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Impact of Early Childbearing on the Health of the Mother and Child: A Statistical Study

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University of Rajshahi

IMPACT OF EARLY CHILDBEARING ON THE HEALTH OF THE MOTHER AND CHILD: A STATISTICAL STUDY

A

Dissertation

Submitted to the University of Rajshahi

in Fulfillment of the Requirements for the

Degree of Doctor of Philosophy

BY

MD. ASHRAFUL ISLAM

University of Rajshahi
June, 2013

Department of Statistics
University of Rajshahi
Bangladesh

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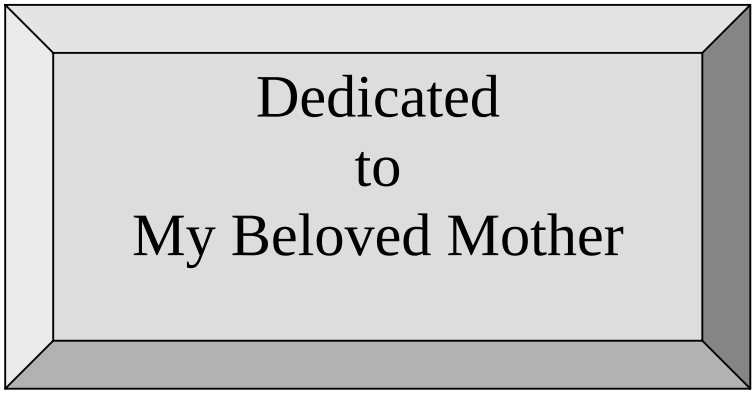
Dedicated
to
My Beloved Mother

CERTIFICATE

We are pleased to certify that the dissertation entitled "Impact of Early Childbearing on the Health of the Mother and Child: A Statistical Study" is the original work of Md. Ashraful Islam and to the best of our knowledge, this is the candidate's own achievement and is not a conjoint work. He has completed this dissertation under our direct guidance and supervision.

We also certify that we have gone through the draft and final version of the dissertation and found it satisfactory for submission to the Department of Statistics, University of Rajshahi in partial fulfillment of the requirements for the degree of Doctor of Philosophy in Statistics.

We wish him a colorful future and every success in his life.

Supervisors

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DECLARATION

I do hereby declare that the dissertation entitled **"Impact of Early Childbearing on the Health of the Mother and Child: A Statistical Study"** submitted to the Department of Statistics, University of Rajshahi for the degree of **Doctor of Philosophy** in Statistics is exclusive my own and original work carried out under the supervision of **Professor Dr. Md. Nurul Islam** and **Professor Dr. Md. Golam Hossain**, Department of Statistics, University of Rajshahi, Bangladesh. No part of it in any form has been submitted to any other University or Institute for any degree, Diploma or for other similar purposes.

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University of Rajshahi *Md. Ashraful Islam*

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ABSTRACT

Recent research has document the focus of rapidly growing interest on adolescents' and their child health in the developing and under developed countries because of its important implications not only for the health of mother but also their children. Early childbearing is an important indicator for women's and their child health. Body mass index is an indicator of nutritional status in a population. This indicator provides the circumstances that can assist intervention to help eradicate many preventable diseases. Health impact of teenage childbearing is not only due to socio-demographic factors but also due to biological factors. Women early age at first marriage were associated with early childbearing and early childbearing is considered as a risk factor for poor prenatal outcomes. There is a need to study demographic trends particularly trends in marriage under the framework of "basic need strategy". The objectives of "basic need strategy" among others are to eradicate poverty, unemployment, hunger and literacy is considered as a major precondition for achieving population goals and the participation of women in development.

The main objective of this study is to evaluate and analyze the impact of early childbearing on the mother and their child health of rural and urban community in Bangladesh. The specific objectives were: first one, to find the effect of socio-demographic factors on early childbearing mother's health; second one, to investigate the changes in age at first marriage of Bangladeshi women over time and third one, to estimate the parameters involving in the age patterns of marriage and evaluate the patterns (using single year age distributions) of distributions of first marriage frequencies and risks of the first marriages of ever married women in Bangladesh.

Finally, the purposes of the study were to demonstrate the applicability of the generalized Poisson regression (GPR) model as an alternative of other statistical methods and to find some predictors of child malnutrition in Bangladesh.

Considering the reproductive women (age 15-49 years), data was extracted from Bangladesh Demographic and Health Survey in this study. For measuring mothers' health a sample of 1908 ever-married women of age 10-24 were used from the total sample of 10,966. For investigate the age at first marriage and its trends over time, data for 47,109 married Bangladeshi women from 1944-1985 were analyzed. To estimate the parameters of Coale's nuptiality model and evaluate the patterns of distributions of first marriage frequencies also risks of the first marriages of ever married women in Bangladesh, eventually all of 10,996 ever married women from age 15 to 49 years were taken. To examine the health problem and risks faced by early childbearing mothers' children in Bangladesh a total sample of 3,207 were extracted.

Logistic regression was used to examine the relative importance of socio-demographic factors on early childbearing mothers' health. ANOVA and linear regression analysis were used to investigate the changes in age at first marriage of Bangladeshi women over four decades. The first marriage frequency and risk of first marriage of women was estimated by Coale and McNeil (1972) model. This model considered five year age group of population. In the present study single year age distribution of ever married female in Bangladesh has been considered. Finally for measuring child health Chi-square test and GPR model were used.

More than 33 percent early childbearing mothers have been suffering from chronic energy deficiency, among them 35.4 percent came from rural and 26.9 percent from

urban. The BMI varied from 11.95 kg/m^2 to 37.79 kg/m^2, with a mean of 19.86 ± 2.70 kg/m^2 (95% CI: 19.74-19.98). About 15.7 percent women fall below the cutoff of 145 centimeters in height. A decreasing trend was found in the number of CED women with increasing educational level. Student t-test revealed that caesarean mother had a higher BMI than non-caesarean mother ($p < 0.001$. The coefficients and odds ratio of logistic regression analysis demonstrated that early childbearing mothers who were from rural areas, illiterate, hard laborer, unemployed partner, poorest, non-caesarian, delivered at home, earlier age at first marriage, early age at first birth, having two or more children, were at higher risk for getting chronic energy deficiency (underweight). Based on Wald statistics (16.258) we conclude that age at first marriage was the most influential variable on early childbearing and undernourished mother in Bangladesh.

The mean and median age at first marriage of ever married Bangladeshi women was 14.73 ±2.96 years and 14.00 years, respectively; rural women got marriage significantly ($p<0.01$) earlier than urban women. More than 85 percent (rural 87.6 percent and urban 78.2 percent) Bangladeshi women got marriage before they reached 18 years old, among them 17.0 percent (rural 18.5 percent and urban 13.1 percent) got marriage very early age (before 13 years old). The present study demonstrated that the age at first marriage of ever married Bangladeshi women was showing increasing tendency with changing time. Using ANOVA, age at first marriage for rural and urban showed significant ($p<0.01$) differences among the birth year cohorts from 1944 to 1985 of the present sample. However, the slope of linear regression line indicated that age at first marriage for both rural and urban women exhibited

increasing tendency during the investigated period. Also, the present study demonstrated that the child marriage among Bangladeshi women showed slightly decreasing tendency during birth year cohorts from 1944 to 1985.

Coale's model was used to find the age pattern of marriage among Bangladeshi women. The model gave us interesting results. Most of female got married before the age of 20 years with almost 100 percent getting married by the time they reach age 30. In Bangladesh the legal age of marriage is 18 years old for the women; however a large proportion (about 95 percent) of marriages below this age still take place.

The GPR model has been found to be reasonable to study the outcome variable because of its under-dispersion (variance < mean) property. Our study also identify several significant predictors of the outcome variable namely; region, place of residence, father's and mother's education, mothers occupation, wealth index, delivery system, place of delivery, source of drinking water of the household, toilet facility, and total number of children ever born to a woman.

These above results suggest that for improving health status of Bangladeshi early childbearing mothers, are need to improve the literacy. The result also suggest that age at first marriage of Bangladeshi women has been increasing for last four decades, and increasing rate of urban women is faster than rural women. Moreover, the study confirms that marriage still remains a universal phenomenon among females in Bangladesh. Early marriage prevails that marriage not only start early but progresses fast and are concentrated within a short span of time at least in the female population. Consistencies of our findings we suggest that the GPR model is an ideal alternative of other statistical models for analyzing child malnutrition in a family.

CHAPTER ONE

INTRODUCTION

"The health of adolescent girls is everyone's business. We all need to step up to the plate to embrace this ambitious agenda."—Melinda Gates

1.1: Background of the study

1.1.1: Mother Health

Adolescent (teenage) women who became pregnant and have babies may not be physically or mentally prepared to take care of their babies, women who have children before 20 years old are usually called early child bearing mothers.

Reproductive health is a state of complete physical, mental and social well-being and not merely the absence of disease or infirmity, in all matters relating to the reproductive system and to its functions and processes. Reproductive health therefore implies that people are able to have a satisfaction and safe sex life and that they have the capability to reproduce and the freedom to decide if, when and how often to do so. Implicit in this last condition are the right of men and women to be informed and to have access to safe, effective, affordable and acceptable methods of family planning of their choice, as well as other methods of their choice for regulation of fertility which are not against the law, and the right of access to appropriate health-care services that will enable women to go safely through pregnancy and childbirth and provide couples with the best chance of having a healthy infant. In line with the above

definition of reproductive health, reproductive health care is defined as the constellation of methods, techniques and services that contribute to reproductive health and well-being by preventing and solving reproductive health problems. It also includes sexual health, the purpose of which is the enhancement of life and personal relations and not merely counseling and care related to reproduction and sexually transmitted diseases. Adolescents are particularly vulnerable because of their lack of information and access to relevant services in most countries. Women's health involves their emotional, social and physical well-being and is determined by the social, political and economic context of their lives, as well as by biology moreover, health and well-being elude the majority of women (United Nations, 1995).

More recently, many researchers have reported that teenage pregnancy and early childbearing is associated with lower socio-economic family background and higher risk of unfavorable health consequences for mother and child in both developed and developing countries. Nearly one fifth (17.5 percent) of the world's inhabitants are aged 10–19 years, and in the least developed nations, this group were raise up to (23 percent) of the population (World population prospects: the 2010 revision).

In Bangladesh 80 percent teenage girls got married which increases the possibility of their having high-risk births in the absence of contraceptive use before the first birth. Early marriage is closely associated with teenage motherhood leading to early initiation of childbearing. More than half of the adolescents become mother age 20 an about another 5 percent pregnant with first child where adolescent fertility contributes substantially to overall fertility accounting for about 22 percent of the total number of births in Bangladesh (Mitra et al., 2001).

Bangladesh is one of the largest Muslim countries in the world, where both early marriage and early conception are widely practiced. Including Bangladesh, early marriage and early conception is a promising matter across the world and remains widespread problem particularly in developing countries (Nasrin and Rahman, 2012).

Early childbearing is an important indicator for status of general health of women (Luker, 1996). In the last few decades, the practice of early marriage and early childbearing is still common in Bangladesh despite substantial development in Human Development Indicators (HDI). In a recent report, 76 percent of the first-born children in Bangladesh were born to women before their 20^{th} birthday also reported that the mortality rate for children born to adolescent mothers was 10.4 percent in Bangladesh (Maitra and Pal, 2007). The female adolescents got married about 50 percent before reaching 20 years and only 5 percent male adolescents did the same. Usually, early marriage and early child bearing have been encouraged in Bangladesh (Mitra et al., 1997). Bangladesh remains a country with high maternal, neonatal and infant mortality (322, 45, and 52 per 100,000 live births respectively) compared too many low-income countries despite impressive gains in the health sector since independence in 1971 with similar conditions (NIPORT, 2003 and 2009).

The pregnancy rate among adolescents is rapidly increasing. Contraceptive use among adolescents is much lower than among married adults. In Bangladesh, where 66.8 percent of adolescents are married, only 9 percent of them use contraceptives, compared with 19.1 percent married adults. Complications of pregnancy and childbirth and unsafe abortion are the main causes of death in adolescents who suffer from toxemia, prolonged labor and cephalopelvic disproportion, anemia, cervical

trauma, premature birth, and death. The most common among teenagers are gonorrhea, chlamydia, syphilis, herpes, genital warts and HIV (Senanayke and Ladjali, 1994).

During adolescence many keys social, economic, biological and demographic events occurs that set the stage for adult life is one of the most crucial periods in an individual's. The period is also considered the "Demographically Dense" phases because most of the demographic movements take place during these years (Hossain et al., 2008).

In Bangladesh, female just below reproductive age and they will begin their reproductive activities very soon because most of them will be married well before legal age as set by the Government of Bangladesh. The mean age of menarche and the mean age of first marriage were 13.4 and 14.8 years respectively also indicated that more than 70 percent of the marriage takes place soon after the onset of menstruation (Islam et al., 1995).

The negative social, health and economic consequences of teenage marriage, adolescent childbearing, unintended pregnancies and in some societies have high levels of pre and extra-marital conceptions (Bogue and others, 1977). In the developed world although such issues concerning adolescents are much publicized, the concepts are relatively new in many developing countries like Bangladesh (ESCAP, 1992).

Women who bear children too early or too late in life, women who bear many children and those who bear children too close together, put themselves and their children in danger. Producing high-risk to mother and child life pregnancies of

younger mother (below 20 years) too many pregnancies (5 or more) and closer birth intervals of (below twenty four months) (Perkin, 1968). The health risk of early childbearing increases before age 20 and after age 39 (Okie, 1998; Ross and Frankenberg, 1993). Among women ages 40-44, the risk of death is five times higher than in their 20s (Royston and Lopez, 1987). Pregnancy before age 20 also poses risk of the younger women's infant (Sulliban et al., 1994).

Risks for medical complications are greater for girls of age 14 years and younger, as an underdeveloped pelvis can lead to difficulties in childbirth. Obstructed labor is normally deal with by caesarean section in industrialized nations. However, in developing regions where medical services might be unavailable, it can lead to eclampsia, obstetric fistula, infant mortality and maternal death. Each year an estimated 70,000 teen girls in developing countries complications of pregnancy result in the deaths. Young mothers and their babies are also at greater risk of contracting collaboration from HIV (Mayor, 2004). An early childbearing mother is at higher risk of poor prenatal morbidities such as gestational diabetes, gestational hypertension and preterm labors compared to the general population (Palacios and Kennedy, 2011). The World Health Organization (WHO) estimated that the risk of death following pregnancy is twice as great for women between 15 and 19 years than for those between the ages of 20 and 24. The maternal mortality rate can be up to five times higher for girls aged between 10 and 14 than for women of about twenty years of age (Locoh, 2006). Women are twice more likely to die from early childbearing ages 15 to 19 than 20s (Noble et al., 1996 and Stars, 1997). In developing countries, efforts to eliminate inequalities in the utilization of basic health care services have been

emphasized for the overall improvement of health (Gwatkin et al., 2002 & 2004; Victora et al., 2002 and Wagstaff, 2001).

Early marriage which is also referred to as child marriage is common all over the world with adverse effects on young children (especially females) who are completed to tie the knot in most cases. Marriage of children and adolescents below the age of 18 is still widely practiced (UNICEF, 2001). Adolescent marriage and childbearing are associated with a range of adverse health outcome, including elevated risks of pregnancy, unsafe abortion an infant, maternal mortality and mobility (Blanc and Way, 1998). Mothers between 15 and 19, risks are associated more with socio-economic factors than with the biological effects of age (Makinson, 1985). Teenage women who are pregnant or mother are seven times more likely to commit suicide than other teenagers (HanaMargret, 2009).

Women have different and unequal access to the basic health resources, including primary health services for the prevention and treatment of childhood diseases, malnutrition, anemia, diarrheal diseases, communicable diseases, malaria and other tropical diseases and tuberculosis, among others. Women also have least and unequal opportunities for the protection, promotion and maintenance of their health. Women's health is also affected by gender bias in the health system and by the provision of inadequate and inappropriate medical services to women (United Nations, 1995). In developing countries inadequate nutrition during pregnancy is the most problem among teenagers (Sanchez et al., 1997 and Pena et al., 2003). In rural hospital in West Bengal, teenage mothers between 15–19 years old were most likely to have anemia,

preterm delivery and low birth weight than mothers between 20–24 years old (Banerjee, 2009).

The World Health Organization estimated that every year, 358 000 women die due to complications related to pregnancy and childbirth; 99 percent of these deaths occur within the most disadvantaged population groups living in the poorest countries of the world (WHO, 2011). Most of these deaths can be avoided by improving women's access to quality care from a skilled birth attendant before, during and after pregnancy and childbirth. Complications related to pregnancy and childbirth is among the leading causes of mortality and morbidity of women of reproductive age in many parts of the developing world (United Nations, 1995).

The teenage birth rate in the United States is the highest in the developed world and the teenage abortion rate is also high (UNICEF, 2001). According to the Guttmacher Institute in recent years, the rate of teen pregnancies in America has increased dramatically. Approximately 750,000 teenage girls between the ages of 15 and 19 become pregnant every year; within this number 82 percent of the pregnancies are unplanned. More than half of teenage pregnancies continue to birth. Teenage girls are often not emotionally prepared for childbirth or being a mother and can experience extreme depression, anxiety, resentment and feelings of failure. Guttmacher Institute states that 43 percent of teenage pregnancies are terminated due to miscarriage or abortion. A pregnancy that results in an abortion can have long-term psychological effects, including depression, post-traumatic stress disorder, extreme regret, sleep disorders, and anxiety disorders, according to (AbortionFacts.com.) this can cause

disruption in every other area of the young woman's life, including school, family, relationships and health (Hana Margret, 2013).

Childbearing during the teens or early 20s is associated with higher rates of maternal mortality (Doblhammer, 2000 and Mirowsky, 2005). According to American Academy of Child & Adolescent Psychiatry teenage mothers are at a higher risk of poverty, inability to maintain a stable job, ending up in abusive homes, having children who perform poorly in school, and having daughters with a 22 percent higher risk of also becoming pregnant during their teenage years (HanaMargret, 2013). Adolescent pregnancies are associated with maternal and fetal complications and teenage pregnancies have been considered as high-risk (Ventura et al., 2000).

Over the past five decades, the health of adolescents has improved slowly than the health of younger children (Sawyer et al., 2012) this is partly because early pregnancy carries a high risk of serious complications of mother health (Bearinger et al., 2007).

1.1.2: Trend in age at first marriage over time

Marriage is the most significant and memorable event of human life cycle as well as the most important foundation in the family formation process from the very beginning of human history for all societies. Age at first marriage has a particular interest because it marks the transition to adulthood in many societies; the point at which certain options in education, employment, and participation in society are foreclosed; and the beginning of regular socially acceptable time for sexual activity and childbearing.

Bangladesh is one of countries has the highest rates of child-marriage across world. Roughly 66 percent of women (aged 20 to 24) married before they turned 18 (UNICEF, 2008). Age at first marriage of woman is an important factor for early childbearing and early childbearing mother is at higher risk for poor prenatal outcomes such as gestational diabetes, gestational hypertension and preterm deliveries than the general population (Palacios and Kennedy, 2011). Early marriage is also associated with an increased risk of HIV infection (Clark, 2004). Bangladesh can be considered as unplanned one-third of births; 19 percent were mistimed and 14 percent were unwanted. About 24 percent of all births in Bangladesh during 1975 were unmarried (Bongaarts, 1990).

Early marriage result in a high proportion of first pregnancies before the age of 20 and consequently high rates of complications such as anemia, abortion prematurely and obstructed labor. On the contrary, later childbearing following later marriage also might have adverse effect on the health of mothers and children. Early motherhood often has devastating effects on the infants too. Low birth weight and malnutrition are common phenomena and cases for the high rate of infant mortality (Rahman et al., 1989).

Many researchers reported the changes of age at first marriage with various populations worldwide over the time (Copen et al., 2012; Marston et al., 2009; Cremin et al., 2009; Chen, 2009; Mukherjee et al., 2007; Löfstedt et al., 2005 and Andersson, 1998).

With respect to Bangladeshi female population researchers have investigated the relationship between age at first marriage and socio-economic factors (Ahmed, 1986),

early childbearing (Kamal, 2012), fertility (Islam et al., 2010), socio-demographic factors (Khan et al., 2011) and body mass index (Hossain et al., 2012).

The marriage of girls is completely dependent on parents' decision. Government and non-government organizations in Bangladesh are trying to make aware to mass people about the disadvantages of early marriage, not only the government has imposed a rule that girls who get marriage before 18 years old, her parents will be punished. Nowadays parents are more conscious about their child's future and girls also conscious about their health and life. Special attention should be paid to marriage of women because it is considered marriage after one year women become mother and mothers considering their potential influence on the family with their contribution to the nation's workforce and productivity. Now it is the important related issues to investigate the age at first marriage of Bangladeshi women and its trends over time.

Trends in age at first marriage over time may provide useful information about changes the level of public health and reflect the general living environmental condition of a given population. This is particularly important for developing countries where health and clinically related reforms are being actively implemented.

1.1.3: Age pattern of marriage

Marriage is an event that marks the beginning of the potential period of child bearing from a demographic point of view where age at marriage can significantly affect the rate of population growth of a country. A negative association between age at marriage and family size is almost expected. In view of this raising the age at marriage is considered to be policy intervention that may initiate a fall of population

growth on a major scale in developing countries like Bangladesh. The study of nuptiality not only for its great impact on fertility but also in its own right as an important demographic factor which affects the marital life cycles of a vast majority of people in a society also drawn attention the policy makers and planners for the reason that delayed marriage may can contribute significantly to reduction in fertility and in turn the population growth.

Non-demographic socio-economic fields' nuptiality patterns and levels have also certain implications as for example; rising age at marriage would permit a great exposure to young adult for non familial activities including education, greater mobility opportunities and attractive labor markets for both sexes. Avoidance of very early childbearing certainly contributes to the health the mother and children (Westoff, 1975).

Early marriage is associated with the traditional rule of agricultural economy, especially among girls and with marriage prevalence but industrialization and economic development are associated with later female marriage with almost unchanged prevalence. Attention needs to be directed to the changing of nature of marriage and family. Preindustrial societies delayed marriage is one of the "fertility control measures". In a study on the European historical experience the nuptiality pattern occupied a late marriage in the population of Western Europe in contrast to Eastern and Central Europe (Freedman, 1964).

Bangladesh is one of the lowest rates of birth registration in the world for this it is very difficult to protect children from trafficking child marriage (UNICEF Bangladesh, 2001). Considering marriage, Bangladeshi custom require older children

to marry before younger ones. In case of younger girl married before elder sister, the elder sister suppose to be cursed and unsuitable for marriage considering this, social legislation against child marriage was passed in British India (including Bangladesh) for the first time in 1929 (D'Souza, 1979).

In Bangladesh, cultural tradition that people should affirm the number of one's children is predetermined by God and food is allocated accordingly. Thus it depends on God for number of children is statistically correlated with higher fertility, early marriage, more fasting, more prayers, less abortion, negative advice on population control and negative opinion of religious leaders on family planning and less use of modern contraceptives.

Generally, a son is essential for continuing of the lineage and old age security. A male child is preferable because if the males in a family are few then the size of the lineage segment (Bangsa) becomes small though males are future earners, but females are economically unproductive as a result parents have to spend a lot for arranging marriage of daughters. Nowadays if parents could control the sex of children born then every couple would decide to have a male child first then a girl is viewed as a problem in the family.

Estimated 75 percent rural girls in Bangladesh marry before the age of 16 and only 5 percent marry after 18 years (Barkat and Majid, 2003). In Bangladesh the mean age of marriage is 14.8 years (Islam and Islam, 1994). The seasonality of marriages exists in rural Bangladesh (Shaikh, 1982). The overall fertility rates and the mean age at marriage of rural woman in Bangladesh were inversely related (Afzal, 1966). In rural Bangladesh total fertility was higher among the women who married at a younger age

(Stoeckel and Chiwdhury, 1969). Women who married after the age of 20 years were more liberal in their attitude towards abortion in Bangladesh (Ahmed, 1982).

Low fertility has been achieved in Eastern Europe through four transitional phases: high nuptiality- high marital fertility; low nuptiality- high marital fertility; low nuptiality- low marital fertility; high nuptiality- low marital fertility; whereas Eastern Europe has cut the sequence by omitting the two intermediate stages (Ryder, 1967). Malthusian and Neo-Malthusian methods of fertility regulation stated the presently low fertility countries achieved (Coale, 1967) hence age at marriage and proportion marrying occupy a very important related to policy interventions for reducing fertility in countries with sustained high fertility like Bangladesh (Duza and Baldwin, 1977; Nortaman and Hofstatter, 1978). Population of developing country commonly exhibits nuptiality patterns characterized by a still higher incidence and considerable younger age pattern marriage in Eastern Europe (Lesthaeghe, 1971).

Low age at marriage and decision regarding marriage made by the parents were the norms in the past. Although marriage has been highly valued in the society, the divorce rate was high. With the advanced of education and social progress in general, changes have taken place. Age at first marriage has gone up parental role in marital decision making has declined and the divorces rate has dropped significantly (Singarimbum, 1975).

The ages of first marriage and proportion marrying which is characterised by the nuptiality behavior is important concern of sociologists and anthropologists. Demographers have only recently started to devote significant attention to this field (Duza and Mokhtary, 1976). Delayed marriage is also associated with a significant increase in female schooling, adult literacy, and quality of marital life (Erica, 2004).

In order to have a clear and complete picture about the age patterns of marriage, not only the average age at which the people marry but also the age at which marriages begins, age span of first marriage, first marriage frequency, risk of first marriage, the ultimate proportion marrying etc. Therefore analysis of these components are necessary through not sufficient for studding the age patterns of marriage. Average age at marriage takes account of the marriage patterns prevailing in a population but does not fully signify the inherent peculiarities. The classical indices characterizing nuptiality schedules such as mean age at marriage yield rather unsatisfactory information since they do not allow for the specification of the age at which marriage starts nor the tempo at which nuptiality schedule proceeds (Lestheaghe, 1971). Knowledge of these parameters is necessary to specify the nuptiality process and to make an in-depth analysis of the age patterns of marriage.

1.1.4: Child health

Child malnutrition in Bangladesh is amongst the highest in the world. Two-thirds of the children under the age of five are under-nourished and about 60% of them who are under six are stunted (Bangladesh Healthcare Crisis, 2012).There are over 60 million children in Bangladesh where as 19 million children under the age of five. That's more than the entire population of the United Kingdom. Although Bangladesh has a stable and growing economy, half of these children continue to live below the international poverty line. Despite these difficulties, Bangladesh has made significant progress towards meeting the child-related Millennium Development Goals (UNICEF Bangladesh, 2007). In Bangladesh 45% of the children fewer than 5 are stunted and unexpectedly same proportion of mothers is accurately malnourished and 70 percent

of them are anemic like other developing agricultural societies, female adolescents are married before they can attain their mental, biological and social development (Mitra et al., 2001).

Early motherhood can affect the psychosocial development of the infant. The children of teen mothers are more likely to be born prematurity and low birth weight predisposing them to many other lifelong conditions (National Campaign to Prevent Teen Pregnancy, 2002). Adolescent pregnant have high-risk such as low gynecologic age, biologic immaturity, inadequate prenatal care, minority status, and low pre pregnancy weight (Scholl et. al., 1992).

Women who are malnourished are more likely to give birth to small or underweight babies repeating this dangerous cycle. Malnutrition in childhood is also associated with developmental delays, lower economic productivity and susceptibility to chronic disease into adulthood. These limitations are compounded when population are forced to seek their livelihoods in remote and disaster prone areas where they are at high risk every year. Chronic hunger is made worse by high rates of disease particularly in children. Malnutrition has lifelong consequences malnourished children are more likely to become ill more often and perform poorly in school (Save The Children, 2012).

Malnutrition and public health are one of the major factors among three major factors that affect the rates of death and disease in children in Bangladesh: injury, malnutrition and public health, including arsenic contamination. However, Bangladesh made substantial progress in reducing malnutrition between 1990 and 2000, with the proportion of underweight children falling from 66.6 percent to 51.1

percent, and the level of child stunting falling from 65.5 per cent to 48.8 percent. If this current rate of improvement continues, the percentage of underweight and stunted children will be halved by 2015. Nevertheless, the prevalence of child stunting and underweight in 2000 are still 'very high' (UNICEF Bangladesh, 2013).

Early marriage of female children is uncontrolled in Bangladesh, especially in slum areas, where there is a noticeable lack of back infrastructure, services and basic shelter (BBS, 2009). Health risks for women and their infants is one of causes for early childbearing and other health behaviors. Improves maternal and child health when a woman waiting at least 18 years old (USAID, 2008; Brown et al., 1991). If an additional child is to be conceived, it is considered healthier for the mother, as well as for the succeeding child, to wait at least 2 years after the previous birth before attempting to conception, after a fetal fatality it is healthier to wait at least 6 months (USAID, 2008). About one-third of babies in Bangladesh are born with low birth weight, increasing infant mortality rate, and leads to increasing risk of diabetes and heart ailments in adulthood (Fighting Malnutrition in Bangladesh, 2012) moreover, one neonate dies in Bangladesh every three to four minutes; 120 000 neonates die every year (One World South Asia, 2012).

Worldwide annually, 13 million children are born to women under age 20, where more than 90 percent case occur in developing countries. Complications of teen pregnancy and childbirth are the leading cause of mortality among women between the ages of 15 and 19 (Mayor, 2004). Age < 15 is very critical, below which the risk of infant death, very low birth weight (<1500 g) and preterm birth (less than 32 weeks) is elevated compared to older adolescent mothers (Phipps and Sowers, 2002).

Maternal and prenatal health is of particular concern among teens that are pregnant or parenting. The worldwide incidence of premature birth and low birth weight is higher among adolescent mothers (Makinson, 1985; The National Campaign to Prevent Teen Pregnancy, 2002 and Scholl et al., 1994).

The World Bank estimated that Bangladesh is ranked 1st in the world of the number of children suffering from malnutrition (Child and Maternal Nutrition in Bangladesh, 2012). In Bangladesh, 26 percent of the populations are undernourished and 46 percent of the children suffer from moderate to severe underweight problem. More or less 43 percent of children under 5 years old are stunted (THE STATE OF THE WORLD'S CHILDREN, 2011). Malnutrition has been steadily declining by 1-2 per cent every year, though the level remains high. The infant mortality rate (IMR) declined from 87 per 1,000 live births in 1989 to 56 per 1,000 live births in 2001. The under-five mortality rate (U5MR) also dropped from 133 to 82 per 1,000 live births over the same period (UNICEF Bangladesh, 2013).

The nutritional status of adolescent girls is a key factor in the persistence of malnutrition in Bangladesh. Low birth weight is estimated to affect 30-50 percent of infants. Children are much more likely to be low birth weight and to remain malnourished throughout their lives if their mothers were malnourished during adolescence and prior to and during pregnancy. Malnourished children are physically weak, they lack resistance to disease, they do less well at school, they are less productive as adults and they remain vulnerable for the rest of their lives (UNICEF Bangladesh, 2013).

The children of teen mother are at higher risk and are usually plagued by intellectual, language, and socio-emotional delays (Day et al., 2009). Developmental disabilities and behavioral issues are increased in children born to teen mothers (American Academy of Pediatrics, 2001; Hofferth and Reid, 2002). Teen pregnant women at risk for macrocosmic infants (LaVallie et al., 2003), fetal-alcohol spectrum disorder, preterm deliveries (Martin et al., 2002), sudden infant death syndrome (Randall et al., 2001), low birth weight infants, and neonatal and post-neonatal deaths (Grossman et al., 2002). The proportion of underweight children of Bangladesh is falling from 66.6 percent to 51.1 percent, and the level of child stunting falling from 65.5 percent to 48.8 percent (UNICEF Bangladesh, 2013).

Young mothers and their new born are more at risk of pregnancy-induced hypertension, anemia, obesity, low birth weight, ante partum fetal death and preterm birth (Stevens and Anarney, 1992; Hoekelman, 1993). Childbearing at an early age have been associated with infant homicide. Undernourished mothers often give birth to infants who will have difficulty growing up and developing into a healthy teenager. They face many health problems such as wasting, stunting, underweight, anemia, night blindness and iodine deficiency (Overpeck et al., 1998).

More than 40 percent of the population of Bangladesh are children, malnutrition and its health effects among children can potentially lead to a lower educational attainment rate (UNICEF Bangladesh, 2012). Malnutrition in children, adolescents and women is a major concern. In addition to causing individual tragedies like maternal and child mortality, malnutrition exacts heavy costs from the health care system through excess morbidity, increased premature delivery, and elevated risks of

heart disease and diabetes. The economic consequences of Bangladesh's malnutrition problem are profound, resulting in lost productivity and reduced intellectual and learning capacity (UNICEF Bangladesh, 2013).

Neonatal death and maternal mortality rates in Bangladesh remain high, primarily because most deliveries take place at home without access of proper medical care. Lack of health facilities, lack of qualified staff and suffer from shortages of supplies. Under-nutrition contributes to child mortality, 22 percent of infants are born with low birth weight and up to 46 percent of children under-five are underweight (UNICEF Bangladesh, 2008).

The country has achieved remarkable progress in population and health over the past 30 years and is one of six countries that are on track to achieve the MDG for reducing child mortality. In the last 15 years, U5MR has declined from 133 deaths per 1000 live births to 65. This decline is occured due to reduction in the child mortality rate from 50 to 14 and the post-neonatal mortality rate from 35 to 15. The neonatal mortality rate, however, remains high at 37 accounting for 57 percent of all under-5 deaths. Although maternal deaths continue to decline steadily, the MMR is still high about 340 per 100,000 live births. Since, the early 1970s, the Total Fertility Rate (TFR) has declined from 6.3 children per women to 2.6 in 2011, and the contraceptive prevalence rate has increased from 8 percent to 56 percent. However, unplanned pregnancies still account for 30 percent of all births. The improvement of the use of family planning and maternal and child health services is particularly slow in some geographical areas of the country (The State of the World Children and Bangladesh Demographic Profile, 2011).

1.2: Bangladesh- at a glance

1.2.1: Geographical location

The People's Republic of Bangladesh is one of the world's most densely populated countries, with its people crowded into a delta of rivers that empties into the Bay of Bengal. Formerly East Pakistan, Bangladesh came into being in 1971, when the two parts of Pakistan split after a bitter war which drew in neighboring India. Bangladesh emerged as an independent in 1971 following a nine-month war of liberation. After a tremendous sacrifice she achieved her independence on 26 March, 1971 from the colonial rule of Pakistan. The war of liberation ended 16 December, 1971. It is situated between latitudes $20^0 34'$ and $26^0 38'$ north and longitudes $88^0 01'$ and $92^0 41'$ east. It covers an area of 143,998 square kilometer with land 130,168 square kilometer and water 13,830 square kilometer almost entirely surrounded by North – India, West – India, East – India, except for a short southeastern frontier with Myanmar and a southern coastline on the Bay of Bengal. Broad deltaic plain Chittagong hills in southeast, low hills in northeast and modest-elevation highlands in north and northwest the highest point is Keokradong 1,230 meter. The country is divided into 7 divisions, 64 districts, 476 upazilas, 556 thanas, 298 Municipalities, 4488 unions for administrative purposes (LGRD, 2010). The country is covered with a network of rivers and canals forming a maze of interconnecting channels. Dhaka is its capital city and Chittagong is the main seaport. Being an active partner, Bangladesh plays vital role in the international and regional forum, particularly in the United Nation (UN), Commonwealth and South Asian Association of Regional Cooperation (SAARC).

1.2.2: Climate

Bangladesh is situated in the tropical belt and it has a warm and humid climate in the summer and a dry and cool weather in the winter. The eastern and northeastern parts of the country are wet whereas the central and western parts are dry (Islam and Uyeda, 2007). There are mainly two seasons are recognized in Bangladesh: a dry winter (December to February) and a humid summer (March to November). According to the wind system and rainfall characteristics, the summer is again sub-divided into three: pre-monsoon (March-May), monsoon (June-September) and post-monsoon (October-November) periods (Islam and Uyeda, 2006). In general, maximum summer temperatures range between 32°C and 38°C. April is the warmest month of the most parts of the country. January is the coldest month, when the average temperature for most parts of the country is about 10°C. The decrease of temperature during July and August is due to the high precipitation activities from the southwest monsoon. In these months, fraction of cloud coverage increases compared to the other months (Rahman et al., 2007). The variation of surface air temperature is over the land area around the Bay of Bengal (Quadir et al., 2004). Bangladesh Meteorological Department (BMD) data on minimum and maximum temperatures observed in 1950-2010 showed an increasing trend and the increase was faster for minimum temperature (Anjumand, 2012).

1.2.3: Ethnic and Religion

Ethnically, Bangladesh is a homogeneous having only one major ethnic group (98.5 percent) known as Bengalese, approximately 600,000 Biharis (Urdu-speaking, non-Bengali Muslims) and 900,000 members of tribal minority groups where main tribal groups are Chakmas, Marmas, Tipperas, and Mros living primarily in Chittagong Hills Tracts. Now Bangladesh is an Islamic state country. In Bangladesh nearly 86.6 percent Muslim, 12.1 percent Hindu, 0.6 percent Buddhist, 0.4 percent Christian, and 0.3 percent other tribal religious people are lived (International Conference; Department of Statistics; University of Rajshahi; Bangladesh, 2012). The country is more or less culturally homogeneous. The national language of Bangladesh is Bengali (official language) spoken by 95 percent, English widely used by 5 percent educated elite and Arabic used in many Muslim homes and have other various tribal languages.

1.2.4: Agriculture and Economy

Bangladesh is a primarily agriculture based economy. Poverty is in deep and throughout the country almost half of the population lives on less than one dollar a day (United Nations Johannesburg Summit-2002 Bangladesh Country Profile). Unemployed about 40 percent among all the population in Bangladesh where many participants are in the labor force work only a few hours a week at low income. An estimated 31.51 percent (2010 est.) of population below poverty line ranking 62 over the world (CIA World Factbook, 2012). Agriculture which is contribute about 30 percent of the country's GDP and employing around 60 percent of the total labor

force. The performance of this sector has an overwhelming impact on major macroeconomic objectives like employment generation, poverty alleviation, human resource development and food security (Rahman et al., 2007). Rice, jute, tea, wheat, sugarcane, potatoes, tobacco, pulses, oilseeds, spices, fruit; beef, milk, poultry are the principal crops of the country (CIA World Factbook, 2012). In Bangladesh, the crop sub-sector dominates the agriculture sector contributing about 72 percent of total production. Fisheries, livestock and forestry sub-sectors are 10.33 percent, 10.11 percent and 7.33 percent respectively (Quadir et al., 2004). The major Industries of Bangladesh are jute, cotton, garments, paper, leather, fertilizer, iron and steel, cement, petroleum products, tobacco, drugs and pharmaceuticals, ceramic, tea, salt, sugar, edible oil, soap and detergent, fabricated metal products, electricity and natural gas where as the principal exportable products are garments, knitwear, frozen shrimps, tea, leather and leather products, jute and jute products, ceramics etc (CIA World Factbook, 2012). The major employer is agriculture, but it is unable to meet the demand for jobs. So, many Bangladeshis in common with citizens from other countries in the region seek work abroad, sometimes illegally (United Nations Johannesburg Summit-2002 Bangladesh Country Profile).The economy has grown 5 to 6 percent per year since 1996 despite political instability, poor infrastructure, corruption, insufficient power supplies, and slow implementation of economic reforms. Although more than half of GDP is generated through the service sector, 45 percent of Bangladeshis are employed in the agriculture sector with rice as the single-most-important product. Bangladesh's growth was resilient during the 2008-09 global financial crisis and recession. Garment exports, totaling $12.3 billion in FY09 and

remittances from overseas Bangladeshis, totaling $11 billion in FY10, accounted for almost 12 percent of GDP. Leading Natural resources are natural gas, arable land, timber and coal (CIA World Factbook, 2012).

1.2.5: Natural hazards

Bangladesh is badly affected by predicted rises in sea levels due to the low-lying country is vulnerable to flooding and cyclones. (United Nations Johannesburg Summit:Bangladesh Country Profile, 2002). Principal rivers of Bangladesh are Padma, Meghna, Jamuna, Surma, Brahmaputra, Karnaphuli, Teesta, Sitalakhya, Rupsha, Madhumati, Gorai, Mahananda, Korotoa etc. (International Conference; Department of Statistics; University of Rajshahi; Bangladesh, 2012). Due to calamities like flood, loss of food and cash crops is a recurring phenomenon, which disrupts the continuing progress of the entire economy. Almost every year Bangladesh is affected by natural disasters such as flood, drought and cyclones (Quadir et al., 2004). Frequency of extreme events such as cyclones with wind speed of >200 kilometer/hour and heavy rainfall in pre-monsoon has increased in recent years (Anjumand, 2012).

1.2.6: Human rights

Bangladesh has been criticized for its human rights record, with particular concern about assaults on women and allegations that police use torture against those in custody (United Nations Johannesburg Summit-2002 Bangladesh Country Profile) but, the government of Bangladesh is trying to improve human rights in all respect.

1.2.7: Population size, growth, fertility and mortality

Bangladesh is now ranking 8th density populated country over the world where as China is the top of the ranking, in 2050 Bangladesh upgraded into 7th most and India upgraded into top (Population Reference Bureau, 2011). Only 45 percent population increased during the first half of the last century this slow growth rate was due to a combination of high birth rates and high death rates. In the second half of the century, population growth was rapid, tripling during the period. The relatively young age structure of the population indicates continued rapid population growth in the future. The total population of Bangladesh is 161,083,804 (July 2012 est.) where 34.3 percent of the population is 0-14 years of age (male 27,551,594/female 26,776,647), 61.1 percent are age between 15-64 years (male 45,956,431/female 50,891,519) and only 4.7 percent population are 65 years and over (male 3,616,225/female 3,778,119). 28 percent of total population (2010) lived in urban with rate of urbanization 3.1 percent annual rate of change (2010-15 est.). Major cities population Dhaka (capital) 14.251 million; Chittagong 4.816 million; Khulna 1.636 million; Rajshahi 853,000 (2009) where as Population growth rate is 1.579 percent (CIA World Factbook, 2012). This young age structure constitutes built-in "population momentum", which will continue to generate population increases well into the future, even in the face of rapid fertility decline. The population projections indicate that the population will increase rapidly even after attaining replacement level fertility. Compared to the enumerated population in 2001, about 18 million people were added, which represent a 14.4 percent increase and a 1.34 percent average annual growth rate, decreasing since last

census (BBS, 2012). Sex ratio at birth 1.04 male(s)/female, under 15 years 1.03 male(s)/female, 15-64 years 0.9 male(s)/female, 65 years and over 0.96 male(s)/female, total population 0.95 male(s)/female (2011 est.) indicating almost equal numbers all over of men and women in the country (CIA World Factbook, 2012). Bangladesh has one of the highest population densities in the world and has on an average of 964 inhabitants per square kilometer (the density in 2001 was 834). At the division level, the density figures range from 1,502 inhabitants per square kilometer in Dhaka division (BBS, 2012). The Bangladesh population policy indicates that the population should stabilize at 210 million by 2060, if replacement level fertility is reached by 2020. This estimate of future population size is reasonably consistent with World Bank projections from 1994 (Bos et al., 1994). Population Reference Bureau 2011World Population Data Sheet indicates that mid-2025 the projected population in Bangladesh would be 183.2 million and mid-2050 reached 226.3 million (Population Reference Bureau 2011World Population Data Sheet). However, there is wide disparity between the estimates of Bangladesh Government and others on the time when the population would stabilize.

1.2.8: Health and Nutritional status

Health and population programs in Bangladesh have made significant achievements, especially in lowering fertility and improving child health status. The demographic transition is well underway as Bangladesh is the only country among the 20 least developed countries where sustained fertility reduction has taken place over the last 15 years. Life expectancy for total population is 70.06 years where male 68.21 years

and female 71.98 years (2011 est.). In recent time life expectancy for female is increasing than male nevertheless it is almost equal (CIA World Factbook, 2012). Over the last 35 years Bangladesh has undergone a remarkable demographic transition. In 1971-1975, women in Bangladesh were having on average 6.3 children. Total fertility rate (TFR) declined to 5.1 fifteen years later and to 4.2 in 1989-1991. The (TFR) plateau at around 3.3 for most of the 1990s, when the three earlier BDHS surveys took place. The Bangladesh fertility rate has declined slightly to 2.7 children per women (BDHS, 2007). In 2012, the Total Fertility Rate (TFR) is 2.55 children born/woman (CIA World Factbook, 2012). Comparison of the Bangladesh TFR, with fertility rates in other Asian country that have implement a demographic and health survey (DHS), indicate that, with a TFR of 2.55 Bangladesh is in mid range among the countries below Afghanistan (6.3 in 2011) Pakistan (3.6 in 2011) Nepal (2.9 in 2001) Bhutan (2.6 in 2011) and India (2.6 in 2011) (Population Reference Bureau 2011World Population Data Sheet). Moreover, fertility rate is higher in rural areas (2.8 children per women) than that of urban areas (2.4 children per women) (BDHS, 2007), a pattern that persisted in various censuses and demographic surveys that have been carried out in the country. The total fertility rate is highest in Sylhet division 3.7 and lowest in Khulna 2.0, the fertility rate for Dhaka and Barisal division are same which is 2.8, Rajshahi 2.4 and for Chittagong 3.2 (BDHS, 2007). Bangladesh women have a pattern of early childbearing. The age specific fertility rates (ASFR) indicate a pattern of early child bearing, with a peak at age group 20-24. The crude birth rate (CBR) for the whole country is 22.53 births/1,000 populations (2012 est.). The crude death rate (CDR) has fallen dramatically from about 19 per 1000 population to 5.71

(July 2012 est.). Although infant and under-five mortality rates are declining they are still high. The infant mortality rate less than five was 48.99 deaths/1,000 live births for total, 51.48 deaths/1,000 live births for male and 46.39 deaths/1,000 live births for female children (2011 est.) (CIA World Factbook, 2012). Several Researchers argued that the fertility decline in Bangladesh achieved primarily due to a successful family planning program (Cleland, 1994; Caldwell et al., 1999; Islam et al, 1998) that succeeded in raising the contraceptive prevalence rate (CPR) from a low level of 8 percent in 1975 to as high as 36 percent in 2007 (Mitra et al., May 2007). Maternal mortality rate (MMR) has come down from 4.7 death per 1000 birth in 1991 to 3.8 in 2003 (SVRS, BBS; November 2006). In 2010 an estimated Maternal mortality rate is 240 deaths/100,000 live births this small but important decline is mainly attributed to increased availability of family planning and immunization services improved antenatal and delivery care and a reduction in the number of births to high-risk mothers. Over 90 percent of children have some degree of malnutrition. Children under the age of 5 years underweight 41.3 percent (2007) ranked 3 over the world where as India has top of the rank with 43.5 percent Children under the age of 5 years underweight. In 2009 Health expenditures was only 3.4 percent of GDP (CIA World Factbook, 2012). Other issues of concern are overall poor utilization of government services, as well as the cost-effectiveness, sustainability and quality of service. There is approximately one doctor for 3390 persons (0.295 physicians/1,000 populations, 2007) and one bed in a hospital for 2500 (0.4 beds/1,000 population 2005) persons in the country (CIA World Factbook, 2012). It is a needed to increase the number of

doctors and number of beds in hospitals besides there also needed to improve quality of health services.

1.2.9: Education

The education system of Bangladesh based on five years primary, five years secondary, and two years higher secondary. Traditionally, gives emphasis on arts and humanities and at last increased emphasis on technical subjects in late 1980s. In 2011 national literacy rate officially 44.70 percent, possibly lower; men 46.81 percent, women 42.59 percent; urban 69.58 percent (Male 62.59, Female 57.83), rural 44.70 percent (Male 46.81, Female 42.59). Total 56.8 percent population age 15 and over can read and write with male 61.3 percent and female 52.2 percent (2010 est.) (BBS, 2012). Government and non government organizations are trying to improve literacy rate through mass education.

1.2.10: Transportation and Communications

Extensive and complex network of some 700 rivers. Major systems are Jamuna-Brahmaputra, Padma-Ganges, Surma-Meghna, and Padma-Meghna, all of which flow south to Mouths of the Ganges and into Bay of Bengal also fifth major system Karnaphuli in Chittagong region. Primary transportation system is employing nearly 300,000 small and medium-sized sail-and human-powered country boats. About 6,000 kilometers and 3,800 kilometers are waterways in monsoon and dry season respectively (BIWTA, 2010). About, 20948 kilometers are of motorable roads despite severe flooding, increasingly important means of moving people and goods (DRH,

2010). Bangladesh Railway is one of the oldest service-oriented organization which provides, environment-friendly, less hazardous and cheap transport service. Bangladesh Railway has got a total network of 2,835.04 route kilometers (BR, 2010). There are three international airports and seven domestic airports, of which two airports are left unused. Another 4 STOL (Short Take-Off and Landing) ports have been built for the convenience of airlines and when necessary. National carrier Biman Bangladesh Airlines are serving twenty-four cities in twenty countries; domestic service to eighteen regional airports (CAO, 2010).

1.3: Feasibility of the study

The researcher is confident of completing the proposed research successfully mentioned bellow:

1. The researcher was a student of the Department of Statistics. He is theoretically oriented in research along with the coursework conducted by the Department of Statistics to formulate the study.
2. A lot of study related to impact of early childbearing on the health of the mother and child has undertaken from developed and developing countries, particularly in India, Pakistan, Nepal, Bolivia, Mongolia, China, Great Britain, and USA. Reports of those studies are available in printed form and website that may be used as reference and guideline.
3. Guidance and supervision from supervisors and logistic support from Department of Statistics, University of Rajshahi contributed to the sound convenience of this research.

1.4: Limitations of the study

Voluntary pregnancy is one of the major limitations of this study because like pregnancy termination, although menstrual regulation, which is a type of voluntary pregnancy termination is legal in Bangladesh whereas, induced abortion is still illegal in the country unless it is necessary to save mother's life considering in government hospitals but unfortunately a lot of non government clinics are performing abortion randomly. In Bangladesh, women are bound to hide the information of induced abortion to escape from social harassment. Parental socio-economic status, working status at the time of marriage for parents, respondent and partner, consanguine marriage were not included in the analyses due to lack of data, which are important factors in analyzing early childbearing mother and child health. As in many other developing countries like Bangladesh, there might have error in reporting the respondents' age, age at first marriage, and age at first birth, etc. At the time of first marriage of respondent, the limitation is parents including father and mother both of them, none of them or single of them were alive. Many women of reproductive age in Bangladesh prefer hiding their actual age to prove them young for a lot of socio-economic conditions thus the fact that registration of age at birth and even age at marriage is not properly followed and maintained, but also lack of knowledge and lack of aware about the importance of age at birth and even age at marriage. Unfortunately the registration of marriage almost unavailable in rural area especially in slum and char area due to marriage registration cost is much higher for this society not only that, marriage register are frequently not available. Bangladesh Demographic Health Survey data are widely used for public health and demographic perspective

although above mentioned limitations. Despite these limitations the strength of this study is that it dealt with the nationally-representative standard.

1.5: Objectives of the study

The Objectives of the study are as follows:

a) Broad objective: The overall objective of this study is to evaluate and analyze the impact of early childbearing on the mothers and their child health of the rural and urban community in Bangladesh.

b) Specific objective: The specific objectives of the study are:

i) To examine the health problems and risks faced by early childbearing mother and their children in Bangladesh.

ii) To determine the associated factors significantly affect early childbearing.

iii) To identify the effect of socio-economic and demographic factors on the health status of early childbearing mothers in Bangladesh.

iv) To investigate the age of first marriage of Bangladeshi women and its trend.

v) To estimate the parameters involving in the age patterns of marriage and evaluate the patterns (using single year age distributions) of distributions of first marriage frequencies and risks of the first marriages of ever married women in Bangladesh.

1.6: Organization of the study

This thesis is organized into six chapters as follows:

Chapter 1 is *Introduction*. This chapter contains general Background of the study, Bangladesh at a glance (Country profile), Feasibility of the study, Limitation of the study, Objective of the study and Organization of the study.

Chapter 2 is *Review of the Literature*. Which covers information of the, 'Impact of Early Childbearing on the Health of the Mother and Child' from home and abroad.

Chapter 3 is *Indicators for Measuring Health and Nutritional Status*. This chapter deals with Introduction, widely used general indicators for measuring health and nutritional status, History of body mass index and some important studies for measurement of early childbearing mother and child health

Chapter 4 is *Data and Methods*. This chapter presents Data, Sample design, Data screening and brief discussion of statistical technique and its application in this study, which is used for measuring the impact of early childbearing on mother and child health

Chapter 5 is *Result*. This chapter shows the result for the Mother health, Trend of first marriage, Frequencies of first marriage and Risk of first marriage using Coale's Nuptiality Model and finally, Child health.

Chapter 6 is *Discussion and Conclusion*. In this chapter the study is completed by providing Discussion of result, Concluding remarks, Policy implications and Future research.

CHAPTER TWO

REVIEW OF LITERATURE

"By engaging girls and young women . . . NGOs and social businesses can address girls' health needs while creating productive livelihoods."—Muhammad Yunus

2.1: Introduction

A review of the works related to the present study reveals a wide range of socio-economic and demographic factors which affect on mother and child health for early childbearing. The socio-economic and demographic characteristics of the people of society are likely different from one another. These may also vary from one geographical setting to another. Thus to know about the previous works done in a particular field, a review of literature is essential. Only a few relevant literatures in this context of the present study are reviewed. Such as: (Abedin , 1982; Ahmed, 1982; Rinehart and Kols, 1984; LeGrand and Mbacke, 1993; Siega-Riz et al., 1996; Bissell, 2000; Sandra et al., 2001; Treffers et al., 2001; Phipps and Sowers, 2002; Spence, 2008; Oyefara, 2009; Khashan and Kenny, 2009; Salihu et al., 2009; Hogan et al., 2010; Palacios, 2010; Kosa et al., 2011; Erika et al., 2011; Riley, 1994; Amin et al., 1998; Erica, 2004; Schuler et al., 2006; Islam, 2007; Akter et al., 2007; Bates et al., 2007; Ronsmans et al., 2008; Rah et al., 2008; Bosch, 2008; Kamal, 2009; Alam et al., 2010; Kamal, 2012; Hossain et al., 2012; Kamal, 2012; Rahman, 1984; Kabir et

al., 1988; Khan et al., 1988; Riley and Khan, 1993; Kapoor, 1995; Cochrane, 1979; United Nations, 1987 & 1995; Elliott et al., 2012; Bangladesh Fertility Survey, 1978; Kabir, 1978; Ahmed, 1986; Satter, 1990; McCormick et al., 1984; Brown et al., 1991; Cooper et al., 1995; Fraser et al., 1995; Reichman and Pagnini, 1997; Berenson et al., 1997; Bhattacharya et al., 2007; Ramachandran and Gopalan, 2011; Finlay et al., 2011; Mills et al., 2013; Desai and Alva., 1998; Botting et al., 1998; Giashuddin et al., 2005; Faruque et al., 2008; Mohsena et al., 2008; Das et al., 2008; Jesmin et al., 2010; Liu et al., 2011; Khan et al., 2011; Khanam et al., 2011; Ahmed et al., 2012; Islam et al., 2013).

2.2: Mother health from other population studies

In many developing countries about 50 percents of pregnancy terminations occur among the early childbearing mothers and the wide choice of family planning now available allow health programmers to offer an appropriate technique to avoid each type of early pregnancy and maternal; child and infant mortality. The early childbearing was determined according to demographic factors such as age, pregnancy and birth interval (Rinehart and Kols, 1984).

LeGrand and Mbacke (1993) showed the effects of young maternal age (less than 18 years and 18-19) on birth weight, child health care and feeding behavior and child mortality, after controlling for other socio-economic and demographic factors using longitudinal data from the cities of Bamako (Mali) and Bobo-Dioulasso (Burkina Faso). They found that teenage pregnancies were associated with significantly worse

prenatal health care and vaccination behavior, lower birth weights, earlier weaning, and especially during the second year of life has higher mortality. They also highlighted worse prenatal health behavior and weakly associated with other poor behaviors and health outcomes were strongly linked by a proxy for mother's school enrollment at the time of pregnancy.

Siega-Riz et al. (1996) examined maternal underweight status and inadequate rate of weight gain during the third trimester of pregnancy increases the risk of preterm delivery using the data from 7589 pregnant women receiving care in public health clinics in the West Los Angeles area. They used multivariate logistic regression techniques to isolate the role of each nutritional variable from other factors that may influence birth outcome and showed underweight status before pregnancy nearly doubled the likelihood of delivering preterm. Inadequate weight gain in the third trimester defined as < 0.34 kg/wk for underweight. They concluded that, women who delivered preterm had patterns of weight gain similar to women delivering term infants.

Bissell (2000) examined the socio-economic consequences of teen pregnancy and childbearing as well as the birth intentions of teenage women who had become mother. He indicated that women who became teen mothers as compared to women who delay childbearing past the teen years were more likely to be socio-economically disadvantaged. The author suggested that, depending on the circumstances of the women in question, socio-economic disadvantage was correlated with but not necessarily a consequence of early childbearing, he also suggested that, cultural norms and individual need can impact on the childrearing decisions of teenage

women. Finally the author concluded that policies and programs aimed for reducing teen pregnancy rates and eliminating the negative consequences experienced by teen mothers and their children were unlikely to be fully effective unless they realistically address the socio-economic inequities faced by many young women.

Sandra et al. (2001) noted the effects of early childbearing on schooling over time and found unmeasured differences between young women who started childbearing early and those who did not, but could instead reflect changes in the effect of early childbearing over time using data from the national longitudinal survey of the labor market experience of youth also the panel study of income dynamics were used to identify the reasons for that difference. They used logistic regression, ordinary least-squares regression and fixed-effects models to examined the impact of early childbearing on rates of high school graduation and college attendance and number of years of schooling completed through age 29 and found from the two data sets showed a significant negative impact of a teenage birth on rates and years of completed schooling i.e., teenage mothers complete 1.9-2.2 fewer years of education than did women who delay their first birth until age 30 or older. Moreover, compared with women who give birth at age 30 or more, teenage mothers had odds of high school completion 10-12% as high and odds of post-secondary schooling 14-29% as high.

"The rise in adolescent pregnancy in the 20th century had been influenced by declining age at menarche, increased schooling, delay of marriage, inadequate contraception and poverty. The main problems were preterm labor, hypertensive disease, anemia, and more severe forms of malaria, obstructed labor in very young

girls in some regions, poor maternal nutrition and poor breastfeeding. The infants of adolescent mothers were more prone to low birth weight and increased neonatal mortality and morbidity. Antenatal care was often inadequate. The most important problem was the increased incidence of preterm labor and delivery, the youngest age groups running the highest risk. Technically, care of adolescents during labor need not differ from care of older women; most adolescents were not at increased risk during labor, although, they were more in need of empathic support. Generally, care of pregnant adolescents should be adjusted to their specific needs" **(Treffers et al., 2001)**

Phipps and Sowers (2002) proved that the rates of infant mortality, very low birth weight (<1500 g), and very preterm delivery (<32 weeks) per 1000 live births using singleton first births (n = 768 029) to women aged 12 to 23 years in the 1995 US birth cohort. The authors used only the data of mothers aged 12 to 23 years at the time of delivery, exclude ages higher than 23 years because attempting to derive comparable age groups along a continuum and ages 11 years and younger because of the rare occurrence of childbearing at these ages. Finally they graphed the rates of infant mortality, very low birth weight, and very preterm delivery by maternal age and found that the inflection point below which the rate of poor birth outcome was lower and begins to stabilize at 16 years. They conclude that early adolescent childbearing is best defined as giving birth at 15 years or younger.

Spence (2008) examined the relationships between patterns of childbearing and health outcomes for mothers using data from the National Longitudinal Survey of Mature Women (N=1,608) and found that the long-term consequences of childbearing vary

by health outcome. Early childbearing was associated with higher risk of ADL (Adrenoleukodystrophy, a rare genetic condition that affects young boys) limitations at ages 65–83, also associated with greater levels of depressive symptomatology. Finally, the author found no significant effects of high parity and these findings emphasize the need to better understand the mechanisms linking childbearing histories to later physical and psychological well-being.

Oyefara (2009) attempted to show the socio-economic consequences of women's age at first childbirth in Osun State, Nigeria. From cross-sectional survey of 1,000 women of reproductive age (15-49 years), the socioeconomic backgrounds of the responding pre-childbirth family were reflected and the author observed that all the respondents had similar pre-childbirth socio-economic background. Timing of the first childbirth of respondents' discriminatory variable separated into two groups, the first group consisted of 500 women, who had their first childbirth under the age of 20 and the second group consisted of 500 women, who had their first childbirth at the age of 20 and above. The author found significant direct relationship between age at first childbirth and educational attainment at ($p<0.01$), as a result the respondent had less or no chance to join school for next time. The study also found there was a significant inverse relationship between the age at first childbirth and marital stability ($p<0.01$). Finally the author said that the women, who had their first childbirth as adolescent, were more likely to have poor socio-economic status at adulthood than those who delay childbearing until their twenties.

Khashan and Kenny (2009) found the effect of body mass index in early pregnancy on adverse pregnancy outcome. They performed a population register-based cohort

study using data from the north western perinatal survey (N = 99,403 babies born during 2004-2006), based at the University of Manchester, UK and noted that the risk of preterm birth increased 1.33 times in underweight women.

Underweight mothers were more likely to experience a preterm delivery. For all preterm births, the risk among underweight mothers increased with ascending underweight severity. Higher risk estimated for spontaneous than medically indicated preterm birth. For each BMI category, extreme risk values for spontaneous preterm births observed among women with very low gestational weight gain (<0.12 kg/week). Severely thin mothers with very low and very high pregnancy weight gain were at the greatest risk for spontaneous preterm birth **(Salihu et al., 2009)**

Maternal mortality remains a major challenge to health systems worldwide. For planning and assessment of progress towards millennium development goal 5 (MDG 5) and retrieve the target of 75% reduction in the maternal mortality ratio (MMR) from 1990 to 2015, reliable information about the rates and trends in maternal mortality is essential. **Hogan et al. (2010)** tried to assess the levels and trends in maternal mortality for 181 countries constructed database of 2651 observations of maternal mortality from 181 countries during 1980—2008, from vital registration data, censuses, surveys, and verbal autopsy studies. To generate estimates of maternal deaths and the MMR for each year between 1980 and 2008 they used robust analytical methods. They found that in 2008 worldwide 342900 maternal deaths occur which was down from 526300 in 1980. The global MMR decreased from 422 in 1980 to 320 in 1990 and was 251 per 100000 live births in 2008 and the yearly rate of decline of

the global MMR since 1990 was 1·3%. More than 50% of all maternal deaths were in only six countries in 2008 (India, Nigeria, Pakistan, Afghanistan, Ethiopia, and the Democratic Republic of the Congo). Including Bangladesh only 23 countries were on track to achieve a 75% decrease in MMR by 2015 and achieving accelerated progress countries such as Egypt, China, Ecuador, and Bolivia.

Palacios (2010) suggested that the childhood experiences may be related to the risk for early childbearing. He also examined the relationship between young women's lived and early childbearing in order to design interventions to support them in postponing pregnancy and when they did become pregnant and found women described stressful childhoods. The author identified two primary themes: "Chaotic childhoods and Diminished childhoods". Chaotic childhoods represented stressful events in youth that introduced or resulted in ongoing chaos in women's lives. "Diminished childhoods" was used to describe early maturity as a result of assuming extensive responsibilities at a young age.

Kosa et al. (2011) tried to find out the association between pre-pregnancy BMI and preterm delivery using the data of 1064 working women who participated in California's statewide prenatal screening program, worked during pregnancy and delivered a live singleton birth in Southern California in 2002–2003. The data were subdivided into two groups one sample included 354 cases delivering at less than 37 weeks and another was the sample of 710 cases with normal- birth weight controls. They used multivariable logistic regression models to compare categorical BMI levels with continuous BMI and found that preterm birth had been highly associated with low maternal pre-pregnancy weight. The author also used nonparametric local

regression which revealed a V-shaped relationship between continuous BMI and preterm delivery (PTD).

Ota et al. (2011) conducted a prospective health-facility-based study in Nha Trang city, in the province of Khanh Hoa. The study included women from eight community health centers' and one provincial hospital in the catchment area of Nha Trang and conducted interviews who were admitted to the aforementioned health institutions for delivery from 3 July 2007 to 15 June 2008. They used univariate and multivariate logistic regression analyses for generating crude and adjusted odds ratios (ORs) with maternal gestational weight gain and BMI category as the main independent variables and small or large size for gestational age as dependent variables. Other independent variable included in the model were maternal age, parity, household income, schooling year, total physical activity, infant gender and gestational age at delivery. They also used cubic spline logistic regression analysis to fit nonlinear curves, principal component analysis to reduce the number of covariables in the multivariate model and bootstrapping to estimate the corresponding 95% CIs by employing bias-corrected and accelerated methods. Their major findings were 78% of the pregnant gained > 10 kg, 18.1 percent whose infants were small for gestational age among women with low BMI group. The risk of having an infant too small for gestational age was much greater than the risk of having one too large for gestational age among women with low BMI or normal BMI up to pregnancy weight gains of 18.8 kg and 12.8 kg respectively. Gestational weight gain was inversely correlated with the risk of having an infant too small for gestational age and directly correlated with the risk of having one too large for gestational age. The study also revealed that compared with

caucasian women, African women were at greater risk of having infants too small and at lower risk of having infants too large for gestational age. The greater the gestational weight gain, the lower the risk of delivering an infant too small for gestational age and the higher the risk of delivering an infant too large for gestational age, a low BMI and pre-eclampsia were associated with a higher risk of having an infant too small for gestational age.

2.3: Mother health from Bangladeshi population studies

Riley (1994) conducted a study on "Determinants of Adolescent Fertility and Its Consequences for Maternal Health, with Special Reference to Rural Bangladesh" using longitudinal survey data collected from Matlab, Bangladesh in 1976-1977 of 10-20 years old cross sectional survey of the same women in 1989-90 from the project of Demographic Surveillance System (DSS) run by International Centre for Diarrheal Disease Research, Bangladesh. He found that reduction in the age at first birth would be small because young age at marriage was associated with longer first birth intervals in this population. The effect on first birth would be moderated by a longer waiting time to the first conception thus decline in a one year age at menarche caused a one year decline in age at marriage. Furthermore, improved nutritional status could have a substantial impact on the health of mothers and their children. Short stature and low body weight were well-recognized predictors of poor birth outcomes for mothers and their infants. Height was of particular interest, because it was already fixed by the time short stature was associated with CPD (Cephalopelvic

Disproportion) and a double risk of CPD in women less than 160 centimeters. The average height of adult Bangladeshi women was considerably less: 149.6 centimeters. Most Bangladeshi women did not have access to medical facilities capable of performing cesarean section, thus CPD would lead to death of the mother and child in some of these cases. Short stature was also associated with low birth weight as is low pre-pregnancy weight. Finally the author concludes that, improving the nutritional status of adolescents and young adult women may leads to a small decrease in age at first birth. However, such efforts if successful could substantially improved maternal and infant mortality and morbidity.

Unexpected assumption of adult roles of young age associated with early marriage and childbearing, employment offers women in developing countries a period of transition between childhood and adulthood. **Amin et al. (1998)** examined 'Transition to adulthood of female garment-factory workers in Bangladesh' using the data from a study in semi-structured interviews with 22 garment factory workers in Dhaka, Bangladesh and found that 47% women entered the garment industry before 15 years of age and 97% of them migrated from rural areas. Throughout early marriage and childbearing a large number of young Bangladeshi women were being given an alternative to lived in which they moved directly from childhood to adulthood. Employment created a period of transition in contrast to the rushed assumption of adult roles at very young ages that marriage and childbearing mandate. This longer transition creates a period of adolescence for young women working in the garment sector that was shown to have strong implications for the women's long-term reproductive health. The authors concluded that, factory work in the garment industry

might be regarded as a positive opportunity for young girls to delay marriage and motherhood and reduced their reliance on more risky forms of employment.

Using Matlab Health and Socioeconomic Survey (MHSS-1996) **Erica (2004)** has provided a paper "Consequences of Early Marriage for Women in Bangladesh". In this paper the author tried to find out the empirical evidence on several dimensions of the potential socio-economic and physical consequences for girls of adolescent marriage in several dimensions. Results indicated that if marriage age was delayed each additional year an estimated of 0.27 pregnancies reduced. Increasing of age of first pregnancy provided additional health benefits in the form of lower incidence of stillbirths and miscarriages among younger women. Delayed marriage was also associated with a significant increase in female schooling, adult literacy, quality of marital life and dowry payments increased an estimated 40% of baseline cost with each additional year that marriage was postponed. The results also revealed that, in rural Bangladesh high rates of girls getting marriage at very young ages attain significantly less schooling, experience more frequent reproductive health complications had higher fertility and experienced lower levels of gender equality in marriage. Finally, the author concluded that most of the benefits to marriage delay came from postponing marriages below age 14.

Early marriage and childbearing among girls was often associated with a wide range of negative social and health consequences for young mothers and their infants and contributed to rapid population growth. **Schuler et al. (2006)** had conducted a study on "The timing of marriage and childbearing among rural families in Bangladesh: choosing between competing risks", findings from qualitative research in three

villages of rural Bangladesh, where a range of interventions had been promoted to encourage later marriage and childbearing. To described socio-cultural supports for early marriage and childbearing, to examined evidence that change towards later marriage and childbearing was beginning and to analyze the social dynamics behind these change processes the author used the data from in-depth interviews and group discussions. The findings revealed that according to norms early marriage and childbearing were beginning to erode and women were the key factor in this erosion for changing gender ideals and aspirations. Among the poorest families tended to experience changing of social environment in terms of heightened risks. Marital strategies among the poorest were, above all, strategies for economic survival, and poor families tended to see the costs of education and delayed marriage for daughters as high and the outcomes as uncertain. At the same time, they had also become aware that early marriage and childbearing entails costs and risks. Finally the authors mentioned that further targeting of interventions to the poorest families may help to influence the economic strategies that so often result in early marriage.

Bangladesh has the highest rate of adolescent childbearing among the developing countries due to high prevalence of teenage marriage and low contraceptive use among married teenagers. **Islam (2007)** studied the fertility behavior of married adolescent (age 15-19) girls in Bangladesh using the data from the 1999-2000 Bangladesh Demographic and Health Survey (BDHS) sample of 10,544 ever-married women of which 1,514 were aged 15-19. For statistical analysis the author used Discrete-time hazard model to estimate the probability of woman having a first birth during adolescence. Result showed that, a very high incidence of early childbearing in

Bangladesh, it was higher among rural and illiterate women as well as women from Rajshahi region and poor economic status. There was a declining trend in adolescent fertility in Bangladesh and adolescents had lower level of family size norms than adults' women. Most important determinants of adolescent childbearing were education, economic status and exposure to television appeared. The author suggested the need for a concerted effort to increase the age at marriage, used of family planning methods, opportunity for education and employment for young females. Adolescents, their parents and community should be made more awarded of the negative health, social and economic consequences of early marriage and childbearing.

A recent survey on low birth-weight showed that a large proportion of adolescent girls in Bangladesh became pregnant before maturation of their reproductive organs increased the risks of maternal death and child mortality. **Akter et al. (2007)** estimated the proportion of women with early marriage (≤18 years) and early childbearing (≤19 years) among rural Bangladeshi women and to explore their relationship with maternal and child nutritional status using the data on 74,808 rural mothers collected in 2005 by the nationally and divisionally representative Nutritional Surveillance Project of Helen Keller International and Institute of Public Health and Nutrition, Government of Bangladesh. They found that most (89.8%) women were married and 66.8% had their first baby born before the age of 20 years. For increasing household socioeconomic status the median age at marriage and first delivery increased. The median age of first delivery was lowest among the poorest expenditure quintile, while it was highest among the richest quintile. A higher proportion of women who had first delivery at the age of less than 20 years was malnourished (body

mass index <18.5 kg/m^2: 37.3% vs 31.1%) and had a higher proportion of under-weight and stunted children (46.8% vs 37.7% and 40.2% vs 31.6% respectively) compared to women who gave first birth at the age of ≥20 years. The median age at marriage and delivery gradually increased (15 to17 years and 17 to19 years respectively) over the 1967-2005 period. Finally the authors concluded that the majority of women were married and a large proportion gave birth during the adolescence period in rural Bangladesh. Adolescent mothers were malnourished and childbearing in this period is associated with under-weight children. Delaying the age of marriage and delivery and improving pre-pregnancy nutrition were, therefore, important to reduce the burden of high child and maternal mortality and breaking the inter-generational cycle of malnutrition.

In traditional settings where early marriage and early childbearing prolong, decisions about age at marriage were often made by parents, and mothers-in-law tend to had considerable influence in speeding up the initiation of childbearing. **Bates et al. (2007)** found a significant association between the education level and the age at first marriage of their daughters; education level of mothers-in-law and the timing of first birth among their daughter-in-law from the paper "Women's education and the timing of marriage and childbearing in the next generation: evidence from rural Bangladesh" using the data from a 2002 survey in six villages in rural Bangladesh. Cox proportional hazard model were used to find out the result and result suggested that there was a significant associations between the educational level of mothers and the age at marriage of their daughters and between the educational level of mothers-in-law and the timing of first birth among their daughters-in-law, although the

association between the former attenuates when controlling for other variables. The authors concluded that there was a significant relationship between female education in one generation and the timing of marriage and childbearing in the next generation in rural Bangladesh.

Ronsmans et al. (2008) examined the trends in a cohort study of stillbirths and early and late neonatal deaths in Matlab, a rural area of Bangladesh between 1975 and 2002, using routinely collected demographic surveillance data. The author used logistic regression to examine the trends over time and between two areas in the three outcome measures, controlling for the effects of parental education, religion, time, geographical location, parity, maternal age and birth spacing. They found a remarkable decline rate in stillbirths, early and late neonatal mortality over time both areas were 24 percent, 39 percent and 73 percent in ICDDR'B compared to government area were 15 percent, 30 percent and 63 percent respectively, though the pace of decline was somewhat faster in the ICDDR,B.

Adolescent pregnancy was associated with adverse birth outcomes, less maternal growth and nutritional status. **Rah et al. (2008)** determined how pregnancy and lactation during adolescence affects postmenarcheal linear and ponderal growth and body composition of 12–19 y olds in rural Bangladesh using (n = 229) early first trimester pregnancy and never-pregnant adolescents (n = 458) of the same age. The authors compared annual changes in anthropometric measurements between the two groups adjusting for confounders using mixed effects regression models. Result reviled that the mean age and age at menarche of adolescents were 16.3 and 12.7 respectively. Mean difference between adolescents' pregnant and never-pregnant girls

growth in height is 0.43 ± 0.1cm. Similarly, whereas never-pregnant girls gained BMI, mid-upper arm circumference, and percent body fat of 0.62 kg/m^2, 0.89 cm, and 1.54 respectively, compared with pregnant girls. Except height differences in changes in all anthropometric measurements were greater among adolescents pregnant compared to non-pregnant adolescents, for menarche < 24 mo vs. ≥ 24 mo; for BMI − 1.40 kg/m^2 vs. −0.60 kg/m^2. Finally they documented that pregnancy and lactation during adolescence ceased linear growth and resulted in weight loss and depletion of fat and lean body mass of young girls.

Age at menarche was associated with anthropometry in adolescence. Timing of menarche may be set early in life but modified by changes in body size and composition in childhood. **Bosch (2008)** tried to find out the association between age at menarche and early-life nutritional status in rural Bangladesh based on a cohort of 255 girls aged <5 years recruited in 1988 were followed up in 2001 in Matlab, Bangladesh. Their analysis was based on nutritional status as assessed by anthropometry and recalled age at menarche using life table techniques and the Cox regression model. Multivariate model was used to examine the association between nutritional status indicators and age at menarche adjusting for potential confounding variables. They found that the median age at menarche was 15·1 years. Adolescent stunting would be the most important determinant of age at menarche while controlling for early-life predictors (birth size, childhood underweight, childhood stunting). They concluded that nutritional status of adolescence were strongly influenced with age at menarche , notably the level of stunting, which was in turn highly dependent on the level of stunting in early childhood. Stunting may be

detrimental for reproductive health in case of early childbearing because of the association between height and pelvic size.

Kamal (2009) presented a paper of titled "Adolescent Motherhood in Bangladesh". The study used nationally representative 2004 Bangladesh Demographic and Health Survey (BDHS-2004) data and found 64.3 percent of the ever married adolescents begun childbearing among them 53.6 percent were already mother and other 10.7 percent were pregnant for the first time. Among the adolescents, 22.8 percent childbirths were mistimed more than two-thirds of the adult married women started childbearing in their teen ages. The results of the multivariate logistic regression analyses revealed that important determinants of adolescent motherhood in Bangladesh were women's education, husband's education, childhood place of residence, sex of household head, religion, wealth and region.

Using data from the baseline survey 2004 of the National Nutrition Programme (NNP-2004), **Alam et al. (2010)** estimated the levels and differentials in nutritional status and dietary intake and relevant knowledge of adolescent girls in rural Bangladesh. Their results revealed that 26% of the girls were thin, 0.3% obese and 32% stunted also found more than half of girl could not name the main food sources of energy and protein, and 36% were not aware of the importance of taking extra nutrients during adolescence for growth spurt. They concluded the overall dietary knowledge among girls was low; if girls had general morbidity in the last fortnight and foul-smelling vaginal discharge than their peers the risks of being thin and stunted were higher. They suggested that community-based adolescent-friendly health and

nutrition education and services and economic development may improve the overall health and nutritional knowledge and status of adolescents.

Kamal (2012) observed the factors affecting "Adolescent motherhood in Bangladesh: Evidence from 2007 BDHS data" using the 2007 Bangladesh Demographic and Health Survey data. The author found that, above 69 percent married adolescents began childbearing among them 56.4 percent were already mothers and above 13 percent were pregnant for the first time. More than 62 percent initiated childbearing before age 19 from the adult married women aged 20–49. The author used multiple logistic regression model and the result revealed that women's education, husband's education, place of residence, ever use of contraceptive method, religion, wealth and region were important determinants of adolescent motherhood in Bangladesh.

Hossain et al. (2012) examined the changes in BMI of married Bangladeshi women and tried to find the association with socio-demographic factors by using Bangladesh Demographic and Health Survey (BDHS) data of 2007. Their analysis based on ANOVA, t-test and multiple linear logistic regression. They found decreasing tendency in BMI over time, as a result the proportion of underweight women had been increasing last two decades in Bangladesh. Lower BMI was especially found among rural women, non-Muslims, employed women, women not living with their husbands (separated) or those who had a home or non-caesarean delivery. Finally, they concluded that in Bangladesh, Body Mass Index (BMI) raised for increasing age, educational level of the woman and her husband, wealth index, age at first marriage and age at first delivery, and decreased with increasing number of ever-born children.

Early childbearing, lower use rate of contraceptive methods and unintended pregnancies were common among married adolescents in Bangladesh. **Kamal (2012)** investigated the socio-economic determinants of childbearing and contraceptive used among married adolescents in Bangladesh using Bangladesh Demographic and Health Survey (BDHS-2007) data. The author used both bivariate and multivariate logistic regression analysis for discovering the association between the socio-economic factors and childbearing and contraceptive used among married female adolescents. Findings suggested that 69% of the married adolescents initiated childbearing and 25% of the most recent pregnancies were unintended and the current contraceptive prevalence rate was 42%. The author also found from multivariate logistic regression the significant variable which increased risk of childbearing among adolescents were no formal education, girl who were married-off before age 16, the poor and the women who had ever used any contraceptive method. He concluded that family planning (FP) was the most significant determinant of any contraceptive used. Number of living children, working status and visitations by FP workers were also important determinants of contraceptive used among the married female adolescents in Bangladesh.

2.4: Trend in age at first marriage over time

Early marriage for females was customary in Bangladesh. In rural areas, majority of girls marry before the age of 12 (BFS, 1978). Although, the average age at first marriage had increased, early marriages were still prevalent in rural Bangladesh (Shaikh, 1982). According to the United Nations International Children Emergency Fund, girls were forced into early marriage and pregnancy (UNICEF, 1994). Early marriage was higher risk for adolescents and for early childbearing a higher rate of infection and death occurs every year in Bangladesh (Rahman, 1984).

Kabir et al. (1988) found that the average age at marriage was more than two years higher for women who had completed secondary school compared to those who did not complete secondary level. Improvement of education and an increase in the age at first marriage is the key element for improving the status of women. There was a positive relation between education and age at first marriage. Female education helped to prevent childhood marriage and childbearing.

Khan et al. (1988) studied on adolescent child bearing and found that teenage pregnancy and its complications appear as a leading cause of death among teenagers in Bangladesh. About 40 percent of death among teenage mothers could be attributed to maternal cause.

Riley and Khan (1993) examined the determinants of age at marriage in Bangladesh considering age at menarche, nutritional status, participation in the informal labor market, vital statistics and socio-economic factors. The average age at menarche in Bangladesh was 15.8 years due to poor nutritional status and health also the average

age at marriage is young at 17.3 years. The unique data set providing on nutritional status in adolescence, age at menarche and age at marriage obtained from the International Center for Diarrheal Disease Research in Matlab on 382 women in 1976 and 1989-90. The authors used Z-scores for anthropometric measurement including socio-economic variables of religion, education, and household wealth (land, radios, wristwatches, traditional quilt, kerosene lamp). Descriptive statistics and Cox proportional hazards models were also provided in the analysis. Their results confirmed that both social and biological factors determine the timing of marriage in rural Bangladesh. Menarche was an important predictor and did not affect the waiting time to marriage, but did act as a step function. Weight was positively related to the hazard of marriage. The "U" shaped relationship between education and age at marriage was not observed in the multivariate models. Household wealth was not important in determining marriage age. They suggested that women's income generation might delay age at marriage. When menarche and nutritional status were added to the socio-economic models, there was not a great reduction in the hazard, increased nutritional status may increase fertility and physical development might be a more important factor in maternal and child outcomes than maternal age.

It was determined the survival status of children and very much under the influence of socio-cultural and socio-economic situation. Low age at marriage not only contributes to population growth but also adversely affected the health of women resulting in maternal mortality. It also provided long childbearing span and results in a higher fertility in the societies where birth spacing is low. Higher fertility was encouraged by such societies which are characterized by low socio-economic status, fatalism and

high degree of religious and superstitious beliefs Pedants (mostly rural /slum areas) perform the marriage of their children particularly daughters soon after their puberty or even earlier due to various reasons such as to satisfy the wishes of grant parents; dowry problem, availability of suitable match (bridegroom) and to dispose of the responsibility. But this might affect the health of women and also result in early pregnancy, abortion and premature births, still birth, which would reflect on the health on the women. The early and frequent pregnancies not only destroyed the health but also that of future generations as well **(Kapoor, 1995)**.

In respect to socio-economic characteristics, women's education was strongly related to their domestic economic power and childbearing pattern. In almost every setting regardless of region, culture or level of development, well-educated women were observed to have fewer children than uneducated women. Yet, the parents in the relationship between women's education and their fertility were diverse, varying by region of the world, by level of development and over time **(Cochrane, 1979; United Nations, 1987 & 1995).**

One indicator of change in marital patterns is the median age at first marriage has risen since the mid 20th century, but a longer historical view may be instructive. **Elliott et al. (2012)** checked the historical marriage trends from 1890-2010 and conduct some hypothesis that, how the median age at first marriage changed; how the proportion never married by age 35 and how the proportion never married by age 45 changed from 1890 to 2010 using the data from decennial census 1890-2000 and American community survey 2010. The authors used the methods of Shyrock and Siegel model (1971) for marital status distribution by age and due to data constraints

Brault adapted the model to 10 year groups. Result reviled that the change for median age for women was greater than that for men the percent of age 35 and older who were never married was higher from 1890 through 1930. Finally they concluded that median age at first marriage in 2010 was highest on record, but didn't exceed the 1890 value until 1990. Sharp increase in proportion never married for black men and women since 1980 further investigation into the factors affecting this increase.

2.5: Age pattern of marriage

Ahmed (1962) estimated the singulate mean age at marriage for male and females. He also estimated the rates of divorce and widowhood and the rate of divorces and widowed per 1000 ever married women were 206 and 159 respectively. The author used 1951 population census data on marital status.

Bangladesh Fertility Survey **(BFS, 1978)** represented a comprehensive national study on nuptiality and introduction to childbearing in 1975. The survey collected information on current marital status, whether marriage was immediately consummated or not, number of time married, date of each marriage, age at marriage, reasons and date of termination of marriage. In this survey more information on marriage was collected than in any of the survey conducted before. The findings of the study pointed out that there had been a gradual increase in age at first marriage of women in Bangladesh. The mean age at marriage of women who married in 1974 was 11.4 years and it rose to 14.0 years for marriages of 1972 increasing further by 1976.

Kabir (1978) estimated the parameters of Coale's model for first marriage; the author used data of the 1974 Bangladesh Retrospective Survey of Fertility and Mortality. He

noted a shift in the age at which a significant number of marriages take place (a_0) from 10.6 in1951 to 11.9 in 1974 and also showed that, the expansion of the period in which the marriages takes place from 12.4 to 16.0 years was suggestive of the change in the pace of marriages. He suggested that the initial age at which marriage takes place has raised and at the same time they were being distributed over a wider range and marriage was still universal in Bangladesh.

Abedin (1982) conducted a study on titled "Pattern of Marriage in a Rural Community of Bangladesh" and estimated the mean and median age at marriage in a rural community in Bangladesh. He also estimated various nuptiality parameters recoursing Coale's nuptiality model and using these values estimated the frequency of first marriage and risk of first marriage.

Ahmed (1986) estimated the trend of age at first marriage in Bangladesh. He used Bangladesh Fertility Survey (BFS, 1975) data and found that in Bangladesh the level of age at first marriage was lowest among all Asian countries. He had observed a trend towards higher age at marriage, the speed was observed to be faster in rural areas than the urban areas although, the speed of the trend was not found to be the same for all regions of Bangladesh. The pattern of urban-rural differentials also was not the same for all regions.

Satter (1990) constructed a nuptiality table for a rural community in Bangladesh. He found that the average waiting time before first marriage for woman surviving to their 25-th birth day was only one year while for a man it is above 7 years. The probability that a woman aged 15 years will remain single for the next 10 years (up to age 25) was 0.6 while this probability for a man is 0.7.

2.6: Child health from other population studies

McCormick et al. (1984) examined the changes in infant mortality and morbidity in four regions of the United States and revealed that high levels of multiparas health problems among the infants of two groups of mothers less than or equal to 17 years and 18-19 year-old many of whom began their childbearing under age 18. They found that neonatal mortality rates were 1.5 times high for infants of these mothers as for other mothers and large proportion of them had relatively high risk for low birth weight (LBW) infants. Post-neonatal mortality rates also remained high and may be increased. Both the high post-neonatal mortality rates and the type of morbidity experienced by surviving infants were consistent with the socio-economic disadvantage of young mothers. They also indicated the limited resources available to these mothers to handle with their children's health needs and their potential vulnerability to decreases in public programs supporting child health care.

Brown et al. (1991) compared pregnancy outcome in 286 teenaged primigravidas (less than or equal to 16 years old) and 267 adult primigravidas (21 to 25 years old) who had similar prenatal care, socio-economic status, and racial balance. They found the incidence of preterm labor and delivery of a low birth weight infant was significantly higher in the teenagers where as the incidence of preeclampsia was significantly higher in the adults. Also found cesarean delivery was not done more frequently in teenagers, nor was there a higher incidence of infants small for gestational age, anemia, and abnormal presentation in labor. The birth weight was

significantly lower in infants of teenagers than adults. Teenagers were still at a significantly greater risk for delivery of smaller infants, preterm labor, and low birth weight infants although prenatal care, socioeconomic factors, and racial balance were comparable for young teenagers and adults.

Cooper et al. (1995) examined the effect of maternal age on birth outcomes among young adolescents. The authors used data for this study from the US 'National Center for Health Statistics' during 1983-86 on 127,668 live births and 2470 infant deaths to mothers aged 10-15 years of age. All records representing single births of primipara, black or white adolescents, were selected for analysis. They found that the youngest adolescents were at greatest risk for negative birth outcomes including very preterm and preterm delivery, low birth weight, small for gestational age (SGA), and neonatal mortality. Birth outcomes differed by maternal age if maternal age increased, the number of very preterm and moderately preterm deliveries decreased, the number of very low and moderately low birth weights decreased, and neonatal and infant mortality decreased. Births to adolescents aged 10-12 years were more likely to be small for gestational age. They used logistic regression analyses controlled for effects of maternal race, marital status, prenatal care, gravidity, education, and metropolitan/nonmetropolitan residency and showed similar results, the risk of preterm and very preterm infants increased for younger age groups compared to the reference group, with the exception that differences in SGA were insignificant. The authors also indicated the importance of examining age-specific birth outcomes among a population that had traditionally been studied in aggregate and underscores the need for increased prevention efforts.

Adolescence pregnancy was associated with an excess risk of poor outcomes, including low birth weight and prematurity this association simply reflects the harmful socio-demographic environment of most pregnant teenagers or biologic immaturity **(Fraser et al., 1995).** To determine adverse risk of young age pregnancy the authors used the data from 134,088 young girls and women of 13 to 24 years old in Utah who delivered singleton first-born children between 1970 and 1990. Relative risk and adjusted relative risk were calculated and found younger teenage mothers (13 to 17 years of age) had a 1.7 times higher risk for delivering a low birth weight infant, 1.9 times higher risk for premature delivery, 1.3 times higher risk of small for gestational age than mothers who were 20 to 24 years of age. Socio-demographic variables were also associated with teenage pregnancy and increase the risk of adverse outcomes.

Reichman and Pagnini (1997) estimated the effects of maternal age on low birth weight, newborns' hospital costs and infant mortality based on individual 1989 and 1990 vital statistics records from New Jersey that were linked with uniform billing hospital discharge records. In that study the authors compared birth outcomes among black and white adolescents aged under 15 years, 15-17 years, and 18-19 years with women aged 20-40 years and showed a U-shaped relationship between maternal age and low birth weight. The authors found teenagers whose age under 15 years had the highest risk of delivering a LBW infant compared to women aged 15-19 years, followed by mothers aged 40 years and older and women aged 35-39 years. Risk of infant mortality increased with the increasing age of the mother; particularly among black women also found the rates of LBW among black women aged 15-19 years

were 3 times higher than among whites. They concluded the apparently poorer birth outcomes of teenage mothers appeared to result largely from their adverse socioeconomic circumstances, not from young maternal age perse.

Berenson et al. (1997) conducted a study of adolescents 15 years of age or younger who required prenatal care at the University of Texas medical branch at Galveston during 1992-94. For the purpose of analysis author subdivided the patients into two groups: (i) the ages of 16 and 17 and (ii) those 20-22 years old who delivered an infant of less or equal to 20 weeks' gestation and initiated care during the same interval at this same facility. To identify differences between groups in demographic characteristics and perinatal complications Chi-square, Kruskall-Wallis or Student's t-test and to determine whether observed differences in outcomes remained while controlling for potentially confounding variables logistic regression analysis were used by the author. They found younger adolescents were significantly more likely to develop anemia and less likely to deliver an infant who required admission to the intensive care unit than their older. There were no differences between the three groups, however, in terms of the prevalence of pregnancy induced hypertension, preterm labor, preterm premature rupture of membranes, chorioamnionitis, meconium staining, endometritis, preterm delivery, low birth weight, low apgar score, or fetal death.

The decreasing prevalence of underweight in young women was a major public health concern and these trends had a major impact on pregnancy outcomes. **Bhattacharya et al. (2007)** performed a retrospective cohort study, based on all nulliparous women delivering singleton babies in Aberdeen between 1976 and 2005 data. They found that

underweight women have 1.7 times higher risk for low birth weight babies (i.e. birth weights less than 2,500 gram). Also found that under weight women had lower risk of pre-eclampsia, induced labor and caesarean section rates compared to obese women.

Ramachandran and Gopalan (2011) compared the pattern of growth of Indian 0-59 months aged children as assessed by three indicators weight for age, height for age and BMI for age with the World Health Organization standards for growth in 2006 and to explore the implications of differences in undernutrition rates. They used Indian National Family Health Survey-3 data and Learning Management System (LMS) software for computing trends in prevalence of undernutrition as assessed by height, weight and BMI for age in the 0-59 month age group and found that during the first three months there was no increase in underweight and stunting rates also found a progressive increase in underweight and stunting rates between 3-23 months of age. Low BMI for age and wasting rates were highest at birth.

Finlay et al. (2011) examined the association between maternal age at first birth and infant mortality, stunting, underweight, wasting, diarrhea and anemia in children in low and middle income countries. The authors used cross-sectional data of 176583 children in 55 low and middle income countries across 118 Demographic and Health Surveys conducted between 1990 and 2008. They used modified Poisson regression model to estimate unadjusted and adjusted RR ratios and found that the first-born children of adolescent mothers were the most vulnerable to infant mortality and poor child health outcomes also found the first time mothers up to the age of 27 had a higher risk of having a child who had stunting, diarrhea and moderate or severe anemia. Finally they mentioned that, child health outcomes remain poor in many low

to middle income countries, the age of the mother at their first birth is a key correlate of child health outcomes and teen mothers had children with the worst health outcomes and children of mothers who had their first birth in their early 20s were also at risk of poor health outcomes compared to first time mothers in their late 20s.

Mills et al. (2013) examined whether notified child maltreatment was associated with adverse psychological outcomes in adolescence, and whether differing patterns of psychological outcome were seen depending on the type of maltreatment. They used the sample of 7,223 mother and child pairs from population-based birth cohort study in Brisbane, Australia. Maltreatment was significantly associated with both internalizing behavior and externalizing behavior at 14, after adjustment for potential confounders. For non-exclusive categories of maltreatment, physical abuse, neglect, and emotional abuse were each significantly associated with both internalizing and externalizing behavior after adjustment. They suggested that, child neglect and emotional abuse had serious adverse effects on adolescent mental health and warrant the attention given to other forms of child maltreatment.

2.7: Child health from Bangladeshi population studies

Desai and Alva (1998) examined the effect of maternal education on three markers of child health: infant mortality, children's height-for-age, and immunization status. The data was extracted from the first round of Demographic and Health Surveys for 22 developing countries in that study. They found in the final model, maternal education had a statistically significant impact on infant mortality and height for age in only a handful of countries. In contrast, maternal education remains statistically significant for children's immunization status in about one-half of the countries even after individual-level and community-level controls were introduced.

Teenage mothers continue to present challenges to social policy and remain of topical interest to the media. **Botting et al. (1998)** discussed the trends in teenage conception rates, their outcomes and long term consequences. On average children born to teenage girls had lower birth weights, increased risk of infant mortality and an increased risk of some congenital anomalies. They were less likely to be breastfed and more likely to live in deprived circumstances. These factors in turn influence their health and long term opportunities.

Giashuddin et al. (2005) reviewed the economic difference in nutrition of under-five children in Bangladesh using Bangladesh Demographic Health Survey data 1999-2000. They used principal component analysis for calculating quintiles on the basis of asset and wealth score, concentration index also calculated to understand the nutrition status and health inequality. Result reviled that, stunting and underweight of the

poorest rural under-five children was almost two times higher than that of the richest children. Higher rate of malnutrition among the under-five children from the poorest class obtained from the negative concentration index.

Bangladesh is one of the countries with the highest rate of malnutrition the recent baseline survey by the National Nutrition Programme (NNP) showed high rates of stunting, underweight and wasting. World Health Organization (WHO) recent statistics showed that about 60 percent of all deaths, occurring among children aged less than five years (under-five children) in developing countries for the causes of malnutrition. An estimated 50.6 million under-five children were malnourished and almost 90 percent of these children were from developing countries. Since most (87-91 percent) delivered take place in home, prevalence of starting complementary food among infants aged 6-9 months had increased substantially with 76 percent. However, the adequacy, frequency, and energy density of the complementary food were in question. Remarkable advances had been made in the hospital management of severely malnourished children. Although the community nutrition centers of the NNP had been providing food supplementation and performing growth monitoring of children, the referral system and management of complicated severely malnourished children are still not in place **(Faruque et al., 2008).**

Mohsena et al. (2008) determined the "Association between socio-economic status and childhood undernutrition in Bangladesh; a comparison of possession score and poverty index" using sample of 4891 under 5 year children from Bangladesh Demographic and Health Survey (BDHS-2004) data. The authors used reference Z-scores of weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ).

Using principal component analysis a five-point (quintile) 'poverty index' was created. Result was reviled that 57.8 percent children were stunted, 7.7 percent were wasted and 25.7 % were also underweight. Underweight and wasting prevalence were 40.7 percent and 14.3 percent respectively. Mean WAZ, HAZ and WHZ did not differ by sex. They concluded that maternal education and possession score were the main predictors of a child's nutritional status. Possession score was a much better indicator of undernutrition than the poverty index.

Das et al. (2008) tried to explore the predictors of child chronic malnutrition of Bangladeshi children using the data of BDHS, 2004. The authors applied logistic regression models to identify the basic, underlying, immediate and temporal predictors according to the framework and finally a combined model developed by using the significant predictors from the preceding four models. In Bangladesh the prevalence of child chronic malnutrition was found high (43%) with 16.4% severely stunted. The findings indicated that child age, region, birth order and birth interval, mother's education, wealth status, number of sleeping room family size and cooking place were the basic important variable of child chronic malnutrition. Food insecurity status, maternal care and receiving colostrums were identified as underlying predictors of child chronic malnutrition; child feeding practices, receiving vitamin-A capsule by mother, acute respiratory infection (ARI) and incidence of diarrhea were immediate predictors of child chronic malnutrition; mother's body mass index (BMI) and age at birth were temporal predictors. From the final model they indicated that chronic malnutrition was widely prevalent among the children belonging to Barisal division, ages 12-23 months, lower birth interval, households having large size, less

sleeping room, poor wealth index, internal cooking place and mothers who were illiterate, thin, and insufficient maternal care recipients.

Among preschool children chronic malnutrition is one of the major causes of morbidity and mortality and the future productivity of nations. From 380 randomly selected children of under five years in Dhaka city, Bangladesh, **Jesmin et al. (2010)** conducted a cross sectional study for understanding the prevalence of chronic malnutrition and identifying the factors affecting height-for-age z-score (HAZ) among preschool children. Results of analysis of their study revealed that the prevalence of stunting among preschool children in Dhaka city were 39.5 percent with 25 percent severely stunted and 14 percent moderately stunted, furthermore socio-economic and demographic factors were most significantly associated with the stunting of children obtained from bivariate analysis. When parents had a higher or tertiary-level education and if the mother held a job and had good knowledge of nutrition children were found to be well-nourished. Well-nourishment of the children were also associated with the height of mothers, good family educational background, normal birth weight, greater frequency of food intake and fewer fever episodes in the last six months. Height of mothers, birth weight of children, education of fathers, knowledge of mothers on nutrition and frequency of feeding were the most significant factors influencing on the stunting of children.

To ensure comparability of the trends in causes of death among children under 5 in Bangladesh, 1993-2004, **Liu et al. (2011)** developed a standardized algorithm to assign causes of death using symptoms collected through the VA studies and found that pneumonia remained the leading cause of death in Bangladesh, contributing to

24% to 33% of deaths among children under 5. They also found for cause-specific mortality fractions due to prematurity/low birth weight (LBW) increased steadily, 10% (uncertainty range [UR]: (7%-15%).

For assessing the levels, trends and gaps between the poorest and the richest in selected health and human development indicators in Bangladesh **Khan et al. (2011)** presented a paper using Bangladesh Demographic and Health Surveys conducted in 1993-94, 1996-1997, 1999-2000, 2004 and 2007 data of selected indicators associated with socio-demographic characteristics among ever-married women. Their findings reviled that negative trends in factors such as literacy, infant and child mortality, fertility rate, home delivery and malnutrition and underweight. Changes in these indicators differed between the poorest and richest quintiles and only the richest quintile experienced rapid urbanization, whereas illiteracy declined more among the poorest.

Khanam et al. (2011) examined the impact of childhood malnutrition on schooling performance in rural Bangladesh. The results revealed that malnourished children were less likely to enroll in school on time and achieve an age-appropriate grade by 26 percentage points and 31 percentage points respectively. Other important determinants of schooling outcomes include infrastructure and education level of parents. One major contribution of this paper was the control for the endogeneity of malnutrition status, which otherwise might lead to bias estimates.

In Bangladesh prevalence of underweight (WAZ < -2) among under five year children is still high (41%), almost one-third of women were undernourished with body mass index of <18.5 kg/m^2, although child and maternal malnutrition had been

reduced. It is confuse that Bangladesh would be able to achieve the United Nations' Millennium Development Goal to address undernutrition with the low annual rate of reduction in child undernutrition of 1.27 percentage points per year. The entire health system needs to be refreshed to overcome the constraints that exist at the levels of policy, governance, and service-delivery, and also for the creation of demand for the services at the household level. It demanded that the policy-makers think urgently about the ways to accelerate the progress **(Ahmed et al., 2012).**

Islam et al. (2013) applied the generalized Poisson regression (GPR) model for predicting the number of under five malnourished children in Bangladesh. Most of the studies to find the predictors, for the issue of malnutrition among under-five children, considering the categorical (dichotomous/polychotomous) outcome variables apply logistic regression model (binary/multinomial). In this study for malnutrition variable (i.e. outcome) the authors defined as the number of under-five malnourished children in a family, which was a non-negative continuous variable. A total sample of 4,460 under-five children was extracted for analyzed from Demographic and Health Survey (BDHS-2007) data. Study identify several significant predictors of the outcome variable namely mother's education, father's education, wealth index, sanitation status, source of drinking water, and total number of children ever born to a woman. Finally the authors concluded that the GPR model was an ideal alternative of other statistical models to analyze the number of under-five malnourished children in a family.

2.8: Perspective of the study

It clearly identified in the review of literature that there exist knowledge gap in the proposed field of study. No systemic and in-depth study has yet been done to evaluate the impact of early childbearing mothers and their child's health. Actual level and trends of early childbearing, maternal health condition, trend of marriage and age pattern of marriage is very important in the context of Bangladesh health policy. There are debates among the statistics in Bangladesh regarding the extent of early childbearing and its effect on maternal health condition has been gradually improving. Questions have been raised over whether Bangladesh ought to undertake appropriate steps to get positive changes towards early childbearing and maternal health. The proposed study may be contributed significantly to fill up the existing knowledge gap and add unexplored knowledge to the existing stock of knowledge. The study findings would be an immense help to the policy makers in formulating an appropriate policies to reduce early childbearing and improving maternal health condition for Bangladesh as well as academicians, and future researchers might be benefited from this study.

2.9: Conclusion

Early childbearing mothers' and their childs' health are important for monitoring progress towards the United Nations Millennium Development Goal to reduce early childbearing by large portion and improve maternal health by the year 2015. The interlinked between early marriage with early childbearing, socio-economic, bio-demographic and maternal health care variables have been tested by applying different statistical analysis. The study is designed to examine the impact of early childbearing on the health of the mothers and their child of Bangladesh. The level and trends of early childbearing mother and their child health condition of Bangladesh; trend of marriage and age pattern of marriage also will be taken under review. Actual picture of early childbearing with mother and child health condition will be measured in a framework of demographic modeling and different statistical techniques. The study also tried to identify the challenges for reducing the early childbearing rate and improving the mother and child health condition for Bangladesh.

CHAPTER THREE

INDICATORS FOR MEASURING HEALTH AND NUTRITIONAL STATUS

3.1: Introduction

Health is the greatest gift, contentment the greatest wealth, faithfulness the best relationship. Maternal health refers the health of women during pregnancy, childbirth and the postpartum period. Mothers today juggle more tasks, work longer hours and sleep less than their perspectives.

There is an inextricable link between the well-being of mothers and their children. When mothers have health care, education and economic opportunity, both they and their children have the best chance to survive and thrive. But, many are not so fortunate. Alarming numbers of mothers' and children in developing countries are not getting the nutrition they need. For mothers, this means less strength and energy for the vitally important activities of daily life. It also means increased risk of death or giving birth to a pre-term, underweight or malnourished infant (Save the Children, State of the World's Mothers, 2012).

Health indicators are summary measures that are designed to describe particular aspects of health or health system performance. Maternal, infant and child mortality and morbidity are key indicators of the health of a society. These measures are the reflection of the current health status of a large segment of the population and a predictor of the health of the next generation.

3.2: The indicators of health and nutritional status

There are so many indicators for measuring health and nutritional status of a given population. Some of them are presented below:

Direct Indicators:

- Nutritional Anthropometry
- Clinical Assessment
- Bio-chemical Estimations

Indirect Indicators:

- Dietary assessment
- Vital Statistics

In addition:

- Socio-economic
- Socio-demographic
- Environmental

3.2.1: Anthropometric Measurements

Anthropometry, which measures the dimensions and composition of the human body

- Weight (kg)
- Height (cm)
- Waist Circumference (cm)
- Hip Circumference (cm)
- Biceps, Supra-Iliac, Sub-scapular

Nutritional Anthropometry

- **Weight :** - Total Body mass
  - Simple, widely used
  - Sensitive to small changes in nutrition
- **Height :** - Genetically Determined
  - Environmentally influenced
  - Stunting reflects chronic undernutrition
- **MUAC :** - Reflects muscle/fat
  - Easy to measure, used for quick screening
  - Independent of age (1-5 years)
- **FFT:** - Measures body fat
  - Correlates well with total body fat

Physical measure of health

- Infant and child mortality
- Nutritional status through anthropometric measurements:-

  (i) Children (ii) Adult
- Hemoglobin status
- Blood glucose status
- Blood pressure
- Morbidity pattern etc.

Anthropometric Indices

- Weight for age
- Height for age
- Weight for Height
- Body Mass Index

Quetlet or body mass index (BMI) is widely accepted as one of the best indicators of nutritional status in adults (James et al., 1988; Ferro-Luzzi et al., 1992; Shetty and James, 1994; Naidu, 1994; Bailey and Ferro-Luzzi, 1995). BMI may be nutritionally rather than genetically related (Rolland-Cachera 1993), despite wide variation in weight and height among human populations (Eveleth and Tanner, 1990; Majumder et al., 1990).

"BMI is a very good and easy screening tool". Because for waist circumference there are no cut points for levels of overweight, obesity, age or height and properly measuring the waistline is a little more difficult than measuring height and weight (Cathy Nonas, MS, RD, American Dietetic Association).

The present study to measures early childbearing mother and their child health and nutritional status Anthropometric indictor would be used.

3.3: The history of body mass index

Essentially, BMI is a simple mathematical formula, based on height and weight that is used to measure health. BMI is a useful tool for measuring weight and health risks and choice for most health professionals. In early BMI used by epidemiologists in

studies of population health, but adopted it quickly by doctors who wanted a quick and easy way to measure health in their patients.

At first the Body Mass Index (BMI) formula was developed in 1832 by Belgium statistician Adolphe Quetelet (1796-1874) and known as a different name the Quetelet Index and did not used for assessing disease risks until the 1970s. Adolphe Quetelet was trying to find the correlation between a man's height and weight and learned that there was no direct correlation between height and weight, but there was a correlation between height squared and weight ("Beyond BMI," an article in the July 20, 2009, issue of "Slate" magazine).

In 1972 the Quetelet Index became part of a landmark study, according to "Beyond BMI". Medical researchers were dissatisfied with the insurance companies' weight-for-height tables because they used subjective assessments of body frame (small, medium, large). The researchers wanted one standard equation.

A study performed at the University of Minnesota sought to measure the height, weight and body fat of more than 7,000 men in an effort to develop new methods of assessing this risk. It was through this research that the Quetelet Index, which had been studied and proven to be fairly effective, was given a more modern name. According to Slate, the popularity of the BMI continued to increase until 1985.

The body mass index (BMI) gained popularity over the years as a simple tool for measuring body's weight relative to height. A simple formula that includes weight and height produces a number that is matched to a point on a BMI chart to show underweight, normalweight, overweight or obese (Martin, 2010 and GSHNF new research, 2009).

The most widely used categories of Body Mass Index for adults are presented in following figure:

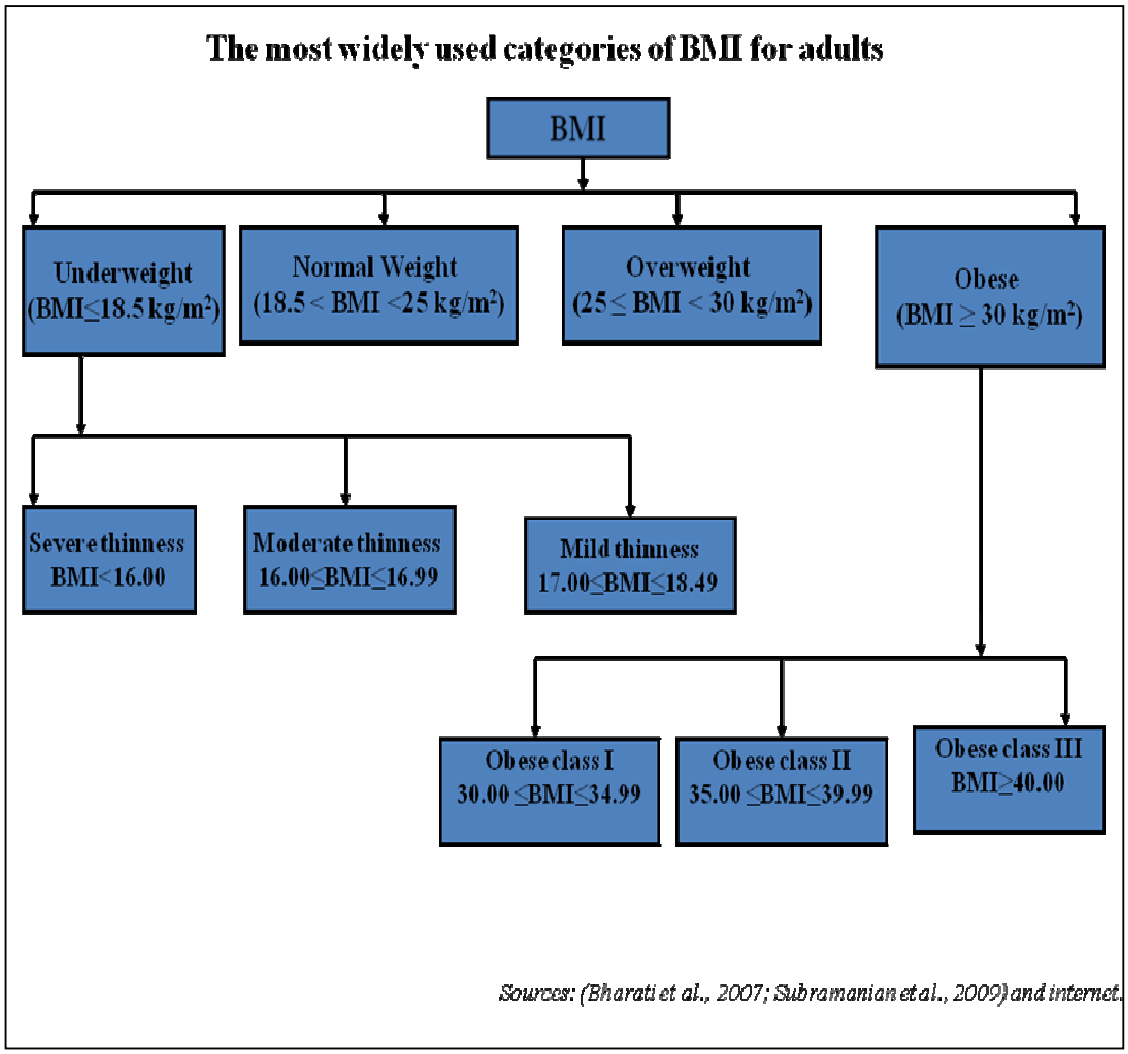


Figure 1: The most widely used categories of BMI for adults

3.4: Mother and child health measurement listed by some important studies

Many researchers conducted study on early marriage and early childbearing and tried to measure the adolescents' mother and their children health and nutritional status using different model and find out various predictors consisting with early marriage and early childbearing from home and abroad. Some of those important studies with model and predictors are given in the table below:

Table 1: Some important studies of mother and child health

Author/s	Year	Title	Model	Indicator
Islam et al.	2013	Predictors of the number of under five malnourished children in Bangladesh: application of the generalized Poisson regression model	Chi-square test and GPR model	Education, wealth index, sanitation status, source of drinking water, and total number of children ever born to a woman.
Hossain et al.	2012	Body Mass Index of Married Bangladeshi Women: Trends and Association with Socio-Demographic Factors	ANOVA, t-test and multiple linear logistic regressions	Body Mass Index (BMI)
Kamal	2012	Adolescent motherhood in Bangladesh: Evidence from 2007 BDHS data	Multiple logistic regression models	Education, place of residence, ever use of contraceptive method, religion, wealth and region

Table 1 (Continued)

Padula et al.	2012	Variations in estimates of underweight, stunting, wasting, overweight and obesity in children from Argentina comparing three growth charts	Z-score for new WHO standards	underweight, stunting, wasting, overweight and obesity
Kamal	2012	socioeconomic determinants of childbearing and contraceptive use among married adolescents in Bangladesh	Bivariate and multivariate logistic regression analyses	family planning (FP), number of living children, working status and visitations by FP workers
Liu et al.	2011	Trends in causes of death among children under 5 in Bangladesh, 1993-2004: an exercise applying a standardized computer algorithm to assign causes of death using verbal autopsy data	Developed a standardized algorithm to assign causes of death using symptoms collected through the VA studies	Neonatal mortality, cause-specific mortality, birth asphyxia/birth injury and prematurity/low birth weight (LBW)
Kosa et al.	2011	The Association Between Pre-pregnancy BMI and Preterm Delivery in a Diverse Southern California Population of Working Women	Multiple logistic regression models	BMI

Table 1 (Continued)

Catherine et al.	2011	Weight and height z-scores improve after initiating ART among HIV-infected children in rural Zambia: a cohort study	Z-scores	Underweight and stunted
Finlay et al.	2011	The association of maternal age with infant mortality, child anthropometric failure, diarrhoea and anaemia for first births: evidence from 55 low- and middle-income countries	Modified Poisson regression model	Association between maternal age at first birth and infant mortality, stunting, underweight, wasting, diarrhoea and anaemia in children
Mohsena et al.	2010	Association between Socio-economic status and childhood undernutrition in Bangladesh; acomparison of possession score and poverty index.	Z-scores and principal component analysis	Weight-for-age (WAZ), height-for-age (HAZ) and weight-for-height (WHZ)
Amouzou et al.	2010	How well does LiST capture mortality by wealth quintile? A comparison of measured versus modeled mortality rates among children under-five in Bangladesh.	LiST model	Neonatal and under-5 mortality

Table 1 (Continued)

Kulaga et al.	2010	he height-, weight-, and BMI-for-age of Polish school-aged children and adolescents relative to international and local growth references	Z-scores	height, weight and BMI
Nahar et al.	2010	Risk Factors Associated with Severe Underweight among Young Children Reporting to a Diarrhoea Treatment Facility in Bangladesh	Z-scores	Length/height-for-age, weight-for-age, weight-for-length, weight-for-height and body mass index-for-age
Alam et al.	2010	Nutritional Status, Dietary Intake, and Relevant Knowledge of Adolescent Girls in Rural Bangladesh	Bivariate techniques and logistic regression model	BMI and height-for-age z-score
Hogan et al.	2010	Maternal mortality for 181 countries, 1980—2008: a systematic analysis of progress towards Millennium Development Goal 5	Generalized negative binomial regression with ordinary least squares (OLS) and robust regression and counterfactual analysis	Maternal mortality
Nasreen et al.	2010	Low birth weight in offspring of women with	Chi-square or Fisher's exact	Socio-economic, anthropometric,

Table 1 (Continued)

		depressive and anxiety symptoms during pregnancy: results from a population based study in Bangladesh.	test, independent samples t test and Univariate logistic regression analyses	obstetric, pregnancy outcome and low birth weight (LBW)
Kamal	2009	Adolescent Motherhood in Bangladesh	multivariate logistic regression analyses	Education, childhood place of residence, sex of household head, religion, wealth and place of region.
Oyefara	2009	Socio-Economic Consequences of Adolescent Childbearing in Osun State, Nigeria	Percentages, means, Pearson Chi-squares, contingency coefficients and Content analysis	Socio-economic consequences of first child birth.
Boschi et al.	2009	The child health epidemiology reference group reviews of the effectiveness of interventions to reduce maternal, neonatal and child mortality.	Child Health Epidemiology Reference Group (CHERG) to the Lives Saved Tool (*LiST*)	Reduce maternal, neonatal and child mortality.
Asaduzzaman and Khan	2008	Factors Related to Childbearing in	Generalized linear model	Socio-economic and demographic

Table 1 (Continued)

		Bangladesh: A Generalized Linear Modeling Approach	(GLM) with Poisson link function	factors of childbearing in Bangladesh
Bosch et al.	2008	Association between age at menarche and early-life nutritional status in rural Bangladesh	Life table techniques and Cox regression model.	Nutritional status indicators (birth size, childhood underweight, childhood stunting) and age at menarche
Rah et al.	2008	Pregnancy and Lactation Hinder Growth and Nutritional Status of Adolescent Girls in Rural Bangladesh	Mixed effects regression models.	Anthropometric measurements
Xie et al.	2008	Assessing influence for pharmaceutical data in zero-inflated generalized Poisson mixed models.	Zero-inflated generalized Poisson mixed (ZIGPM) regression model	Pharmaceutical study
Bates et al.	2007	Women's education and the timing of marriage and childbearing in the next generation: evidence from rural Bangladesh	Cox proportional hazard models	Early marriage and early childbearing
Mercedes et al.	2007	Development of a WHO growth reference for school-aged children and adolescents	Box-Cox power exponential (BCPE) method	WHO growth reference

Table 1 (Continued)

Islam M	2007	Adolescent Marriage, Fertility and Reproductive Health in Bangladesh	Discrete-time hazard model	Probability of woman having a first birth during adolescence.
Heidi et al.	2006	Adolescents' Use of Maternal and Child Health Services in Developing Countries	Logistic regression analysis	Adolescents' use of antenatal care, delivery care and infant immunization services
WHO Multicentre Growth Reference Study Group	2006	WHO Child Growth Standards based on length/height, weight and age	Z-score and Box-Cox power exponential (BCPE) method	Height, weight and age
Phipps and Sowers	2002	Defining Early Adolescent Childbearing	R-GINDEX and Bivariate comparison	prenatal care, maternal age, very low birth weight, infant mortality and preterm delivery
Riley and Khan	1993	Age at first marriage for women in Matlab, Bangladesh: the role of biological and social determinants	Z-scores, Descriptive statistics and Cox proportional hazards models	Age at menarche, nutritional status, participation in the informal labor market, vital statistics, and socioeconomic factors

3.5: Conclusion

The long-term consequences of early marriage and early childbearing are lower physical health outcomes in later life for both mother and their children. Adolescent mother undernutrition, low body mass index (BMI), chronic energy deficiency and micronutrient deficiencies is highly prevalent in many underdeveloped and developing countries like Bangladesh.

So, to determine the associated factors significantly affect early childbearing and to investigate the effect of socio-economic and demographic factors on the health status of early childbearing mothers in Bangladesh logistic regression model would be used in this study.

ANOVA has used to examine the interclass variation of age at first marriage of Bangladeshi women and linear regression analysis was applied to detect the presence of trends in age at first marriage.

To investigate the changes in the pattern of first marriage probability by age of female Coale's nuptiality model would be used for single year age distribution and find out the risks of the first marriages for Bangladeshi women.

Traditionally, measurement of population health meant measuring adult health; child health indicators have been few and quite unsophisticated, limited to measures such as infant mortality rates, under 5 mortality rates, sometimes low birth weight and perhaps prevalence of certain diseases. However, there is a growing concern about children's health and about ways of measuring it, within countries and between countries and over time. Behind this concern is increasing awareness that children's health is an indicator of the well-being and progress of a society, and the recognition of children as an especially vulnerable group, deserving protection and promotion in its own right.

To examine the health problem and risks faced by early childbearing mothers' children Generalized Poisson Regression (GPR) model has used in the present study.

CHAPTER FOUR

DATA AND METHODS

4.1: Introduction

The main purpose of the present study is to examine the impact of early childbearing on the mother and child health in Bangladesh. Here, by early childbearing mean reproductive performance of women (through the childbearing) in early ages. Therefore, in order to see the impact of early childbearing first needed to examine the pattern of high risk and low risk childbearing by age, having such data for every woman. Pregnancies of younger women who become pregnant before the age of 20 faces greater health difficulties because the female body is only physically mature enough to bear healthy children by the age of 20 (Khan et al., 2011). Health impact of teenage childbearing is not only due to socio-demographic factors but also due to biological factors.

In this chapter, would be discussed about nature and type of data needed to fulfill the earlier cited objectives, sources of data has taken to undertake such research and brief discussion of statistical technique used for measuring the impact of mother and child health and nutrition.

4.2: Sources of data

In many developing countries like Bangladesh, vital registration system has not been started on a national basis. So, the study badly depends on the information of demographic data on census and sample survey. The secondary sources of data has extracted from the BDHS survey conducted under the authority of the National Institute for Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare, Bangladesh and implemented by Mitra and associate, a Bangladeshi research firm located in Dhaka. Technical assistance provided by ORC Macro of Calverton, Maryland (USA) through the MEASURE DHS program, financial support for the survey provided by the U.S. Agency for International Development (USAID)/ Bangladesh. The data also included survey documents, outcome of recent research work on relevant field, reading materials: books, journals, published and unpublished documents and website.

4.2.1: Selection of the respondents

In statistics, population is an aggregate of the elements possessing certain characteristics of interest in particular investigation, but in demography population means the human beings.

Here in this study, for measuring mother health from sample of 10,966 ever married women of Bangladesh demographic and health survey (BDHS, 2007), 1908 ever-married women of age 10-24 were used from all districts in Bangladesh. The study did not include ages higher than 24 years because of attempting to measure recent

health status of women who complete early childbearing preceding five years of the survey.

The sample population consisted of 56,057 (by the period, 1993–2007) Bangladesh Demographic and Health Survey (BDHS) conducted in 1993-1994, 1996-1997, 1999-2000, 2004 and 2007) ever married Bangladeshi women ages at the time of measurements 15 to 49 years for investigate the age at first marriage and its trends over time.

To estimate the parameters involving in the age patterns of marriage and evaluate the patterns (using single age distributions) of distributions of first marriage frequencies and risks of the first marriages of ever married women in Bangladesh, eventually all of 15 to 49 years ever married women are taken from Bangladesh demographic and Health Survey (BDHS) of 2007.

To examine the health problem and risks faced by early childbearing mothers' children in Bangladesh, total sample of data set 3207 were extracted from BDHS-2007; 10,996 ever married women of all districts in Bangladesh. The women over 19 year age of first birth were reduced from the number of cases.

4.2.2: Nature and sample design

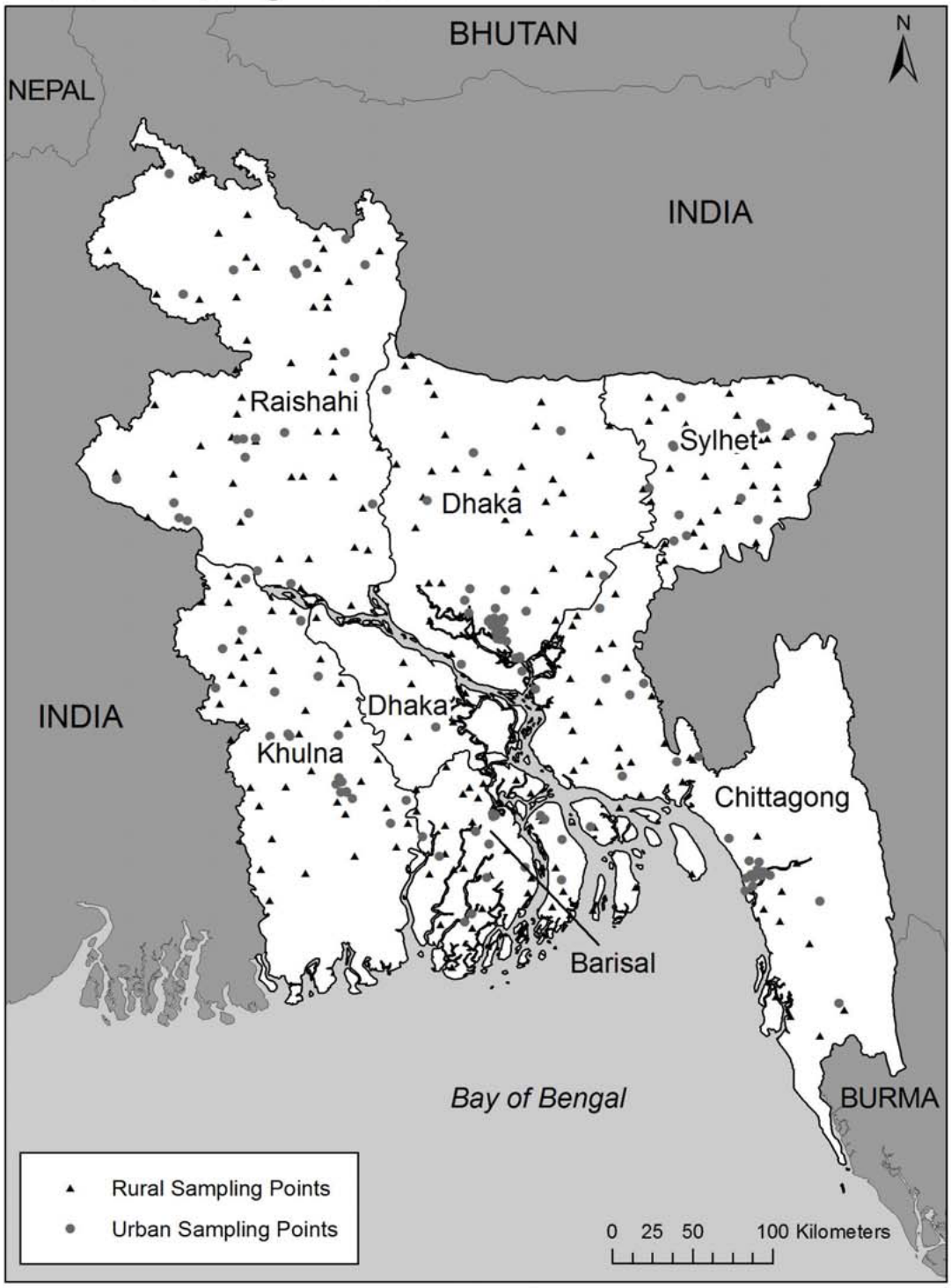
The BDHS employs a nationally representative sample that covers the entire population residing in private dwelling units in Bangladesh. The survey used the sampling frame provided by the list of census enumeration areas (EAs) with population and household information from the Population Census. Bangladesh is divided into six administrative divisions: Barisal, Chittagong, Dhaka, Khulna, Rajshahi, and Sylhet. In turn, each division is divided into zilas, and each zila into

upazilas. Rural areas in an upazila are divided into union parishads (UPs), and UPs are further divided into mouzas. Urban areas are divided into wards, and wards are subdivided into mahallas. These divisions allow the country as a whole to be easily divided into rural and urban areas. EAs from the census were used as the Primary Sampling Units (PSUs) for the survey, because they could be easily located with correct geographical boundaries and sketch maps were available for each one. An EA, which consists of about100 households, on average, is equivalent to a mauza in rural areas and to a mohallah in urban areas. The survey is based on a two-stage stratified sample of households. At the first stage of sampling, 361 PSUs were selected. Figure 2 shows the geographical distribution of the 361 clusters visited in the BDHS. The selection of PSUs had done independently for each stratum and with probability proportional to PSU size, in terms of number of households. The distribution of the sample over different parts of the country was not proportional, because that would have allocated the two smallest divisions, Barisal and Sylhet, too small a sample for statistical precision. Because only a small proportion of Bangladesh's population lives in urban areas, urban areas also had to be over-sampled to achieve statistical precision comparable to that of rural areas.

Therefore, it was necessary to divide the country into strata, with different probabilities of selection calculated for the various strata. Stratification of the sample was achieved by separating the sample into divisions and, within divisions, into urban and rural areas. The urban areas of each division were further subdivided into three strata: Statistical Metropolitan Areas (SMAs), municipality areas, and other urban areas. In all, the sample consisted of 22 strata; because Barisal and Sylhet do not have SMAs. The 361 PSUs selected in the first stage of sampling included 227 rural PSUs

and 134 urban PSUs. A household listing operation was carried out in all selected PSUs. The resulting lists of households used as the sampling frame for the selection of households in the second stage of sampling. On average, 30 households selected from each PSU, using an equal probability systematic sampling technique. In this way, 10,819 households selected for the sample. However, some of the PSUs were large and contained more than 300 households. Large PSUs were segmented, and only one segment selected for the survey, with probability proportional to segment size. Households in the selected segments were then listed prior to their selection. Thus, BDHS sample cluster is either an EA or a segment of an EA. The survey had designed to obtain 11,485 completed interviews with ever-married women age10-49. According to the sample design, 4,360 interviews were allocated to urban areas and 7,125 to rural areas. All ever-married women age 10-49 in selected households were eligible respondents for the women's questionnaire. In addition, ever-married men age 15-54 in every second household were eligible to be interviewed.

Figure 2: Map of BDHS-2007 Urban and Rural Sampling Points



4.2.3: Questionnaire

According to the goal of this research problem, a questionnaire formulated. Data has been collected through individual questionnaire. The questionnaire had developed considering the following characteristics:

(i) Number of questions in the questionnaire should be limited;

(ii) A respondent should adequately be assumed that his identity will not be against her interest;

(iii) Avoid long and confusing questions and formulate simple and short questions;

(iv) Start with easy questions then slowly put the difficult;

Because maintaining ones of its sequences are essential in the questionnaire for the research work. The BDHS used five questionnaires: a Household Questionnaire, a Women's Questionnaire, a Men's Questionnaire, a Community Questionnaire and a Facility Questionnaire. Their contents were based on the measure BDHS model Questionnaires. These model questionnaires were adapted for use in Bangladesh during a series of meetings with a Technical Task Force (TTF) that included representatives from NIPORT, Mitra and Associates, ICDDRB: Knowledge for Global Lifesaving Solutions, the Bangladesh Rural Advancement Committee (BRAC), USAID/Dhaka, and Macro international. Draft questionnaires were then circulated to other interested groups and reviewed by the BDHS Technical Review Committee.

The questionnaires were developed in English and then translated and printed in Bangla. The Household Questionnaire was used to list all the usual members of and visitors to selected households. Some basic information collected on the

characteristics of each person listed, including age, sex, education, and relationship to the head of the household. The main purpose of the Household Questionnaire was to identify women and men who were eligible for individual interviews. In addition, the questionnaire collected information about the dwelling unit, such as the source of water, type of toilet facilities, floor and roof materials, and ownership of various consumer goods. The Household Questionnaire also used for recording height and weight measurements of all women age 10-49 and all children below six years of age. The Women's Questionnaire was used for collecting information from ever-married women age 10-49. Women were asked questions on the following topics:

- Some common personal characteristic of the respondents such as age, sex, education, religion, occupation etc.
- Reproductive history.
- Knowledge and use family planning methods.
- Antenatal and delivery care.
- Breastfeeding and weaning practices.
- Vaccinations and health care of their children.
- Marriage.
- Family size preferences.
- Husband's background and work status.
- Height and weight of children (under five year age) and mother.

4.2.4: Training and Survey

Forty-two field staff got traning and organized into six teams to carry out the listing of households and delineation of easy and to administer the community and facility questionnaires. In addition, six supervisors were deployed to check and verify the

work of the listing teams. Listers also got training for using of Global Positioning System (GPS) units so that they could obtain location coordinates for each selected EA and for facilities located within each EA. Fourteen interviewers were trained for the pretest. The questionnaires were pretested on 100 women and 100 men in two rural areas in Barisal district and two urban areas in Dhaka. Based on observations in the field and suggestions made by the pretest teams, revisions were also made in the wording and translation of the questionnaires. Training for the main survey had been conducting for four weeks. A total of 128 field staff recruited based on their educational level, prior experience with survey, maturity, and willingness to spend up to five months on the project.

Training included lectures on how to complete the questionnaires, mock interviews between participants, and field practice. Fieldwork for the BDHS was carried out by 12 interview teams, each consisting of one male supervisor, one female field editor, five female interviewers, two male interviewers, and one logistics staff member. Four quality control teams ensured data quality; each team included one male and one female data quality control worker. In addition, NIPORT monitored fieldwork with another set of quality control teams. Data quality also monitored through field check tables generated concurrently with data processing. This permitted the quality control teams to advise field teams about problems detected during data entry. Tables were specifically generated to check various data quality parameters. Fieldwork also monitored through visits by representatives from USAID, Macro International, and NIPORT. Fieldwork implemented in five phases.

4.2.5: Data Collection

Data Collection Methodology (DCM) is a team of survey methodologists specializing in the use of qualitative and quantitative research methods to enhance quantitative enquiry and promote good practice. DCM offers expertise in the development, testing and evaluation of survey data collection instruments including self-completion forms, record-keeping diaries and questionnaires administered by interviewers (on paper, by computer-assisted telephone interviewing (CATI) or computer-assisted personal interviewing (CAPI). DCM also conducts in-depth studies to explore concepts and themes relating to the design of data collection instruments, or relating to more general survey and statistical matters. Where possible, DCM aims to contribute to the theoretical development of survey methods. The qualitative methods DCM applies include focus groups, in-depth interviews, behavior coding, cognitive question testing and expert reviews of survey questions and documentation. Quantitative techniques to aid questionnaire evaluation were also used. DCM has been part of the methodology directorate of the Office for National Statistics (ONS). DCM was formerly known as Qualitative Methods Applied to Surveys (QMAS). Clients of DCM include other areas of ONS, other government departments, local authorities, academic institutions and charities. DCM is not normally able to work for clients in the private sector or for private individuals such as students. The data should be collected keeping in view the objectives of the study of the BDHS data. The editing of the completed questionnaire helped in mending and recording errors or eliminating data that are obviously erroneous and inconsistent. All kind of mistakes have been corrected where it was found in questionnaire and all answers have been observed carefully. As a result there is no irreverent information. The tendency should not collect too many data, but the

important one and some of which are never subsequently examined and analysis. In this survey the method of especially collect from BDHS data used. The enumerators were mainly respondents to collect information and recorded them properly. Attention was given to recorded factual and true statement made by the respondents. In any survey enumerators' role is the most significance with respect to coverage and reliability of data collection. The success and failure of the enumerators in eliciting relevant respondents is largely and exclusively dependent on efficiency, capability and responsibility.

4.2.6: Data Processing

All questionnaires for the BDHS were periodically returned to Dhaka for data processing at Mitra and Associates. The processing of data collected in the field began shortly after fieldwork commenced. Data processing consisted of office editing, coding of open-ended questions, data entry, and editing inconsistencies found by the computer program. The data were processed by 10 data entry operators and two data entry supervisors working in double shifts using six microcomputers.

4.2.7: Quality of the Data

Any kind of research finding based on the survey data mainly depends primarily on the reliability of the data. From various socio-economic and demographic points of view Bangladesh is an underdeveloped country. Due to very low literacy rate, citizens are not conscious about the importance of providing correct information's in census and survey. Because of these, various errors are included in any survey data, such as, age heaping, miss-reporting, digit preference, etc, in case of retrospective surveys.

Some of the respondents, especially women also refuse in giving information totally and partially due to religious and social superstition. Although the standard in terms of organization, co-ordination, supervisors and intensive training of the interviews and the associated field supervisors and editors, BDHS is expected to result in better quality of data, there is obvious need for an assessment of the quality of data to prove the validity of the finding of the study.

4.2.8: Selection of Variable

Table 2: Selection of variable and their source from different article

Variable factor	Selected Variables	Sources
		Dependent Variable
For assessing mother health	**Body Mass Index (BMI)**	Hossain et al., 2012,2009; Alam et al., 2010; Rasmussen and Yaktine, 2009; Craig et al., 2009; Stommel and Osier, 2012; Leah et al.,2009; Pediatrics, 2010; Shahabuddin et al., 2000; Rah et al.,2008; Khan & Kraemer, 2009.
For assessing child health	**Z-Score**	WHO, 2012; Kulaga et al., 2010; WHO, 2007; USCDC, 2002; Rosset et al., 2011; Matthews et al., 2010; Bell et al., 2007; Riley & Khan, 1993; Finlay et al., 2011; Padula et al., 2012; Sutcliffe et al., 2011.
		Independent Variable
Socio-economic Variable	**Respondent Occupation**	Islam et al., 2006; Amin et al., 2007; Finlay et al., 2011, Alam et al., 2010; Wang, 2012; Hossain et al., 2012.
	Partner Occupation	Islam et al., 2006; Finlay et al., 2011; Rasmussen and Yaktine, 2009; Hossain et al., 2012.

Table 2 (Continued)

Socio-demographic Variable	**Wealth Index**	Kamal, 2012 & 2009; Islam et al., 2006; Schuler et al., 2006; Amin et al., 2007; Finlay et al., 2011; Treffers et al., 2001; Alam et al., 2010; Hossain et al., 2012.
	Division	Kamal, 2012 & 2009; Rasmussen and Yaktine, 2009; Khan & Kraemer, 2009; Hossain et al., 2012
	Place of residence	Kamal, 2012 & 2009; Rasmussen and Yaktine , 2009; Subramanian et al., 2009; Khan & Kraemer, 2009; Hossain et al., 2012.
	Women education level	Kamal, 2012 & 2009; Hossain et al., 2012; Islam et al., 2006; Schuler et al., 2006; Bates et al., 2007; Finlay et al., 2011, Treffers et al., 2001; Alam et al., 2010; Craig et al., 2009; Wang, 2012.
	Partner education level	Kamal, 2012 & 2009; Islam et al., 2006; Schuler et al., 2006; Finlay et al., 2011, Treffers et al., 2001; Alam et al., 2010; Craig et al., 2009; Khan & Kraemer, 2009; Hossain et al., 2012.
	Delivery System	Hossain et al., 2012; Alam et al., 2010; Rasmussen and Yaktine , 2009; Khan & Kraemer, 2009; Shafique et al., 2007.
	Place of Delivery	Hossain et al., 2012; Alam et al., 2010; Rasmussen and Yaktine, 2009; Khan & Kraemer, 2009; Shafique et al., 2007.
	Age at First Marriage	Islam et al., 2006; Schuler et al., 2006; Bates et al., 2007; Amin et al., 2007; Khan & Kraemer, 2009; Hossain et al., 2012 & 2009.
	Age at First Birth	Amin et al., 2007; Finlay et al., 2011; Wang, 2012; Khan & Kraemer, 2009; Hossain et al., 2012 & 2009; Shafique et al., 2007.
	Total Children Ever Born	Hossain et. al.,2012; Shafique et al., 2007; Khan & Kraemer, 2009

Table 2 (Continued)

Children Health	**Children Height**	WHO, 2012; Kulaga et al., 2010; WHO, 2007; USCDC, 2002; Rosset et al., 2011; Matthews et al., 2010; Bell et al., 2007; Riley & Khan, 1993; Finlay et al., 2011; Padula et al., 2012; Sutcliffe et al., 2011; Subramanian et al., 2009
	Children Weight	WHO, 2012; Kulaga et al., 2010; WHO, 2007; USCDC, 2002; Rosset et al., 2011; Matthews et al., 2010; Bell et al., 2007; Riley & Khan, 1993; Finlay et al., 2011; Padula et al., 2012; Sutcliffe et al., 2011; Subramanian et al., 2009
	Children Age	WHO, 2012; Kulaga et al., 2010; WHO, 2007; USCDC, 2002; Rosset et al., 2011; Matthews et al., 2010; Bell et al., 2007; Riley & Khan, 1993; Finlay et al., 2011; Padula et al., 2012; Sutcliffe et al., 2011
Mother Health	**Respondent Height**	Hossain et al., 2012; Alam et al., 2010; Rasmussen and Yaktine, 2009; Craig et al., 2009; Stommel and Osier, 2012; Subramanian et al., 2009; Rah et al.,2008
	Respondent Weight	Hossain et al., 2012; Alam et al., 2010; Rasmussen and Yaktine, 2009. Craig et al., 2009; Stommel and Osier, 2012; Rah et al., 2008
	Respondent Age	Hossain et al., 2012; Alam et al., 2010; Rasmussen and Yaktine, 2009; Craig et al., 2009; Khan & Kraemer, 2009

4.2.9: Data screening

The presence of abnormal points in data set, can affect the interpretation of results (Stevens, 1996). For this reasons the present authors were check the data set for outliers and found outliers in the data set. These were identified using statistical techniques (Dunn and Clark, 1974).

4.2.9.1: Data screening for measuring maternal health

Data from a sample of 10,996 Bangladeshi ever married women were collected by BDHS-2007. Some missing values were found in the data set, which reduced the number of cases. Currently pregnant, respondent age over 24 years and women over 19 year first birth age were excluded in the present section. After removing outliers, excluding currently pregnant, respondent age over 24 year and women over 19 year first birth age and units with missing data; finally the data set was reduced to 1908.

Table 3: Data screening for measuring mother health at a glance

Criteria	Sample size
Total sample size of BDHS-2007 data	10996
Currently pregnant	718
Respondent age over 24	4037
Women over 19 year first birth age	3535
Outliers	37
Missing values for Delivery data	674
Other missing values	87
Final sample size for present study	1908

4.2.9.2: Data screening for investigate the age at first marriage and its trend over time.

The sample of ever married women consisted of 56,057 (by the period (1993–2007) Bangladesh Demographic and Health Survey (BDHS) conducted in 1993-1994, 1996-1997, 1999-2000, 2004 and 2007) ever married Bangladeshi women ages at the time of measurements 15 to 49 years.

Table 4: Data screening for investigate the age at first marriage and its trend over time

Surveys conducted year	Total sample	After removing outlier sample size
1993-1994	14640	13860
1996-1997	9127	7511
1999-2000	9854	8716
2004	11440	8929
2007	10996	8093
Total sample	56057	47109

4.2.9.3: Data screening for age pattern of first marriage

Eventually all of 15 to 49 years 10996 ever married women are taken from Bangladesh demographic and Health Survey (BDHS) of 2007.

4.2.9.4: Data screening for measuring child health

Total sample size of BDHS-2007 data was 10,996 ever married women. The women over 19 year age of first birth, missing values for delivery data, weight and height missing values, some other missing value and some outlier were found in the data set, which reduced the number of cases. After removing outliers, excluding respondent age over 19 year first birth delivery missing data and units with some other missing data; finally the data set was reduced to 3207.

Table 5: Data screening for measuring child health

Criteria	Sample size
Total sample size of BDHS-2007 data	10996
Women over 19 years age of first birth	3535
Missing values for Delivery data	3816
Weight and height missing values	384
Outliers	39
Other missing values	15
Final sample size for present study	3207

4.2.10: Software and technical support of the study

In this study entire analysis is done in personal computer, which is now one of the most effective and wonderful technical inventions. Well known statistical package named SPSS (Statistical Package for Social Science) windows version 17.00 is used for analysis. SPSS can take data from almost any type of the file and use them to generate reports, charts and plots of distributions and trends, descriptive and complex analysis provides the following facilities.

- Case summary produces the mean number of the quantitative variable gains grouping variable.
- The frequencies produced frequency table, measures of central tendency and desperation, histogram and bar charts.

- The descriptive procedure computes unvaried summary statistics and saves standardized variables. Descriptive computes descriptive for continuous variables, more frequently because it does not sort values into a frequency table.
- Stepwise regression procedure is use to built a model, for which find out the most significant influential variable.
- The logistic regression procedure is used to build to analysis models, the complex relationship in socio-economic and demographic factors. It also has facilities for automatically converting categorical variables into sets of contrast variables.
- ANOVA build a statistical linear model for one-way analysis of variance (ANOVA) corresponding to each dimension to examine the interclass variation.
- The standard approach of linear regression analysis is to take data, fit a model, and then evaluate the fit using statistics such as t, F, and R^2. This was applied to detect the presence of trends in age at first marriage.
- Using single age distribution investigates the changes in the pattern of first marriage probability and the risks of the first marriages by Coale's nuptiality model.
- Finally we used R 2.14.1 to estimate parameters of the Generalized Poisson Regression (GPR) model to examine the nutritional status and risks faced by children of early childbearing mothers.
- Besides, others well known package like Excel-2007 were used when needed. The entire thesis was type in MS-word 2007.

4.3: Methodology

Research methodology is the philosophy of research to systematically solve the problem. In this methodology, study the various steps that are generally adopted by a researcher in studying his research problem along with behind them. It is necessary for the researcher to understand not only the research methodology but also consider the logic behind the methods which is used in the context of the research study and explain the research is conducted.

4.3.1: One-way analysis of variance (ANOVA)

Analysis of Variance (ANOVA) summarizes how much of the variance in the data (total sum of squares) is accounted for by the factor effect (factor sum of squares) and how much is random error (residual sum of squares). Ideally most of the variance is explained by the factor effect. The ANOVA table provides a formal F-test for the factor effect. The F-statistic is the mean square for the factor divided by the mean square for the error. This statistic follows an F distribution with (k-1) and (N-k) degrees of freedom.

For testing of significance namely the student's t-test and analysis of variance (ANOVA) it is essential to developed for use with some assumptions.

The ***assumptions*** include:

i) Random selection of the subjects, for study;

ii) Existence of the homogeneity of variance between groups under study; and

iii) Variable under study was assumed to follow normal distribution with coefficient of skewness as zero and coefficient of kurtosis as three.

To test the validity of the data in ANOVA, randomness, normality and homogeneity of cohort variances were tested by using the Kolmogorov-Smirnov non-parametric test, use of a normal probability plot, and the Levene test, respectively (Montgomery, 2001).

4.3.1.1: Levene test for equality of variance

Levene's test (1960) is used to test if K samples have equal variances. Equal variances across samples are called homogeneity of variance. Some statistical tests, for example, the analysis of variance, assume that variances are equal across groups or samples. The Levene test can be used to verify that assumption. Levene's test is an alternative to the Bartlett test. The Levene test is less sensitive than the Bartlett test to departures from normality. If, have strong evidence that the data do in fact come from a normal, or nearly normal distribution, then Bartlett's test has better performance.

The Levene test defined as:

$H_{0:}$ $\sigma_1 = \sigma_2 = \ldots = \sigma_k$

$H_{1:}$ $\sigma_i \neq \sigma_j$ for at least one pair (i , j).

Given a variable Y with sample of size N divided into k subgroups where N_i is the sample size of the i^{th} subgroup, the Levene test statistic is defined as:

$$W = \frac{(N-k)}{(k-1)} \frac{\sum_{i=1}^{k} N_i \left(\overline{Z}_i - \overline{Z}_{..}\right)2}{\sum_{i=1}^{K} \sum_{j=1}^{Ni} \left(Z_{ij} - \overline{Z}_{i.}\right)2}$$

Where, Z_{ij} can have one of the following three definitions:

1. $Z_{ij} = \left|Y_{ij} - \overline{Y_{i.}}\right|$

Where, Y_i is the mean of the i^{th} subgroup.

2. . $Z_{ij} = \left|Y_{ij} - \widetilde{Y}_{i.}\right|$

Where, $\widetilde{Y}_{i.}$ is the median of the i^{th} sub-group

3. $Z_{ij} = \left|Y_{ij} - Y'_{i.}\right|$

Where $Y'_{i.}$ the 10% is trimmed mean of i^{th} subgroup

$\overline{Z_{i.}}$ are the group means of the Z_{ij} and $\overline{Z_{..}}$ is the overall mean of the Z_{ij}. The three choices for defining Z_{ij} determine the robustness and power of Levene's test. By robustness, we mean the ability of the test to not falsely detect unequal variances when the underlying data are not normally distributed and the variables are in fact equal. By power, we mean the ability of the test to detect unequal variances when the variances are in fact unequal.

Data Limitations in the Homogeneity of Variance Test:

1. If none of the cells have more than one observation, nothing is calculated. It is impossible to calculate a standard deviation without at least two observations.
2. When only one cell has more than one observation, Minitab will generate all output except Bartlett's and Levene's test statistics. At least two standard deviations are necessary to calculate these test statistics.

3. When at least two cells have more than one observation, the Bartlett's test statistic is always calculated. Levene's test statistic is calculated provided at least one cell contains more than two observations.

***Critical Region*:**

The Levene test rejects the hypothesis that the variances are equal if $W > F_{(\alpha, k-1, N-K)}$. Where $W > F_{(\alpha, k-1, N-K)}$ is the upper critical value of the F distribution with (k-1) and (N-k) degrees of freedom at a significance level of α. In the above formulas for the critical regions, the Handbook follows the convention that F_{α} is the upper critical value from the F distribution and $F_{1-\alpha}$ is the lower critical value.

Variable transformation is needed under the most severe violations of the assumption of ANOVA. It is often happens that the same transformation which is utilized simultaneously stabilizes variance produces linear relationships and provides more nearly normal distribution. Box and Cox (1964) suggested that the useful formula for appropriate transformations like

$\mathbf{Y = (X^{\lambda}-1)/\lambda}$., Where, λ is chosen by analyst. After converting the data from X to Y then ANOVA can be performed on transformation data. For nonequality of variances, the transformation of the scale of measurement may bring about near equality of variances.

4.3.1.2: Tests for normality of the variables

Normal distribution is also known as Gaussian distribution or Demoivrian distribution as Demoivry and Gauss discovered and developed this distribution. Normal distribution has a unique place in the theoretical and applied statistics. The assumption that variables like head height, body weight etc follow normal distribution

occurs repeatedly in statistical tests of significance. Consequences of violating the assumption vary from relatively severe for inferences on variables. Techniques for assessing the truth of the assumption that variables follow normal distribution are provided below.

The characteristics of a normal distribution are,

i. The distribution is symmetrical, i.e., mean = median = mode and the coefficient of skewness is equal to zero.

ii. The coefficient of kurtosis is equal to three.

4.3.1.3: Fisher's least significant difference (LSD)

Procedure: `

1. Perform overall test of

H_0: $\mu_1 = \mu_2 = \ldots\ldots\ldots = \mu_t$

Vs H_1 : $\mu_1 \neq \mu_2 \neq \ldots\ldots\ldots \neq \mu_t$

2. If outcome is "do not reject H_0'', then stop. Otherwise continue to #3.

3. Perform desired hypothesis tests of (Preplanned) paired comparisons using contrast tests:

H_0: $\mu_i = \mu_j$

Vs H_1: $\mu_i \neq \mu_j$(two sided)

The LSD aspect comes from the rejection region for the test statistic

$$t = \frac{\hat{l}_{ij} = 0}{\sqrt{\hat{v}(l_{ij})}}$$

$$= \frac{\bar{y}_{i.} - \bar{y}_{j.}}{\sqrt{\{S_w 2(\frac{1}{n_i} + \frac{1}{n_j})\}}}$$

One rejects H_0 if $t > t_{\alpha/2}$ (with $(n_T - t)$ df). This is the same as reject H_0 if

$$\bar{y}_{i.} - \bar{y}_{j.} \geq t_{\alpha/2} \sqrt{S_w 2(\frac{1}{n_i} + \frac{1}{n_j})}$$

When the sample sizes are equal (each $n_i = n$), the quantity on the right hand side becomes $t_{\alpha/2} \sqrt{S_w 2(\frac{2}{n})}$, which is the original meaning of the least significant difference.

4.3.2: Regression analysis

Regression analysis has become one of the most widely used statistical tools for analyzing multifactor data. It is appealing because it provides a conceptually simple method for investigating functional relationships among variables. The standard approach in regression analysis is to take data, fit a model, and then evaluate the fit using statistics such as t, F, and R^2. Regression analysis is a set of data analytic techniques that examine, the interrelationships among a given set of variables. Regression analysis has numerous areas of applications. A partial list would include economics, finance, business, law, meteorology, medicine, biology, chemistry, engineering, physics, education, sports, history, sociology, agricultural sciences and psychology. Regression analysis is learned most effectively by analyzing data are of direct interest to the reader. Readers were invited to think about questions (in their own areas of work, research, or interest) that can be addressed using regression analysis.

4.3.2.1: Steps in regression analysis

Regression analysis includes the following steps:

a) Statement of the problem
b) Selection of potentially relevant variables
c) Data collection
d) Model specification
e) Choice of fitting method
f) Model fitting
g) Model validation and criticism
h) Using the chosen models for the solution of the posed problem.

4.3.2.2: Various classification of regression analysis

Table 6: Various Classifications of Regression Analysis

Type of Regression	Conditions
Univariate	Only one quantitative response variable
Multivariate	Two or more quantitative response variables
Simple	Only one predictor variable
Multiple	Two or more predictor variables
Linear	All parameters enter the equation linearly, possibly after trans -formation of the data
Nonlinear	The relationship between the response and some of the predictors is nonlinear or some of the parameters appear nonlinearly, but no transformation is possible to make the parameters appear linearly
Analysis of Variance	All predictors are qualitative variables
Analysis of Covariance	Some predictors are quantitative variables and others are qualitative variables
Logistic	The response variable is qualitative

4.3.3: Simple linear regression model

In a simple linear regression model $Y = \beta_0 + \beta_1 X + U$, β_0 is the regression interception. The estimate β_0 determines the level of the fitted line. i.e., it indicates the distance of the line directly above or below the origin. β_1 is called the regression coefficient. The slope of the line measured by the estimates of β_1 that gives the average amount of change of Y per unit change in the values of X. The sign of estimate of β_1 indicates the type of relationship between Y and X. And U is a stochastic error term. Y is the dependent variable and X is independent variable.

Let the linear regression model is

$$Y_i = \beta_0 + \beta_1 X_{1i} + \beta_2 X_{2i} + \ldots\ldots\ldots + \beta_{k-1} X_{k-1i} + U_i \qquad (2)$$

In the above model Y_i and X_{ji} (i= 1,2,..,n and j=1,2,…,k-1) are the dependent and predictor or explanatory variables respectively. U's are stochastic disturbance term. B_0 and β_j are the intercept term and regression coefficient respectively.

To estimate the parameter β by OLS method we must make certain assumptions about the manner in which the X and U are generated.

The assumptions are:

1) **Liner regression model**. The regression model is linear in the parameters.
2) **X values are fixed in repeated sampling**. Values taken by the repressors X are considered fixed in repeated samples. More technically, X is assumed to be non-stochastic
3) **U_i is a random real variable**.

4) **Zero mean value of disturbance U_i**. Given the values of X, the mean or expected

value of the random disturbance term U_i in any particular period is zero.

technically, the conditional mean value of U_i is zero. Symbolically, we have

$$E(U_i/X_i) = 0$$

5) **Homoscedasticity or equal variance of U_i**. Given the values of X, the variance of U_i is the same for all observations. That is, the conditional variances of U_i are identical Symbolically, we have

$$Var(U_i/X_i) = E\,[\,U_i - E(U_i)/X_i]^2$$

$$= E(U_i^2/X_i) = \sigma^2$$

i.e., the variable U has a normal distribution U~N (0, σ2)

6) **Zero covariance between U_i and X_i or $E(U_i/X_i)=0$**

$$Cov(U_iX_i) = E[U_i - E(U_i)][X_i - E(X_i)]$$

$$= E[U_i\{X_i - E(X_i)\}]$$

$$= E(U_iX_i) - E(U_i)E(X_i)$$

$$= E(U_iX_i) - 0$$

$$= 0$$

i.e., U is independent of the explanatory variable.

7) **Variability in X values**. The X values in a given sample must not all be the same. The explanatory variable is measured without error.

Simple regression analysis was applied to detect the presence of secular trends in the variables among the birth-years cohorts from 1976 to 1983 and then polynomial model was fitted the cohort data (Kutner, Nachtsheim and Neter, 2004).

4.3.4: Logistic regression analysis

Binomial (or binary) logistic regression is a form of regression, which is used when the dependent variable is a dichotomy, and the independent variables are of any type. Multinomial logistic regression exists to handle the case of dependent variables with more classes than two. When multiple classes of the dependent variable can be ranked, then ordinal logistic regression is preferred to multinomial logistic regression. Continuous variables are not used as dependent variables in logistic regression. Unlike logit regression, there can be only one dependent variable.

Logistic regression can be used to predict a dependent variable on the basis of continuous and/or categorical independent variables and to determine the percent of variance in the dependent variable explained by the independent variables; to rank the relative importance of independent variables; to assess interaction effects, and to understand the impact of covariate control variables. Logistic regression applies maximum likelihood estimation after transforming the dependent variable into a logit variable (the natural log of the odds of the dependent variable occurring or not). In this way, logistic regression estimates the probability of a certain event occurring. Note that logistic regression calculates changes in the log odds of the dependent variable, not changes in the dependent variable itself as Ordinary Least Square (OLS) regression does (Menard, 2002).

Because the use of a dichotomous dependent variable, OLS regression violates the assumptions of normality and homoscedasticity as normal distribution is impossible with only two values. Also, when the values can only be 0 or 1, residuals (error) will be low for the portions of the regression line near Y=0 and Y=1, but high in the middle, hence the error term will violate the assumption of homoscedasticity (equal

variances) when a dichotomy is used as a dependent variable. Even with large samples, standard errors and significance tests will be in error because of lack of homoscedasticity. Also, for a dependent variable, which assumes values of 0 and 1, the regression model will allow estimates below 0 and above 1. Also, multiple linear regressions do not handle non-linear relationships, whereas log-linear methods do. These objections to the use of regression with dichotomous dependent variables apply to polytomous dependent variables also.

Logistic regression is popular because for it the researcher can overcome many of the restrictive assumption of OLS regression:

a) Logistic regression does not assume a linear relationship between the dependent variables and the independent variables.
b) The dependent variable need not be normally distributed (but does of distribution, such as Normal, Poisson, Binomial, Gamma).
c) The dependent variable need not be homoscedastic for each level of the independent variables, that is, there is no homogeneity of variance assumption.
d) Error terms are not assumed normally distributed.
e) Logistic regression does not require that the independent variables be interval.
f) Logistic regression does not require that the independent variables be unbounded.

However, other assumptions are still applying.

i. **Meaningful coding.** Logistic coefficients will be difficult to interpret if not coded meaningfully.

ii. **Error terms are assumed to be independent variable.** Violations of this assumption can have serious effects.

iii. **Linearity.** Logistic regression does not require linear relationships between the independent factor or covariates and the dependent variable, as does OLS regression, but it does assume a linear relationship between the independent variables and the log odds (logit) to the dependent variable.

iv. **Additivity.** Like OLS regression, logistic regression does not account for interaction effects except when interaction terms are created as additional variables in the analysis.

v. **No multicollinearity.** To the extent that one independent variable is a linear function of another independent variable, the problem of multicollinearity will occur in logistic regression, as it does in OLS regression. As the independent variables increase in correlation with each other, the standard errors of the logit (effect) coefficients will become inflated. Multicollinearity does not change the estimates of the coefficients, only their reliability.

4.3.4.1: The model of logistic regression

Logistic regression analysis is the most used regression technique available for modeling dichotomous dependent variables. Logistic regression is a mathematical modeling approach that can be used to describe the relationship of several predictor variables $X_1,X_2,\ldots,X_k$ to a dichotomous dependent variable Y (Menard, 2002). Let's try to write the model as

$$Y = \beta_0 + \sum_{j=1}^{k} \beta_j X_j + \varepsilon \quad \text{..... (1)}$$

We would logically let Y_i=0 if the ith unit does not have the characteristic that Y represents (e.g., diabetes mellitus), and Y_i=1 if the unit does possess that characteristic (where, i=1,2,…,n). Here the collection of k independent variables which is denoted by the vector $X' = (X_1, X_2, \ldots, X_k)$ and β be a (k+1)×1 vector of unknown parameters.

It thus follows that ε_i can also take on only two values:

$$1 - \beta_0 - \sum_{j=1}^{k} \beta_j x_{ji} \quad \text{, if } Y_i=1$$

And $$-\beta_0 - \sum_{j=1}^{k} \beta_j x_{ji} \quad \text{, if } Y_i=0$$

Therefore, ε_i cannot be even approximately normally distributed. Consequently, the model given by Eq. (1) is inapplicable for a binary dependent variable.

In simple linear regression the starting point in determining a model is a scatter plot of Y versus X, but this is of limited value when there are only two possible values of Y. Consequently, it is necessary to consider other plots. One such plot results from smoothing the Y values, and then plotting these smoothed values against X. We might also consider a plot of E(Y/X) against X. It is customary to let $E(Y_i/X_i)=\pi_i$, which is $Pr(Y_i=1)$. Here π_i represents the probability. Thus, the graph might be a S-shaped curve that has been found to be appropriate in many applications for which Y is a binary random variable (0, 1).

[For (0,1) random variables such as Y, it follows from basic statistical principles about expected values that E(Y) is equivalent to the probability pr(Y=1). E(Y)=0×pr(Y=0)+1×pr(Y=1)=pr(Y=1)]

The function

$$\Pr(Y=1)=\pi(X)=\frac{\exp\left(\beta_0+\sum_{j=1}^{k}\beta_j X_j\right)}{1+\exp\left(\beta_0+\sum_{j=1}^{k}\beta_j X_j\right)} \quad \text{..... (2)}$$

Will produce a similar S-shaped graph. The model in terms of Y would be written as

$Y=\pi(X)+\varepsilon$

It follow from Eq. (2) that $\pi/(1-\pi)=\exp\left(\beta_0+\sum_{j=1}^{k}\beta_j X_j\right)$

So, $\log\left(\frac{\pi(X)}{1-\pi(X)}\right)=\beta_0+\sum_{j=1}^{k}\beta_j X_j$ .....(3)

Since Eq. (3) results from using a logistic transform (also called a logit transform), the model is called a logistic regression model. The logit may be continuous and depending on the range of X it may range from - ∝ to +∝ (Hosmer and Lemeshow, 1989). The left side of Eq. (3) is also called the log odds ratio.

4.3.4.2: Odds ratio

The odds ratio is a measure of effect size particularly important in Bayesian statistics and logistic regression. Here "measure of effect" means a measure that compares two or more groups in predicting the response (dependent) variable (Chatterjee and Hadi, 2006). To know the details about an odds ratio, at the initial time we need to know about odds. An odd is the ratio of the probability that some event (e.g., developing diabetes mellitus (D)) will occur divided by the probability that the same event will not occur (e.g., not developing diabetes mellitus (ND)). Mathematically we can define the odds for some event D is

$$\text{Odds (D)} = \frac{\Pr(D)}{\Pr(ND)} = \frac{\Pr(D)}{1 - \Pr(D)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (4)$$

Now the odds ratio is defined as the ratio of (two odds) the odds of an event occurring in one group to the odds of it occurring in another group, or to a sample-based estimate of that ratio. These groups might be men and women, an experimental group and a control group, or any other dichotomous classification. If the probabilities of the event in each of the groups are Pr (D_A) [for group A] and Pr (D_B) [for group B], then the odds ratio is

$$DR_{AvsB} = \frac{odds(DA)}{odds(DB)} = \frac{\Pr(DA)}{1 - \Pr(DA)} / \frac{\Pr(DB)}{1 - \Pr(DB)} \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \quad (5)$$

An odds ratio of 1 indicates that the condition or event under study is equally likely in both groups. An odds ratio greater than 1 indicates that the condition or event is more likely in the first group. And an odds ratio less than 1 indicates that the condition or event is less likely in the first group. The odds ratio must be zero or greater than zero.

As the odds of the first group approaches zero, the odds ratio approaches zero. As the odds of the second group approaches zero, the odds ratio approaches positive infinity. Now we need to write the logistic regression model, called the logit form of the model. The "logit" is a transformation of the probability pr(Y=1), defined as the natural log odds of the event D={Y=1}. In other words,

$$\text{Logit}[\text{pr}(Y=1)]=\log_e[\text{odds}(Y=1)]= Log_e\left[\frac{\Pr(Y=1)}{1-\Pr(Y=1)}\right] \quad \text{..... (6)}$$

If we then substitute the logistic model formula (1) for pr(Y=1) into equation (6), it follows that

$$\text{Logit}[\text{pr}(Y=1)]= \beta_0 + \sum_{j=1}^{k} \beta_j X_j \quad \text{……..(7)}$$

Equation (7) is called the logit form of the model. The logit for is given by the linear function $\beta_0 + \sum_{j=1}^{k} \beta_j X_j$. For convenience, many authors describe the logistic model in its logit form given by (7) rather than in its original form defined by (1)

Let us partition the data set $X_1, X_2, \ldots, X_k$ into two groups A and B as

$X_A = (X_{A1}, X_{A2}, \ldots X_{Ak})$ and $X_B = (X_{B1}, X_{B2}, \ldots, X_{Bk})$

For example, if k=3, and X_1 is smoking status (1=yes, 0=no), X_2 is age (continuous) and X_3 is race (1=black, 0=white), then a partition can be written as $X_A = (1, 45, 1)$ and $X_B = (0, 45, 1)$

$$OR_{X_A \; vs \; X_B} = \frac{\exp(\beta_0 + \sum_{j=1}^{k} \beta_j X_{A_j})}{\exp\left(\beta_0 + \sum_{j=1}^{k} \beta_j X_{B_j}\right)} = \exp\left\{\sum_{j=1}^{k}\left(X_{A_j} - X_{B_j}\right)\beta_j\right\}$$

4.3.4.3: Estimation of parameters

The most common method used to estimate unknown parameters in linear regression is least squares. Under usual assumptions, least square estimations have some desirable properties. But, when least squares method in applied to estimate a model with a dichotomous outcome the estimators no longer have these same properties. In such situation, the general method for estimating the parameters of logistic regression models is the method of maximum likelihood (Menard, 2002).

In logistic regression the likelihood equation is nonlinear and explicit function parameters. Therefore, we use a very effective and well-known iterative method, Newton-Raphson method. For this method we have to evaluate score vector and Information matrix.

4.3.4.4: Score vector

Let L(β) be the likelihood function where, $\beta = \left(\beta_0, \beta_1, ..., \beta_p\right)^{/}$ in a (p+1)× 1 matrix of parameters and is defined as

$$L(\beta) = \prod_{i=1}^{n} \left[\pi(x_i)\right]^{y_i} \left[1 - \pi(x_i)\right]^{1 - y_i}$$

The log likelihood is defined as,

$$\text{Ln L}(\beta) = \sum_{i=1}^{n} \left[y_i \ln \pi(x_i)\right] + \sum_{i=1}^{n} (1 - y_i) \ln\left[1 - \pi(x_i)\right]$$

Taking the first derivation of log-likelihood we write,

$$\text{U}(\beta) = \frac{\partial \ln L(\beta)}{\partial \beta}$$

Which, is called score vector (Jacob, Patricia, Steven and Aiken, 2002). The likelihood equations can be obtained by solving U(β)=0 and are as follows.

$$\sum_{i=1}^{n} [y_i - \pi(x_i)] = 0$$

And $\sum_{i=1}^{n} x_{ij}\left[y_i - \pi(x_i) = 0\right]$ for i = 1, 2 ,....., p

4.3.4.5: Information matrix

Taking second derivative of likelihood function we get a p (p+1) × (P+1) matrix. The negative of this matrix is given by,

$$I(\beta) = -\left[\frac{\partial^2 \log L(\beta)}{\partial\beta\partial\beta^{/}}\right]$$

$$= \begin{bmatrix} -\frac{\partial^2 \log L}{\partial\beta_0{}^2} & -\frac{\partial^2 \log L}{\partial\beta_0\partial\beta_1} & \cdots -\frac{\partial^2 \log L}{\partial\beta_0\partial\beta_p} \\ -\frac{\partial^2 \log L}{\partial\beta_1\partial\beta_0} & -\frac{\partial^2 \log L}{\partial\beta_1{}^2} & \cdots -\frac{\partial^2 \log L}{\partial\beta_1\partial\beta_p} \\ -\frac{\partial^2 \log L}{\partial\beta_p\partial\beta_0} & -\frac{\partial^2 \log L}{\partial\beta_p\partial\beta_1} & \cdots -\frac{\partial^2 \log L}{\partial\beta^2{}_p} \end{bmatrix}$$

The matrix I(β) is called the information matrix or fisher's information about β. The variance covariance matrix can be obtained by taking inverse of the information matrix (Jacob, Patricia, Steven and Aiken, 2002).

$$\hat{\text{var}}\left(\hat{p}\right) = I\left(\hat{p}\right)^{-1}$$

4.3.4.6: Newton Raphson method

In numerical mathematics different iterative procedures are used to solve non linear equations. The Newton Raphson method is the most commonly used iterative procedure for solving likelihood equations for logistic regression. An iterative procedure in a successive approximation technique and each approximation is called analysis iteration. Cox and Minkley (1974) Kalbfleisch and Prentice (1980) Lawless (1981) have given a detail description of the Newton-Raphson method. According to their discussing we describe the technique here.

Generally the Newton-Raphson method uses an iterative process to approach one root of a function. The specific root that the process locates depends on the initial, arbitrarily chosen x-value.

$$x_{n+1} = x_n - \frac{f(x_n)}{f'(x_n)}$$

Here, x_n is the current known x-value, $f(x_n)$ represents the value of the function at x_n, and $f'(x_n)$ is the derivative (slope) at x_n. x_{n+1} represents the next x-value that we are trying to find.

The Newton-Raphson method is based on first order Taylor series expansion of the score vector

$$U(\beta) = \frac{\partial \ln L(\beta)}{\partial \beta}$$

Where L(β) is the likelihood function for the column vector β as we defined earlier.

Suppose $\hat{\beta}$ is the maximum likelihood estimate of β, and β_0 is the first guess (initial value) of β. Expanding $U_j(\beta)$ in a Taylor series about β_0 we have

$$U_j(\beta)= \frac{\partial \log L(\beta)}{\partial \beta_j} = \frac{\partial \log L(\beta_0)}{\partial \beta_j} + \frac{\partial^2 \log L(\beta_0)}{\partial \beta_j \partial \beta_j}\left(\hat{\beta}\,\beta_0\right)$$

Ignoring the higher order terms the score vector at β can be written as

$U(\hat{\beta})=U(\beta_0)-I(\beta)(\hat{\beta}-\beta_0)$

Where β^* is some value between β_0 to $\hat{\beta}$ and I(β) is a (p+1)× (P+1) matrix with entries

$$I_{ij}(\beta) = -\frac{\partial^2 \log L(\beta)}{\partial \beta_j \partial \beta_j}$$

Since $\hat{\beta}$ satisfies $U(\hat{\beta})=0$, we have the approximation

$\hat{\beta} = \beta_0+I(\beta_0)^{-1} U(\beta_0)$

Where the important estimate β and the equation for I(β) is said to define analysis iteration scheme for obtaining () by Newton-Raphson method.

The Newton-Raphson procedures can be summarized by following steps:

(A) Obtain an initial estimate β_0 of $\hat{\beta}$.

(B) Calculate $U(\beta_0)$ with $I(\beta_0)$.

(C) Calculate the next approximation β_1 of $\hat{\beta}$ using (A) Important estimate.

(D) Steps (A) and (B) replacing β_0 with $\beta_1^{/}$

(E) Continue the steps until convergence is achieved.

We stop repeating, if $U(\beta_0)$ in close to 0 and the difference between two successive approximation is nearly zero.

The Newton-Raphson method also provides analysis estimate of the information matrix and hence the variance covariance matrix of $\hat{\beta}$.

4.3.4.7: Maximum Likelihood Estimator (MLE)

MLE is the method used to calculate the logit coefficients. This contrasts to the use of ordinary least squares (OLS) estimation of coefficients in regression. OLS seeks to minimize the sum of squared distances of the data points to the regression line. MLE seeks to maximize the log likelihood, LL, which reflects how likely it is (the odds) that the observed values of the dependent may be predicted from the observed values of the independents.

MLE is an iterative algorithm that starts with an initial arbitrary "guesstimate" of what the logit coefficients would be, the MLE algorithm determines the direction and size change in the logit coefficients that will increase LL. After this initial function is estimated, the residuals are tested and a re-estimate is made with an improved function, and the process is repeated (usually about a half-dozen times) until convergence is reached (that is, until LL does not change significantly). There are several alternative convergence criteria (Hosmer and Stanley, 2000).

4.3.4.8: Testing the parameter of logistic model

Here we discuss some fundamental theory testing the significance of the parameters of logistic regression model. For testing the significance of the parameters of logistic regression following test procedures are usually used.

1. Likelihood ratio test
2. Wald test
3. Score test

4.3.4.9: Likelihood ratio test

A general test procedure introduced by Neyman and Pearson in 1928 is known as the likelihood ratio test. This test is based on maximum likelihood estimates. The likelihood ratio test can be used for testing a simple or composite hypothesis against a simple or composite hypothesis.

In logistic regression, the likelihood ratio test was used for testing the overall significance of coefficient for all the parameters. Our hypothesis is as follows

H_0: $\beta_1=\beta_2=\ldots\ldots\ldots\ldots=\beta_p=0$

Vs. H1: At least one of them is not equal to zero.

The likelihood Ratio test is based on the ratio of two likelihood functions. The comparison of observed values to predicted values using the likelihood function are based on the following expression:

$$D = -\sum \ln\left(\frac{L_0}{L_1}\right)$$

Where, L_0=likelihood function for the current model

L_1=likelihood function for the standard model.

A standard model is one that contains as many parameters as there are in the data set. The quantity inside the brackets in the above expression is called the likelihood ratios and a test based on it is called likelihood ratio test. The statistic D in equation (β) is

called the deviance by McCullagh and Nelder (1985) and plays a central role in some approaches to assessment of goodness-of-fit.

For assessing the significance of an independent variable we compare the value of D with and without the independent variable in the equation. The effect of including the independent variable in the model can be obtained by G as follows.

G=D(for the model without the variable)-D(for the model with the variable).

i.e. G measure the change in D due to inclusion of the independent variable in the model, G can be expressed as

$$G = -\sum \ln\left[\frac{(\text{likelihood without the variable})}{(\text{likelihood with the variable})}\right]$$

Under the null hypothesis that β_i's (i=1,2,……, p)are equal to zero, the statistic G follows chi-square distribution with p degrees of freedom. If the null hypothesis is rejected, we may conclude that all the coefficients are not equal to zero i.e. at least one of the coefficient (β_i) has significant effect.

4.3.4.10: Wald test

The wald test procedure was introduced by Wald in 1943 and was named according to his name. In logistic analysis due to the nature of maximum likelihood estimation Wald test has a definite advantage over the likelihood estimation Wald test has a definite advantage over the likelihood ratio test. But it has the same assumption as those of likelihood ratio test, when the overall null hypothesis H_0: $\beta_1=\beta_2=\ldots\ldots\ldots\ldots=\beta_p=0$ in rejected then to idenfity the significant coefficient Wald test is used.

The Wald test is obtained by comparing the maximum likelihood estimate of any parameter to the estimate of its standard error.

For testing

H_0: $\beta_i=0$

Vs. H_1: $\beta_i \neq 0$ for i=0,1,2,……, p

The univariate Wald statistic is defined as

$$W_i = \frac{\hat{\beta}_i}{S.E.\left(\hat{\beta}_i\right)}$$

Where, $\hat{\beta}_i$ I is maximum likelihood estimate of β_i and SE ($\hat{\beta}_i$) denotes the standard error of ($\hat{\beta}_i$). Under the null hypothesis W_i follows a standard normal distribution.

In the multivariabte analysis the Wald test can be expressed as

$$W = \hat{\beta}\left[Var\left(\hat{\beta}\right)\right]^{-1}\hat{\beta}$$

Where $\hat{\beta}$ is the maximum likelihood estimate of vector of parameter β and $Var\left(\hat{\beta}\right)$ is the estimated variance-covariance matrix, which is the inverse of the information matrix under the null hypothesis.

H_0: $\beta_0=0,\beta_1=0,\ldots\ldots\ldots\ldots,\beta_p=0$

W follows chi-square distribution with k degrees of freedom

Wald test has the limitation that it behaved in an aberrant manner and often failing to reject the null hypothesis when the coefficient is significant, which was examined by Hauck and Donner (1987), and Jennigs (1986).

4.3.4.11: Score test

For testing whether the overall effect is significant or not the score test is used. We assumed that the asymptotic distribution of score vector is known and Cox and Hinkly (1974) showed that under the following regularity condition score vector U(β) is asymptotically normally distributed with mean 0 and variance-covariance matrix I(β). The regularity conditions are

1. The order of integration and differentiation are interchangeable.
2. The dimension of the parameter space Ω is finite and the value of the parameter is interior to Ω.
3. The probability distributions for different values of β exist in the neighborhood of the true parameter value.

Under above regularity conditions the central limit theorem can be applied to the above score vector U(β). As a result U(β) follows asymptotically normally distributed with mean vector 0 and variance-covariance matrix $[I(\beta)]^{-1}$.

For β be the (p+1) vector of parameters the hypothesis can be written as

$H_0: \beta = \beta_0$

Vs. $H_1: \beta \neq \beta_0$

Under the null hypothesis the score statistic $U(\beta_0)$ is asymptotically normally distributed with mean vector 0 and variance-covariance $[I(\beta_0)]^{-1}$.Then we can define the test statistic for score test is,

$$S^2 = \left[U(\beta_0)\right]\left[I(\beta_0)\right]^{-1}\left[U(\beta_0)\right]'$$

Where, S^2 follows an asymptotic chi-square distribution with p degrees of freedom. From the chi-square distribution table with p.d.f. we can get the value of S^2 at α% level of significance. If $S^2 > S^2_{as}$ then we may reject the null hypothesis at α% level of significance. We may conclude that the β may not be equal to β_0.

4.3.4.12: Hosmer and Lemeshow's goodness of fit test

The Hosmer-Lemeshow goodness-of-fit statistic is, using their notation, given by

$$\hat{C} = \sum_{k=1}^{g} \frac{\left(O_k - n'_k \bar{\pi}_k\right)^2}{n'_k \bar{\pi}_k\left(1-\bar{\pi}_k\right)}$$

Where g denotes the number of groups, n'_k is the number of observations in the k^{th} group, o_k is the sum of the Y values for the k^{th} group, and $\bar{\pi}_k$ is the average of the $\hat{\pi}$ for the k^{th} group. The statistic follows chi-square distribution with degrees of freedom g-2 (one for taking sum and other for estimating $\hat{\pi}$). Notice that this differs slightly from the usual chi-squared goodness-of-fit test, as the denominator in the above equation is not the expected frequency. Rather, it is the expected frequency for the k^{th}

group multiplied times one minus the average of the estimated probabilities for the k^{th} group. Thus, each of the g denominators will be less than the g expected frequencies, and there will be a considerable difference when $\bar{\pi}_k$ is close to 1. The methods of Hosmer and Lemeshow (1980) and Lemeshow and Hosmer (1982) specify that 10 groups be used. If the H-L goodness-of-fit test statistic is greater than .05, as we want for well-fitting models, we fail to reject the null hypothesis that there is no difference between observed and model-predicted values, implying that the model's estimates fit the data at an acceptable level. That is, well-fitting models show non-significance on the H-L goodness-of-fit test. This does not mean that the model necessarily explains much of the variance in the dependent, only that however much or little it does explain is significant. On the other hand, the H-L statistic assumes sampling adequacy, with a rule of thumb being enough cases so that no group has an expected value < 1 and 95% of cells (typically, 10 deciles groups time 2 outcome categories = 20 cells) have an expected frequency > 5. Collapsing groups may not solve a sampling adequacy problem since when the number of groups is small the H-L test will be biased toward non-significance (will overestimate model fit).

4.3.5: Generalized Poisson regression model

The generalized Poisson probability function of the number of malnourished children (*Y)* in a family can be written as

$$f(y,\mu,\alpha)=\left(\frac{\mu}{1+\alpha\mu}\right)^{y}\frac{(1+\alpha y)^{y-1}}{y!}\exp\left(-\frac{(1+\alpha y)}{(1+\alpha\mu)}\right).....(1)$$

The mean and variance of Y are given by $E(Y_i|\, x_i)=\mu_i$ and $V(Y_i|\, x_i)=\mu_i(1+\alpha\mu_i)^2$, where the mean of the dependent variable is related to the explanatory variables

through the link function $\mu_i = \mu_i(x_i) = \exp(x_i\beta)$. In this link function, x_i is a $(k-1)$ dimensional vector of covariates, β is a k-dimensional vector of regression parameters, and α is a dispersion parameter. The standard Poisson regression model is a special form of the generalized Poisson regression model. When α is equal to zero, the probability function of generalized Poisson random variable reduces to the Poisson probability function. The positive value of α in equation (i) indicates the over-dispersion, whereas the negative value of α indicates the under-dispersion property of the distribution (Consul & Felix, 2007).

For selecting the right type of Poisson regression model, it is necessary to check the existence of dispersion problem in the data. The moment estimators of the two parameters in the Poisson distribution given by Consul and Jain (1973) are as follows:

$$\hat{\mu} = \sqrt{\frac{\bar{y}^3}{S^2}}$$

And $$\alpha = 1 - \sqrt{\frac{\bar{y}}{S^2}}$$

Where $\hat{\mu}$ and s^2 are sample mean and variance respectively. The asymptotic variances of the moment estimators given by Shoukri (1980) are:

$$V\left(\hat{\mu}\right) \approx \frac{\hat{\mu}}{2n}\left[\hat{\mu} + \frac{2 - 2\hat{\alpha} + 3\hat{\alpha}^2}{1-\hat{\alpha}}\right]$$

And

$$V\left(\hat{\alpha}\right) \approx \frac{1-\hat{\alpha}}{2n\hat{\mu}}\left[\hat{\mu} - \hat{\mu}\hat{\alpha} + 2\hat{\alpha} + 3\hat{\mu}^{2}\right]$$

The adequacy of the GPR model over the PR model is assessed by setting the following hypothesis

$$H_0: \alpha = 0$$

$$Vs\ H_1: \alpha \neq 0.$$

This test of hypothesis determines whether the dispersion parameter is statistically different from zero. The rejection of H_0 recommends the use of the GPR model rather than the standard Poisson regression model. To perform the test, the asymptotically normal Wald type "Z" statistic defined as the ratio of the estimate of α to its standard error is used.

The estimation of regression coefficients β is obtained by the maximum likelihood approach (Islam et al., 2013). The log-likelihood functions of the GPR model is

$$Log\left(L\left(\beta,\alpha,y\right)\right) = \sum_{i=1}^{n}\left[y_i \log\left(\frac{\mu_i}{1+\alpha\mu_i}\right) + \left(y_i - 1\right)\log\left(1+\alpha y_i\right) - \frac{\mu_i\left(1+\alpha y_i\right)}{1+\alpha\mu_i} - \log\left(y!\right)\right]$$

…….…… (2)

Where,

$$\mu_i = \mu_i\left(x_i\right) = \exp(x_i\beta)$$

4.3.6: Multicollinearity problem of multiple regression analysis

In regression analysis, there is an important assumption is that the explanatory variables are independent each other i.e. there is no relationship between the explanatory variables to estimate the OLSE. But, in most applications of regression, the explanatory variables are related each other. This problem is called multicollinearity problem. In other words, it can be said that multicollinearity means the existence of a perfect or exact linear relationship among some or all explanatory variables of regression model. Collinearity refers to the existence of a single linear relationship between/ among the variables (Chatterjee and Hadi, 2006).

4.3.6.1: Types of multicollinearity

i) Exact/ perfect/ Serious multicollinearity and

ii) Near multicollinearity.

Exact multicollinearity:

If the explanatory variable of a regression model is exactly linearly related, this situation is defined as the problem of exact multicollinearity. In other hand/words, if the inter-correlation between the explanatory variable is perfect i.e. $r_{xi,yj} = +1$ or -1 then this situation is defined as the problem of exact multicollinearity or serious/ perfect multicollinearity.

Near multicollinearity:

If the explanatory variables are nearly linearly related, then this situation is defined as the problem of near multicollinearity.

4.3.6.2: Sources of multicollinearity

i) Data collection method employed,

ii) Constraints on the model or in the population,

iii) Model speciation,

iv) An over defined model and

v) Presence of high leverage point.

4.3.6.3: Techniques for detecting multicollinearity

i) Examination of correlation matrix (ECM),

ii) Variance inflation factor (VIF),

iii) Eigen values and condition number (ECN) and

iv) Eigen values decomposition (EVD).

Variance inflation factor (VIF):

The diagonal elements of the matrix C = $((X'X)^{-1}$ are very useful in detecting multicollinearity. The j^{th} diagonal element of C can be written as $C_{jj} = 1/(1-R^2_j)$;

Where R_j^2 is the co-efficient of determination obtained when X_j is regressed on the remaining (P=1, j = 1,2,…,P) regressors.

We known, $V(\hat{\beta}) = \sigma^2 (X'X)^{-1}$

$$V(\hat{\beta}_j) = \sigma^2 C_{jj}$$

Since, the variance of the j^{th} regression coefficient is $\sigma^2 C_{jj}$, we can view C_{jj} as the factor by which the variance of $\hat{\beta}_j$ is increased due to near linear dependencies among the regressors. For this $C_{jj} = 1/(1-R^2_j)$ is called the variance inflation factor (VIF) by marquardf (1970).

$$VIF_j = C_{jj}$$

So, after calculation, the decisions are as follows:

i) If $0 < VIF_j < 5$, then we can say that there is no evidence of multicollinearity.

ii) If $5 \leq VIF_j \leq 10$, then we can say that there is moderate multicollinearity and

iii) If $VIF_j > 10$, then we can say that there is several multicollinearity.

4.3.7: Variable selection procedures

When there are a large number of potential predictor variables, a set of procedures that does not involve computing of all possible regression equations has been proposed. These procedures have the feature that the variables. These procedures have the feature that the variables are introduced or deleted from the equation one at a time, and involve examining only a subset of all possible equations.

In discussing variable selection procedures, we distinguish between two broad situations:

1. The predictor variables are not collinear; that is, there is no strong evidence of multicollinearity and
2. The predictor variables are collinear; that is, the data are highly multicollnear.

Depending on the correlation structure of the predictor variables, we propose different approaches to the variable selection procedure. In generally, variable selection procedure allows the researcher to ask (and hopefully answer) the general question "what is the best predictor of success" Researchers might want to learn what are the best predictors of success. Psychologists may want to determine which.

Personality variable best predicts social adjustment. Sociologists may want to find out which of the multiple social indicators best predict whether or not a new immigrant group will adapt and be absorbed into society.

The variable selection procedure can be classified into two broad categories such as:

a) The forward selection procedure and

b) The backward elimination procedure and

4.3.7.1: Forward selection procedure

The forward selection procedure starts with an equation containing no predictor variables, only a constant term. The first variable included in the equation is the one which has the highest simple correlation with the response variable. If the regression coefficient of this variable is significantly different from zero it is retained in the equation, and a search for a second variable is made. The variable that enters the equation as the second variable is one which has the highest correlation with dependent variable after has been adjusted for the effect of the first variable, that is, the variable with the highest simple correlation coefficient with the residuals from step 1. The significance of the regression coefficient of the second variable is then tested. If the regression coefficient is significant, a search for a third variable is made in the same way. The procedure is terminated when the last variables are included in the equation. The significance of the regression coefficient of the last variable introduced in the equation is judged by the standard t-test computed from the latest regression equation. When you select the forward variable selection option, the independent variables will be individually added or deleted from the model at each

step of the regression (depending on your choice of F to Enter or F to Remove) until the "best" regression model is obtained (Chen, 2004).

4.3.7.2: Backward stepwise regression

The backward elimination procedure starts with the full equation and successively drops one variable at a time. The variables are dropped on the basic of their contribution to the reduction of error sum of squares. This is equivalent to deleting the variable which has the smallest t – test in equation. If all the t – tests are significant, the full set of variables is retained in the equation.

Assuming that there are one or more variables that have insignificant t – tests, the procedure operates by dropping the variable with the smallest insignificant t – test. The equation with the remaining (p-1) variables is then fitted and the t- tests for the new regression coefficients are examined (if we include p number of variables).

The procedure is terminated when all the t – tests are significant or all variables have been deleted. In most backward elimination algorithms the cutoff value for the t – test is set high so that the procedure runs through the whole set of variables, that is , starting with the p – variable equation and ending up with an equation containing only the constant term. The backward elimination procedure involves fitting at most p + 1 regression equations. When you select this technique, the independent variables will be removed from the regression equation (Chen, 2004).

When you select the backward elimination option, the independent variables will be removed from the regression equation one at a time (depending on your choice of F to Enter or F to Remove) until the "best" regression model is obtained.

4.3.7.3: Variable selection procedures present certain dangers

Variable selection procedures can be a valuable tool in data analysis, particularly in the early stages of building a model. But they present certain dangers:

1) Since the procedures automatically snoop through many models, the model selected may fit the data too well. That is, the procedure might look at many variables and select ones that, by pure chance, happen to fit well.

2) The three automatic procedures are heuristic algorithms, which often work very well but which may not select the model with the highest R- squared value (for a given number of predictors).

3) Automatic procedures cannot take into account special knowledge the analysis may have about the data, and the model selected may not be the beat from a practical point of view.

4.3.7.4: General remarks on variable selection methods

The variable selection procedures discussed above should be used with caution. These procedures should not be used mechanically to determine the "best" variables. The order in which the variables enter or leave the regression equation in stepwise regression procedures should not be interpreted as reflecting the relative importance of the variables. If these caveats are kept in mind, the variable selection procedures are useful tools for variable selection in non collinear situations. All procedures will give nearly the same selection of variables with non collinear data.

Several stopping rules have been proposed for the variable selection procedures. A stopping rule that has been reported to be quite effective is as follows:

- In FS: stop if minimum t-test is less than1.
- In BE: stop if minimum t-test is greater than1.

We illustrate the effect of different stopping rules in variable selection procedure. We recommend the backward elimination procedure over forward selection technique for variable selection (FS) procedure. One obvious reason is that in backward elimination (BE) procedure the regression equation with the full variable set is calculated and a available for inspection even thought it may not be used as the final equation. Although we do not recommend the use of stepwise regression procedure is better able to handle multicollinearity than the FS procedure (Mantel, 1970).

Variable selection procedures several equations are generated, each equation containing a different number of variables. The various regression equations generated can then be evaluated using a statistic such as multiple R, multiple R – square, the residuals for the various regression equations should also be examined. Regression equations with unsatisfactory residual plots are rejected. Only a total and comprehensive analysis will provide an adequate stepwise regression equations and a useful regression equation.

4.3.8: Criteria for evaluating models

There are four statistics are printed for each model:

1) ***R – squared (R^2)***: R^2 is also called the coefficient of determination.

The R^2 = SSR/ SST can be interpreted as the proportion of the total variation in Y that is accounted for by the predictor variable X. We may easily write R^2 as

$$\mathbf{R^2} = \frac{SSR}{SST}$$

$$= 1- \frac{SSE}{SST}, \ldots\ldots\ldots\ldots\ldots\ldots\text{(I)}$$

Additionally, it can be shown that

$$R^2 = \quad [Cor(Y, X)]^2 = [cor(Y, \hat{Y})]^2$$

Where, SST = SSR + SSE and SST = $\sum(y_i - \bar{y})^2$, SSR = $\sum(\hat{y}_i - \bar{y})^2$ and SSE= $\sum(y_i - \hat{y}_i)^2$

SST: Total sum of squared,

SSR: Sum of squares due to regression and

SSE: Sum of squared residuals (errors).

In simple linear regression, R^2 is equal to the square of the correlation coefficient between the response variable Y and the predictor X or to the square of the correlation coefficient between the response variable Y and the fitted values $\hat{Y}$.

The interpretation of the R^2 = square. The goodness- of-fit index, R^2, may be interpreted as the proportion of the total variability in the response variable Y that is accounted for by the predictor variable X. Note that $0 \leq R^2 \leq 1$ because $SSE \leq SST$. If, R^2 is near 1 then X accounts for a large part of the variation in Y. For this reason, R^2 is known as the coefficient of determination because it gives us an idea of how the predictor variable X accounts for (determines) the response variable Y. The same interpretation of R^2 will carry over to the case of multiple regressions. The high value of R^2 indicates a strong linear relationship between servicing time and the number of units repaired during a service call. When comparing models with the same number of predictors, choosing the model with the highest R – squared is equivalent to choosing the model with the smallest SSE (Montgomery, 2001).

2). *Adjusted R – Squared ($\overline{R}^2$):*

This is R – squared for degrees of freedom. If a variable is added to an equation, R^2 will get larger even if the added variable is of no real value. This is an approximately unbiased estimate of the population R^2 and is calculated by the formula

$$R^2_{(adj)} = 1 - \frac{SSError/(n-p)}{SSTotal/(n-1)} \quad \ldots\ldots\ldots\ldots\ldots\ldots \text{(II)}$$

When comparing models with different numbers of predictors, choosing the model with the highest adjusted R- squared is equivalent to choosing the model with the smallest mean square error (MSE) (Hosmer and Stanley, 2000) .

3). *Mallows C_p:*

Mallows develop this statistic in 1973. The Cp statistic is given by the formula

$$Cp = \frac{SS_p}{MSE_m} - (n-2p) \ldots\ldots\ldots\ldots\ldots\ldots \text{(III)}$$

Where SSEp is SSE for the best model with p parameters (including the intercept, if it is in the equation), and MSEm is the mean square error for the model with all m predictors.

In general, we look for models where Cp is small and is also close to p. If the model is adequate (i.e., fits the data well), then the expected value of Cp is approximately equal to p, the number of parameters in the model. A small value of Cp indicates that the model is relatively precise (has small variance) in estimating the true regression coefficients and predicting future responses. This precision will not improve much by adding more predictors. Models with considerable lack of fit have values of Cp larger than p or for more on Cp (Menard, 2002).

4.) ***Information Criteria: Akaike and Other Modified Forms***

The Akaike (1973) information Criteria (AIC) in selecting a model tries to balance the conflicting demands of accuracy (fit) and simplicity (small number of variables). The Akaike (1973) information Criteria (AIC) for a p- term equation (a constant, and (p-1) variables) is given by formula

$$AIC_p = n \ln(\frac{SSEp}{n}) + 2p \text{……..(IV)}$$

The models with smaller AIC are preferred. AIC penalizes the model that has larger number of variables. The numerical value of AIC for a single model is not very meaningful or descriptive. AIC can be used, however, to rank the models on the basis of their twin criteria of fit and simplicity. Larger differences in AIC indicate significant difference between the quality of the models. A great advantage of AIC is that it allows us to compare non-nested models. A group of models are nested if they can be obtained from a larger model as special cases. The AIC must be calculated on the same set of observations. If there are many missing values for some variables were missing will be dropped.

Several modifications of AIC have been suggested. One popular variation called Bayes Information Criteria (BIC), originally proposed by Schwarz (1978), is defined as

$$BIC_p = n \ln(\frac{SSEp}{n}) + p (\ln n) \text{…….. (V)}$$

The difference between AIC and BIC is in the severity of penalty for p. The penalty is far more severe in BIC when n>8. This tends to control the over fitting (resulting in a choice of larger p) tendency of AIC.

Another modification of AIC to avoid over fitting is the bias corrected version, AIC^c proposed by Hurvich and Tsai (1989), is given by

$$AIC^c_p = AIC_p + \frac{2(p+2)(p+3)}{n-p-3} \quad \text{..... (VI)}$$

The correction to AIC in (VI) is small for large n and moderate p. The correction is large when n is small and p large. One should never fit a large and complex model with a small number of observations. In general the correction to AIC will be minor, and we will not discuss AIC^c further. To guard against over fitting in our analysis we will Examine BIC (Menard, 2002).

4.4: Methods for measuring mother health

4.4.1: Descriptive statistics for health and socio-demographic variables

The tabulation and percentages provide a useful description for data from any distribution; especially for variable with order or unordered categories. So percentage distribution is used to know tabulation and percentage for all data.

For the assessment of health status BMI is regarded as the best instrument (Roche et al., 1981; FAO, 1993; Ferro-Luzzi et al., 1992; WHO, 2003; Flegal et al., 2005; Subramanian et al., 2009, Hossain et al., 2012). The classification of BMI by (WHO, 2003) to access the health status is as follows:

Table 7: Classification of body mass index (BMI)

Classification	BMI (kg/m^2)
Under weight	<18.5
Normal weight	18.5-24.9
Overweight	25.0-29.9
Obese	>=30.0

For screening of chronic energy deficiency (CED) grades, we took 18.5 as the cutoff point. The subjects were also classified on the basis of chronic energy deficiency (CED) grades following (James at al., 1988; Ferro-Luzzi et al., 1992; and Khongsdier, 2001; Bharati et al., 2007) as follows:

Table 8: Classification of chronic energy deficiency (CED)

Classification	BMI (kg/m^2)
CED grade III (sever thinness)	< 16.0
CED grade II (moderate thinness)	16.0-16.9
CED grade I (mild thinness)	17.0-18.49

4.4.2: T-test

For analyzing of data at first t-test has used in this study for comparison of mean values was utilized to find the differences in BMI between categories: urban versus rural; place of delivery at hospital/clinic versus at home; Caesarean versus non-Caesarean delivery; wealth index of poor versus rich and housewife versus labor/business. Statistical significance was accepted at $p<0.05$.

4.4.3: Application of one-way analysis of variance (ANOVA) for mother health in present study

To examine the interclass variation of the BMI, a one-way analysis of variance (ANOVA) was utilized. The model corresponding to each variable is:

$$Y_{ij} = \mu + \beta_i + \xi_{ij} \qquad [1]$$

$$i = 1, 2,..., k,$$

$$j = 1, 2,\ldots, r,$$

Where,

Y_{ij} is the j^{th} observation (response variable) for the i^{th} educational groups

μ is the general mean effect;

$\beta_i = \mu_i - \mu$ the additional effect of i^{th} educational groups;

μ_i is the average effect of i^{th} educational groups;

ξ_{ij} is the random error term,

Which follows normal distribution with mean zero (0) and variance (σ^2), k is the number of educational groups, and r is the number of observations for each groups.

The ANOVA procedure is primarily concerned with testing the hypothesis

H_0: $\beta_1 = \beta_2 = \ldots = \beta_p = 0$, or equivalently $\mu_1 = \mu_2 = \ldots = \mu_p = \mu$

Vs. H_1: at least two of the means (μ's) are not equal where P>2.

By means of a single $F_{\alpha, p-1, n-q}$ test. If the hypothesis of equality of educational group means is rejected, it may be concluded that there are differences among the educational group means. The standard assumptions of the ANOVA, randomness, normality and homogeneity of cohort variances were checked using the Kolmogorov–Smirnov non-parametric test, a normal probability plot, and the Levene test, respectively (Hossain et al., 2004).

4.4.4: Application of multiple logistic regression analysis in this study

Multiple logistic regression was used to examine the relative importance of socio-demographic factors on early childbearing mothers' health. In logistic regression the dependent variable is usually dichotomous, that is, the dependent variable can take the value 1 with a probability of success p, or the value 0 with probability (1-p) of failure. This type of variable is called a Bernoulli (or binary) variable. In this model, body size (BMI) was considered as a dependent variable coded as 0= Normal and overweight (BMI≥18.51) and 1= Underweight (BMI≤18.50). Subjects (15 samples) who had BMI>30 (kg/m^2) were excluded in this analysis.

Table 9: Variables considered for Logistic Regression Analysis (Categories and Codes)

Characteristics	Variable Level	Codes and Categories
Division	X_1	1=Barisal 2=Chittagong 3=Dhaka 4=Khulna 5=Rajshahi 6=Sylhet
Type of place of residence	X_2	0=Urban 1=Rural
Respondent education level	X_3	0=No Education 1=School Education 2=Higher Education
Partner education level	X_4	0=No Education 1=School Education 2=Higher Education
Respondent Occupation	X_5	0=Housewife 1=Hard labor
Partner Occupation	X_6	0=Employed 1=Farmer/worker
Wealth Index	X_7	1=Poorest 2=Poorer 3=Middle 4=Richer 5=Richest
Delivery System	X_8	0=Non-caesarian 1= Caesarian
Place of Delivery	X_9	0=Hospital/Clinic 1=Home
Age at First Marriage	X_{10}	Continuous
Respondent Age at First Birth	X_{11}	Continuous
Marriage to First Birth Interval	X_{12}	Continuous
Total Children Ever Born	X_{13}	Continuous

The underlying multiple logistic regression models corresponding to each variable is:

$$\log\left(\frac{p}{1-p}\right) = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 + \beta_4 X_4 + \beta_5 X_5 + \beta_6 X_6 + \beta_7 X_7 + \beta_8 X_8 + \beta_9 X_9 +$$

$$\beta_{10} X_{10} + \beta_{11} X_{11} + \beta_{12} X_{12} + \beta_{13} X_{13} \quad \ldots\ldots [1]$$

Where,

p = the probability of underweight (BMI≤18.50) (coded 1)

1-p = the probability of normal and overweight (BMI≥18.51) (coded 0)

β_0= intercept term, and

β_i = unknown logistic regression coefficients, (i = 1, 2, 3,….13).

The parameter β_i refers to the effect of X_i on the log odds such that Y= 1, controlling the other $X_{i's}$. In regression analysis (either linear or logistic) there is an important assumption which is made is that the explanatory variables not very much intercorrelated. If the regressors are too much correlated, then the problem is termed as multicollinearity problems. There are some systematic ways of detecting multicollinearity through none of them are perfectly satisfactory (Hossain et al., 2011). If, all the coefficients have very low standard errors, there is no evidence of the possibility of multicollinearity in a data set (Chan, 2004). For the multivariable analyses, logistic regression models were used to calculate odds ratios and 95% confidence intervals for the odd ratios, for all of the independent variables. All the statistical analysis should p-value of less than 0.05 was regarded as statistically significant.

4.4.5: Application of Stepwise regression in this study

Stepwise Regression is a technique for selecting influential variable in regression models (Chatterjee & Hadi, 2006). Finally in this study Stepwise Regression model (backward LR) will be used to find out the most influential factors on BMI. In Stepwise regression analysis both methods, forward LR and backward LR, compute the final step by subsequently adding (forward LR) or taking away (backward LR) variables. Both methods stop the iterative process once a process step is reached which no longer improves results significantly compared to the last step taken. Backward elimination may have the advantage that it will take into consideration suppressor effects that might be lost in forward inclusion (Menard, 2002). The backward elimination procedure starts with the full equation and successively drops one variable at a time. The variables are dropped on the basis of their contribution to the reduction of error sum of squares. The contribution of individual variable for each step was checked by Wald statistic test. If all the Wald-test values are significant, the full set of variables is retained in the final step. Statistical significance was accepted at $p<0.05$.

4.5: Methods for investigate the age at first marriage and its trends over time

Age at first marriage was classified into three classes according to age; (i) 12 years and younger, (ii) between 13 and 17 years and (iii) 18 years and older. To look the difference pattern of changes in age at first marriage, the sample was subdivided into two classes according to residence; (i) Urban and (ii) Rural. The sample was

subdivided into forty two groups according to their birth year cohorts from 1944 to 1985 to find the average trends in age at first marriage over time.

4.5.1: Application of one-way analysis of variance (ANOVA) for age at first marriage in present study

ANOVA was used to examine the interclass variation of age at first marriage. The statistical linear model for one-way analysis of variance (ANOVA) corresponding to each dimension as

$$Y_{ij} = \mu + \alpha_i + \varepsilon_{ij},\ i = 1, 2, \ldots, p, \text{ and } j = 1,2, \ldots, q,$$

Where,

Y_{ij} is the j^{th} observation (response) in the i^{th} birth year cohort,

μ is the general mean effect,

$\alpha_i = \mu_i - \mu$ the additional effect of i^{th} birth year cohort,

μ_i the average effect of i^{th} birth year cohort, and

ε_{ij} the error term.

ANOVA procedure is primarily concentrated on testing the hypothesis

$$H_0: \alpha_1 = \alpha_2 \ldots = \alpha_p = 0 \text{ equivalently } \mu_1 = \mu_2 = \ldots = \mu_p = \mu$$

Vs. H_1: at least two of the means (μ's) are not equal where P>2.

By means of a single $F_{\alpha, p-1, n-q}$ test. If the hypothesis of equality of cohort means is rejected, we may conclude that there are differences among the cohort means. The standard assumptions of the ANOVA, randomness, normality and homogeneity of cohort variances were checked using the Kolmogorov–Smirnov non-parametric test, a normal probability plot, and the Levene test, respectively (Hossain et al., 2004).

4.5.2: Application of simple linear regression model

Linear regression analysis has applied to detect the presence of trends in age at first marriage among the birth year cohorts from 1944 to 1985. The underlying multiple linear regression model corresponding to each variable is:

$$Y = \beta_0 + \beta_1 X_1 + \beta_2 X_2 + \beta_3 X_3 \quad (2)$$

Where,

Y is the response variable (age at first marriage),

Xi (i = 1, 2, 3) are the predictor variables (inter parameter measurements),

B_0 is the intercept term,

β_1, β_2 and β_3 are the unknown regression coefficients and

ε is the error term with a $N(0, \sigma^2)$ distribution.

Finally, statistically significance level was accepted at $p<0.05$.

4.6: Methods for evaluating the patterns of distributions of first marriage frequencies (using single year age distribution) and risks of the first marriages

Coale's nuptiality model is fitted to data on the age distribution of ever married populations of the year 2007. Attempts are made to capture the inherent peculiarities of the marriage pattern by estimating the parameters of the Coale's model for the different division in Bangladesh. Furthermore, first marriage frequency by single age is computed using the probability model given by (Coale and McNeil, 1972) and age patterns of risk of first marriage by means of model given by (Coale, 1971).

4.6.1: Parameters of the Coale's nuptiality model and their significance

The standard schedule of first marriage frequencies together with a schedule of proportion ever married and schedule of person-year lived in ever married status have been constructed by Coale' in interval of one-tenth of a year by making minor adjustments to the true schedule of first marriage frequencies recorded in Sweden from 1865 to 1869. The parameters which specify the marriage pattern in relation to the nuptiality schedule are as follows:

a_0 = The location parameter or the origin of the curve, which is not the minimum age at marriage but rather the age which a consequential number of marriages first occur. More precisely, the model implies that about one percent of the women will eventually marry have done so by age a_0, so that a_0 is close to the first percentile of the distribution (Rodriguez and Truessell, 1980).

k= The scale parameter indicating the tempo of marriage (also the time scale at which first marriage takes place). Literally, k implies the number of year in the standard schedule into which one year of marriage in the actual population may be packed, and therefore, represents the rate of marriage relative to Swedish female standard, 1865-1869. When k=1.0 the first marriages will spread over a range of 40 years, so that a women who reaches the age of a_0+40 without ever having married is unlikely to do so. Therefore, k represents the rate (tempo) of marriage relative standard schedule. The first marriage range depends on the values of k. If k less than or greater than 1.0, this period of 40 years is reduced or extended

proportionately i.e., if k is low, the rate of marriage (tempo) is high and first marriage range is short and vice versa.

c= The proportion who ultimately marry indicating the proportion ever married in a cohort fertility computed for each age group reflects the cumulative fertility rate of the age cohorts which, for women 45-49, may be assumed to be completed family size. The completed family in the case of cohort fertility will be level of fertility when first marriages has effectively ceased.

In actual population a_0 varies from 10 to 18 years, k from about 0.25 indicating a very short time scale and a very steep rise in the proportion ever married by age, to about 1.75 indicating a very slow tempo, and the value of c is very close to unity in some populations where marriage is almost universal where as in others as low as 0.75 (Lestheaghe, 1971). To other measures can be derived using the values of a_0 and k. One A_0=40.k which measures the age span within which majority of first marriages occur and the other A= a_0 +40k, the maximum age beyond which first marriage is unlikely to take place.

4.6.2: Estimation of the parameters and their implication

Fitting of the nuptiality schedule of an actual cohort is accompanied by the procedure given by Coale (1971). An outline of the estimation procedure is described below:

According to Coale determination of the parameters is based on a set of ratios R_1, R_2 and R_3 computed from the distribution of ever married population. Here we consider single year age distribution through in original model. Coale considered age interval for computing the ratio. Thus, the set of ratios is defined as follows:

R_1 = The ratio of proportion ever married in 15 year of age in which marriage occurs to the proportion ever married in 16 year of age.

R_2 = The ratio of proportion ever married in 16 year of age to the proportion ever married in 17 year of age and

R_3 =The ratio of proportion ever married in 17 year of age to the proportion ever married in 18 year of age.

To define the ratios more succinctly, if a_0 is in15 then,

$$R_1 = \frac{\Pr oportion \quad evermarried \quad in15}{\Pr oportion \quad evermarried \quad in16}$$

$$R_2 = \frac{\Pr oportion \quad evermarried \quad in16}{\Pr oportion \quad evermarried \quad in17}$$

$$R_3 = \frac{\Pr oportion \quad evermarried \quad in17}{\Pr oportion \quad evermarried \quad in18}$$

A given value of any of this ratios (R_1, R_2 and R_3) can occur with differential combinations of k and a_0 but if two ratios (i.e., R_1 and R_2) are specified one combination of k and a_0 is possible. Hence k and a_0 can be estimated by locating (through interpolation) the values would yield the observed R_1 and R_2 or the observed R_2 and R_3. If, the experience of the cohort fertility computed for each age group reflects the cumulative fertility rate of the age cohorts which, for women 45-49, may be assumed to be completed family size. The completed family in the case of cohort fertility will be the level of fertility were perfectly consistent with a transformed

standard curve, the values of k and a_0 indicated by R_1 and R_2 and by R_2 and R_3 would be the same. A perfect fit is rare, the recommended procedure is to combine R_2 with R_1 if $R_1 > (1 - R_3)$ and with R_3 if $R_1 < (1 - R_3)$ (Coale, 1971). The value of c (proportion ultimately ever married)is estimated by determining the person years lived ever married at the beginning and end of the third year age (17 and 18 if marriage begin between 15) in the transformed standard schedule with the estimated values of k and a_0. Specifically, one determines

$$k.z_s(17 - a_0)/k \text{ And } k.z_s(18 - a_0)/k$$

Where, z_s is the average number of person-years lived ever married. The difference between these two, divided by five is the proportion ever married in a cohort fertility computed for each age group reflects the cumulative fertility rate of the age cohorts which, for women 45-49, may be assumed to be completed family size. The completed family in the case of cohort fertility will be the level of fertility subject to a curve characterized by calculated values a_0 and k and with an ultimate proportion ever married of 1.0. The required estimate of c is then

$$\text{c}=\frac{proportion \quad evermarried \quad in16}{k\left[z_s\left(\frac{17-a_0}{k}\right)-z_s\left(\frac{16-a_0}{k}\right)\right]}$$

The proportion ever married of age a is $\text{G(a)}=c.G_s\left[(a-a_0)/k\right]$ where, $(a - a_0)/k = x_s$ is the standardized age and $G_s(x_s)$ is the marriages at age a (annual on the time scale of x_s) is $c.g_s(x_s)$. But one year on the x_s scale is k years for the given cohorts fertility computed for each group reflects the cumulative fertility rate of

age cohorts which, for women 45-49, may be assumed to the completed family size. The completed family in the case of cohort fertility will be level of fertility, hence g(a)=$(c/k)g_s[(a-a_0)/k]$. Similarly, z(a)=$c.k.z_s[(a-a_0)/k]$

Fitting of Coale's nuptiality model to actual data requires the distribution of ever married population by age. Such distribution of females of Bangladesh for the Bangladesh Demographic and Health survey 2007.

4.6.3: Age structure of first marriage

The first marriage by age is defined as the ratio of the number of the first marriages in the interval relative to the number of person-years lived in the interval and is denoted by g(a). In other words, it is defined as the number of first marriages in the interval of age, say a to a+1 divided by the number of persons (irrespective of marital status) in the age interval. Values of g(a) have been computed for females with the help of the standard first marriage frequencies, $g_s(x_s)$ by the following equation.

$$g(a) = \frac{c}{k} \cdot g_s x_s$$

The values of g(a) thus found for females in single years of age. Similar g(a) value can also be estimated from the closed form of analytical expression of the probability density function of age at first marriage given by (Coale and McNeil, 1972).

4.6.4: Risk of first Marriage

The risk of marriage means the change of exposure to the marriage. It can be defined as the rate of first marriage at each age for those eligible for first marriage, i.e., those who are still single. Estimation of risk of first marriage can be made using the relation

$$r_s(x_s) = g_s(x_s)/[1 - G_s(x_s)]$$

Where, $r_s(x_s)$ is the standard risk of first marriage at age x_s

$g_s(x_s)$ is the standard first marriage frequency at age x_s and

$G_s(x_s)$ is the standard proportion ever married up to age x_s.

As standard earlier $x_s = (a - a_0)/k$ denotes the standardized age

For an observed population knowing a_0, k and c the risk of first marriage say R(a) can be in turn from the estimated relation

$$R(a) = g(a)/[c - G(a)]$$

Where, $g(a) = c/k.g_s(x_s)$

= The first marriage frequency between ages a to a+1 and

$G(a) = c.G_s(x_s)$

= proportion ever married up to the exact age at which can be estimated from the standard schedule of proportion ever married $G_s(x_s)$ at x_s.

According to Coale's the risk of first marriage for an observed population can be estimated directly from the following double exponential model.

$$r(a) = \frac{0.174}{k} \exp(-4.41 \exp(-0.309((a - a_0)/k)))$$

The r(a) function smoothes the values given by R(a). After that it approaches a horizontal asymptotic. R(a) values are ataractic in higher ages in all indicated divisions. The fact is that in higher ages, the risks of marriage are sensitive to errors in the cumulated values of first marriage frequencies and the first marriage arbitrary adjustment of cross-sectional data (Coale, 1971).

The function of R(a) values for females which as stated earlier. Again, noting that values of R(a) and r(a) must be mathematically less than unity, but some values of R(a) at the higher ages are found to be greater than one, this may be defective data. The fact values of a_0 , k, c, A_0 and A and the values of r(a) and g(a) what have been generated recurring Coale's nuptiality model to Bangladesh population reflect that marriage in Bangladesh has began to show some changes from the recent past without much changes in the basic parameters of nuptiality.

4.7: Methods for measuring health and nutritional status of early childbearing mothers' children in Bangladesh

4.7.1: Dependent variable for generalized Poisson regression model

Researchers can define nutritional status of early childbearing mothers' children differently. The nutritional status of a child is typically based on several measurements namely height, weight, sex and age of the child. Three commonly used measures for nutritional status are height-for-age, weight-for-height and weight-for-age (Waterlow et al., 1977). These measures are then expressed as Z-scores from the median of the reference population. In this study, 'weight-for-height' has used because it can describe current nutritional status by linking body mass in relation to body length. It does not require the exact age information of the child, which is necessary for the 'weight-for-age' (NIPORT, 2009). It can also track whether a child recently receives sufficient contents of nutrients to build and maintain bodyweight along with other factors such as genetic growth, environment, and disease burden on activity level (Bhagowalia et al., 2011). This study followed the national report of Bangladesh (NIPORT, 2009) and the guidelines of the World Health Organization for define child malnutrition (Bhagowalia et al., 2011). According to these reports, a child is malnourished if the Z-score is below -2 SD (standard deviation) from the median of the reference population. The dependent variable in this study was expressed as the number of under-five malnourished children in a Bangladeshi family.

4.7.2: Covariates/predictor variables for generalized Poisson regression model

Table 10: Variables considered for generalized Poisson regression model (Categories and Codes)

Predictor variables	Group
Division	1=Barisal 2=Chittagong 3=Dhaka 4=Khulna 5=Rajshahi 6=Sylhet
Place of residence	0=Urban 1=Rural
Mother's education	0=No Education 1=School Education 2=Higher Education
Father's education	0=No Education 1=School Education 2=Higher Education
Mother's occupation	0=Housewife 1=Hard labor
Father's occupation	0=Employed 1=Farmer/worker
Wealth index	1=Poorest 2=Poorer 3=Middle 4=Richer 5=Richest
Delivery System	0=Non-caesarian 1= Caesarian
Place of Delivery	0=Hospital/Clinic 1=Home
Toilet facility	0=No 1=Yes
Sources of drinking water	1=Piped water 2=Tube well water 3=Others
Access to media	0=No 1=Yes
Total number of children ever born to a woman	Continuous
Total number of children dead in a family	Continuous

This study considers several covariates (Table 10) as predictors which are commonly reported in the nutritional studies of children. Two of these variables namely wealth index and access to media are composite variables. The wealth index is an asset-based index that reflects the relative socioeconomic status of the household and is widely used in low- and middle-income countries to quantify inequalities and to control the confounding effect of socioeconomic variables. It is based on the household ownership variables (e.g. car, refrigerator, television), housing characteristics (e.g. materials of the floor, roof, walls) and access to services (e.g. availability of electricity) (Khan et al., 2011). Access to media, which is also a composite index, is based on three mass media variables namely whether they listen to ratio, watch television, and read newspaper or magazine. This is categorized into two groups, where 'yes' means respondents have access to at least one of these media and 'no' means no access to any of these media.

4.7.3: Application of Generalized Poisson regression model in this study

At the outset of analyses, sample mean and sample variance of the dependent variable are calculated in order to check whether it follows the standard Poisson regression model or GPR model. Then the Z test is performed to check whether the dispersion parameter significantly deviates from zero.

Here the null hypothesis is,

$H_0 : \alpha = 0$ i.e. the value of dispersion parameter is zero.

Vs $H_1 : \alpha \neq 0$ i.e. the value of the dispersion parameter is unequal to zero.

Bivariate analyses (based on Pearson Chi-square test) are performed to examine association between dependent variable and each of the selected predictors. All significant predictors are then finally included into the GPR model. As the dependent variable is more appropriate for the GPR model because of its under-dispersion property, we applied this model to estimate the regression parameters (β) including 'p' values based on Wald Chi-square values. Finally, Incidence Rate Ratio (IRR) and 95% confidence interval are calculated for each group of the categorical predictors.

CHAPTER FIVE

RESULTS

5.1: Introduction

Recent research document has focused on rapidly growing interest on adolescents' and their child health in the developing and under developed countries because of its important implications not only for the health of mother but also their children. The main objective of this study is to evaluate and analyze the impact of early childbearing on the mother and their child health of rural and urban community in Bangladesh.

This chapter expressed about the result on health impact of early childbearing mothers and their children.

5.2: Mother health

5.2.1: Descriptive statistics for early childbearing mothers in Bangladesh

The descriptive statistics provide a useful description for data from any distribution; especially for variable with order or unordered categories. Means and standard deviations of respondent's age, age of first birth, weight, height and BMI of married and currently non-pregnant Bangladeshi women who give at least one birth were present in current section.

A total of 1908 early childbearing currently non-pregnant Bangladeshi mother were analyzed. The age of subjects varied from 15 to 24 years, with mean age 20.29 ± 2.54 years (95% CI: 20.17–20.40). The average weight was 44.96 ± 7.09 kg (95% CI: 44.64-45.27), with range 27.50 to 88.00 kg. The mean height of sample population was 150.32 ± 5.42 cm (95% CI: 150.08-150.56), ranging from 129.60 to 168.20 cm. BMI of our subjects varied from 11.95 kg/m^2 to 37.79 kg/m^2, with a mean of 19.86 ± 2.70 kg/m^2 (95% CI: 19.74-19.98). The age at first childbirth of these women varied from 12 to 19 years, with the mean being 16.46 ± 1.67 years (95% CI: 16.38-16.53) (Table 11).

Table 11: Descriptive statistics for age, age of first birth, height, weight and BMI of early childbearing young mothers in Bangladesh

				95% CI for mean		Mini-mum	Maxi-Mum
Variable	Mean	SD	SE	Lower	Upper		
Age	20.29	2.54	0.06	20.17	20.40	15	24
Age of first birth	16.46	1.67	0.04	16.38	16.53	12	19
Weight (kg)	44.96	7.09	0.16	44.64	45.27	27.50	88.00
Height (cm)	150.32	5.42	0.12	150.08	150.56	129.60	168.20
BMI (kg/m^2)	19.86	2.70	0.06	19.74	19.98	11.95	37.79

The cutoff point taken 145cm at which mothers can be considered at risk because of short stature is normally between 140 and 150 centimeters (BDHS, 2007). Overall,

the mean height for women was 150.32 ± 5.42 cm where about 15.7 percent (n=299) women fall below the cutoff of 145 centimeters (Table 12).

Table12: Frequency distribution of height of early childbearing mothers

Mothers Height category	N	Percentage
Less than 145 cm	299	15.7
145 cm and upper	1609	84.3

When study the women according to body size (BMI categories), noted that more than 61% of the women had normal weight (61.6%), while 33.3% were undernourished (underweight). Very few were overweight (4.3%) and obese (0.8%) (Table 13), and they were more likely to be from the urban areas (Fig.3). The percentage of underweight women was higher in rural areas compared to that of urban areas (Table 14).

Table 13: Frequency distribution of body size (BMI category) of early childbearing mothers

BMI category	N	Percent
Underweight (BMI ≤ 18.5 km/m^2)	636	33.3%
Normal weight (18.5 < BMI < 25 km/m^2)	1175	61.6%
Overweight (25≤BMI<30 km/m^2)	82	4.3%
Obese (BMI ≥30 km/m^2)	15	0.8%

Table 14: Difference between urban and rural in the proportion (percentage) of underweight and obese mothers

	Underweight	Obese
Rural	35.40%	0.80%
Urban	26.90%	1.80%

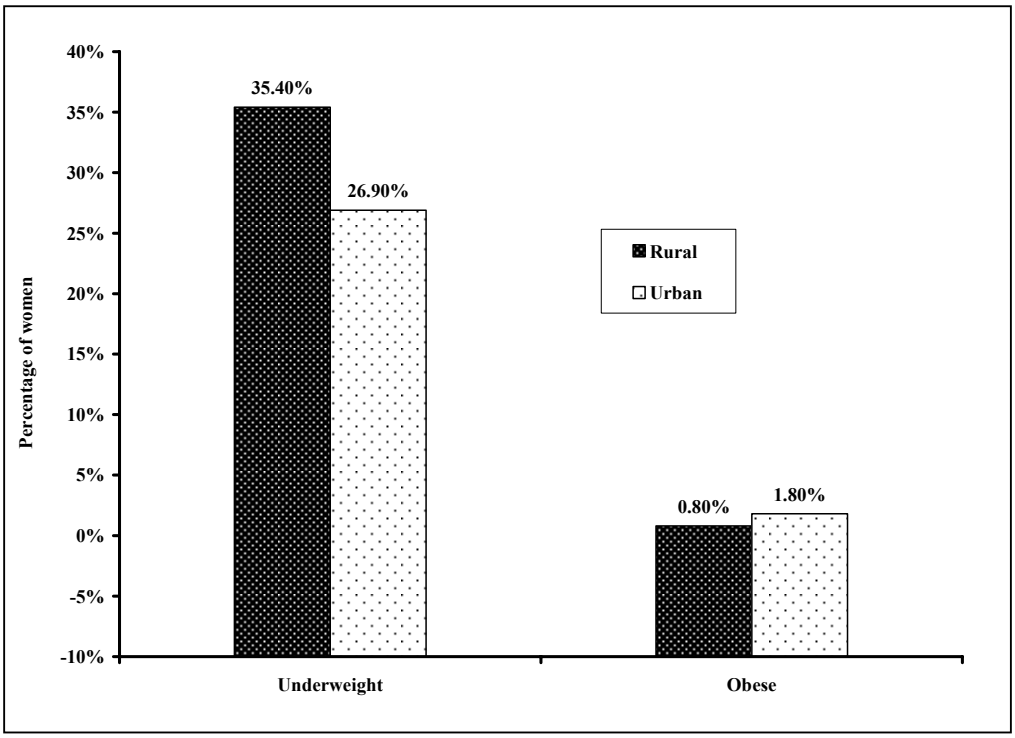


Figure 3: Difference between urban and rural in the proportion (percentage) of underweight and obese mothers

There were found a large variation by background characteristics. The mean BMI values of the study population depicted graphically by educational status of early childbearing mother (Table 15). There was an increasing trend of BMI in both urban and rural sectors with increasing educational level of women in Bangladesh. Moreover, the average BMI value of urban mother was more than that of rural mothers for each education level (Fig. 4). These results suggest that education is an important factor for body mass index of Bangladeshi early childbearing mother in Bangladesh.

Table 15: Descriptive statistics for BMI by different educational status of early childbearing young mothers in Bangladesh

Mothers Education Level	BMI						
	N	Mean	SD	95% CI for mean		Mini-mum	Maxi-mum
				Lower	Upper		
No education	540	19.38	2.45	19.18	19.59	14.85	37.79
Primary	662	19.64	2.59	19.44	19.84	14.51	33.28
Secondary	553	20.17	2.59	19.95	20.38	11.95	29.98
Higher	153	21.41	3.58	20.83	21.98	15.42	33.39

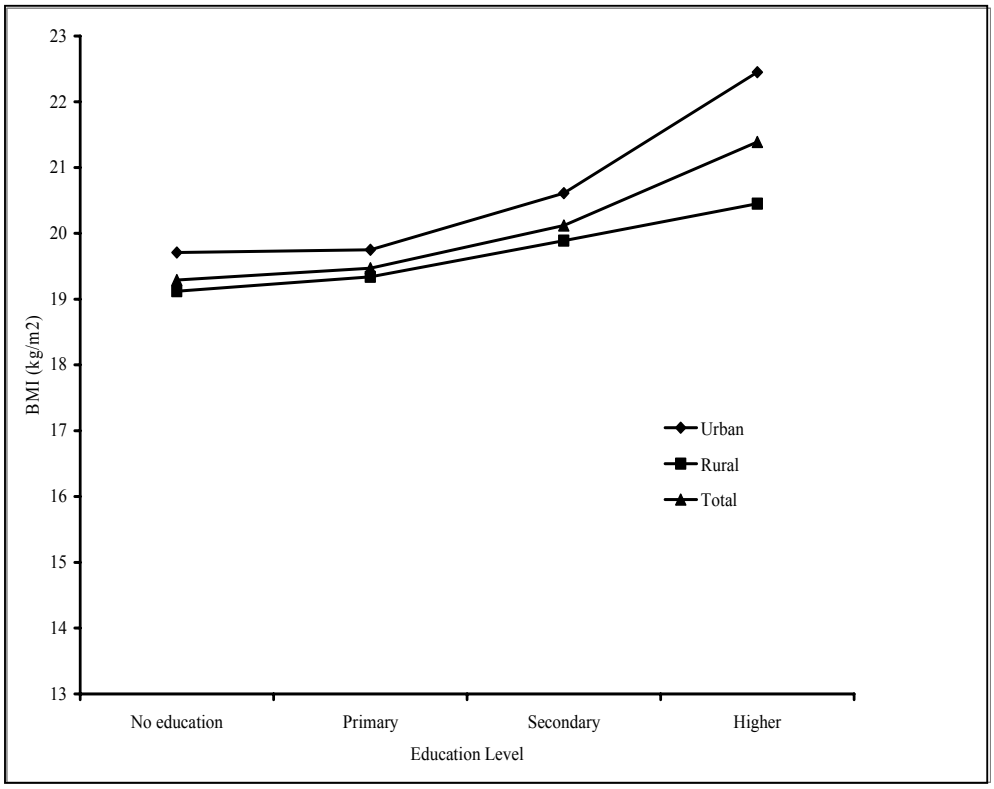


Figure 4: Relationship between respondent education level and body mass index

When analyze the BMI according to chronic energy deficiency (CED), noted that 33.3% early childbearing mothers were suffering from chronic energy deficiency (BMI $\leq$ 18.5). Among them 10.69% mothers had severe thinness (CED grade III), 22.01% had moderate thinness (CED grade II) while 67.30 % had mild thinness (CED grade I) (Table 16). The risk of CED of early childbearing women who came from rural environment was higher than that of urban women for all categories of CED (Fig. 5).

Table 16: Frequency distribution of chronic energy deficiency (CED) mothers among CED grades

CED category	N	Percent
CED grade III (sever thinness) (BMI< 16.0 kg/m^2)	68	10.69%
CED grade II (moderate thinness) (16.0 kg/m^2≤BMI<17.0 kg/m^2)	140	22.01%
CED grade I (mild thinness) (17.0 kg/m^2≤BMI≤18.5kg/m^2)	428	67.30%

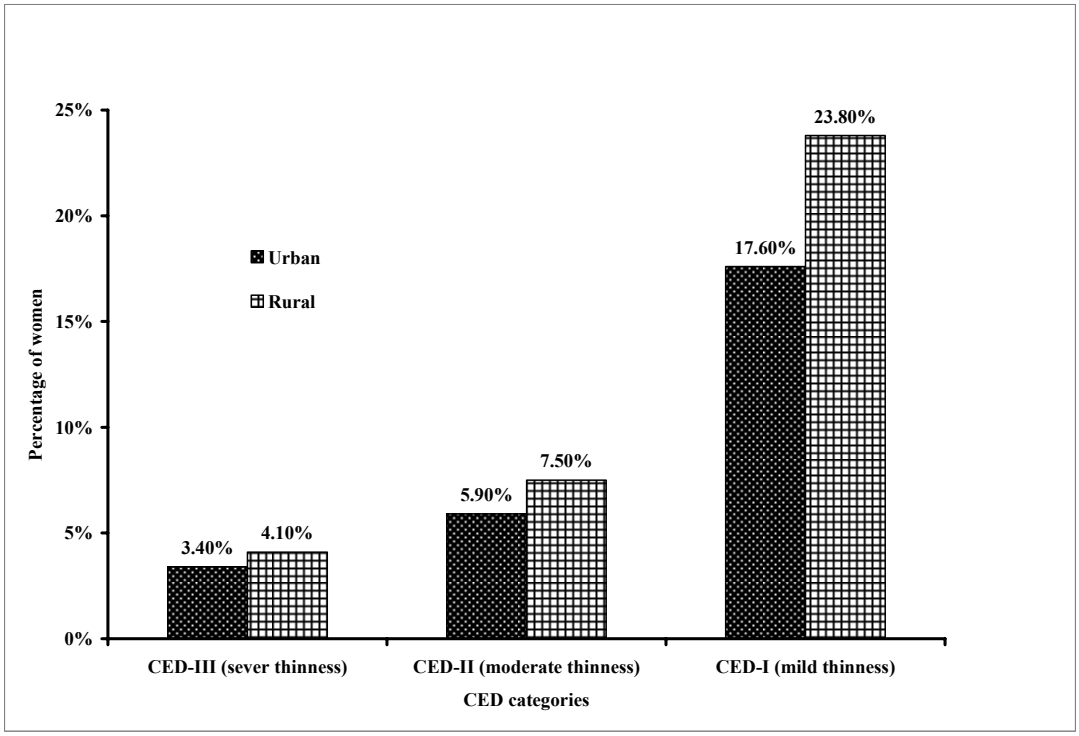


Figure 5: Differences between urban and rural early child bearing mothers in proportion (percentage) of several categories of CED

As educational attainment, more than 42 percent (42.45) illiterate women suffer from Chronic Energy Deficiency (CED) disease. Which was higher than primary, secondary and higher educated women (36.01 percent, 20.0 percent and 1.6 percent respectively). Deferent CED category gave similar result and maximum 47.1 percent illiterate women were suffered from CED grade III (Table 17). A decreasing trend was found in the number (proportion) of women who were suffering CED as the educational level increased. These results suggested that education and residences were important factors for CED (Fig. 6).

Table 17: Descriptive statistics for CED by different educational status of early childbearing young mothers in Bangladesh

Chronic Energy Deficiency (CED)	Mothers Education Level							
	No Education		Primary		Secondary		Higher	
	N	%	N	%	N	%	N	%
CED grade III (sever thinness)	32	47.1	24	35.3	10	14.7	2	2.9
CED grade II (moderate thinness)	49	35.0	63	45.0	27	19.3	1	0.7
CED grade I (mild thinness)	189	44.2	142	32.2	90	21.0	7	1.6
Total	270	42.45	229	36.01	127	20.0	10	1.6

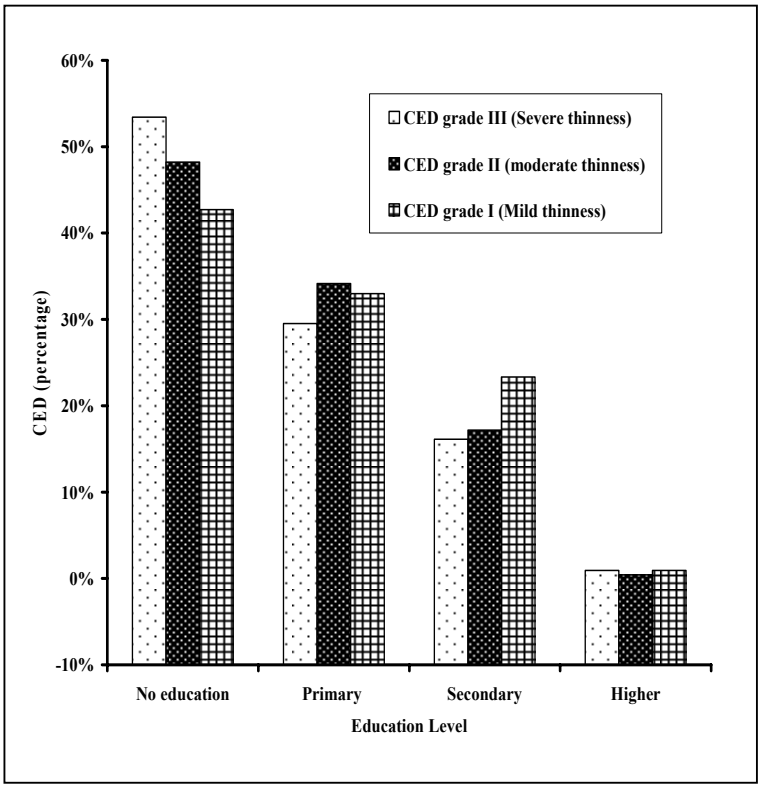


Figure 6: Association between the several categories of chronic energy deficiency (CED) and education level of mothers

5.2.2: Mean differences in BMI between different socio-demographic factors for early childbearing mothers in Bangladesh

The differences of mean BMI between two groups of residence type, delivery place, delivery system, wealth index and occupation of respondents are presented in the current section. More than 68 percent mother was living in a rural environment. Mother who lived in urban areas had higher BMI than rural ($p<0.05$). A higher percent of women (84.2%) still delivered babies at home and they had a significantly lower BMI ($p < 0.05$) than women who delivered at a hospital/clinic. Women who

delivered at a hospital/clinic were classified into two classes: Caesarean and non-Caesarean. It was found that caesarean mother had a higher BMI than those who delivered without surgery ($p < 0.001$). In our study, the majority of women were poor (62.3%), and they had a lower BMI than rich women ($p < 0.05$). More than 75 percent of women (75.5%) were housewives, and these had a higher BMI than those of others ($p < 0.05$) (Table 18).

Table 18: Mean differences in early childbearing mothers BMI by socio-demographic factors and their significance

Socio Demographic Factors	Group	N	Mean	SD	SE	Mean difference	p-value
Type of place of Residence	Urban	607(31.8%)	20.36	3.05	0.12	0.74	0.000
	Rural	1301(68.2%)	19.62	2.49	0.07		
Place of Delivery	Hospital/ Clinic	301(15.8%)	21.02	3.17	0.18	1.38	0.000
	Home	1607(84.2%)	19.64	2.55	0.06		
Delivery system	Caesarian	133(7.0%)	21.61	3.29	0.28	1.88	0.000
	Non-Caesarian	1775(93.0%)	19.73	2.61	0.06		
Wealth Index	Rich	720(37.7%)	20.59	3.08	0.11	.1.18	0.004
	Poor	1188(62.3%)	19.41	2.33	0.06		
Respondent Occupation	Housewife	1441(75.5%)	19.97	2.78	0.07	0.45	0.038
	Other	467(24.5%)	19.52	2.39	0.11		

5.2.3: Analysis of variance for BMI of Bangladeshi women by educational status

One-way analysis of variance (ANOVA) has utilized for examine the interclass variation. The mean BMI values of the study population depicted graphically by educational status of women (Table 15). There was a significant ($p<0.05$) increasing trend of mean BMI among educational status of women in Bangladesh (Fig. 4) (Table 19).

Table 19: One way analysis of variance (ANOVA) for BMI of Bangladeshi women by educational status

	Sum of squares		Degrees of freedom		Mean square		
	Between group	Within group	Between group	Within group	Between group	Within group	F_{cal}
BMI	396.33	13538.55	3	1904	132.11	7.11	18.58**

** 1% level of significance

5.2.4: Results for multiple logistic regression analysis for anthropometric measurements of early childbearing mothers when body mass index (BMI) is response variable

Logistic regression model were used to calculate odds ratios and 95% confidence intervals for the odd ratios, for all of the independent variables. The result of logistic regression models are presented in (Table 20)

Based on different region in Bangladesh the logistic regression coefficients of different division were negative and statistically significant ($p<0.05$) except Rajshahi division ($p>0.05$). Sylhet division considered as the reference category of the different region in Bangladesh. The odds ratios of Barisal, Chittagong, Dhaka, Khulna and Rajshahi are 0.627, 0.568, 0.629, 0.664 and 0.778 respectively. This means that the mother of Sylhet division had a chance to be undernourished 0.627 ($p<0.05$), 0.568 ($p<0.05$), 0.629 ($p<0.05$), and 0.664 ($p<0.05$) times higher than Barisal, Chittagong, Dhaka and Khulna division respectively. This result suggests that the mother of Sylhet division have higher risk for undernutrition.

The logistic regression coefficients demonstrated that the effect of place of residence was positive and statistically significant ($p<0.01$). Mothers who came from rural areas had a 41.6% ((1.416-1)*100) chance to be undernourished, higher than urban mothers.

Women's educational level had significant ($p<0.01$) contribution to the body size of Bangladeshi early childbearing women. Illiterate (no education) women were considered as reference category for the level of education. The regression coefficients and odds ratio demonstrated that illiterate mothers had a chance to be undernourished 0.661 and 0.328 times higher than secondary educated ($p<0.01$) and higher educated ($p<0.01$) women, respectively. Similar result was found for partner's/husband's educational level (Table 20). Results suggest that both woman's and her husband's educations are important factors for women health status.

Mothers who were involved with hard labor had 1.298 times higher risk of being undernourished than mothers who were housewife ($p<0.05$). On the other hand, the

women whose partners were unemployed had 46.6% [(1.466-1.00) x 100] higher risk of being undernourished than mothers whose partners were employed ($p<0.01$).

Regarding economic condition, the logistic regression coefficients of wealth index at different levels were negative and statistically significant ($p<0.05$). Poorest group were considered as the reference category of the level of wealth index. The odds ratios of poor, middle, rich and richest are 0.703, 0.663, 0.615 and 0.363 respectively which shown a clear decreasing tendency, it means that the poorest women had high risk of becoming underweight than that of the other three. As a result, for decreasing economic status, the health condition of early childbearing mother in Bangladesh was strictly decreased. The odds ratios of regression analysis found poorest mothers had a chance to be undernourished 0.703 ($p<0.05$), 0.663 ($p<0.05$), 0.615 ($p<0.05$), and 0.363 ($p<0.001$) times higher than poor, middle, rich and richest mothers, respectively. Above results suggest that wealth index can play an important role among young mothers towards improvement of health status.

The risk of being undernourished for mothers who delivered naturally was 0.335 times higher than those who had delivery by caesar. In addition, mother who delivered at home was 2.219 times higher risk of being undernutrition compared to mothers who delivered at hospital/clinic.

Age at first marriage and age at first childbirth was negatively related to underweight and both were statistically significant ($p<0.05$). It means that women who got marriage one year earlier had additional 6.8% [(1-0.932)*100] chance to become undernourished following every subsequent delivery. In addition, women who got first baby one year earlier had a chance to become underweight [(1-0.957)*100] 4.3% higher than their counter part. Marriage to first birth interval showed insignificant

result where significant and positive association was found between children ever born and underweight. The coefficient and odds ratio of logistic regression showed that women had risk for getting underweight 1.057 times higher at every single birth compared to the previous birth (Table 20). If the number of ever born children was increased, the percentages of underweight women were also increased but number of obese women was decrease (Fig.7).

In regression analysis (either linear or logistic) there is an important assumption, which is made, that the explanatory variables not very much intercorrelated. If the regressors are too much correlated, then the problem is termed as multicollinearity problems. There are some systematic ways of detecting multicollinearity through none of them are perfectly satisfactory (Hossain et al., 2011). Since in our analysis all the coefficients have been found to be significant because of very low standard errors, and thus there is no possibility of arising multicollinearity in our data (Chan, 2004).

Table 20: Estimates of the odds ratios for selected socio-economic and demographic characteristics through logistic regression analysis

Variable	Coefficient	SE	Wald	p -value	OR	95% CI for odds ratio	
						Lower	Upper
Division	---	---	13.255	0.021	---	---	---
Barisal Vs Sylhet	-0.467	0.189	6.096	0.014	0.627	0.433	0.908
Chittagong Vs Sylhet	-0.565	0.176	10.309	0.001	0.568	0.402	0.802
Dhaka Vs Sylhet	-0.464	0.171	7.359	0.007	0.629	0.449	0.879
Khulna Vs Sylhet	-0.410	0.184	4.969	0.026	0.664	0.463	0.952
Rajshahi Vs Sylhet	-0.251	0.170	2.166	0.141	0.778	0.558	1.087

Table 20 (Continued)

Place of Residence	0.346	0.107	10.401	0.001	1.414	1.146	1.745
Respondent education level	---	---	23.495	0.000	---	---	---
Secondary Vs No educated	-0.414	0.129	10.342	0.001	0.661	0.514	0.851
Higher Vs No educated	-1.114	0.371	9.040	0.003	0.328	0.159	0.678
Partner education level	---	---	30.446	0.000	---	---	---
Secondary Vs No educated	-0.359	0.107	11.155	0.001	0.699	0.566	0.862
Higher Vs No educated	-0.948	0.220	18.554	0.000	0.387	0.252	0.596
Respondent's Occupation	0.261	0.119	4.787	0.029	1.298	1.028	1.639
Partner's Occupation	0.382	0.098	15.306	0.000	1.466	1.210	1.775
Wealth Index	---	---	35.633	0.000	---	---	---
Poor Vs Poorest	-0.352	0.150	5.515	0.019	0.703	0.524	0.943
Middle Vs Poorest	-0.270	0.151	3.212	0.043	0.663	0.568	0.826
Rich Vs Poorest	-0.485	0.156	9.727	0.002	0.615	0.454	0.835
Richest Vs Poorest	-1.013	0.175	33.364	0.000	0.363	0.257	0.512
Delivery System	-1.093	0.248	19.424	0.000	0.335	0.206	0.545
Place of Delivery	0.756	0.152	24.708	0.000	2.129	1.580	2.868
Age at First Marriage	-0.071	0.022	10.522	0.001	0.932	0.893	0.972
Age at First Birth	-0.044	0.022	4.002	0.045	0.957	0.917	0.999
Marriage to 1st birth interval	0.004	0.002	3.377	.066	1.004	1.000	1.009
Children Ever Born	0.055	0.020	7.955	0.005	1.057	1.017	1.098

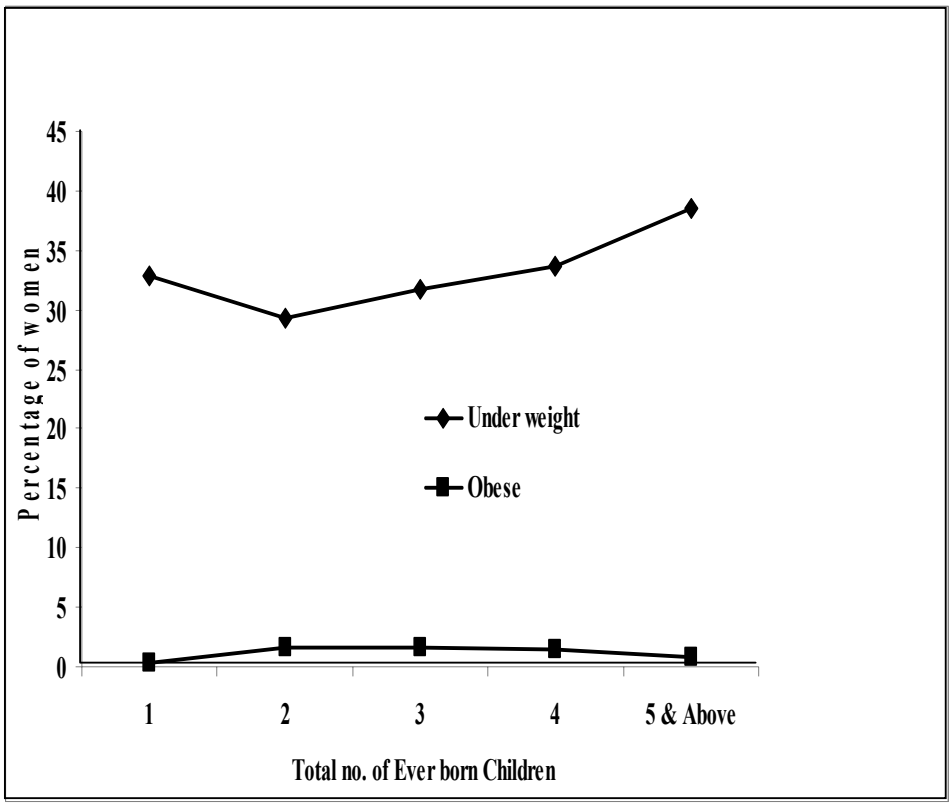


Figure 7: Association between proportions (percentage) of underweight and obese women with the total ever-born children

5.2.5: Stepwise regression analysis results for find out the most influential factors on response variable body mass index (BMI)

Stepwise regression (backward elimination) has used to find out the most influential factors on response variable Body Mass Index (BMI). In stepwise regression analysis, all of seventeen socio-demographic response variables were included in the first step for BMI as a dependent variable (Table 21). In first step, the least significant variable based on the Wald statistics was number of household member (0.013) and the corresponding p-value indicating also insignificant. So, number of household member is the variable which has excluded from the model in the second step. In the second step, marriage to first birth interval (0.021) was least significant and p-value indicating also insignificant; therefore, this variable was excluded from the model in third step. The other variables i.e. women age, husband occupation, age of partner, religion, partner education level and finally division were excluded from the model by repeating the same procedure. The final step included the variables based on Wald statistics; type of place of residence, mother education level, mother occupation, wealth index, delivery system, place of delivery, age at first marriage, age at first birth and total children ever born which were statistically significant ($p<0.05$). Based on Wald statistics finally, concluded that age at first marriage (16.258) was the most influential variable on early childbearing and undernourished mother in Bangladesh (Table 21).

Table 21: Summary of the stepwise (backward elimination) regression analysis (first and final steps) for find out the most influential factors, where BMI is the response variable

Step	Variable	Coefficient	SE	Wald	df	p-value
Step 1	Age of mother	-0.533	0.132	1.080	1	0.124
(a)	Division	0.079	0.031	2.290	1	0.342
	Type of place of residence	0.124	0.119	7.013	1	0.000
	Respondent education level	-0.196	0.131	8.233	1	0.013
	Partner education level	-0.156	0.102	2.332	1	0.491
	Respondent occupation	0.224	0.124	3.236	1	0.004
	Partner occupation	0.116	0.112	1.086	1	0.172
	Wealth index	-0.188	0.046	9.592	1	0.013
	Delivery system	-0.538	0.306	3.077	1	0.042
	Place of delivery	0.346	0.195	3.168	1	0.048
	Age at first marriage	0.008	0.072	16.377	1	0.008
	Age at first Birth	0.093	0.072	4.635	1	0.037
	Marriage to first birth interval	-0.025	0.172	0.021	1	0.909
	Total children ever born	0.199	0.080	6.184	1	0.027
	Number of household member	-0.007	0.060	0.013	1	0.724
	Religion	-0.251	0.183	1.867	1	0.058
	Age of father	-0.303	0.240	1.594	1	0.207
	Constant	-1.715	0.731	5.498	1	0.019
Step 9	Type of place of residence	0.116	0.106	7.455	1	0.000
	Respondent education level	-0.187	0.113	7.624	1	0.006
	Respondent occupation	0.215	0.123	3.044	1	0.001
	Wealth index	-0.126	0.041	9.731	1	0.002
	Delivery system	-0.534	0.305	3.064	1	0.030
	Place of delivery	0.380	0.192	3.908	1	0.042
	Age at first marriage	0.098	0.036	16.285	1	0.000
	Age at first birth	0.095	0.064	4.627	1	0.024
	Total children ever born	0.191	0.078	6.016	1	0.014
	Constant	-1.899	0.639	8.846	1	0.003

(a) Variable(s) entered on step 1: Age of mother, Division, Type of place of residence, Respondent education level, Partner education level, Respondent occupation, Partner occupation, Wealth index, Delivery system, Place of delivery, Age at first marriage, Age at first birth, Marriage to first birth interval, Total children ever born, Number of household member, Religion and Age of father.

5.3: Study on age at first marriage among ever married women in Bangladesh

Since age at first marriage was found influential variable for getting baby at early age, so need to study on age at first marriage among Bangladeshi ever married women. In this study, secular trend in age at first marriage over time among ever married women is to be observed. Also, Coale's model has been used to find the age pattern of marriage among ever married Bangladeshi women.

5.3.1: Frequency distribution of age at first marriage

The total sample of 47,109 married Bangladeshi women from 1944-1985 were analyzed in the present section. The age of subjects varied from 15 to 49 years with mean age 32.22 ± 8.82 years. The average age at first marriage of the women was 14.73 ± 2.96 years (95% CI: 14.70–14.75), ranging from 6 to 39 years (Table 22), and the median was 14.00 years. Women lived in rural environment got marriage (14.47 ± 2.77 years) significantly ($p<0.01$) earlier than urban women (15.41 ± 3.35 years). The mean age at first marriage in BDHS-surveys conducted year 1993-1994, 1996-1997, 1999-2000, 2004 and 2007 was 14.15, 14.21, 14.99, 15.05 and 15.50 year, respectively (Table 22).

Table 22: Descriptive statistics for age at first marriage by year of surveys conducted years and residence

Surveys conducted year	N	Mean	SD	Median	95% CI for Mean		Mini-mum	Maxi-mum
					Lower Bound	Upper Bound		
1993-1994	13860	14.15	2.81	14.00	14.16	14.25	6	35
1996-1997	7511	14.21	3.01	14.00	14.09	14.22	6	35
1999-2000	8716	14.99	3.00	14.00	14.93	15.05	6	37
2004	8929	15.05	2.81	14.00	14.99	15.11	10	39
2007	8093	15.50	3.05	15.00	15.44	15.57	9	37
Total sample	47109	14.73	2.96	14.00	14.70	14.75	6	39
Residence							Mean Difference	
Urban	12637	15.41	3.35	15.00	15.35	15.47	0.94**	
Rural	34472	14.47	2.77	14.00	14.44	14.50		

**: 1% level of significant

The frequency distribution of age at first marriage of Bangladeshi women by residence is presented in (Table 23). More than 68% (urban 65.1% and rural 69.1%) women got marriage between 13 to 17 years old. A remarkable number (17.0%) of Bangladeshi women got marriage before they reached at 13 years old, among them 18.5% were living in rural environment and 13.1% in urban, while only 14.9% (urban 21.8% and rural 12.4%) women got marriage at 18 years old and older (Table 23).

Table 23: Frequency distribution of age at first marriage by residence

	Residence		
	Urban	Rural	Total
AAFM≤12	1651 (13.1%)	6377 (18.5%)	8028 (17.0%)
13≤AAFM≤17	8229 (65.1%)	23837 (69.1%)	32066(68.1%)
18≤AAFM	2757 (21.8%)	4258 (12.4%)	7015(14.9%)

AAFM: Age at first marriage

5.3.2: Secular trends of age at first marriage

Figure 8 displays mean age at first marriage of Bangladeshi women BDHS-surveys conducted years from 1993-1994 to 2007. The age at first marriage showed the increasing tendency with changing time (1993-1994, 1996-1997, 1999-2000, 2004 and 2007).

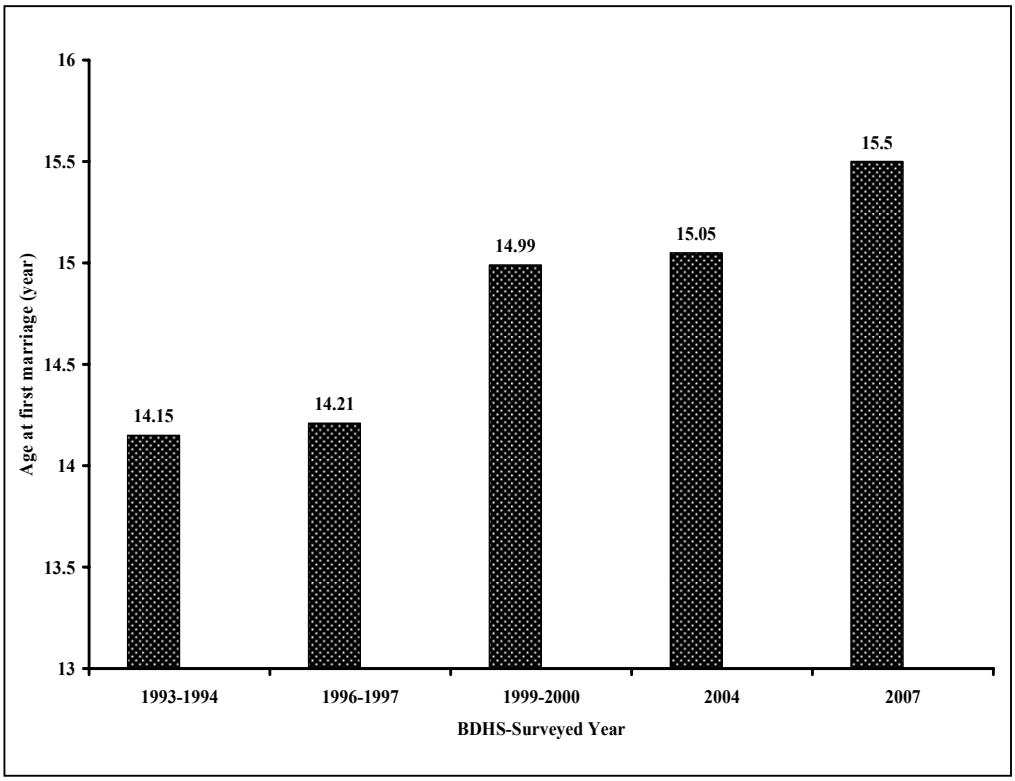


Figure 8: Trends in age at first marriage of Bangladeshi women during the BDHS-investigated years

5.3.2.1: Result of One-way Analysis of Variance (ANOVA) for age at first marriage by birth year cohorts from 1944 to 1985

Since the data of the current section has subdivided into cohorts by birth year, this facilitated a study of possible trends over time. The variation in age at first marriage among the birth year cohorts from 1944 to 1985 examined with the ANOVA. Before using ANOVA, it is necessary to ensure that the standard assumption underlying the ANOVA model is satisfied. Consequently, the data were checked for randomness,

normality and homogeneity. The Kolmogorov–Smirnov non-parametric test and the normal probability plot exhibited no serious problems concerning the randomness and normality of the data. In addition, the Levene test showed that the data were homogeneous. Thus, the data satisfied the standard assumptions of the ANOVA model. The ANOVA results demonstrated that the variations in age at first marriage of Bangladeshi women among the birth year cohorts from 1944 to 1985 were statistically significant ($p<0.01$) for urban, rural and whole samples (Table 24).

Table 24: ANOVA results for age at first marriage by birth year cohorts from 1944 to 1985

Residence	Source of variation	Sum of Squares	df	Mean Square	F_{cal} -value	p-value
Urban	Between Groups	4260.99	38	112.13	10.279	0.001
	Within Groups	137424.41	12598	10.91		
Rural	Between Groups	4289.83	38	112.89	14.972	0.003
	Within Groups	259628.98	34433	7.54		
Total sample	Between Groups	8910.38	38	234.48	27.266	0.001
	Within Groups	404797.94	47070	8.60		

5.3.2.2: Result of linear regression analysis for age at first marriage on year of birth from 1944 to 1985

To further examine the presence of trends in age at first marriage, linear regression coefficients were computed. The mean age at first marriage values of the study population are depicted graphically in Figure 9 by birth year cohort from 1944 to 1985. This figure showed yearly fluctuations in average age at first marriage. This is characteristic of such cohort study.

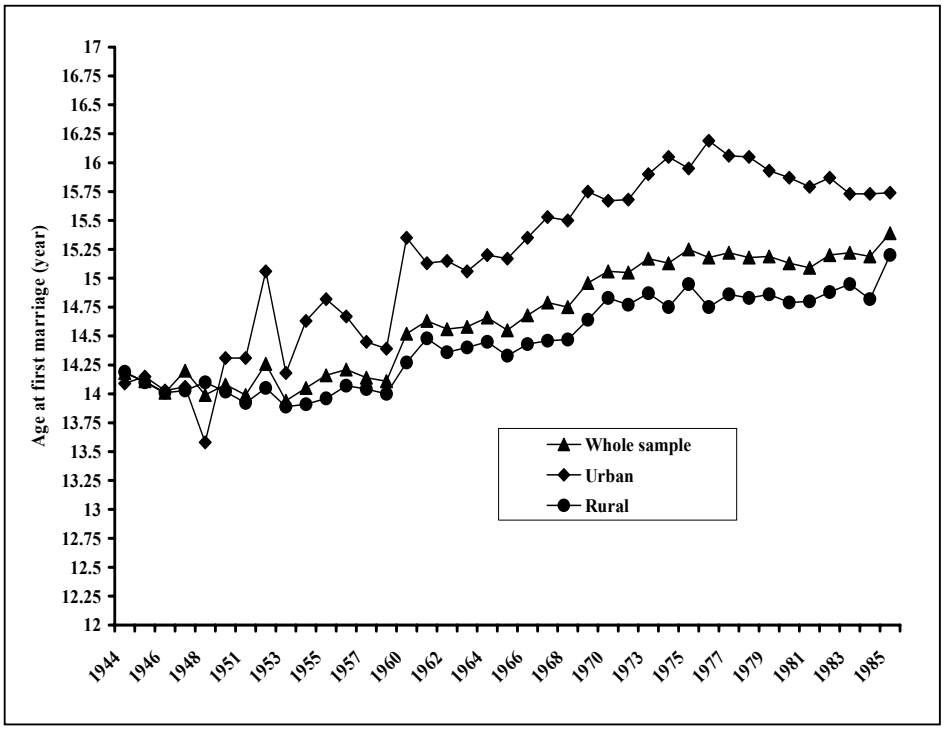


Figure 9: Trends of age at first marriage of Bangladeshi women over time

These fluctuations of age at first marriage further examined with linear regression. The coefficients of regression analysis demonstrated that the average rate of increase of age at first marriage for urban women was 0.051 years (95% CI: 0.05-0.06, $p<0.01$), and for rural was 0.031 years (95% CI: 0.03-0.03, $p<0.01$), age at first marriage for the whole sample was 0.040 years (95% CI: 0.04-0.042, $p < 0.01$) among the birth year cohorts from 1944 to 1985 (Table 25). Results indicated that age at first marriage of Bangladeshi women were showing increasing tendency among the birth year cohorts from 1944 to 1985.

Table 25: Coefficient of linear regression analysis for age at first marriage on year of birth from 1944 to 1985

Residences	Model	Coefficient	SE	T-value	p-value	95% CI of coefficient	
						Lower	Upper
Urban	(Constant)	-85.48	5.812	-14.71	0.003	-96.88	-74.09
	Year of birth	0.051	0.003	17.36	0.001	0.05	0.06
Rural	(Constant)	-47.206	2.778	-16.99	0.001	-52.65	-41.76
	Year of birth	0.031	0.001	22.20	0.002	0.03	0.03
Total sample	(Constant)	-63.316	2.561	-24.724	0.001	-68.34	-58.29
	Year of birth	0.040	0.001	30.475	0.002	0.04	0.042

Figure 10 displays the trends in child (age at first marriage ≤17) marriage and marriage after 18 years and older. Child marriage among Bangladeshi women showed slightly decreasing tendency for both urban and rural female population during the birth year cohorts from 1944 to 1985, while the marriage at 18 years and older showing increasing tendency (Figure 10).

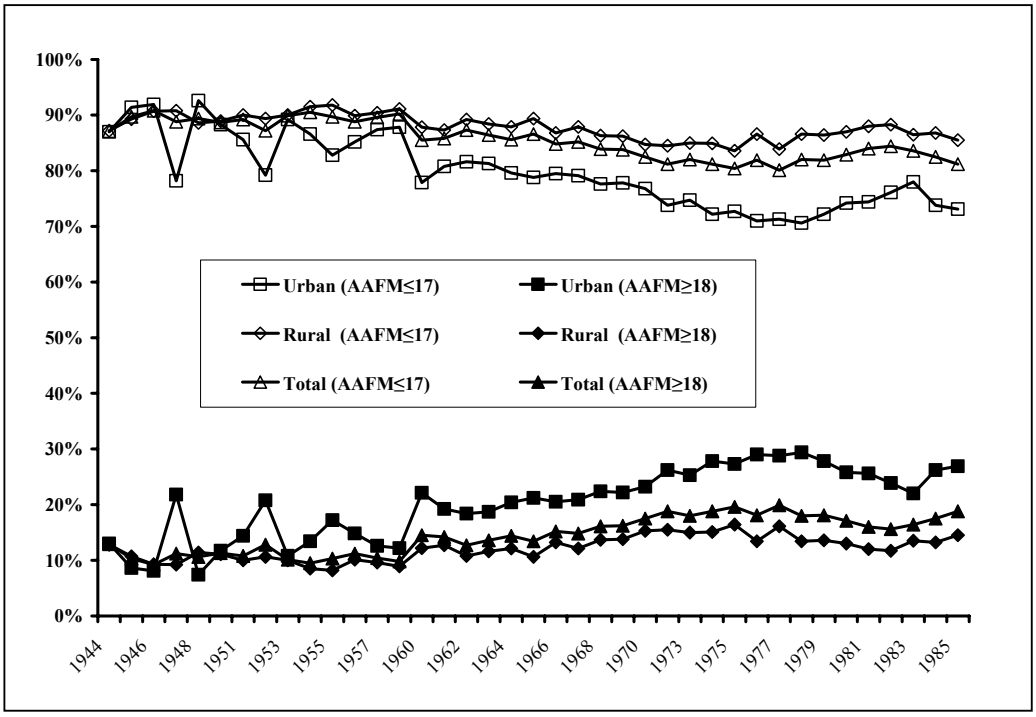


Figure 10: Trends in child and adult age at first marriage of Bangladeshi women over time

5.4: Age pattern of Marriage (Coale's Model)

5.4.1: Estimation of the parameters of Coale's nuptiality model

Extracted data of total sample 10,996 from Bangladesh demographic and health surveys (BDHS-2007) eventually all of 15 to 49 years ever married women were analyzed in the present section. According to the procedure outlined by Coale the values of R_1, R_2 and R_3 computed from the distribution of ever-married females by single year of age given in (Table 26).

Following the procedure mentioned earlier the values of the parameters a_0, k and c and that of A_0 and A for females for the year 2007 are estimated and presented in (Table 26). The value of a_0 for single year age distribution is 15.33 and the value of k is 0.553. The quantity of marriage implied by the estimated value of the parameter c is very close to unity for all Bangladeshi females. Hence, marriage in Bangladesh has always remained universal; i.e., almost all females marry. The span of marriage, which measures the age span within which majority of first marriages occur, indicated by A_0 is 22.12. This result is very low with compared to other country perspective. So, in Bangladesh the majority of first marriage occurs in very low ages. The values of A reflect the maximum age beyond which first marriage is unlikely to take place. It is indicated that a female who reached the age of 37 years without having married for the first time in Bangladesh.

Table 26: Estimated values of the parameters of Coale's nuptiality model for Bangladeshi women

Female		
Parameter		Value
	R_1	0.448
R	R_2	0.547
	R_3	0.602
a_o		15.33
k		0.553
c		1.00
A_0		22.12
A		37.45

The values of g(a) thus found for females in single years of age are presented in Table 26. This g(a) value can be estimated from the closed form of analytical expression of the probability density function of age at first marriage given by Coale and McNeil (1972).

5.4.2: First marriage frequencies of Bangladeshi women

The graph of g(a) is depicted in figure 1 for females. It is observed from the distribution of first marriage frequencies, g(a) in (Table 27) that most of the marriages of females occur within age of 22 in Bangladesh.

The rate of first marriage of females has highest at age 20 in Bangladesh. Thus it is apprehended that the peak age of first marriage of females has shifted from age 19 to 20 under study. Very few marriages of females occur after age 30. This implies that marriage occurs at very early ages, the tempo of marriage is very high and first marriage is completed with in a short period.

It is evident that the first marriages for females occur at a low intensity at the initial age of marriage with an increasing tendency up to the peak age of marriage and after that, the frequency of first marriage goes on decreasing (Figure 11). This shows the first marriage frequency for female's increases steeply after age a_0 up to the peak age of marriage showing the sharp peak and decline rapidly for short age span indicating too high intensity of occurrence of first marriage. The frequency of first marriage decline slowly in later ages compared to the initial ages. The most crucial ages of first marriage of females are probably first few years of marriageable ages.

Table 27: First marriage frequencies of females by age of Bangladesh

Age	Frequency of first marriage	Age	Frequency of first marriage
(a)	g(a)	(a)	g(a)
16	0.0158773	27	0.0261299
17	0.0526939	28	0.0190956
18	0.1018796	29	0.0134177
19	0.1354055	30	0.0102171
20	0.1411197	31	0.0082639
21	0.1273767	32	0.0066003
22	0.1035794	33	0.0049186
23	0.0809214	34	0.0035443
24	0.0622417	35	0.0024593
25	0.0464191	36	0.0018264
26	0.0351172	37	0.0011935

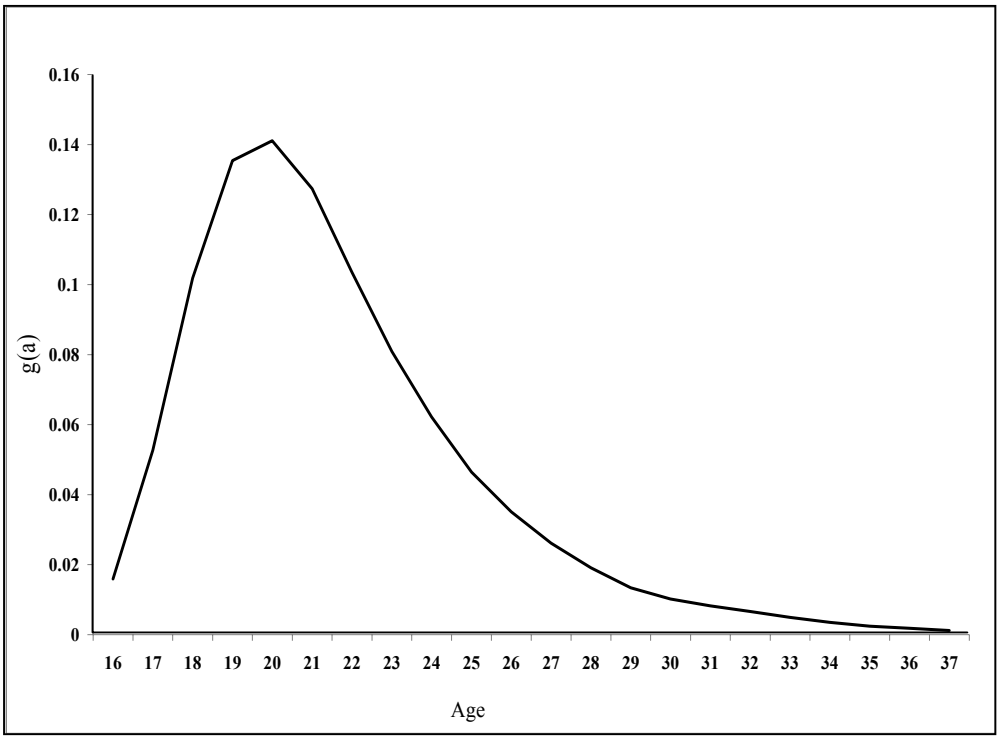


Figure 11: First marriage frequencies of females by single year age for Bangladesh.

5.4.3: Risk of first marriage

The value of r(a) for females in Bangladesh are estimated and presented in (Table 28). In female population, the risk of first marriage was observed to be lower at young ages compared to later ages. Such risk rises very steeply with in a very short span of marriageable age after the age of which a reasonable number of first marriages occur. It increases very sharply from initial age up to age 22 in Bangladesh. After that it approaches a horizontal asymptotic. The r(a) values were ataractic in higher ages in

all over the region in Bangladesh. The fact was that in higher ages, the risks of marriage were sensitive to errors in the cumulated values of first marriage frequencies and the first marriage arbitrary adjustment of cross-sectional data (Coale, 1971).

The pattern of r(a) for females is depicted in (Figure 12). It shows that the risk of first marriage rises steeply after the beginning age at marriage due to a very short span of marriageable ages and then it reaches the asymptotic. By age 22 r(a) values almost reach asymptotes.

Table 28: Risk of first marriage of females by age of Bangladesh

Age	Risk of first marriage	Age	Risk of first marriage
(a)	r(a)	(a)	r(a)
16	0.016397	27	0.324798
17	0.061135	28	0.325525
18	0.127752	29	0.325934
19	0.193032	30	0.326162
20	0.243234	31	0.326291
21	0.276853	32	0.326363
22	0.297672	33	0.326403
23	0.310008	34	0.326425
24	0.317139	35	0.326438
25	0.321204	36	0.326445
26	0.323503	37	0.326449

Figure 12: Risk of first marriage of females by age of different Divisions in Bangladesh

5.5: Child Health

5.5.1: Descriptive statistics of early childbearing mothers' children in Bangladesh

In the section of child health, total sample of 3207 early childbearing mothers' children has analyzed. The estimated mean of the sample was $\bar{Y}$= 0.626 and the variance was ($s_y^2 = 0.369$) which reveals the under-dispersion property of the data. Within the total sample, 18.6 percent children of childbearing mothers' were malnourished (>Median – 2 SD) among them 15.2 percent were moderate wasting (Median – 3 SD to Median – 2 SD) and 3.4 percent were severe wasting (< Median – 3 SD) (Table 29).

Table 29: Frequency distribution of children's nutritional status on the basis of weight- for- height (WHZ) Z-score

Cut-off level	N	Percent
Normal (≥ Median – 2 SD)	2608	81.3
Moderate Wasting (Median – 3 SD to Median – 2 SD)	489	15.2
Severe Wasting (< Median – 3 SD)	110	3.4

The mean number of the ever born children was 2.81 ± 1.817 ranging from 1 to 12. Where, the average of number of living children was 2.55 ± 1.561 with range 1 to 10. The mean number of children died in a family was 0.26 ± 0.614 where, maximum 6 children died in a family (Table 30).

Table 30: Descriptive statistics for overall mean SD and SE of children in Bangladesh

Variable	Mean	SD	SE	Minimum	Maximum
Total children ever born	2.81	1.817	0.032	1	12
Number of living children	2.55	1.561	0.028	1	10
Total number of children dead in a family	0.26	0.614	0.011	0	6

Table 31 shows the average number of ever born children, living children and number of children dead in a family by different division. Among all divisions Sylhet was the most vulnerable region of Bangladesh because of where averagely maximum children were born (mean 3.58 ± 2.25 and 95% CI: 2.46 ± 2.96), alive (mean 3.16 ± 1.62 and 95% CI: 2.99 ± 3.34) and died (mean 0.42 ± 0.80 and 95% CI: 0.34 ± 0.49). Chittagong were the next vulnerable region where average number of ever born children, living children and children died in a family were (mean 3.03 ± 1.94 and 95% CI: 2.87 ± 3.18), (mean 2.77 ± 1.69 and 95% CI: 2.64 ± 2.91) and (mean 0.28 ± 0.59 and 95% CI: 0.24 ± 0.35) respectively. The average number of ever born children, living children and children died in a family of Dhaka, Barisal, Rajshahi and Khulna division were (mean 2.83 ± 1.73 and 95% CI: 2.70 ± 2.96), (mean 2.56 ± 1.46 and 95% CI: 2.45 ± 2.67) and (mean 0.27 ± 0.59 and 95% CI: 0.23 ± 0.32); (mean 2.80 ± 1.75 and 95% CI: 2.64 ± 2.96), (mean 2.56 ± 1.51 and 95% CI: 2.42 ± 2.69) and (mean 0.25 ± 0.57 and 95% CI: 0.20 ± 0.30); (mean 2.41 ± 1.49 and 95% CI: 2.29 ± 2.53), (mean 2.20 ± 1.29 and 95% CI: 2.09 ± 2.30) and (mean 0.21 ± 0.60 and 95% CI: 0.16 ± 0.26) and (mean 2.19 ± 1.72 and 95% CI: 2.06 ± 2.32), (mean 2.02 ± 1.14 and 95% CI: 1.91 ± 2.13) and (mean 0.17 ± 0.46 and 95% CI: 0.12 ± 0.21) respectively.

Table 31: Descriptive statistics of children in Bangladesh by different division

Characteristics	Division	Statistic					95% CI for Mean	
		Mean	SD	SE	Mini-mum	Maxi-mum	Lower Bound	Upper Bound
Total children ever born	Barisal	2.80	1.75	0.082	1	9	2.64	2.96
	Chittagong	3.03	1.94	0.078	1	11	2.87	3.18
	Dhaka	2.83	1.73	0.066	1	10	2.70	2.96
	Khulna	2.19	1.72	0.065	1	8	2.06	2.32
	Rajshahi	2.41	1.49	0.062	1	10	2.29	2.53
	Sylhet	3.58	2.25	0.105	1	12	3.37	3.79
Number of living children	Barisal	2.56	1.51	0.071	1	9	2.42	2.69
	Chittagong	2.77	1.69	0.068	1	10	2.64	2.91
	Dhaka	2.56	1.46	0.056	1	8	2.45	2.67
	Khulna	2.02	1.14	0.056	1	6	1.91	2.13
	Rajshahi	2.20	1.29	0.053	1	9	2.09	2.30
	Sylhet	3.16	1.62	0.090	1	10	2.99	3.34
Total number of children dead in a family	Barisal	0.25	0.57	0.027	0	3	0.20	0.30
	Chittagong	0.28	0.59	0.024	0	4	0.24	0.35
	Dhaka	0.27	0.59	0.023	0	4	0.23	0.32
	Khulna	0.17	0.46	0.023	0	4	0.12	0.21
	Rajshahi	0.21	0.60	0.025	0	6	0.16	0.26
	Sylhet	0.42	0.80	0.038	0	5	0.34	0.49

Table 32 provides descriptive statistics for all predictors. According to this table, most of the respondents (67.8 percent) come from rural environment where maximum 21.3 percent from Dhaka division. Most of the mother was housewives (71.9 percent) few were involved with hard labor (28.1) where as more than half of the children's father was farmer (56.0 percent). Illiteracy rate is lower among mothers of children (27.7 percent) as compared to their fathers (35.3 percent). In contrast, the rate of higher education is higher among fathers of children (7.9 percent) than their mothers (2.9 percent). Nearly 52 percent of the families have access to the mass media. About two-third of the families (61.3 percent) have no toilet facility.

Table 32: Basic characteristics of children parents and households in Bangladesh

Variable	Group	N	Percent
Division	Barisal	452	14.1
	Chittagong	615	19.2
	Dhaka	682	21.3
	Khulna	412	12.8
	Rajshahi	591	18.4
	Sylhet	455	14.2
Place of residence	Urban	1033	32.2
	Rural	2174	67.8
Mother's education	Illiterate	889	27.7
	Primary	1090	34.0
	Secondary	1136	35.4
	Higher	92	2.9
Father's education	Illiterate	1133	35.3
	Primary	994	31.0
	Secondary	827	25.8
	Higher	253	7.9
Mother's occupation	Housewife	2306	71.9
	Hard labor	901	28.1
Father's occupation	Employed	1411	44.0
	Farmer/worker	1796	56.0
Wealth index	Poorest	679	21.2
	Poorer	713	22.2
	Middle	649	20.2
	Richer	608	19.0
	Richest	558	17.4
Delivery System	Non-caesarian	3029	94.4
	Caesarian	178	5.6
Place of Delivery	Hospital/Clinic	410	12.8
	Home	2797	87.2
Toilet facility	No	1966	61.3
	Yes	1241	38.7
Sources of drinking water	Piped water	170	5.3
	Tube well water	2660	82.9
	Others	377	11.8
Access to media	No	1558	48.6
	Yes	1649	51.4
Religion	Muslims	2967	92.5
	Non-Muslims	240	7.5

5.5.2: Bivariate analysis (Chi-square/Exact test) of early childbearing mothers' children in Bangladesh

Table 33 shows the summary results of bivariate analyses (Chi-square/Likelihood ratio test) between outcome and predictor variables. All the predictors except religion and fathers occupation show significant ($p<0.001$) associations with outcome variable. The significant variables used in the multivariate analysis.

Table 33: Bivariate associations (Chi-square/Exact test) between the living children in a family and different predictors in Bangladesh

Characteristics	Test value	p-value
Division	213.006	0.000
Place of residence	35.80	0.000
Mother's education	647.62	0.000
Father's education	176.99	0.000
Mother's occupation	37.588	0.000
Father's occupation	12.42	0.019
Wealth index	142.29	0.000
Delivery System	56.76	0.000
Place of Delivery	111.13	0.000
Toilet facility	11.74	0.000
Sources of drinking water	70.74	0.000
Access to media	140.95	0.000
Religion	24.16	0.427
Total children ever born	7691.89	0.000
Total number of children dead in a family	271.836	0.000

5.5.3: Generalized Poisson regression analysis for measuring nutritional status of early childbearing mothers' children in Bangladesh

The estimated value of the dispersion parameter (α) and its standard deviation are -0.40275 and 0.000538, respectively. Null hypothesis of the study formulated as $H_0 : \alpha = 0$, (Z= -15.1405 and $p < 0.05$) is rejected at 5% level of significance.

According to the results of GPR analysis (Table 34), variables namely division, mother's education, father's education, mothers occupation, wealth index, delivery system, place of delivery, toilet/sanitation, sources of drinking water, as well as total number of children were statistically associated with the child malnutrition in Bangladesh.

Based on different region in Bangladesh the estimated regression coefficients of different division were negative and statistically significant ($p<0.05$). Sylhet division has considered as the reference category of the different region in Bangladesh. The estimated IRR of Barisal, Chittagong, Dhaka, Khulna and Rajshahi were 0.564, 0.680, 0.601, 0.265 and 0.364 respectively. This means that the children of Sylhet division had a chance to be undernourished 43.6% [(1-0.564)*100] ($p<0.05$), 32% [(1-0.680)*100] ($p<0.05$), 39.9% [(1-0.601)*100] ($p<0.05$), 73.5% [(1-0.265)*100] ($p<0.05$) and 63.6% [(1-0.364)*100] ($p<0.05$) higher than Barisal, Chittagong, Dhaka Khulna and Rajshahi division respectively. This result suggests that the children of Sylhet division have higher risk for undernutrition. Also, children came from rural areas had a 1.193 (95% CI: 1.026-1.388) times higher chance to be undernourished than urban.

The incidence rate of children suffering from malnutrition is higher for mothers having illiterate (IRR=1.652; 95% CI=1.230-2.190) and primary education (IRR=1.328; 95% CI= 1.032-2.005) as compared to mothers with higher education. Similar results also found for father's education. The children whose mother relates with hard labor an estimated 1.306 times (95% CI: 1.118-1.525) higher chance suffering from malnutrition than children of housewife mother.

Regarding economic condition richest group has considered as the reference category of the level of wealth index. The incidence rate of malnutrition among children is estimated to be nearly 1.712 times higher in the poorest quintile than the richest quintile. The estimated IRR of poorer, poor, middle and rich are 1.712, 1.602, 1.401 and 1.263 respectively which is shown a clear decreasing tendency, it means that the poorest women have high risk of becoming underweight than that of the other three. As a result, for decreasing economic status, chance of suffering from malnutrition among children in Bangladesh is strictly decreased. From this view point, it can be said that wealth index can play an important role among children towards suffering malnutrition.

The risk of being malnourished for children who delivered naturally was 63.6% [(1-0.335)*100] higher than those who had delivery by Caesarian section. In addition, children who delivered at home were 1.510 times higher risk of being malnutrition compared to deliver at hospital/clinic. The children who drink piped water and tubewell water are nearly 12.9% [(1-0.871)*100] and 27% [(1-0.830)*100] less likely to experience malnutrition than the children drinking other sources of water (such as dug well water, unprotected well, surface water, unprotected spring, river or dam or lake or ponds or canal, rain water, etc).

Similarly, toilet facility is strongly associated with malnutrition status of children. A child from a family having no sanitary toilet facility has 1.335 times higher incidence rate of experiencing malnutrition than a child with toilet facility. The total number of children ever-born in a family is also positively associated. The estimated IRR showed that children had risk for getting malnourished 1.061 times higher at every single birth compared to the previous birth (Table 34).

Table 34: Results of the multivariable generalized Poisson regression analysis to study the number of living children in Bangladesh

		Estimated regression coefficient				95% CI for IRR	
Predictors	**Categories**	**(ß)**	**$\chi 2$**	**p-value**	**Estimated IRR**	**Lower**	**Upper**
Division	Barisal	-0.573	22.311	0.000	0.564	0.434	0.734
	Chittagong	-0.386	12.201	0.002	0.680	0.533	0.867
	Dhaka	-0.508	18.110	0.000	0.601	0.473	0.764
	Khulna	-0.326	32.243	0.000	0.265	0.199	0.354
	Rajshahi	-0.110	26.351	0.000	0.364	0.283	0.469
	Sylhet	---	---	---	---	---	---
Place of	Urban	0.077	0.441	0.302	1.193	1.026	1.388
residence	Rural	---	---	---	---	---	---
Mother's	Illiterate	0.537	7.012	0.000	1.652	1.230	2.109
education	Primary	0.488	6.810	0.036	1.328	1.032	2.005
	Secondary	0.331	3.005	0.074	1.288	0.937	1.834
	Higher	---	---	---	---	---	---
Father's	Illiterate	0.349	5.171	0.003	1.338	1.056	2.001
education	Primary	0.285	3.920	0.021	1.203	0.909	1.610

Table 34 (Continued)

	Secondary	0.224	2.263	0.875	1.024	0.760	1.381
	Higher	---	---	---	---	---	---
Mother's	Housewife	0.267	16.340	0.001	1.306	1.118	1.525
occupation	Hard labor	---	---	---	---	---	---
Father's	Employed	0.431		0.548	1.044	0.907	1.203
occupation	Farmer/worker	---	---	---	---	---	---
Wealth	Poorest	0.747	22.901	0.000	1.712	1.179	2.655
index	Poor	0.564	10.381	0.003	1.602	1.037	2.134
	Middle	0.310	12.460	0.001	1.401	0.919	1.738
	Rich	-0.238	4.461	0.041	1.263	0.893	1.522
	Richest	---	---	---	---	---	---
Delivery	Non-caesarian	-0.621		0.000	0.346	0.239	0.500
System	Caesarian	---	---	---	---	---	---
Place of	Hospital/Clinic	0.703		0.000	1.501	1.195	2.574
Delivery	Home	---	--	---	---	---	---
Toilet	No	0.56	56.321	0.000	1.335	1.106	1.816
facility	Yes	---	---	---	---	---	---
Sources of	Piped water	-0.399	3.181	0.044	0.871	0.611	1.198
drinking water	Tube well water	-0.583	16.480	0.000	0.830	0.421	1.078
	Others	---	---	---	---	---	---
Access to	No	0.066	1.410	0.207	1.135	0.744	1.591
media	Yes	---	---	---	---	---	---
TNCEBW	Continuous	0.051	11.044	0.001	1.061	1.021	1.091
TNCDF	Continuous	-0.044	0.161	0.732	1.103	0.904	1.402

TNCEBW-Total number of children ever born to a woman, TNCDF-Total number of children dead in a family

CHAPTER SIX

DISCUSSION AND CONCLUSION

6.1: Introduction

Mothers are the cornerstone of families; their health and wellbeing is fundamental to the health of newborn babies and children. A healthy mother puts a potential influence on the family and their contribution to the nation's workforce and productivity. It is therefore important to identify and manage the health related problems of early childbearing mothers and their children for developing country especially in Bangladesh. The ultimate goal should be accelerate efforts to save lives of mother and their children.

Bangladesh already achieved substantial gains in the field of health during the last three decades despite modestly declining poverty and inadequate health services. However, infant mortality rate (IMR) and maternal mortality ratio (MMR) continue to be unacceptably high compared to many other developing countries, with persisting socio-economic differentials. Taking experiences of low resource setting into account, upgrading the quality and coverage of safe motherhood services (including neonatal care) will have the largest payoff in averting deaths and reducing disability among women and children in Bangladesh.

Adolescence is a transitional period for women and an important stage of an individual's life. Despite the downward trend, teenage pregnancy remains very prevalent in Bangladesh. Early childbearing has a negative impact on the three

dimensions: health of the mothers and their infants; individual social and economic effects; and societal level impacts.

It is well documented that there are adverse health consequence of early childbearing for both the mother (for example low body mass index, anaemia, haemorrhage, sepsis, preclampsia, obstructed labour) and the baby (e.g., low birth-weight, malnutrition, early death) many of which are private information to the woman and remain unobserved to the researcher.

This study examines the relationship between early childbearing and adverse health outcomes from mother and their child in Bangladesh.

6.2: Discussion

6.2.1: Mother Health

The data has used in current section gathered by the BDHS-2007 which was a national survey that covered both the rural and urban population. The ages of women more than 24 years were not count because, for attempting to measure recent health status of women who completed early childbearing preceding five years of the survey. The study showed that early childbearing was still common and the practice was deeply entrenched among Bangladeshi culture. Many Bangladeshi women become mothers at very early aged (Singh, 1998) and 76% of them bearded their first child before the age of twenty (Mitra and Pal, 2007). Incidence of early childbearing of this country was the highest among Asian countries (Kamal, 2012). Based on the same database (BDHS, 2007), one of the researchers, Kamal (2012) studied various socio-

cultural and economic characteristics of adolescent mothers in Bangladesh without looking at their general health status. Other local studies showed the association of BMI with various socio-demographic factors of women aged 15 to 49 years (Shafique et al., 2007; Khan and Kraemer, 2009). More recently Hossain et al. (2012) reported changing trend in BMI of Bangladeshi women over last three decades. In the current section, BMI has used to analyze the general health status and its association with various socio-cultural factors in early childbearing mothers of this country.

Most of the adolescent pregnancies were pre-planned and highly valued in Bangladesh (Finner and Henshaw, 2006). According to the 65th World Health Assembly report there were about 2 million girls under the age of 15 and 16 million girls aged between 15 to 19 years giving birth every year worldwide, among them one-fifth gave birth at age of before 18 (WHO, 2012). In the poorer regions of the world this figure may reach one- third. It was also estimated that about 95% of all adolescent births occur in low and middle income countries, and they were more likely in the poor, less educated and rural areas. In developing countries, about 90% of births in adolescents occur within marriage. The percentage was close to 100% in Western Asia/Northern Africa, Central Asia, and South- Central and South-Eastern Asia, while this was only 70-80% in South America and in Sub-Saharan Africa (Mangiaterra et al., 2008). The National Campaign to Prevent Teen Pregnancy of World Health Organization reported that earlier childbearing and failure to complete high school reduce career opportunities for many young women (The National Campaign to Prevent Teen Pregnancy, 2002). The study did not find any comparative

effects of early and non-early childbearing but simply found the impact of socio-demographic factors on mother's health outcomes among early childbearing mothers. Findings of the current study showed that the mean BMI of young childbearing women in Bangladesh was 19.86 kg/m^2, which varied from 11.95 to 37.79 kg/m^2. The mean height of mother was 150.32 cm (Table 1). More than 15% percent mothers (15.7%) in our study were less than 145 cm (Table 2). This finding also agreed with the previous analysis of the same relationship from DHS data in India (Subramanian et al., 2009). Teenage was the only time in a person's life where their rate of growth will increase; adolescents can gain 15 percent of their ultimate adult height and 50 percent of their adult weight in this time period (Levinson, 2012). A woman's height can be used to predict the risk of difficulty during pregnancy, given the relationship between height and pelvic size. The risk of giving birth to low-weight babies was also higher among women of small stature (Kramer, 2003) and perhaps gestational age at birth (Kramer et al., 1992). Short maternal stature was highly associated with uterine volume and blood flow and was associated with risks of cesarean delivery (Maternal anthropometry, WHO; 1995) and cephalo-pelvic disproportion, the risk of which was likely modified by newborn size (Lee et al., 2009). A few cohort studies had examined the relationship between maternal stature and childhood outcomes. In a study from Nepal, shows maternal height was associated with stunting and underweight, but not wasting (Christian, 2010). Özaltin et al. (2010) has showed that maternal height was inversely associated with risks of child mortality, underweight, stunting, and wasting. With every one cm increase in height, the relative and absolute risks of each of these adverse outcomes were significantly decreased. Compared with the highest maternal

height category of more than 160 cm, women with short stature (<145 cm) had an approximately 40% higher risk of any of their offspring dying. A similar analysis revealed risks of stunting and underweight in offspring to be 2-fold greater among short mothers, whereas that of wasting was only 17% higher. Short stature (<145 cm) affects more than 10% of women of reproductive age across south-central Asia, but only 1% to 2% in sub-Saharan Africa (Black et al., 2008) .

Body mass index (BMI) is the best instrument for the assessment of general health status of a given population (FAO, 1993 and Ferro-Luzzi et al., 1992). It may be nutritionally rather than genetically related (Rolland-Cachera, 1993), despite wide variation in weight and height among human populations (Eveleth and Tanner 1990; Majumder et al. 1990). Low BMI (underweight BMI ≤18.5 kg/m^2) has been associated with a higher risk of low birth weight and higher mortality rate of pregnant mothers (Hosegood and Campbell, 2003).

Findings showed about 61.6% of the mothers were of normal weight, 33.3% were undernourished, and only 0.8% was considered obese (Table 3). The numbers (percentages) of underweight mothers living in rural area were more than that of urban area, while the number of obese were more in urban than in rural environment (Fig. 1). Mother who lived in urban areas had higher BMI than rural areas ($p<0.05$) (Table 7). This information was quite consistent with two other studies on Bangladeshi women for normal and underweight (Hossain et al., 2012 and Khan & Kraemer, 2009). A relatively similar pattern also observed in a large population study on women in our neighboring country India, where 56.9% of married women were reported to be of normal weight, 31.2% were underweight, 9.4% were overweight and

2.6% were obese (Bharati et al., 2007). Another study showed that focused on women living in the slum of Dhaka reported 54% of women were underweight (Prayer et al., 2003). May be one of possible reasons behind the high number rural women with low BMI that, the majority of mother in Bangladesh (about more than 77 percent of women) lived in rural areas and they have no opportunity to serve proper health outcomes (NIPORT, 2009). It can be another cause that, most of the teen aged Bangladeshi female want to keep themselves slim for looking attractive without performing any kind of exercise only controlling diet, but for early marriage and getting child they lose their health condition and savor.

Education was a major protective factor for early pregnancy: the more years of schooling, the fewer early pregnancies. Birth rates among women with low education are higher than for those with secondary or tertiary education (WHO, 2012). Young women with higher levels of education are more likely to postpone marriage and childbearing as a result enjoy good health (Alan Guttmacher Institute, 1996). The present study found that there was an increasing trend of mean BMI with the educational status of women in Bangladesh. The mean BMI value found for lower education was 19.38 kg/m^2 and for higher education is 21.41 kg/m^2 (Table 4). With educational attainment the proportion of women who were undernourished declines sharply and the proportion of women who were overweight rises dramatically. Moreover, the average BMI value of urban mother was more than that of rural mothers for each education level (Fig. 2). From earlier study it is found that, there was strong correlation between low BMI for earlier childbearing and failure to complete high school and reduces career opportunities for many young women (The National

Campaign to Prevent Teen Pregnancy, 2002). Teenage mothers with some secondary education were roughly one-third as likely to have had low BMI as those who had less education (Yinger et al., 1992). Another study in 2001 found that women who gave birth during their teens completed secondary level schooling 10–12% and loose BMI 8-10% as often where as women who wait until age 30 pursued post-secondary education 14–29% (The National Campaign to Prevent Teen Pregnancy, 2002). This means that education has directly influenced on early childbearing women's BMI. A study showed that, there had been significant improvement in the level of female education and urban employment opportunities for young females in recent years, their effects on delaying age at marriage or age at first birth finally on mothers' health (NIPORT, 2005).

Finding of the present study showed that, 33.6% early childbearing women suffered Chronic Energy Deficiency (CED). Among them 10.69% women suffered severe thinness or CED grade III, 22.01% women suffered moderate thinness or CED grade II and maximum 67.30 % women suffered mild thinness or CED grade I (Table 5). The risk of CED among rural woman was higher than urban woman (Fig 3). Chronic energy deficiency in teen aged pregnant women declined from 52 percent in 1996-97 to 45 percent in 1999-2000, but it was still high in Bangladesh (UNICEF Bangladesh, 2013). The high prevalence of chronic energy and micronutrient deficiencies of today's adolescent mother is directly linked with the quality of the next generation. Without addressing these deficiencies, the vicious cycle of inter-generational undernutrition, chronic diseases, and poverty perpetuates. Early adolescence after the first year of life is the second critical period of rapid physical growth and changes in

body composition, physiology, and endocrine. Rapid growth and changes heighten their nutritional requirements and risks of undernutrition. Parents simply need to provide more nutrients and offers the last opportunity to intervene and recover growth faltered in childhood and also support growth spurt and skeletal development to break the vicious cycle of inter-generational undernutrition (Golden and Martorell et al., 1994). Satyanarayana et al. (1991) showed that the difference in mortality rates between adult females with CED grade I and normal CED is only about 1% per year, but it increases rapidly when BMI was less than 17. Bangladeshi women experience delayed adolescent growth (Mostafa, 2009) and late age at menarche (Hossain et al., 2010), compared to Western standards, due to widespread chronic malnutrition. This may be one of the reasons behind the high number of individuals with CED grade I in most of the women in Bangladesh. Many researchers (Roberts, 1953; Newman and Munro, 1955; Dobzhansky, 1962 and Schreider, 1968) recognized that a lean linear body build with a low weight to surface area ratio was one of the general characteristics of the people living in tropical and subtropical climates. This may be one of the reasons behind the high number of individuals with CED grade I in most of the populations in Bangladesh.

When study the chronic energy deficiency (CED) on the basis of education level; maximum (42.45 percent) illiterate women suffered from CED with compared to other education level. Different CED categories gave similar result maximum (47.1 %) illiterate women suffered from CED grade III (Table 6). The proportions of CED decreased distinctly with the increase of literacy status of women and the CED almost approaches zero at the highest level of education (Fig. 4). As a result, for early

marriage and childbearing Bangladeshi women who dropped out from school, did not get any job; finally lead poor and vulnerable life. Thus, the study concluded that, increase of women education level was strongly associated with the decrease of suffering of CED, increase of women's BMI and decrease the number of early childbearing mothers in Bangladesh. On the other hand early childbearing is related to low education, higher CED sufferings and malnutrition of women.

From the logistic regression analysis, the study noted interesting result which is, all of the regional dummies were negative and statistically significant except Rajshahi. These imply that compared to the reference category Sylhet, underweight mothers rates were lower in other regions. The odds ratios of Barisal, Chittagong, Dhaka, Khulna and Rajshahi were 0.627, 0.568, 0.629, 0.664 and 0.778 respectively (Table 9). This means that the mother of Sylhet division had a chance to be undernourished 0.627 ($p<0.05$), 0.568 ($p<0.05$), 0.629 ($p<0.05$), and 0.664 ($p<0.05$) times higher than Barisal, Chittagong, Dhaka and Khulna division respectively. It was particularly surprising that Khulna and Rajshahi division was clearly better off in terms of the condition of mother health services; it is not associated with lower underweight mothers' rates. Dhaka, Barisal and Chittagong were the next corresponding region of lower undernourished mother. Strauss and Thomas (1998) had argued that local infrastructure could be developed the health regressions. This could happen because of two reasons. First, individuals might choose their residence based on the availability of public health services (Rosenzweig and Wolpin, 1988). Second, local infrastructure itself might be placed selectively by public policy; perhaps in response to local health conditions (Rosenzweig and Wolpin, 1986). The first issue is unlikely

to be particularly important for a country like Bangladesh. Selective placement of health services is however potentially a much more important issue in this respect, which is also evident in striking regional variation in health expenditure. On the other hand, underweight mother rate of the Sylhet division was high and this deserves further in-depth analysis may be conducted for available socio-economic and demographic indicators.

In Indian subcontinent, early marriage and pregnancy was more common in traditional rural communities compared to the cities (Mehta et al., 1998). Multivariate analysis reveals that, the risk of underweight of rural women was 1.146 times higher than that of urban women (Table 9). A lower probability of childbearing can be seen for teenagers with living in urban areas compared to those who were in rural areas. Singh (1998) hypothesized that young girls living in urban areas may have greater motivation to attain higher education and to work for wages, as well as a greater availability of work opportunities and thus are less likely to have teenage pregnancy compared to their rural counterparts. A few analysis from Bangladesh support this hypothesis and suggest that early childbearing among teenagers was less common among urban residents than rural residents (NIPORT, 2005). A study of nine countries in Latin America and the Caribbean found that 40 to 60 percent of rural women had a child before age 20, compared to 25 to 36 percent of urban women (Wulf and Singh, 1991).

The multivariate analysis showed that the risk of being underweight for women with no education was 0.66 times higher than those with secondary school education. The risk for being underweight for illiterate mothers was 0.33 times higher compared to

those with higher education. Almost similar result was found for partner's/husband's educational level (Table 9). There were a few literatures on teenage pregnancy in developed countries that focuses on the problems of adverse health outcomes and welfare dependence on schooling (Senderowitz & Paxman, 1985 and Geronimus & Korenman, 1992). Education may makes people more receptive to new ideas such as, age at marriage, early childbearing patterns and better health policy (Nancy, 1997). The effect of schooling on adolescent childbearing was not straight forward. Even though there was evidence that higher levels of education are associated with lower probability of giving birth during adolescence in Bangladesh (Islam, 1999) and elsewhere (Gupta and Leite, 1999), teenage girls may discontinue schooling after getting married and/or getting pregnant. It was important to note that the husband's education had a modest effect on early childbearing mothers' health. This finding had important policy implications, as it was not only women's education but also that of their husband, which can help women to less undernourished (Nahar and Min, 2008). While women's education was found to be the strongest predictor at the individual level, the husband's education also had a positive impact on teenage mother health in the most recent year. The effect is significant for certain levels, but for not all. A woman with more than secondary education has 37% less hazard of having undernourished compared than husband who had more than secondary education (Nahar and Min, 2008). It has also noted that higher status of education of women and her husband's strongly associated with decrease undernourished women in Bangladesh. On the other hand, early childbearing was linked with low education, higher CED sufferings and undernourished women in Bangladesh.

Respondent's occupation was positively and partner's occupation was negatively related to BMI. Mothers involved with hard labor had 1.298 times and whose partners were unemployed had 46.6% higher risk of being undernourished than mothers who were housewife and partners were employed (Table 9). Educational levels and job opportunities (which are closely associated with early childbearing) for mothers, had risen in most countries. Early childbearing were continuous barrier to improvements in the educational, economic and employment status of women in all parts of the world. Overall, for young women early marriage and early motherhood can severely employment opportunities and were likely to have a long term, adverse impact on the quality of their lives and the lives of their children (United Nation, 1995). The earlier literature had argued that the effect of income or economic status on early childbearing mother health is harder to predict than that of women's education or place of residence (Dreze and Murthi, 2001). The relation between early childbearing and physical health may be explained by prolonged unemployment, more children and economic hardship (Mirowsky, 2002). A study of 100 teenage mothers in the United Kingdom found that only 11% received salary, while the remaining 89% were unemployed (Social Exclusion Unit, 1999). Negative economic consequences of early marriage and early childbearing result in both marriage and childbearing at an early age tend to limit a woman's job opportunities (Bissell and Mary, 2000). This was partly attributed to the fact that employed women were generally more educated, more conscious regarding the timing of childbearing and also has enough information of adverse effect of early motherhood.

Analysis showed that wealth index influences the BMI of Bangladeshi women. Poorer mothers had the highest chance to be undernourished compared to those from richer family. Numerous studies had shown the link between teenage pregnancy and negative socio-economic effects on both the mother and her child. However, recent reviewed had found the evidence inconclusive about whether early pregnancy was the cause or consequence of adverse socio-economic factors (Mangiaterra, 2008). The basic causes of under nutrition in developing countries were poverty, poor hygienic conditions, and little access to preventive and health care (Mitra, 1985; WHO, 1990). The higher the level of early childbearing occurs in the poorer country (Alan Gunmacher Institute, 1994). A study by Besharov and Gardiner (1997) reported that poverty delivered higher rates of teenage pregnancy. In Latin America, teen mothers were seven times more likely than older mothers to be poor (Koontz and Conly, 1994). Teen pregnant mother were high-risk due to factors more common among this age group, such as poverty, inadequate prenatal care and low pre pregnancy weight all of these might continue to influence the outcome of subsequent pregnancies (School et al., 1992). Poor countries such as Niger and Bangladesh had far more teenage mothers compared with richest countries such as Switzerland and Japan (UNFPA, 2002). Bangladesh ranks in the bottom quartile of healthcare spending in the region of South-East Asia; the percentage of GDP allocation for health is 3.3% which is far below the level needed to scale up essential health interventions (Majumder, 2011). The high rate of early childbearing mothers in Bangladesh could be explained by the fact that more than 35% of women were living under poor economic conditions, and

32% were illiterate and may not have enough knowledge about good health practice (NIPORT, 2009).

The present study demonstrated that place of childbirth, total number of children ever born, delivery system, respondent age at first marriage, age at first birth were most important factors for underweight women in Bangladesh.

The female body was only physically mature enough to bear healthy children by the age of 20 but worldwide about 16 million adolescent girls aged 15-19 give birth each year, roughly 11% of all births worldwide. Almost 95% of these births occur in developing countries. Half of all adolescent births occur in just seven countries: Bangladesh, Brazil, the Democratic Republic of Congo, Ethiopia, Nigeria, India and the United States (Population Division, 2008). A study on Bangladeshi population conducted by Nahar and Min (2008) suggest that the overall probability of first birth before age 20 among Bangladeshi women remained static or even increased slightly over time. Teen mother had a much higher risk of dying from maternal causes compared to women in their 20s and 30s. These risks increase greatly as maternal age decreases, with mother under age 16 facing four times the risk of maternal death as women over 20.

Age at marriage had a strong connection with age at first birth: a one-year increase in age at marriage decreases the chance of teenage first birth by 10% or more (Nahar and Min, 2008). If the marriage of a pubescent girl was delayed, her parents and sometimes the girl herself are made to feel guilty. Similar scenarios were more common in slum areas. Where poverty was acute, a young girl may be regarded as an economic burden and parents looking for early marriage of their daughters as an

alternative way of reducing the burden. Field and Ambrus (2005) find that for each additional year that marriage was delayed is linked with 0.30 additional years of schooling and 6.5% advanced probability of literacy.

Early childbearing mother might had less information about the advantages of using available health inputs (for example, hospital delivery or a range of vaccinations) and/or might even have little say in aspects of female/child health care (Geronimus and Korenman, 1992). Previous research used the Bangladesh DHS data sets and showed that nearly 95% of all births were occured at home and in the majority of these cases (57%) assistance was provided by (often untrained) local birth attendants (dais), followed by other relatives (25%). It was possible that young women experiencing complications in pregnancy were more likely to go to the hospital for delivery and/or vaccinate the child, which in turn, may affect the maternal health outcomes.

Maternal death rates for adolescents under 16 are 4 times greater than for women in their 20s (Mangiaterra, 2008). Women who begin childbearing as teenagers were estimated to had two to three more children than women who delay their first birth until their twenties or later (Koontz and Conly, 1994). According to the National Campaign to Prevent Teen Pregnancy, nearly 1 in every 4 teen mothers would experience another pregnancy within two years of having their first (Statistics on Teen Pregnancy). During and after pregnancy teenage mothers appeared to suffer from a long list of liabilities: additional births, poor health outcomes poor educational attainment and low earnings (Frank and Furstenberg, 2003).

These results were partially in agreement with the findings of another Bangladeshi study by Hossain et al. (2012) observed that, poor economic conditions, illiteracy, large family size, early age at marriage, early age at first delivery and insufficient medical facilities in rural areas are the main causes for decreasing of BMI of married non-pregnant women in Bangladesh. By using the BDHS-2004 database, Khan and Kraemer (2009) found that age, educational level, region of residence, marital status and type of occupation affect the BMI of married non-pregnant urban women of the country. However, that study was conducted based on only urban women. Shafique et al. (2007) mentioned that age, level of education, wealth index, residence and area were important factors to influence the BMI using data from the Nutritional Surveillance Project (NSP) from 2000 to 2004.

6.2.2: Trend in age at first marriage

Marriage was the most important factor causing women for early childbearing and nearly all first births (98%) occur among teenagers in Bangladesh. In developing countries, about 90% of births to adolescents occur in marriage. The proportion was close to 100% in Western Asia (Mangiaterra et al., 2008). Also study found age at first marriage was the most influential variable (Based on Wald statistics, 16.258) on early childbearing and undernourished mother in Bangladesh, so it is essential to know about the trend and age pattern of marriage of Bangladeshi women.

The data used in the current section were extracted from the Bangladesh Demographic and Health Surveys conducted in 1993-1994, 1996-1997, 1999-2000, 2004 and 2007. The samples were nationally representative, covering both urban and rural areas of

Bangladesh. Previous studies in Bangladesh had examined the relationship between age at first marriage and socio-economic, demographic variables and body mass index (Ahmed, 1986; Kamal, 2012; Islam et al., 2010; Khan et al., 2011; Hossain et al., 2012). One of the researchers Uddin (2009) investigated the age at first marriage for husband and wife between Muslim and Santal communities in rural Bangladesh. In addition, in the current section the change in age at first marriage of Bangladeshi women over four decades (birth year cohorts from 1944 to 1985) has been identified.

Result demonstrated that the mean and median age at first marriage of Bangladeshi women was 14.73 ± 2.96 years and 14.00 years for whole sample and women from rural environment got marriage earlier than urban. When observed the individual surveyed period of BDHS, the mean age at first marriage in surveys conducted years 1993-1994, 1996-1997, 1999-2000, 2004 and 2007 was 14.15, 14.21, 14.99, 15.05 and 15.50 year, respectively. Bangladesh bureau of statistics (BBS, 2012) estimates the mean age at age at marriage for male was 23.9 and for female were 17.0. In Bangladesh, childbearing begins early due to early marriage and the social expectation to have children soon after marriage. Although the average age at marriage for females had been rising intermittently since the 1960s (United Nations, 2000; Xenos and Gultiano, 1992) and the age at birth also increasing but most of increasing was observed among the older cohorts (age 25 and above), not the younger group.

Bangladeshi women got marriage earlier than USA, Copen et al. (2012) reported that the median age at first marriage of USA women was 25.8 years; they extracted data from National Survey of Family Growth (NSFG) collected from 2006 to 2010.

Zimbabwean women got marriage later than Bangladeshi Cremin et al. (2009) found that the median age at first marriage of Zimbabwean women was 18.5 years. The mean age at first marriage of Chinese women is upper than Bangladeshi women, Löfstedt et al. (2005) reported that the mean age at first marriage of Chinese women was 22.5 years, also women in the neighboring countries Nepal got marriage later than Bangladeshi women; Aryal (2007) reported that the median age at first marriage of Nepalese women was 17 years.

6.2.2.1: Secular trends in age at first marriage

The current study has demonstrated that the age at first marriage of Bangladeshi women showed increasing tendency with changing time from 1993-1994 to 2007. The tendency of child marriage had been decreasing for rural and urban area during the investigated period from 1944 to 1985. This result of the current study were in agreement with that of Kamal (2012), he used BDHS (2007) data and found that the child marriage of Bangladeshi women was decreasing. The average age at first marriage of Bangladeshi women showed fluctuated among the birth year cohorts from 1944 to 1985. These fluctuations were examined by linear regression to find the trends, and the coefficients of regressions demonstrated that the age at first marriage of Bangladeshi women had been increasing during for the last four decades. The present finding corroborate the study of Marston et al. (2009) they reported that the age at first marriage of women in Sub-Saharan Africa showed increasing tendency over time. This increasing tendency of age at first marriage had also been found in USA (Copen et al., 2012) and China (Löfstedt et al., 2005). The present study also

demonstrated that the increasing rate of age at first marriage of urban women was more than rural women.

The legal age of marriage in Bangladesh was 18 years for women and 22 years for male, but a large proportion of marriages still take place before the legal age (NIPORT, 2009). The present study also demonstrated that more than 85% women of Bangladesh got marriage before the legal age of marriage, early marriage had occurred in rural area (87.6%) more than in urban (78.2%). Over the past two decades, the proportion of women marrying before the legal age had decreased from 73 percent in 1989 to 65 percent in 2011 (NIPORT, 2013). Moreover, the proportion of women marrying by age 15 year was declined by two-thirds over time, from 65% among women in the oldest cohort (surveyed year 2004) to 21% among women in the youngest cohort (surveyed year 2007). Similarly, the proportion of women marrying by ages 18 and 20 decreases substantially from the oldest cohort to the youngest cohort (NIPORT, 2009).

Education and economic condition were important factor for age at first marriage (Kamal, 2012; Jin et al., 2005; NIPORT, 2009), the number of women who were living in urban area are generally more educated than rural area and more than half percent of the population residing in urban environment was in the highest wealth index, compared with only 9 percent of the rural population (NIPORT, 2009). The changes in economic condition and education level towards elevated in urban area faster than in rural area may be one of the regions to found differentials in the change of age at first marriage between urban and rural.

6.2.3: Age pattern of marriage

In previous section the researcher only investigated trends in age at first marriage over time. It was important to observe the age pattern of marriage of Bangladeshi ever married women. In this section, researcher has tried to give the impression of being age pattern of marriage, i.e., in the age of beginning of marriage, the pace of marriage, age-span of marriage of ever married Bangladeshi women using Coale's nuptiality model by accumulate data from eventually all of 15 to 49 years 10,996 ever married women from Bangladesh demographic and Health Survey (BDHS, 2007).

It had been suggested that the age patterns of marriage could differ in terms of the age at which marriage begins, the rate at which it progresses and the proportion of those who ultimately ever marry. In other words, the age patterns of marriage in different communities could differ only in origin, horizontal scale and vertical scale but still retaining the same functional form (Coale, 1971). The information in the observed marriage schedules can be effectively captured and concise description of the marriage process can be made by means of the parameters can, it turn, be used to smooth observed schedule of proportion ever married and to estimate the age structures of first marriage frequencies and risk of first marriage for the population concerned. Some of the above mentioned items of information can be indirectly estimated by making use of the model nuptiality schedule developed by Coale (1971).

The phenomena of age patterns call for the analysis of marriage patterns by means of nuptiality model in order to capture the inherent peculiarities underlying in the marriage pattern. Coale's model nuptiality schedule provides an excellent means of

quantifying and of the above mentioned phenomena of age patterns of marriage (Coale, 1971). Not only that, Coale's model nuptiality schedule provides a scope to smooth the observed distribution of ever married population but also lead to estimate the first marriage frequencies by age and risks of first marriage.

Coale's nuptiality model is fitted to data on the age distribution of 10,996 ever married women of the year 2007 extracted from BDHS-2007. Attempts are made to capture the inherent peculiarities of the marriage pattern by estimating the parameters of the Coale's model. For estimating first marriage frequency by Coale and McNeil (1972) and risk of first marriage by Coale (1971) uses five year age group population. But in the present study the ratios as well as parameters of Coale's model R_1, R_2, R_3, a_0, k, c, A_0 and A we use single year age distribution of ever married female in Bangladesh. Using BDHS-2004 data (Khaleq, 2011) estimates the parameter of Coale's model by five year age distribution of female and found that the value of a_0, k, c, A_0 and A were 10.6, 0.73, 1.00, 29.21 and 39.81 respectively. Using single year age distribution of ever married female in Bangladesh we found the value of a_0, k, c, A_0 and A are 15.33, 0.553, 1.00, 22.12 and 37.45 respectively (Table 1). Which gives, comparatively higher values for k (0.553vs0.73), also for A_0 (22.12vs29.21) and for A (37.45vs39.81) which is apprehended. So we can conclude that the Coale's nuptiality model gives better results for single year age distribution of ever married female in Bangladesh.

The quantity of marriage implied by the estimated value of the parameter c is very close to unity for all Bangladeshi females. Hence, marriage in Bangladesh has always

remained universal; i.e., almost all females marry. The span of marriage, which measures the age span within which majority of first marriages occur, indicated by A_0

is 22.12. This result is very low with compared to other country perspective. So, in Bangladesh the majority of first marriage occurs in very low ages. The values of A reflect the maximum age beyond which first marriage is unlikely to take place. It is indicated that a female who reached the age of 37 years without having married for the first time they are unlikely to do marry in Bangladesh.

It is worthwhile to mention here that through the model nuptiality schedule is intended for female population, the same can be fitted also the male population (Islam,1996). Hill(1977) has pointed out the model gives very adequate fit to a variety of female nuptiality schedule and although some fall outside the ranges of model values tabulated by Coale, Abedin (1982) has found an excellent fit of Coales model nuptiality schedule to a rural female population at sub national level.

It is evident that the first marriages for females occur at a low intensity at the initial age of marriage with an increasing tendency up to the peak age of marriage and after that the frequency of first marriage goes on decreasing (Fig. 1). From this it also concluded that the first marriage frequency for female's increases steeply after age a_0 up to the peak age of marriage showing the sharp peak and decline rapidly for short age span indicating too high intensity of occurrence of first marriage. The frequency of first marriage decline slowly in later ages compared to the initial ages. The most crucial ages of first marriage of females are probably first few years of marriageable ages.

6.2.3.1: Risk of First marriage

In female population, the risk of first marriage is observed to be lower at young ages compared to later ages. Such risk rises very steeply within a very short span of marriageable age after the age of which a reasonable number of first marriages occur. It increases very sharply from initial age up to age 22 in Bangladesh. After that it approaches a horizontal asymptotic. The r(a) values are ataractic in upper ages in all over the region in Bangladesh. The fact is that in higher ages, the risks of marriage are sensitive to errors in the cumulated values of first marriage frequencies and the first marriage arbitrary adjustment of cross-sectional data (Coale, 1971).

The pattern of r(a) for females is depicted in (Fig. 2). It shows that the risk of first marriage rises steeply after the beginning age at marriage due to a very short span of marriageable ages and then it reaches the asymptotic. By age 22 r(a) values almost reach asymptotes.

6.2.4: Child health

There is almost universal agreement about the importance of children, who are often referred to as the "future of a nation" and a "nation's greatest resource" (Lerner et al., 2005). Despite this strong commitment to the health of children, there are still concerns about poor health outcomes amongst children. Furthermore, the disparity in children's health and their determinants is lower in the Bangladesh than elsewhere (Gunn et al., 1999). Early childbearing is a major contributor to maternal and child mortality, and to the vicious cycle of ill-health and poverty (UN Secretary-General in

2010). Due to measuring child health data were extract from the Bangladesh Demographic and Health Surveys (BDHS, 2007), after removing outliers, excluding respondent age over 19 year first birth, delivery missing data and units with some other missing data; finally the data set was reduced to 3207.

Study demonstrates that the GPR model is an ideal alternative to study the malnutritional status of children. This model is a good alternative because most of the results of this study are found to be consistent with the findings of many other studies (Haughton and Haughton, 1997; Pongou et al., 2006; Mohsena et al., 2010; Abuya et al., 2012; Das et al., 2008; Ojiako et al., 2009; Giashuddin et al., 2005; Siddiqi et al., 2011; Roy, 2000; Murray and Lopez, 1997; Rayhan and Khan, 2006; Hong, 2007).

In generally for a certain population weight-for-height describes children current nutritional status. A child who is below minus two standard deviations (-2 SD) from the reference median for weight-for-height is considered to be too thin for height, or wasted, a condition reflecting acute or recent nutritional deficit. Wasting is considered severe if the child is below minus three standard deviations (-3 SD) below the reference mean. Severe wasting is closely linked to mortality risk. Study reveals that 18.6 percent children were malnourished (>Median – 2 SD), among them 15.2 percent were moderate wasting (Median – 3 SD to Median – 2 SD) and 3.4 percent were severe wasting (< Median – 3 SD) (Table 1). These results were quite consisting with (BDHS, 2011), they found 16 percent of children were considered wasted or too thin for their height and 4 percent are severely wasted. Wasting peaks at age 18-23 months (17 percent). There had been some improvement in child nutritional status over the past four years. The pattern and change in wasting had been small and inconsistent. It

increased from 15 percent in 2004 to 17 percent in 2007, and declined to 16 percent of children in 2011 (NIPORT, 2011). Childhood wasting or low birth weight was associated with increasing rate of neonatal and infant mortality (Christian, 2008).

The last few decades Bangladesh had brought significant improvements in child health. Despite the substantial decline in child mortality rates in Bangladesh over the last two decades (Bairagi et al., 1999), child mortality continues to remain a major problem in Bangladesh. Analysis showed that the mean number of children died in a family was 0.26 ± 0.614 where, maximum 6 children died in a family (Table 2). Previous research showed that, infant mortality rates in 1996 – 97 were as high as 100 per thousand births (compared to 79 in India, 31 in China and 18 in Sri Lanka in 1992) and under-five mortality rates were even advanced at 130 per thousand births (Mitra and Pal, 2007). According to (UNICEF Bangladesh-2013) the mortality rate in children under-five declined from 152 deaths per 1,000 live births to 94 deaths per 1,000 live births. Data from the 2011, BDHS showed that under-five mortality in the five years preceding the survey was 53 per 1,000 live births. This means that one in nineteen children born in Bangladesh dies before reaching the fifth birthday (BDHS, 2011). The under 5 mortality rate, per 1,000 births is 55 and the neonatal mortality as a percentage of under 5's mortality was 57 (UNFPA, 2011). Early childbearing was often connected with higher than average mortality rates. The mortality rate for children born to adolescent mothers was 10.4% where the corresponding number for the all samples was 7.4% (Makepeace and Pal, 2007). In recent years adolescent childbearing had also emerged as an issue of increasing concern in Bangladesh. Early marriage had resulted in early child birth with high risks of both maternal and infant

mortality. In fact child mortality rates were more than double for adolescent mothers (Mitra and Pal, 2007).

Findings of the present study noted interesting result was that all of the regional dummies were negative and statistically significant. These imply that compared to the reference category in Sylhet, rates of malnourished children were lower than the other regions. It was particularly surprising that Khulna and Rajshahi division was clearly better off in terms of the condition of child malnutrition. Barisal, Dhaka and Chittagong were the next corresponding region of lower malnourished children. In terms of ever born children, living children and number of dead children; Sylhet were most vulnerable region where as, Khulna were the better and Rajshahi were in second best position with compared to other division (Table 3). According to the GPR model, the malnutritional status of children was insignificant between rural and urban areas. This finding was both consistent with (Das et al., 2008) and contradictory with (Hien and Kam, 2008). Higher level of malnutrition in rural areas than urban areas reported from a similar study in Vietnam (Hien and Kam, 2008). Some possible causes in rural areas according to this study were lack of economic, socio-cultural, healthcare and instuitional facilities (Hien and Kam, 2008). Like Vietnam, Bangladesh also suffered from limited infrastructure and facilities in terms of modern healthcare services, sanitation, education, electricity and economic facilities among in rural areas. Particularly health services were concentrated in urban areas than rural areas (Khan et al., 2011). Child malnutrition was negligible in Bangladesh, in terms of urban-rural disparity; this was not the case for many other indicators. For instance, one more recent study reports remarkable urban-urban disparities for antenatal care service, age

at marriage, low age at birth (which means early childbearing), fertility and child mortality in Bangladesh (Khan et al., 2011). Higher age at marriage, smaller family size and lower mortality rate of children in urban areas as compared to rural areas also reported from another study in Vietnam. What are the reasons for this inconsistency? One of the possible reasons might be related to the adjustment of the GPR model by other potential predictors, namely household wealth and maternal education (Fotso, 2006). Inclusion of other predictors along with place of residence into the same model may reduce the strength of urban-rural nutritional disparity.

Parental educational attainment does not generally have a particularly strong direct effect on child mortality but has significant effects on child nutrition, early childbirth, hospital delivery and child vaccination (UNICEF Bangladesh, 2013). Furthermore, many studies suggest that mother education is linked with child health outcomes. The relationship of maternal education with child malnutrition is more demonstrable than paternal education, health service availability, and socio-economic status (Das et al., 2008; Martin et al., 1983; Wamani et al., 2004; Frost et al., 2005). An infant whose mother has no education is twice as likely to die before its first birthday as an infant whose mother has a post secondary education (UNICEF Bangladesh, 2013). However, some studies also showed, parental educational effects on child nutrition (Desai and Alva, 1998; Siddiqi et al., 2011). When parents' educational level was studied multivariate analysis founds a significant positive relationship between mother's education and child nutrition. This result was consistent with many other studies (Haughton and Haughton, 1997; Pongou et al., 2006; Mohsena et al., 2010; Jesmin et al., 2011; Abuya et al., 2012; Das et al., 2008; Hien and Kam, 2008; Ojiako

et al., 2009; Giashuddin et al., 2005; Siddiqi et al., 2011; Roy, 2000; Rayhan and Khan, 2006; Hong, 2007; Frost et al., 2005 and Frongillo et al., 1997). Such a relationship could exist because maternal schooling was strongly connected with good child care and good health. Women with upper as compared to lower educational level were more likely to raise their family income, which helped the families to provide more quality diets and better healthcare to their children. Additionally, educated mothers can efficiently use limited household resources and available healthcare facilities, limit their family size, maintain better health promoting behaviors and provide healthcare to their children (Hien and Kam, 2008; Frost et al., 2005). It was suggested that parents education specific to health care utilization, health related mass media campaigns and effective counseling on positive aspects of health care by health professionals to the patients attending the clinics were necessary to reduce health care barring and positively contribute to the child nutrition in Bangladesh (The National Campaign to Prevent Teen Pregnancy, 2002).

In Bangladesh; the country was riddled with malnutrition, illiteracy due in great part to abject poverty among about half of the country's 150 million people (Save The Children, 2012). Both researchers and policy makers agree that increasing the stock of human capital is essential to increase the rate of growth of any economy. Good health was now regarded as a basic pre-requisite for human capital formation, which in turn help increasing the income levels in a country. Poor child health therefore had long-term implications in the form of poor adult health and low levels of human capital formation (Mangiaterr et al., 2008). There was a large literature on child malnutrition in low and middle income countries that offers a range of policy options that had the

potential to improving child health. Improving child health was one of the important challenges in the battle against poverty (Mangiaterr et al., 2008). The relationship between economic inequality and children nutritional status was investigated by many studies (Pongou et al., 2006; Giashuddin et al., 2005; Wamani et al., 2004; Hong, 2007; Larrea and Kawachi, 2005). Generally the greater degree of economic disparity was related with higher mortality (Ross et al., 2000). At the national level the relationship between economic disparity and malnutrition was not straight forward, because better economy did not necessarily mean better health care for all. Social and economic disparity in a country may differently influence the accessibility to food and healthcare services including the burden of disease. A number of studies had illustrated that children from poorer households were more likely to be malnourished than children from wealthier households (Pongou et al., 2006; Doak et al., 2002; Thang and Popkin, 2003; Zere and McIntyre, 2003). Social deprivation was also linked with a child's nutritional status (Armstrong et al., 2003). In Bangladesh the nutritional status of children differs in different economic classes (Giashuddin et al., 2005), which can be attributed to the fact that rich families had more ability to allocate necessary resources for their children than poor families. Financial, social, and material resources in the child's household were showed significant relationships between teenage childbearing and child health outcomes (Mollborn and Dennis, 2012). For most families, household income was the most important determinant of their economic situation. Children living in low-income households were more likely to had insufficient economic resources to support a minimum standard of living and this can affect a child's nutrition, access to medical care, the safety of their

environment, level of stress in the family and the quality and stability of their care (ABS, 2006; AIHW, 2005). Understandably allocation of more resources to their children improves their health conditions by reducing multiple health risks.

The finding of the present study revealed a strong positive association between number of children ever born to a woman and malnourished children in a family. These results were consistent with the findings of previous study (Haughton and Haughton, 1997; Hien and Kam, 2008). Generally, families with more children experience more economic strain for food consumption and hence they were more likely to suffer from poor nutritional status. In other words, inadequate allocation of household resources among many children may lead to the low nutritional status. Particularly poor families cannot fulfill the nutritional requirements of the children. Families with more children generally devote less time to take care of their children (Hien and Kam, 2008). Because of negative impacts of higher fertility on nutritional status of children, increasing birth interval should be an important strategy to improve the nutritional status among children in Bangladesh.

Men were generally the main earner of a family in Bangladesh, due to the flourishing garment sectors employment opportunities were increasing for women. In Bangladeshi culture generally, family income was strongly associated with the type of father's occupation. Normally fathers with more prestigious job have prominent income than fathers with low level jobs and therefore children from the upper income families should had better nutritional status. From the regression analysis, it can be noted that there was an insignificant relationship of father's occupation with the nutritional status of children. This can be explained by the lack of proper nutritional

knowledge and confounding effect of education of parents. Like father's occupation, religion also did not play any significant role in explaining the nutritional status of the children in Bangladesh.

The findings suggested that factors that were source of drinking water and type of toilet also showed significant involvement with child malnutrition. Pongou et al. (2006) reported similar results. These were believable because access to safe drinking water and hygienic toilet were the pre-conditions for maintaining sound health and nutrition among children. The incidence of various water-borne diseases can be reduced by improving the supply system of drinking water (Smith and Haddad, 1999). Therefore increasing access to the safe drinking water and hygienic sanitation were important to improve the nutritional status among children in Bangladesh.

6.3: Conclusion

The findings of the research hold implications for policy that could be useful in devising ways to solve the issues related to early childbearing and health impact on mother and their children for Bangladesh. In the decade of 1980s most of the mother and child health (MCH) programs focused on the child, with maternal care mainly limited to family planning. The justifiable need for more attention for women contributed to the downplaying of links between maternal and child health. Women's right to the enjoyment of the highest standard of health must be secured throughout the whole life cycle in equality with men. Women are affected by many of the same health conditions as men, but women experience them differently. The prevalence among women of poverty and economic dependence, their experience of violence,

negative attitudes towards women and girls and other forms of discrimination, the limited power many women have over their sexual and reproductive lives and lack of influence in decision-making are social realities which have an adverse impact on their health.

Current study suggested that adolescent marriage is a common phenomenon in Bangladesh, especially in the rural area. Early childbearing is directly linked with early marriage, which is a common practice in this country. Poor economic conditions, illiteracy, early age at marriage, early age at first birth, insufficient medical facilities, lack of suitable work and having more children are the main causes of being underweight for early childbearing mothers in Bangladesh. The other unsinkable cause related to early childbearing may be lack of food and inequitable distribution of food for girls and women in the household particularly in rural and poor urban areas, are all overburden women and their families and have a negative effect on their health. Good health is essential to leading a productive and fulfilling life, and the right of all women to control all aspects of their health.

Since early childbearing is directly linked with early marriage it is important to check the trend in age at first marriage and age pattern of marriage especially for women. At first it has been checked the trend in age at first marriage of Bangladeshi women and found that, the mean and median age at first marriage for the first and last surveyed years of BDHS was 14.15 years (median 14.00 years) and 15.50 years (median 15.00 years), respectively. The increasing rate in age at first marriage of urban women was more than rural women. The mean and median value of age at first marriage of Bangladeshi women was 14.73 ± 2.96 years and 14.00 years for whole samples,

respectively, showing an increase tendency over four decades. Moreover, child marriage (≤17 years old) of Bangladeshi women showed slightly decreasing tendency during the investigated period from 1944 to 1985.

Secondly, the study checked the age pattern of marriage from Bangladeshi ever married women using Coale's nuptiality model. Some interesting results were found when analyzed age patterns of marriage by means of Coale's model nuptiality schedule. It has been found that marriage still remainder a universal phenomenon in Bangladesh. Early marriage prevails in the population and that marriage not only start early but progresses fast and are concentrated within a short span of time at least in the female population. The model has yielded proportions of ever married which are very close to observed schedule. To study the nuptiality behavior of Bangladeshi population, it is meaningful to mention that, under changing condition of marriage pattern, application of Coale's nuptiality model might be questionable. On the other hand, apart from this, knowledge about the parameters which control the marriage pattern are well studied by means of Coale's model by providing quite a few interesting parameters to capture the inherent peculiarities of the marriage pattern of the country. The fact values of Coale's nuptiality model a_0 , k, c, A_0 and A and the values of r(a) and g(a) of Bangladesh population reflect that marriage in Bangladesh has began to show some changes from the recent past without much changes in the basic parameters of nuptiality.

To study child health, Generalized Poisson Regression (GPR) model has applied and the model demonstrates that, it is an appropriate model to identify predictors affecting the nutritional status of teen mothers' children in Bangladesh. Region, place of

residence, father's and mother's education, mother's occupation, wealth index, delivery system, place of delivery, source of drinking water of the household, toilet facility, and total number of children ever born to a woman are significantly related with child malnutrition in Bangladesh. Various strategies are reported by many studies (Black et al., 2008; Faruque et al., 2008; Ahmed and Ahmed, 2009; Ahmed et al., 2012; Deolalikar, 2005; Rayhan and Khan, 2006). Increasing educational facilities from parents can improve the child nutrition. Facilitating access to safe drinking water and sanitation for poor families is also necessary to improve the child nutrition. It should keep in mind that adequate nutrition of children is a prerequisite to build a healthy and productive nation (Ahmed et al., 2012). In addition, to achieve the Millennium Development Goal of halving child undernutrition by 2015, Bangladesh needs to scale up target-oriented programmes such as poverty-reduction income generating interventions and improvement of public food transports for the poor people and deprived regions (Deolalikar, 2005).

6.4: Policy Implementation

Bangladesh Integrated Nutrition Project (BINP) developed programs such as the Adolescent Girls Forum, which focused on teaching young women about healthy diets, reproductive health, delaying pregnancy, and women's rights.

Bangladesh government is also trying to increase women education level, age at first marriage and also trying to reduce the number of early childbearing women in several ways such as; emphasized delaying age at first marriage and age at first pregnancy in its current five-year plan, expanded stipend program for the unmarried female student

and but unfortunately early marriage and early childbearing have not been substantially changed. Government and non-government organizations should take care of women about their health especially in rural area and they may take following policies:

Government and non-government organizations

- As early adolescent marriage seems to contribute to a greater likelihood of marital dissolution, a voice for adolescent women in making decisions about marriage should at least be promoted. Increase more and more attention from the modern women's rights and children's rights movement in terms of early marriage and early conception.

- Bangladesh have laws that regulate marriage, both in terms of minimum age and consent, these laws may not be applied and few prosecutions are ever brought against lawbreakers- parents, officiators or spouses. This exercise should be stop as earlier as possible.

- In order to enhance further the age at marriage and to reduce the rate of adolescent marriage, adolescents, their parents and the community should be more aware of the negative health, social and economic consequences of early marriage, early pregnancy and large family size.

- Enhanced social mobilization, information, education and communication (IEC) campaigns and regulate home visits by Family Welfare Visitors (FWVs) and Family Welfare Assistants (FWAs).

- The country basic education system and its curricula should be redesigned to meet present day needs such as, education on family life, sexual and reproductive health, demographic health, socio-cultural development and the role of women in society.

- Should give more emphasis to public health and structural adjustment; contribute to enlarge the public health systems. In addition, take delivery of appropriate guarantees from private health-care institution and make sure of universal access to affordable health care and confirm further health-care availability.

- The Government also could take appropriate measures to create more employment opportunities for young women and make efforts to employ more young women in white-collar jobs, especially in the fields of health and education.

- There is a need to increase community awareness about the adverse effect of teenage pregnancy through a mass media campaign. While there are targeted efforts nationally and by several international agencies to delay marriage and first birth, their efforts need to be strengthened further.

- Expanded scholarship programs for education among unmarried girls from ultra poor background not only in selected localities but all over in Bangladesh and strictly monitor the immediate effect on the age of marriage among girls as a result the long-term benefits will only be realized when benefits of girls' education become more evident to society.

- Moreover these incentive schemes will be more effective when problems of frequent teachers absenteeism, lack of education materials or discriminatory behaviors of teachers and peers are tackled with a view to improve quality of existing schools.

- Policy makers should need to devise alternative ultramodern policies to protect the interests of these younger yet high risks mothers like as, use of contraception, use of skilled antenatal, childbirth and postnatal care, girls to complete secondary school and introduction of laws relating to minimum age at marriage among adolescents especially in rural area of Bangladesh.

- Other possible influences on the young mothers health includes smoking habits, weight goals, weight-loss methods, body-shape perceptions, eating attitudes and behaviors, self-concept and physical activity and age at menarche.

Individual, Family, and Community Care

- Adolescent mothers often lack of knowledge, education, experience, income, and power of opinion relative to older mothers. Thus, programs should emphasize several approaches to overcome these relative disadvantages.

- Enhanced knowledge about pregnancy complications and recognizing the signs of complications should be widely dispersed to pregnant adolescents, their families and the community at large.

- Programs should also find ways to reduce the cost of pregnancy care for adolescents, who tend to have fewer financial resources.

Outpatient and Clinical Care

- It is important to provide adolescents with an early start to antenatal care and to options for continuing or terminating pregnancy, particularly because adolescents tend to delay seeking abortion, resort to the use of less skilled providers, use more dangerous methods, and delay seeking care for complications.

- Since adolescents are especially more at risk to anemia in pregnancy, it is important for programs to make a special effort to diagnose and treat for anemia.

- Discussion of the "Plan for Birth and Complications," including the place of birth, availability of transportation, companion of choice, and costs involved is essential, particularly for adolescents in light of the higher incidence of complications both for the mother and her newborn.

Health Systems Features

- In addition to the special interventions that would enhance the range of care for adolescents and their babies, country's can integrate features into their

health systems that can improve adolescents' access to quality care and, ultimately, health outcomes.

- Making pregnancy safer for the youngest mothers and their babies is a priority for country's as they struggle to meet targets for improving basic health care. Maternal and newborn health programs should have a clear role.

As a leader You Can Help

- Encourage education for girls. Religious leaders, Community leaders and Parents should send their daughters to school through the end of secondary school.

- Support local Youth Serving Organizations (YSO) that offer young couple's education, services and information about child spacing and family life. Such organizations are essential to helping young couples understand how to plan for healthy, happy families.

For child malnutrition

- Adverse outcomes such as low birth weight can be reduced by improving the nutritional status of adolescents during pregnancy.

- Since higher fertility (i.e. number of children ever born to a woman) has a negative impact on child nutrition, government should implement policies to limit family size by increasing birth space.

- Comprehensive and concerted nutritional interventions such as exclusive breastfeeding, complementary feeding, supplementation of micronutrients to children and mother, hygiene interventions, and management of severe malnutrition are also needed to improve child nutrition.

Education of girls as well as boys will not only ensure basic literacy for all, but also will provide a realistic basis for training women in income-generating activities and primary health care. Theoretically some of the strategic documents and policy papers (like education policy, health improve policy, women right based policy etc) are sound and seems to be implementable, but in reality, the outcomes are yet to be noticeable. The government needs to be creative in renewing and revising strategies and approaches for implementation, responding to the current challenges by not only resorting to old failed policies packaged in new covers. Unless measures are taken to address early marriage and sequentially early conception, it will continue to be a major stumbling block to the achievement of human rights.

6.5: Prospects for future research

There were another several anthropometric indicators for measuring physical health of mother and children such as for mother hemoglobin status, blood glucose status, blood pressure also morbidity pattern and for child health weight for age, height for age also body mass index. This research conducted based on secondary data where the indicator variable blood glucose status, blood pressure and morbidity pattern were absent. So, in future include this indicators a further elaborative research is necessary in this regard. From multivariate analysis both mother and child health, addition of other predictors along with place of residence into the same model may reduce the strength of urban-rural nutritional difference. From this view further detailed research is warranted. From findings, delivery system was positively influenced on early childbearing mothers' undernutrition. Here come up a major question, "Does early childbearing increase cesarean delivery?" So in recent future as in depth research have need of in this perspectives on an emergency.

However, more and better research is needed to expand the evidence base on effective interventions for pregnant adolescents and to translate knowledge into action at the country level.

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ABBREVIATIONS

AAFM	Age at First Marriage
ADL	Adrenoleukodystrophy (a rare genetic condition that affects young boys)
AIC	Akaike Information Criteria
ANOVA	Analysis of Varience
ARI	Acute Respiratory Infection
ASFR	The Age Specific Fertility Rates
BBC	British Broadcasting Center
BBS	Bangladesh Bureau of Statistics
BCPE	Box-Cox Power Exponential
BDHS	Bangladesh Demographic and Health Survey
BE	Backward Elimination
BIC	Bayes Information Criteria
BINP	Bangladesh Integrated Nutrition Project
BMD	Bangladesh Meteorological Department
BMI	Body Mass Index
BR	Bangladesh Railway
BRAC	Bangladesh Rural Advancement Committee
CAPI	Computer Assisted Personal Interviewing
CATI	Computer Assisted Telephone Interviewing
CBR	Crude Birth Rate
CDC	Cairo Demographic Center
CDR	Crude Death Rate
CED	Chronic Energy Deficiency
CMH	Child and Mother Health
CPD	Cephalopelvic Disproportion
CPR	Contraceptive Prevalence Rate
DCM	Data Collection Methodology
DHS	Demographic and Health Survey
DSS	Demographic Surveillance System
DU	University of Dhaka
EAs	Enumeration Areas
ECM	Examination of Correlation Matrix
ECN	Eigen values and Condition Number
ESCAP	The Economic and Social Commission for Asia and the Pacific
EVD	Eigen Values Decomposition

FAO	Food and Agriculture Organization
FP	Family Planning
FS	Forward Selection
FWAs	Family Welfare Assistants
FWVs	Family Welfare Visitors
GDP	Gross Domestic Product
GLM	Generalized Linear Model
GPR	Generalized Poisson Regression
GPS	Global Positioning System
HAZ	Height-for-Age
HDI	Human Development Indicators
HIV	Human Immunodeficiency Virus
HTSP	Healthy Timing and Spacing of Pregnancy
ICDDR'B	International Center for Diarrheal Disease Research, Bangladesh
IEC	Information, Education and Communication
IMR	Infant Mortality Rate
IRR	Incidence Rate Ratio
JHU	Johns Hopkins University
LBW	Low Birth Weight
LGRD	Local Government and Rural Development
LL	Log Likelihood
LMS	Learning Management System Software
LSD	Least Significant Difference
MDG	Millennium Development Goal
MHSS	Matlab Health and Socioeconomic Survey
MLE	Maximum Likelihood Estimation
MMR	Maternal Mortality Rate
MSE	Mean Square Error
NIPORT	National Institute for Population Research and Training
NNP	National Nutrition Programme
NSFG	National Survey of Family Growth
NSP	Nutritional Surveillance Project
NY	New York
OLS	Ordinary Least Square
OLSE	Ordinary Least Square Estimates
ONS	Office for National Statistics
PR	Poisson Regression
PSUs	Primary Sampling Units
QMAS	Qualitative Methods Applied to Surveys
SAARC	South Asian Association of Regional Cooperation

SGA	Small for Gestational Age
SMAs	Statistical Metropolitan Areas
SPSS	Statistical Package for Social Science
SSE	Sum of Squared Residuals (Errors)
SSR	Sum of Squares due to Regression
SST	Total Sum of Squared
STOL	Short Take-off and Landing
TFR	Total Fertility Rate
TTF	Technical Task Force
U5MR	The Under-five Mortality Rate
UN	The United Nations
UNFPA	United Nations Population Fund
UNICEF	The United Nations International Children Emergency Fund
UPs	Union Parishads
UR	Uncertainty Range
USA	United States of America
USAID	United States Agency for International Development
VIF	Variance Inflation Factor
WAZ	Weight-for-Age
WHO	World Health Organization
WHZ	Weight-for-Height
YSO	Youth Serving Organizations
ZIGPM	Zero-Inflated Generalized Poisson Mixed