)}. \tag{7}$$

Let $C_B(i,x,t)$ be the proportion of births of mothers of age *x* and parity *i* over the total number of births:

$$C_B(i,x,t) = \frac{B(i,x,t)}{B(t)}. \tag{8}$$

As in equation (4) above it is possible to obtain the total MMR from the age- and parity-specific MMRs in (7) and the proportion of births in (8) as the double addition over ages and parities:

$$MMR(t) = \frac{D_o(t)}{B(t)} = \sum_i \sum_x \frac{D_o(i,x,t)}{B(t)} = \sum_i \sum_x MMR(i,x,t) C_B(i,x,t). \tag{9}$$

It is possible to use again age- and parity-specific obstetric death rates and fertility rates to calculate equation (9) similar to the operations done in (6): If both terms of the ratio on the right hand side of equation (7) are divided by the number of women of specific age *x*,

$w(x,t)$, we obtain a ratio of age- and parity-specific death rates for obstetric causes, $m_o(i,x,t)$, divided by the age- and parity-specific fertility rates $f(i,x,t)$, as :

$$MMR(i,x,t) = \frac{D_o(i,x,t)}{B(i,x,t)} = \frac{\left(\frac{D_o(i,x,t)}{w(x,t)}\right)\left(\frac{w(i,x,t)}{w(i,x,t)}\right)}{\frac{B(i,x,t)}{B(x,t)}} = \frac{m_o(i,x,t)}{f(i,x,t)} C_w(i,x,t). \qquad (10)$$

Where $C_w(i,x,t)$ corresponds to the proportion of women at age x and parity i over women at this age but in all parities. Finally, substituting the ratio furthest to the right in equation (10) in (9) returns:

$$MMR(t) = \sum_i \sum_x C_B(i,x,t) C_w(i,x,t) \frac{m_o(i,x,t)}{f(i,x,t)}. \qquad (11)$$

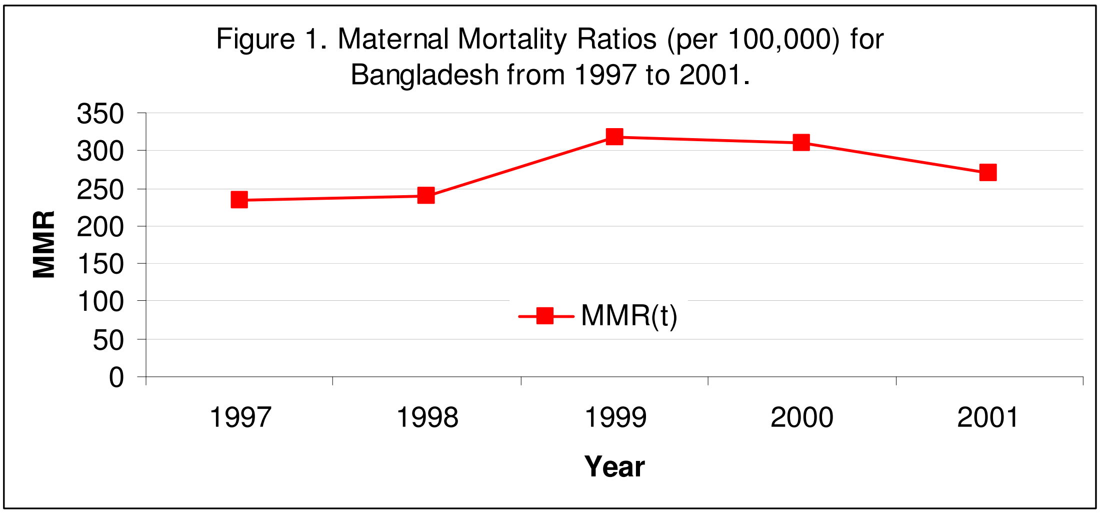
3.3 Data Needed to Construct All the Above Equations:

- $D_o(i,x,t)$: Age- and parity-specific obstetric death counts per year
- $B(i,x,t)$: Age- (of mothers) and parity-specific birth counts per year
- $w(i,x,t)$: Age- and parity-specific women population size per year

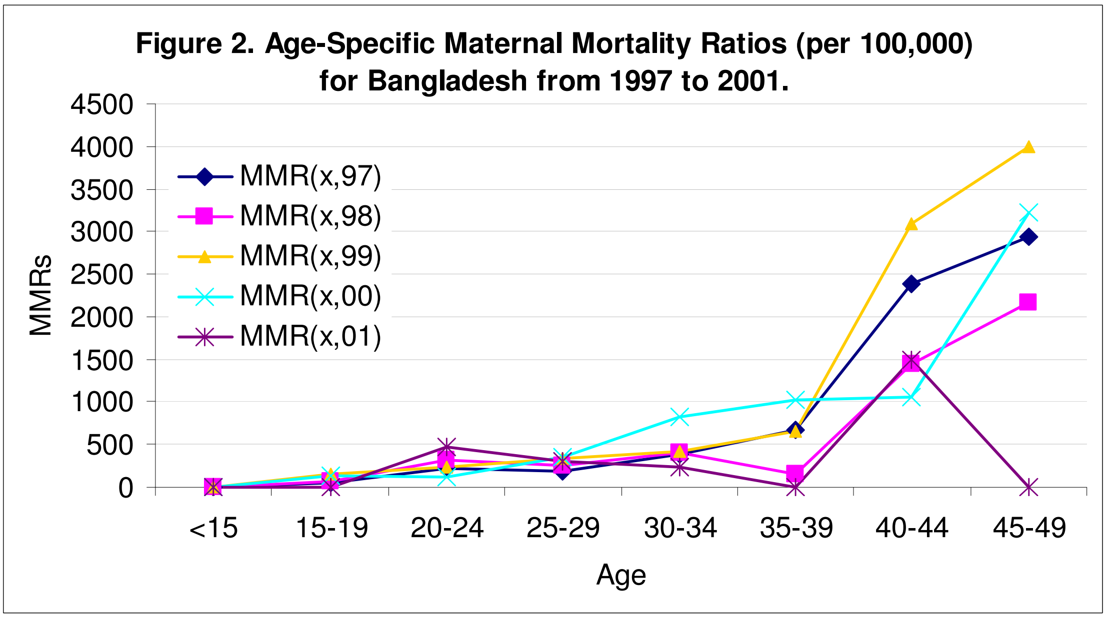
4. Preliminary Results

The results included in this manuscript are only preliminary findings, which will be enriched from experience from other DHS special surveys on maternal mortality that will be assessed.

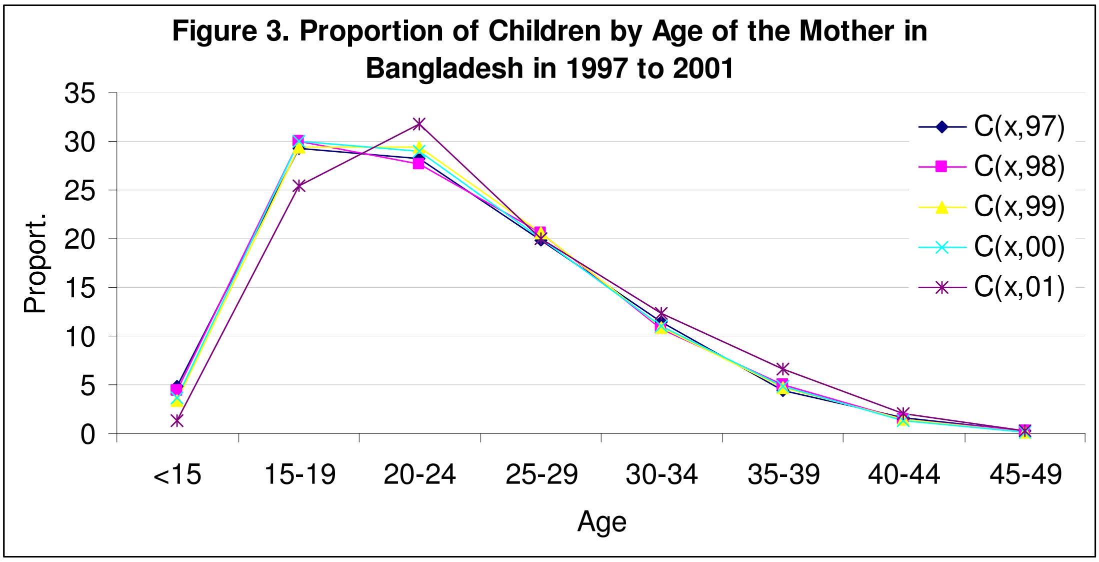
Figure 1 presents the trend in the MMR in Bangladesh from 1997 to 2001.



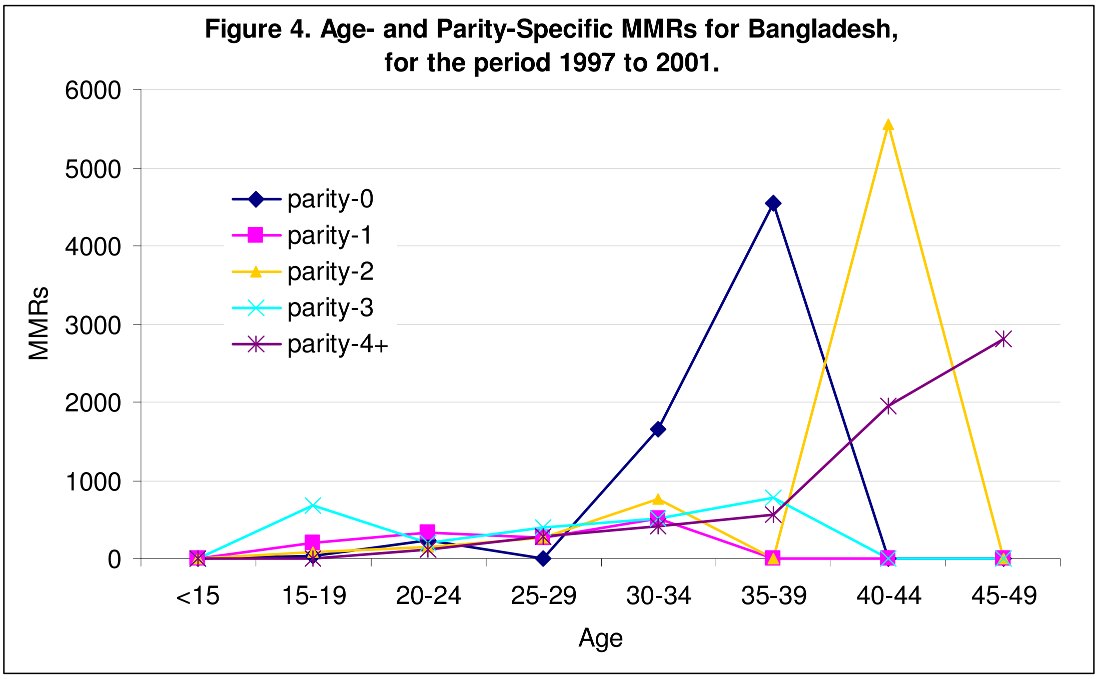
As shown in Figure 1, the increase in the last years of the twentieth century in MMR ceased with a decreasing trend observed since 2000. However, it is not clear if all age-groups have benefited equally from the latest reductions. Opposed to the clear trend in MMR Figure 2 shows the age-pattern of MMRs for the same years as in Figure 1.



The steep increase in age-specific MMRs after age 35 is evident in Figure 2 for all years, except 2001. Although MMR for 1997 had the lowest values of all the analyzed periods, in Figure 2 at older ages age-specific MMRs for 1997 are among the highest. As presented in equation (4), a very important factor which is missing in this diagram is the information provided by the composition of births by age of the mother, $C_B(i,x,t)$. A skew bell shape age pattern is observed in the trend of these proportions for all the years giving higher weight for the youngest age groups.



Finally, we have included also the calculation of the age- and parity-specific maternal mortality ratios for Bangladesh for the whole period from 1997 to 2001. We aggregated the results of all the years to obtain more robust values and avoid the year to year fluctuations, although we plan to analyze them independently also. These results are included in Figure 4 below.



The revealing part of Figure 4 is the transition from ages and parities of peak MMRs: while parity zero includes an excess of MMR at ages 35-39, for parity two, this is not found until age 40-44 and similarly for parity four and more with the highest value found until age 45-49.

Reference

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4. Hogan, M., Foreman, K., et al. (2010). Maternal mortality for 181 countries, 1980-2008: a systematic analysis of progress towards Millennium Development Goal 5. *The Lancet* 375: 1609-1623