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ORIGINAL ARTICLE

Determinants of the age of mother at first birth in Bangladesh: quantile regression approach

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Abstract

Objective This paper attempts to explore the determinants that determine the mother's age at first birth in Bangladesh by using a data set obtained from Bangladesh Demographic and Health Survey (BDHS)-2014.

Study design The sampling frame used for the 2014 BDHS is the complete list of enumeration areas (EAs) covering the whole country prepared by the Bangladesh Bureau of Statistics for the 2011 population census of the People's Republic of Bangladesh. An EA is a geographic area covering on average 113 households. However, the 2014 BDHS sample was stratified and selected in two stages. In the first stage, 600 EAs were selected with probability proportional to the EA size. Also, in the second stage of selection, a fixed number of 30 households per cluster will be selected with an equal probability systematic selection from the newly created household listing.

Methods The quantile regression model produces more unbiased estimates than the linear regression model when the data do not follow the assumed normal distribution. Thus, this paper considers the quantile regression model.

Results The results suggest that variables such as the type of place of residence, religious status, husband's age and his occupation, body mass index, and wealth index of the respondent are positively related to the age of mother at first birth. However, variables such as current age, highest educational level, and occupation of the respondent, division and husband/partner's education level are negatively related to the age of mother at first birth.

Conclusion The results show that the average age of mothers at first birth is just under 18 years, which is just under the age of marriage in Bangladesh. It is quite alarming to the government of Bangladesh. Therefore, the government should take the necessary steps to achieve an increase in the age of mothers at first birth.

Keywords Quantile regression · Age at first birth · Bangladesh

Introduction

The age at first birth is the age (in years) of women at birth of her first child. The first birth is one of the most significant as well as important events in a woman's life ,and indicates the beginning of undertaking the intensive responsibilities of motherhood and childcare. These responsibilities reduce the quality of life (Nahar and Zahangir 2013). However, early entry into motherhood lengthens the reproductive period and subsequently increases fertility. It is a major determinant of large family size and rapid population growth, especially in countries where the use of contraception is low (Islam 1999). Several studies have emphasized that lower age at first birth results in higher completed fertility (Presser 1971; Marini and Hodsdon 1981; Kohler et al. 2001). In addition, population growth is more rapid when women give their first birth during adolescent ages (Senderowitz and Paxman 1985; Singh 1998). Moreover, more than 40% of adolescent women in the developing world give birth before the age of 20. Also, when pregnancy occurs before adolescents are fully developed, they are exposed to higher risks of maternal morbidity as well as mortality (Alauddin and MacLaren 1999). Among women aged 15 to 19, pregnancy is the leading cause of death (UNFPA 2003).

The age at which she first gives birth decreases the young woman's decision-making power in areas related to her own reproductive health (MEASURE Evaluation 2017). In contrast, increasing the age at first birth has

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positive impacts on the health status of a young mother and baby. Also, it can dramatically impact a young woman's future from an economic, social, and emotional perspective (MEASURE Evaluation 2017). The age at first birth has been shown to be significantly associated with age at first marriage, ever use of any contraception, spousal age difference, religion, respondent's working status, and husband's occupation in Bangladesh (Nahar and Zahangir 2013). Moreover, among the five factors, awareness of parents and fecundity factor explain the age at first birth most in Bangladesh (Rabbi and Kabir 2013). Furthermore, the education of a woman, place of residence, and religion play the greatest roles in influencing age at first birth in Tanzania (Ngalinda 1998). Also, a number of social determinants (race, religion, and smoking at a young age) have a direct effect on age at first birth. In addition to that, education has the most determinant effect on age at first birth (Rindfuss and John 1983). Similarly to other developing countries, in Bangladesh, socio-economic, demographic, etc. variables play a vital role in fertility. Some researchers have examined the relationship between mortality and age at first birth, and found that there is a positive relationship between becoming a first-time mother before 20 years of age and mortality (Doblhammer 2000; Grundy and Kravdal 2008; Henretta 2007). However, the maternal age at first birth has been rising in many countries (Sakai et al. 2017). In most of the previous studies, the researchers tried to identify significant determinants of fertility by examining the age at first birth via the usual multiple regression analysis or factor analysis. Nevertheless, the quantile regression model has an advantage, in that it is robust to the preference of outliers and it doesn't only concern itself with the mean and median behaviour (Yeh et al. 2009). In addition, the quantile regression model has produced estimates that were more unbiased than the estimates produced by linear regression model when the data did not follow the assumed normal distribution (Olsen et al. 2012). The boxplot of the age at first birth presented in Fig. 1 illustrates that its distribution does not follow the normal distribution. For this reason, this paper considers the quantile regression models. The main aim of this paper is to explore the underlying factors that determine the mother's age at first birth in Bangladesh with the help of quantile regression.

Methods

Data

The data for this study is obtained from Bangladesh Demographic and Health Survey (BDHS) 2014, which is a nationally representative survey. The survey was conducted under the authority of the National Institute for Population, Research, and Training (NIPORT), Ministry of Health and Welfare, Bangladesh and funded by USAID. The access link of data set is http://dhsprogram.com/data/available-datasets.cfm. The sampling frame used for the 2014 BDHS is the complete list of enumeration areas (EAs) covering the whole country prepared by the Bangladesh Bureau of Statistics for the 2011 population census of the People's Republic of Bangladesh. An EA is a geographic area covering on average 113 households. However, the 2014 BDHS sample was stratified and selected in two stages. In the first stage, 600 EAs were selected with probability proportional to the EA size. In the second stage of selection, a fixed number of 30 households per cluster will be selected, with an equal probability systematic selection from the newly created household listing. For the 2014 BDHS survey, 17,989 households were selected. The details of the sampling procedure are available in the report of Bangladesh Demographic and Health Survey 2014. This paper considers the age at first birth of mother as the dependent variable, and type of place of residence, religious status, husband's age, occupation, and education level, current age, highest educational level, and occupation, body mass index, and wealth index of the respondent as independent variables.

Quantile regression

The quantile regression model was introduced in 1978 by Koenker and Bassett (1978) and recently has been widely applied in many research areas, especially in econometrics and statistics. Suppose Y to be a random variable with cumulative distribution function $F_Y(y)$ i.e., $F_Y(y) = P(Y \leq y)$. Then the quantile function is given by $Q_Y(\tau) = F_Y^{-1}(\tau) = \inf$

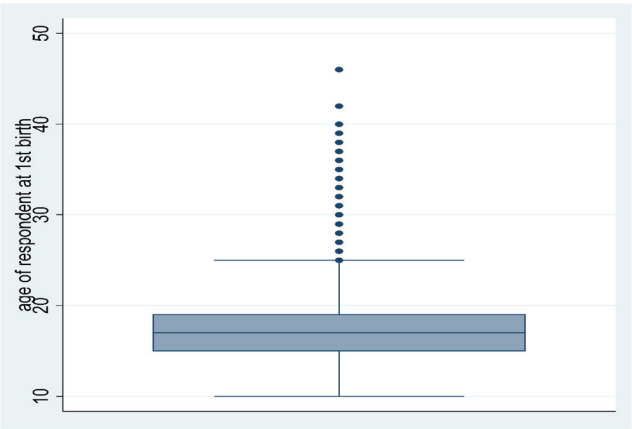

Fig. 1 Boxplot of the age of mother at first birth

$\{y : F_Y(Y) \geq \tau\}$, $\tau \in [0, 1]$. The parametric quantile regression model can be described as $y_i = \beta_{0\tau} + \beta_{1\tau}x_{1i} + \ldots + \beta_{k\tau}x_{ki} + \varepsilon_{i\tau} \forall\, i \in \{1, 2, \ldots, n\}$, where, $\beta_{0\tau}$, $\beta_{1\tau}$, …, $\beta_{k\tau}$ are the quantile coefficients that may depend on τ. The quantile coefficients of the model are computed by solving the following equation

$$\arg\min_{(\beta_{0\tau},\ldots,\beta_{k\tau}\in R^2)} \left\{ \sum_{y_i \geq A} \tau |y_i - \beta_{0\tau} - \beta_{1\tau}x_{1i} - \ldots - \beta_{k\tau}x_{ki}| + \sum_{y_i < A} (1-\tau)|y_i - \beta_{0\tau} - \beta_{1\tau}x_{1i} - \ldots - \beta_{k\tau}x_{ki} \right\}$$

Data availability The data set used in this study is available from the website "The DHS Program". In order to gain access to the data files, you have to complete the registration. The data set is available from the following link http://dhsprogram.com/data/available-datasets.cfm.

Results

This study has one dependent variable (age of mother at 1st birth) and ten explanatory variables. Among them, some variables are continuous and some have nominal level of measurement. Firstly, we look at the characteristics of our main concerned variable, i.e., the age of mother at first birth, and the statistics are represented in the following table.

It is observed that the minimum age of mother at first birth is 10 years, while the maximum age is 46 years. Interestingly, it is observed that the average age of mothers at first birth is just under the age of marriage. The skewness of the dependent variable indicates that its distribution is positively skewed: this means that the data are not perfectly normally distributed. This implies that the quantile regression approach would be suitable for the model. Table 1 shows the percentiles 10th, 25th, 50th, 75th, 90th, and 95th. Before estimating the quantile regression model, detecting outliers is essential. To detect the outliers, the study is using the most well-known approach, called boxplot. The boxplot of the age of mother at first birth shows the presence of outliers in the data (Fig. 1).

It can be seen from Fig. 1 that the age of mother at first birth does not follow the normal distribution. This implies that the quantile regression approach would be preferred to develop models such as the OLS model. First, we perform the quantile regression for different quantiles (0.1, 0.25, 0.5, 0.75, 0.90, and 0.95). However, in order to test the significance of running several quantile regression, we consider the following hypothesis and the results of the test statistic are given in the following table.

Table 2 Test of equality of slope of different quantile regression

Hypothesis	F	*P* value	Hypothesis	F	*P* value
q10 = q25	21.56	0	q25 = q95	227.60	0
q10 = q50	54.89	0	q50 = q75	34.71	0
q10 = q75	107.61	0	q50 = q90	116.89	0
q10 = q90	127.20	0	q50 = q95	393.71	0
q10 = q95	326.00	0	q75 = q90	34.02	0
q25 = q50	11.05	0	q75 = q95	92.10	0
q25 = q75	34.49	0	q90 = q95	38.57	0
q25 = q90	90.99	0			

H_0: the estimates for all quantiles are statistically equal versus H_1: the estimates for all quantiles are not statistically equal.

Considering the p value of Table 2, the information reveals that the p value is less than 0.000; therefore the test significantly rejects equality of the estimated coefficients for the quantiles in each case. This also implies that the use of different quantile regression approaches is appropriate in the research. However, now it is important to select the most appropriate model, which is done by the pseudo R-squared method. The values of pseudo R-square for different quantiles are presented in Table 3.

The results given in Table 3 demonstrate that the pseudo-R^2 varies quantile by quantile; it is generally smaller for the lower tails of distribution than the higher quantiles of distribution. The value of pseudo-R^2 lies between about 50% and close to 72% which means that the considered predictors explained the variance at different levels of the age of mother at first birth. Therefore, the evaluation of the model implies that it is not weak at all quantiles. Furthermore, we prefer the 90th quantile regression model because it provides the highest value of pseudo-R^2. Finally, we estimate all quantile regression considered in this study. The

Table 1 Descriptive statistics of the age of mother at first birth

Mean	Std. dev	Min	Max	Skewness	Kurtosis	Percentile						
						5%	10%	25%	50%	75%	90%	95%
17.47	3.07	10	46	1.25	6.001	14	14	15	17	19	21	23

Table 3 Pseudo R-square estimates for multiple quantile regression

Quantile	0.10	0.25	0.5	0.75	0.90	0.95
Pseudo R^2	0.4919	0.5092	0.5698	0.6959	0.7194	0.7018

estimated coefficients for the selected sample quantiles (10th, 25th, 50th, 75th, 90th and 95th), the standard errors, and confidence interval for quantile regression coefficient estimates which are obtained by a method suggested by Koenker and Hallock (2001) are presented in the following table.

As the results presented in Table 4 suggest that, among the ten independent variables, five variables are positively associated with the dependent variables, whereas the remaining half of the independent variables are negatively associated with the age of mother at first birth for the 90th quantile. Also, it is observed that all coefficients except division are statistically significant at the 1% level of significance. The coefficient of division is only significant at the 10% level of significance for 90th quantile. However, a small difference is observed in other quantiles. The graphical representations of the estimates for all quantile are given in Fig. 2.

The effect of the current age of the mother on her age at first birth is positive and small for lower tails of distribution as higher quantiles. However, at the lowest quantile (0.1), the plot shows that the coefficient for current age is approximately 0.01. By examining the pattern of the plot presented in Fig. 2, it can be seen that, as the current age of mothers increases from the 0.01 quantile to the 0.95 quantiles, it becomes more related to the age at first birth and the coefficient increasing from approximately 0.01 to just over 0.3. Moreover, a similar pattern is observed for the variable highest education level of the mother. The coefficient change over the range about 0.5 to approximately 1.17 for the quantile varies between 0.1 and 0.95. The type of placeis negatively associated with the age of mother at first birth. The value of the coefficient starts at more than −0.2 at quantile 0.25 and ends at just under −0.6 for the quantile 0.95. In the case of the variable division before the quantile 0.8 the coefficient is negative, but after that it is positive. Furthermore, religious status of the mother is positively related to the age at first birth for all quantiles. A similar pattern is observed for the variables mother's occupation and husband/partner's education level. Both of them have a positive effect on the dependent variable considered in this study. Husband's age and his occupation, as well as the body mass index, are negatively related to the mother's age at first birth. In addition, the wealth index is negatively related to the age at first birth of the mother except the quantile 0.75 (Fig. 2).

Table 4 Coefficients for quantile regression model

Variables	Estimated coefficient					
	Q10	Q25	Q50	Q75	Q90	Q95
Respondent's current age	0.104874*** (0.0051829)	0.143033*** (0.0074596)	0.169596*** (0.007197)	0.20884*** (0.0102431)	0.2867*** (0.0133432)	0.32239*** (0.0121901)
Highest educational level	0.467407*** (0.058888)	0.703531*** (0.0401676)	0.846746*** (0.0451276)	0.93487*** (0.0611572)	0.98696*** (0.0779994)	1.16632*** (0.129479)
Type of place of residence	0.006528 (0.0585975)	−0.21747*** (0.0581243)	−0.33388*** (0.0802231)	−0.3804*** (0.07993)	−0.4228*** (0.1033833)	−0.5654*** (0.0994425)
Division	−0.00343 (0.015256)	−0.03321* (0.013166)	−0.01267 (0.018228)	−0.03257 (0.022667)	0.036985* (0.01506)	0.1261*** (0.034406)
Religion	0.037188 (0.1776683)	0.066497 (0.2540105)	0.530201** (0.3021372)	0.56761** (0.2256679)	0.64891*** (0.1912027)	0.323142 (0.0265527)
Husband's age	−0.06113*** (0.0043967)	−0.07502*** (0.005781)	−0.08716*** (0.0072208)	−0.082*** (0.0079846)	−0.0829*** (0.0094263)	−0.0687*** (0.0078553)
Husband/partner's education level	0.109988*** (0.0331702)	0.162214*** (0.0396462)	0.256944*** (0.0377942)	0.32995*** (0.0467945)	0.61744*** (0.0585413)	0.83094*** (0.0824133)
Husband/partner's occupation	−0.00236 (0.0017161)	−0.001319 (0.0009911)	−0.001583 (0.0028201)	−0.00637* (0.0035723)	−0.0393*** (0.0113072)	−0.0114*** (0.0035296)
Respondent'soccupation	0.009415*** (0.0019545)	0.010915*** (0.0016645)	0.014876*** (0.0027378)	0.02353*** (0.0049992)	0.03618*** (0.0061737)	0.04517*** (0.0099477)
Body mass index	−0.000098 (0.0000615)	−0.000031** (0.0000175)	−0.000086 (0.0000931)	−0.000096 (0.0001099)	−0.0306*** (0.00685)	−0.0004*** (0.000038)
Wealth index	−0.06769*** (0.0191646)	−0.0822*** (0.0160072)	−0.01109 (0.0398464)	0.060473 (0.0327069)	−0.0252*** (0.0042949)	−0.1182*** (0.0246935)
Constant	12.82114*** (0.2912)	13.06011*** (0.2937476)	13.547*** (0.4215565)	13.7273*** (0.4870316)	12.701*** (0.4661367)	12.8568*** (0.4843928)

Standard errors are in brackets

* $p < 0.10$; ** $p < 0.05$; *** $p < 0.01$

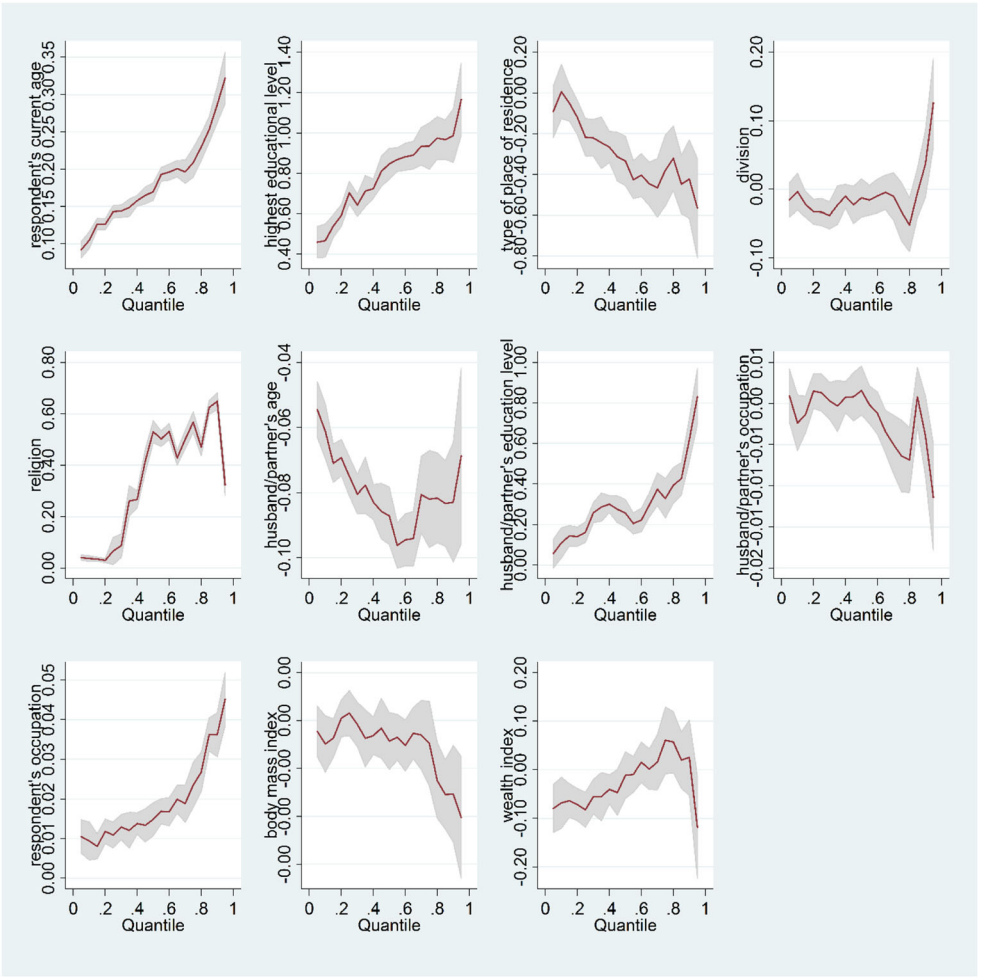

Fig. 2 Graphical representation of the quantile regression estimates

Conclusion

The first birth is really the most important event as well as marking the transition for a woman into motherhood. It is also an important indicator for maternal health. In the current study, the quantile regression technique is employed to explore the underlying factors that determine the respondent's age at first birth using the data of BDHS-2014. The results of pseudo-R^2 show that the regression for the quantile 0.95 is better than other quantile regression in this study. The results suggest that variables such as the type of place of residence, religious status, husband's age, and his occupation, body mass index, and wealth index of the respondent are positively related to the age of mother at first birth. However, variables such as current age, highest educational level and occupation of the respondent, division, and husband/partner's education level are negatively related to the age of the mother at first birth. It is observed that the minimum age of mother at 1st birth is 10 years while the maximum age is 46 years. In our study it is found that the average age of mothers at first birth is just under 18 years, which is just under the age of marriage in Bangladesh. This is alarming to the government of Bangladesh. Therefore, the government should take the necessary steps in order to achieve an increase in the age of mothers at first birth.

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Authors' contributions MMH performed statistical analyses, interpreted results, and drafted the manuscript. AKM contributed to designing the study and interpreting results, and critically reviewed the manuscript and approved the final version.

Compliance with ethical standards

Ethics approval and consent to participate This study is considered a secondary data set and Ministry of Health and Welfare, Bangladesh is responsible in this regard.

Consent for publication Not applicable.

Competing interests The authors declare that they have no competing interests.

Abbreviations BDHS, Bangladesh Demographic and Health Survey; NIPORT, National Institute for Population, Research, and Training; USAID, United States Agency for International Development; OLS, Ordinary Least Square

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