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# A Study on Infant and Under five Mortality in Bangladesh

Rahman, Md. Mahfuzar

University of Rajshahi

# A Study on Infant and Under-five Mortality in Bangladesh

A
Dissertation Submitted to the University of Rajshahi
in Fulfillment of Requirements
for the Degree of
Master of Philosophy

## M.Phil Dissertation
## By
## Md. Mahfuzar Rahman


Supervised by

Dr. Md. Rafiqul Islam
Associate Professor
Department of Population Science and Human Resource Development
University of Rajshahi



Department of Population Science and Human Resource Development
University of Rajshahi
Rajshahi-6205, Bangladesh



June 2009

**Dedicated**
**To**
**My Beloved Parents**

# Certificate

I am pleased to certify Mr. Md. Mahfuzar Rahman for submission of the M.Phil dissertation entitled **"A Study on Infant and Under-five Mortality in Bangladesh"** to the University of Rajshahi, Bangladesh.

I do hereby certify that the works embodied in this dissertation were carried out by the candidate and to the best of my knowledge; he used the secondary data of Bangladesh Demographic and Health Survey (BDHS), 2004 published by National Institute for Population Research and Training (NIPORT) of the Ministry of Health and Family Welfare, Dhaka, Bangladesh. His work is original and genuine. No part of this study has been submitted on substance for any higher degree or diploma.

I wish him a colorful future and every success in life.

30.06.09

(Dr. Md. Rafiqul Islam)
Associate Professor
Department of Population Science
and Human Resource Development
University of Rajshahi
Rajshahi-6205
Bangladesh

MD. RAFIQUL ISLAM
Associate Professer
Population Science and Human
Resource Development Dept. R.U

# Statement of Originality

I do hereby declare that the M.Phil thesis entitled **"A Study on Infant and Under-five Mortality in Bangladesh"** submitted to the Department of Population Science and Human Resource Development, University of Rajshahi, Bangladesh for the Degree of Master of Philosophy (M.Phil) is completely a new and original work done by me. To the best of my knowledge and confidence, it has not been submitted partially or wholly to any University or Academic Institution for pursuing any degree or diploma.

Mahfuzar Rahman 30.06.2009
(Md. Mahfuzar Rahman)
M.Phil Fellow
Department of Population Science and
Human Resource Development
Session: 2007-2008
University of Rajshahi
Rajshahi-6205
Bangladesh

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University of Rajshahi

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Md. Mahfuzar Rahman

# Abstract

Infant and under-five mortality are the sensitive indices of development and often reflect a country's quality of life. But there is little understanding of whether Bangladesh will be capable of achieving all of the Millennium Development Goals (MDGs) especially the MDG 4 relating to infant (0-11 months) and under-five (0-59 months) mortality. In this view, an attempt has been made to estimate childhood mortality and to identify the covariates of infant and under-five mortality measuring the contribution of each of the covariates to overall variation, with a view to reducing infant and under-five morbidity and mortality in Bangladesh so that the country may be able to reach the MDG 4 target by the year 2015. For this, data are taken from the Bangladesh Demographic and Health Survey (BDHS), 2004, for the ten-year period preceding the survey (with a total sample size 7427, of whom 5004 from rural and 2423 from urban areas), having an eligible woman (ever-married and aged 10-49) with at least one or more child(ren) and the study is executed separately for the overall country level, rural level and urban level of Bangladesh. For analyzing the data, indirect techniques (Brass, Sullivan and Trussell methods), abridged life table technique and well-known statistical tools such as Pearson chi-square ($\chi^2$) test, logistic regression model and discriminant analysis have been performed.

From the results, it is revealed that the probabilities of dying (${}_nq_x$) calculated, using Brass, Sullivan and Trussell methods are increasing with the increase of age of mothers. Again in case of data classified by duration of marriage of mothers, it is observed that the ${}_nq_x$ is increasing with the increase of marital duration. But for the urban male, these probabilities are decreasing from the marital duration of 0-4 years to 10-14 years and then again increasing up to the last marital duration group. The results of $\chi^2$ test indicate that among all the selected variables e.g. mothers' education, age of mother at birth, is child twin?, toilet facility, T.T. injections, breastfeeding, antenatal visits, after birth checked health, parity and preceding birth interval are statistically and significantly associated with the infant and under-five mortality. The

results of logistic regression analysis using these ten significant variables (the two variables such as child's sex and sources of drinking water are excluded because of their insignificant association showed through $\chi^2$ test) revealed that is child twin?, breastfeeding, antenatal visits and after birth-checked health have highly significant ($p<0.01$) influence on infant and under-five mortality. The impact of toilet facility on infant and under-five mortality, except under-five mortality of urban level, is not statistically significant. The results of abridged life table indicate that the survival function ($l_x$) decreases smoothly throughout the period both the rural and urban areas of Bangladesh and these changes are little after the neonatal period. The $_nq_x$ function is decreasing with the increase of age and it is higher in rural area than that of urban area. In case of the expectation of life, it is higher for literate and working mothers than that of illiterate and not working mothers respectively. The results also indicate that life expectancy is the highest in age group of 1-2 months for all the studied areas. In discriminant analysis, the stepwise procedure has been picked up and only the significant variables are ranked according to the rank of Wilk's Lambda values and the results show that breastfeeding is the most important variable. Also the canonical discriminant function coefficients (unstandardized and standardized) for the predictor variables have also been calculated and the results are almost similar to Wilk's Lambda. The related results of discriminant function also indicate that the discriminant function is statistically significant and discriminates well.

However, improvements in the health system for increased coverage of antenatal and postnatal care, for avoiding pregnancy related complications especially during twin births and for improving the breastfeeding practices (both inclusive and exclusive) are essential which may the effective strategies to reach families and communities with targeted messages and information.

# Contents

# *List of Tables*

**Title** **Page No.**

# *List of Figures*

# *List of Abbreviations*

| | |
|---|---|
| AIDS | :Accquired Immune Deficiency Syndrome |
| ARI | :Acute Respiratory Infection |
| ASDRs | :Age Specific Death Rats |
| BDHS | :Bangladesh Demographic and Health Survey |
| BCG | :Bacille-Calmette-Guerin Vaccine against Tuberculosis |
| BFS | :Bangladesh Fertilty Survey |
| CEB | :Children Ever Born |
| CCR | :Correct Classification Rate |
| DHS | :Demographic and Health Survey |
| EAs | :Enumeration Areas |
| GDP | :Gross Domestic Product |
| HIV | :Human Immune Virus |
| HR | :Human Resource |
| HDSS | :Health and Demographic Surveillance System |
| HRD | :Human Resource Development |
| HNPSP | :Health, Nutrition and Population Sector Program |
| HDI | :Human Development Index |
| HPI | :Human Poverty Index |
| ICDDR, B | :International Centre for Diarrhoeal Disease Research, Bangladesh |
| IMR | :Infant Mortality Rates |
| IMCI | :Integrated Management of Childhood Illness |
| ICPD | :International Conference on Population and Development |
| IEC | :Information, Education and Communication |
| LBW | :Low Birth Weight |
| LDC | :Least Developed Country |
| MDGs | :Millennium Development Goals |
| NIPORT | :National Institute for Population Research and Training |
| PRSP | :Poverty Reduction Strategy Paper |
| PRB | :Population Reference Bureau |
| PSUs | :Primary Sampling Units |
| TT | :Tetanus Toxoid |
| TTF | :Technical Task Force |
| UNICEF | :United Nations Children's Fund |
| UN | :United Nations |
| USAID | :United States Agency for International Development |
| UP | :Union Parishad |
| US$ | :US Dollar |
| WSSD | :World Summit on Sustainable Development |

# *Chapter One*
# *Introduction*

## 1.1 Country Profile

Bangladesh is situated in the Eastern part of South Asian Sub-continent and covers an area of 147,570 square kilometers. It is almost bordered by India on the East, West and North, except for a short Southeastern frontier with Myanmar and a Southern coastline on the Bay of Bengal. It is located between 20° 34′ and 26° 38′ North latitudes and 88° 01′ and 92° 41′ East longitudes.

The Moguls ruled the country from the 13th century to the 18th century, when the British took over and administered the subcontinent until 1947. During British rule, Bangladesh was a part of India. In 1947, the independent states of Pakistan and India were created. The present territory of Bangladesh was the West part of Pakistan from 1947 to 1971. Bangladesh emerged on the world map as a sovereign state on March 26, 1971 after fighting a nine-month bloody war of liberation. Bangladesh is one of the largest deltas in the World. Except for some hilly regions in the Northeast and Southeast part, the country is low and flat and consists of alluvial soil. The most significant feature of the landscape is the extensive network of large and small rivers that are of primary importance to the socioeconomic life of the nation. Chief among these and lying like a fan on the face of the land, are the Ganges-Padma, Brahmaputra-Jamuna, and the Megna rivers.

The climate of Bangladesh is dominated by seasonal monsoons. The country experiences a hot summer season with high humidity from March to June; a somewhat cooler, but still hot and humid monsoon season from July through early

October; and a cool, dry winter from November to the end of February. The Annual temperature ranges between $55^0$ and $80^0$ Fahrenheit. Being located in he monsoon belt, it receives heavy rainfall, which varies from a minimum of 125 cm to maximum of 500 cm. The fertile delta is subject to frequent natural calamities, such as floods, cyclones, tidal bores, and drought.

For administrative purposes, the country is divided into 6 divisions, 64 districts, and 496 upazilas (sub-districts), 4,451 unions (unions being a cluster of villages) (BBS, 2001). Muslims constitute almost 90% of the population of Bangladesh, Hindus account for about 9%, and others constitute the remaining 1%. The national language of Bangladesh is Bangla (Bengali), which is spoken and understood by all. English is practiced here as the second language.

Agriculture is the most important and single largest producing sector of the economy, and it contributes about 22% to the Gross Domestic Product (GDP). This sector also accounts for around 48% of the total labor force (BBS, 2008b). Average per capita income in Bangladesh increased to US$599 during the fiscal year July 1, 2007- June 30, 2008, mainly due to remittances from citizens working abroad. If average per capita income were to reach US$750, Bangladesh would progress from its present least developed country (LDC) status to a middle-income economy (IANS, 2008). Rice, wheat, jute, sugarcane, tobacco, oilseeds and potatoes are the principal crops. The country produces about 51 million kilograms of tea per year, a sizeable quantity of which is exported to foreign markets. Bangladesh produces about 1,057,000 metric tons of superior quality jute annually and 16% of export earnings come from raw jute manufactures (BBS, 2001). The manufacturing sector, although small, is increasing in importance as a result of foreign investments; it contributes about 17% of GDP. The manufacturing sector is dominated by the ready-made garments industry (BBS, 2008b). Unemployment and underemployment are serious problems and pressure on the land in rural areas has led to movement of people from rural to urban areas.

Bangladesh takes place 140th among nations on the Human Development Index (HDI), as presented in the 2007-2008 Human Development Report. The country's HDI value is 0.547, placing it in the category of medium human development countries. Within South Asia, Bangladesh only outranks Nepal, which ranks 142nd on the HDI (UNDP, 2007).

Bangladesh is still struggling to emerge from poverty. It ranks 93rd among 108 developing countries on the Human Poverty Index (HPI) (UNDP, 2007). The HPI is a multidimensional measure of poverty for developing countries; it takes into account social exclusion, lack of economic opportunities, and deprivations in survival, livelihood, and knowledge.

Bangladesh is the most densely populated country in the world with limited land and resources. During the first half of the last century, the population increased by 45%. In the second half of the twentieth century, this growth was rapid and the population tripled during this period. The relatively young age structure of the population indicates continued rapid population growth in the future. One-third of the population is under 15 years of age, 63% are of age 15-64 years, and 4% are of age 65 or older (CIA, 2008). Projections indicate that the population will increase rapidly even after attaining replacement-level fertility because of the echo effect of the high fertility experienced in the past.

Family planning was introduced in Bangladesh (then East Pakistan) in the early 1950s through the voluntary efforts of social and medical workers. The government, recognizing the urgency of moderating population growth, adopted family planning as a government-sector program in 1965. The First Five-Year Plan (1973-1978) emphasized "the necessity of immediate adoption of drastic steps to slow down the population growth" and reiterated that "no civilized measure would be too drastic to keep the population of Bangladesh on the smaller side of 15 crore (i.e., 150 million) for sheer ecological viability of the nation" (GOB, 1994:7). Beginning in 1972, all subsequent governments that have come into power in Bangladesh have identified population control as the top priority for government action.

Bangladesh has undergone a major demographic transition because of declining fertility over the last twenty years. In 1999, there were five million more children between the ages of 10 and 14 than between the ages of five and nine. The fertility rate has declined from about 6.3 births per woman in the early 1970s to 3.3 births in the mid 1990s. According to the PRB (2008), the current total fertility rate is 2.7. The life expectancy at birth is 62 years for male and 64 years for females. Acquired Immune Deficiency Syndrome (AIDS) is nor widespread in Bangladesh. The HIV/AIDS prevalence rate is less 0.01%. Despite improvements in the spread of education, levels of education attainment still remain low in Bangladesh and there is a strong differential that persists between male and female and between urban and rural residents. The literacy rate is 53.5%.

To overcome the multidimensional problems and to meet the challenge in the spirit of the 1994 International Conference on Population and Development (ICPD) in Cairo, the Government of Bangladesh launched the Health, Nutrition and Population Sector Program (HNPSP) in 2003. This program entails providing a package of essential and good quality health care services that are responsive to the needs of the people, especially children, women, the elderly, and the poor.

Recently, the government adopted the Bangladesh Population Policy. Its goals are to improve the status of family planning and maternal and child health, including reproductive health services, and to improve the living standard of the people of Bangladesh by striking a desired balance between population and development in the context of the Millennium Development Goals (MDGs) and Poverty Reduction Strategy Paper (PRSP).

**1.2 Background of the Study**

Infant and under-five mortality is a sensitive index of the level of development of a society or a community and seen as the criteria of "success and failure" of a nation. It reflects the states of social, economic, demographic and environmental conditions in a society. A healthy and long life is the greatest gift to the individuals. On the other hand, ill health and volatile mortality at the younger ages disrupt all the development efforts. High level of morbidity and mortality leads to low work input, which in turn hinders the development. Also, high levels of mortality threaten the survival of a family. So, in the studies on the development of a society or a family, studying infant and under-five mortality has an important place and also as the levels of mortality predominantly affect the levels of overall fertility.

Every year, over 10 million children, aged less than five years, die globally before their first birthday and about 40% of these deaths take place within the first 28 days of life. Developing countries are often characterized as having high infant mortality and high fertility. These two are demonstrated by high key indicators of infant mortality rates (IMR) and fertility rates. A large number of childhood morbidity and mortality in the developing countries is caused by five conditions: acute respiratory infection (ARI) (mostly pneumonia), diarrhoea, measles, malaria and malnutrition. The Integrated Management of Childhood Illness (IMCI) strategy encompasses a range of interventions to prevent and manage this major childhood illness both in health facilities and at the home. The IMCI strategy incorporates many elements of diarrhoeal and ARI control programs as well as child related aspects of malaria control, nutrition, immunization and essential drugs. Mosely and Chen (1984) had introduced an effective analytical framework for the study of the determinants of child survival in developing countries (Figure 1.1). The framework is based on the premise that all social and economic determinants of child mortality necessarily operate through a common set of biological mechanism or proximate determinants to exert an impact on mortality.

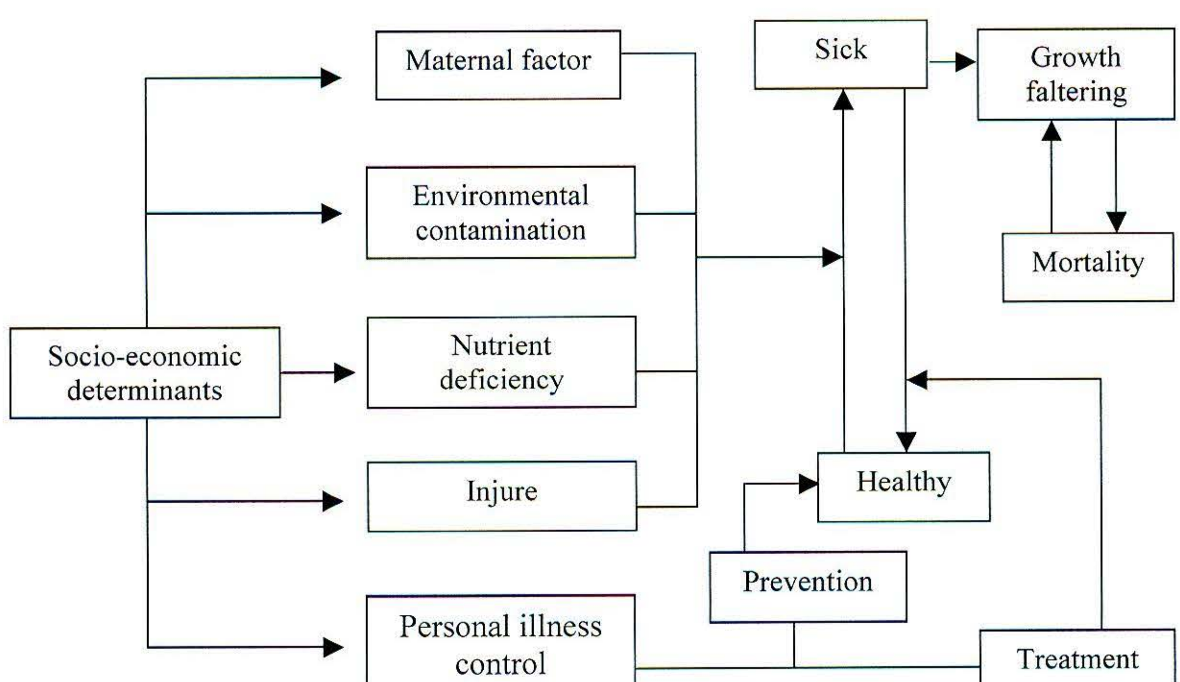


**Figure 1.1.** Mosely and Chen (1984) conceptual framework

Bangladesh, a relatively small country, has experienced very high population growth rates in the last fifty years. During this time, various steps were taken to lowering fertility and mortality in the country. Although the recent decline in infant and under-five mortality is remarkable, death from causes other than infectious diseases and malnutrition remains an important component of child mortality. The decline is mainly due to adult female schooling, delayed child bearing among women and expanded measles immunization coverage. The reduction in such mortality and improvements in are likely to contribute to human resource development (HRD) as a consequence of greater socio-economic development and quality life. The MDGs were developed out of the eight chapters of the United Nations Millennium Declaration, signed in September 2000 that are revised in October 2007 when the United Nations General Assembly adopted four additional targets. Among the eight goals and twenty one targets, the MDGs declaration for the infant and under-five mortality is as follows:

| Goals and Targets | Indicators for Monitoring Progress |
|---|---|
| **Goal 4:** Reduce child mortality.<br>**Target 5:** Reduce by two-thirds, between 1990 and 2015, the under-five mortality rate. | 13. Under-five mortality rate.<br>14. Infant mortality rate.<br>15. Proportion of one-year-old children immunized against measles. |

Several studies have shown that a number of social, economic, demographic and environmental factors affect infant and under-five mortality. But the causal relationship between infant and under-five mortality and its socio-economic and other covariates is not well established. In order to suggest some specific developmental measures (e. g. in health, in education, in employment etc.) to achieve the MDGs target declare for of infant and under-five mortality, it would be important to identify some socio-economic, demographic and environmental factors, which have the significant influence on the mortality. Such information will obviously be useful to the planners, to have a selective-sectoral development plan and program.

**1.3 Infant and Childhood Mortality in Bangladesh**

Infant and child mortality rates reflect a country's level of socioeconomic development and quality of life. It is also a reflection of the care, health and nutritional status of infant and children and indicates the social, cultural and economic progress in the country. Actually, they are used for monitoring and evaluating population and health programs and policies. In underdeveloped countries where there is high death rate, birth rate is bound to be very high. In a country Nigeria, almost 50% children die before they reach the age of only one year; whereas 90% children die before reaching five year of age (Raj, 1996).

In Bangladesh, the infant mortality rate (IMR) barely dropped (from 168 infant deaths per 1,000 live births to 161 deaths) during the two decades between 1951 and 1971. In the immediate aftermath of Bangladesh's independence, the IMR actually increased to 173. But since then, the rate has fallen secularly and rapidly, reaching a level of 125 by 1984-85, 80 in 1994-95 (World Bank, 2005). While there has been an appreciable drop in under-five death rates from 151 deaths per thousand live births in 1990 to 87 in 1999, the rate has since slowed considerably, with the figure standing at 82 in 2001 (GOB, 2005). The under-five mortality rate for the most recent five-year period (which roughly corresponds to the period 1999-2003) is 88 deaths per 1,000 live births, and infant mortality is 65 deaths per 1,000 live births. Child and under-five mortality declined 52 and 34% respectively between the periods 1989–2004 (BDHS, 2004). Data from the 2007 BDHS show that under-five mortality (65 deaths per 1,000 live births) has continued its notable decline. Large decreases were observed in both child mortality (age 1-4 years) and post-neonatal mortality. One of every 15 Bangladeshi children dies before reaching age five, compared with one in 11 in the 2004 BDHS. Likewise, the number of children who die before reaching the first birthday has decreased from one in fifteen children to one in 19 (52 deaths per 1,000 live births). Around 71% of infant deaths occur during the first month of life (neonatal mortality). There is a strong association between under-five mortality and mother's education. It ranges from 32 deaths per 1,000 live births among children of women with secondary complete or higher education to 93 deaths per 1,000 live births among children of women with no education. As in the 2004 BDHS, the highest levels of under-five mortality are observed in Sylhet division (107 deaths per 1,000 live births), and the lowest under-five mortality is observed in Khulna division (58 deaths per 1,000 live births).

**Table 1.1. Trends in Infant and Under-five Mortality Rates in Bangladesh**

| | **Mortality rates (per 1,000 live births)** | | | | |
|---|---|---|---|---|---|
| Survey (BDHS) | 1993-1994 | 1996-1997 | 1999-2000 | 2004 | 2007 |
| Appropriate reference period | 1989-1993 | 1992-1996 | 1995-1999 | 1999-2003 | 2002-2006 |
| Mid-year | 1991 | 1994 | 1997 | 2001 | 2004 |
| Infant mortality | 87 | 82 | 66 | 65 | 52 |
| Under-five mortality | 133 | 116 | 94 | 88 | 65 |

**Sources:** Bangladesh Demographic and Health Survey, BDHS, 2004 and BDHS, 2007

The life expectancy at birth during 1920-1940 increased by 10 years from 20 to 30, and during 1941-1961, it increased by 15 years from 30 to 45; whereas, during 1970's this trend of mortality decline was arrested, partly because of devastating cyclone in November, 1970; independence war of 1971 and subsequent disruption of rehabilitation caused by a major famine in 1974 resulting from a fragile economic base, a poor transportation and communication system and inefficient food distribution (UN, 1984). Thus, in 1974 the life expectancy at birth was 45.3 for males and 46.6 for females. But according to the PRB (2008), the life expectancy at birth for males and females is 62 and 64 year respectively and for the overall population is 63 years.

Mortality decline since 1920 was perhaps the result of health measures that largely controlled the major epidemics such as plague, cholera, malaria and smallpox. Large-scale programs were undertaken to reduce infant and child mortality by maternal and child welfare institutions. As a result, smallpox was largely controlled by 1970; and in 1976, country was declared free from smallpox. Anti-tuberculosis program of Bacille-Calmette-Guerin (BCG) vaccine against tuberculosis was put into operation since 1950. Malaria was largely controlled by the use of DDT. However, it was reappeared in some places. It has been found that " Diarrhoeal diseases of cholera and gastro-enteritis types are still prevalent. Mortality in the childhood occurs mostly from infectious diseases such as dysentery, whooping cough, measles and diphtheria" (UN, 1984).

**1.4 Millennium Development Goals (MDGs) and Reduction in Infant and Under-five Mortality in Bangladesh**

Is Bangladesh on target for achieving the Millennium Development Goal: 4 (MDG 4) of declining infant and under-five mortality? According to a recent analysis by the United Nations, of the 10 regions covering developing countries, five (North Africa, East Asia, Southeast Asia, Latin America/Caribbean, and the former Soviet Republics in Europe) were on track to achieve MDG 4 (United Nations, 2007). South Asia is described as still having high mortality, and the MDG 4 target is not expected to be met by 2015. Sub-Saharan Africa still had very high mortality while the three regions (West Asia, Oceania, and former Soviet Republics in Asia) had moderate mortality and unlikely to meet the MDG 4 target if the current trends prevailed. In a recent analysis of 68 countries of the world, selected because they together account for 97% of maternal, newborn and child deaths worldwide each year, the United Nations Children's Fund (UNICEF) reports that only 16 were on track to achieve MDG 4, including Bangladesh (UNICEF, 2008). An earlier joint report in February 2005 by the Government of Bangladesh and the United Nations Country Team in Bangladesh articulated concern at the slowing of the pace in the decline of under-five mortality, based on data available at that time (GOB, 2005). The target for Bangladesh is to reduce under-five mortality from 151 deaths per 1,000 live births in 1990 to 50 in 2015. The report expected that if this MDG is to be achieved, the country needs to achieve and continue a reduction of three childhood deaths per 1,000 live births every year. The report highlighted the need to focus attention on neonatal and perinatal causes of death, deaths due to pneumonia, diarrhoea, injuries, poor care-seeking practices, malnutrition, and low birth weight (LBW).

What can it declare about achieving MDG 4 of declining child mortality in Bangladesh from the findings of the five Bangladesh Demographic and Health Surveys (BDHS) since 1993 (BDHS Preliminary Report, 2007). From 1991 to 2004 (mid-years of the BDHS 1993-1994 and 2007), under-five mortality in Bangladesh reduced by almost half, i.e. at an average rate of 5.3% per year (Table 1.2), which exceeds the required annual decline of 4.3% needed to achieve the MDG of a two-third reduction in under-five mortality by 2015 from the 1990 levels. However, if this estimation is disaggregated, the decline was almost 10% among 1-4 year(s) old children and about 6% annually among post neonates [1-11 month(s)]. However, the diminution was only 2.6% annually in neonates. Much (57%) of the under-five mortality is now in neonates, and it seems unlikely that the high rates of decline will be sustained among children aged over one month. It is essentially observed substantial slowing down between 1997 and 2001. It is also clear that, if a considerable reduction in neonatal mortality is not achieved, Bangladesh may not achieve MDG 4 (Table 1.2). While the trends in mortality propose that we need to 'work harder' in achieving MDG 4, it may be that we also require to 'work smarter' in identifying the remaining issues that are preventing further improvements.

**Table 1.2. Trends in Annual Average Rates of Reduction of Mortality in Bangladesh**

| | Annual average rate (%) of reduction in mortality | | | | |
|---|---|---|---|---|---|
| | 1991-1994 | 1994-1997 | 1997-2001 | 2001-2004 | 1991-2004 |
| Neonatal mortality | -2.6 | -4.6 | -0.6 | -3.4 | -2.6 |
| Post neonatal mortality (1-11 months) | -1.0 | -11.0 | -0.0 | -14.5 | -6.3 |
| Child mortality (1-4 years) | -9.5 | -6.8 | -5.4 | -16.4 | -9.3 |
| Under-five mortality | -4.5 | -6.8 | -1.6 | -9.6 | -5.4 |

**Source:** Bangladesh Demographic and Health Survey, (BDHS) 2007: Preliminary Report

## 1.5 Importance of the Study

In recent decades, overall child mortality rates have decreased globally. By 1993-1994, according to the first Demographic and Health Survey (DHS) in Bangladesh, the child mortality rate (mortality before reaching the age of five years) was 133 per one thousand live births and the infant mortality rate (mortality before reaching the age of one year) was 87 per one thousand live births (reference period 1989-1993). Infant deaths thereby accounted for 65% of all under-five deaths. Since then Bangladesh recorded a sharp decline in under-five deaths – with 65 deaths per one thousand live births in the period 2002-2006 and a 0.5 percentage points decline each year. In contrast, infant deaths declined by only 0.2 percentage points (from 87 to 52 deaths per one thousand live births) over the same period. Since the launch of the Millennium Development Goals (MDGs) at the Millennium Summit in New York in September 2000, the MDGs have become the most widely accepted yardstick of development efforts by governments, donors and NGOs. The MDGs are a set of numerical and time-bound targets related to key achievements in human development. They include halving income-poverty and hunger, achieving universal primary education and gender equality, reducing infant and child mortality by two-thirds and maternal mortality by three-quarters, reversing the spread of HIV/AIDS and other communicable diseases, and halving the proportion of people without access to safe water. These targets are to be achieved by 2015 from their levels in 1990. Almost all the countries in the world, including Bangladesh, have committed themselves to attaining the targets embodied in the Millennium Declaration by 2015. Unfortunately, there is little understanding of whether Bangladesh will be able to attain all of the MDGs. There is even less understanding of what it will take – by way of economic growth, infrastructure investments, and sectoral interventions – to attain the different MDGs, especially in case of infant and child mortality. Keep in mind these bases and other related developmental efforts; this study will be necessary and very helpful to maintain a pace of annually reducing infant and under-five deaths and to achieve the MDGs in infant and under-five deaths by the year 2015 that must be able to play a core role for the development of human resource (HR) in Bangladesh.

## 1.6 Concepts and Terminology

### Infant Mortality

Infant mortality is an indication of the likelihood that a child who born will die during the first year of life.

### Under-five Mortality

Under-five mortality is an indication of the likelihood that a child who born will die between birth and fifth birthday of life.

### Children Ever Born (CEB)

According to the United Nations, CEB is defined as "Information on the number of children born alive should include all children born alive during the lifetime of the women concerned up to the census date (i. e. excluding foetal deaths). The number recorded should comprise all live born children, whether legitimate or illegitimate, or whether born of the present or of prior marriages, and regardless of whether they are living or dead at the time of the census, or whether they may be living."

**Average Parity**

When women are grouped according to some other variables such as age or duration of marriage, the average number of children ever born by the group, known as their average parity.

**Duration of Marriage**

Duration of marriage is defined as the time elapsed since entry into first union, regardless of whether this union is legal.

**Covariates of Infant and Under-five Mortality**

The social, economic, demographic and environmental factors to which the levels of infant and under-five mortality are related are known as covariates of infant and under-five mortality.

## 1.7 Review of Literature

The review of literature is a vitally important part of research work. A conception can be gained about the previous research work through the study of the literature review. There is now a vast literature dealing with infant and childhood mortality and their covariates. Reviewing of all of these studies is not within the scope of this study. However, some of the relevant, consistent and well-discussed literatures in the context of the present study are reviewed in the following:

**Saha and Soest (2009)** analyzed siblings' death at infancy, controlling for unobserved heterogeneity and a causal effect of death of one child on survival chances of the next child using longitudinal data of the Health and Demographic Surveillance System (HDSS) in Matlab, Bangladesh and exploiting dynamic panel data models. Matlab is a rural area split into two: a "treatment" area where along with standard government services extensive maternal and child health interventions are available, and a "comparison" area where only the standard government services are available. The observed infant mortality rates are 50 per 1,000 live births in the treatment area and 67.4 per1, 000 in the comparison area. They used separate models for the two areas and analyze the differences in infant mortality between the two areas using several decompositions. In the comparison area, the model predicts that the likelihood of infant death is about 30% larger if the previous sibling died at infancy than if it did not, and the estimates suggest that, in the absence of this "scarring" effect, the infant mortality rate among the second and higher order births would fall by 6.2%. There is no evidence of such a scarring effect in the treatment area, perhaps because learning effects play a larger role with the available extensive health interventions. They also found that distance to the nearest health clinic could explain a substantial part of the gap in infant mortality between the two areas.

**Giashuddin *et al.* (2009)** investigated the inequality in mortality and morbidity for one to four year old children, especially by cause of injury, among socio-economic groups. In their study, quintiles were used to measure disparities in mortality by the economic status in terms of household's goods. The concentration indices confirmed that injury related death was higher among the poor children as compared to rich children. They found that inequalities also appeared in mortality due to infectious and non-communicable diseases. The children of poorest families suffered more in injury morbidity than the children of rich families. Income inequality was significantly visible in both leading causes of mortality and morbidity. The multivariate logistic regression analysis substantiated that female injury mortality was higher but the illness became lower than males and also indicated that poor children were 2.8 times more likelihood to suffer from injury mortality than rich children, taking into account all the other factors.

**Bhalotra, Valente and Soest (2008)** showed in their study that Muslim children in India face substantially lower mortality risks than Hindu children. This is surprising because one would have expected just the opposite: Muslims have, on average, lower socio-economic status, higher fertility, shorter birth-spacing, and are a minority group in India that may be expected to live in areas that have relatively poor public provision. They also showed controlling for mother's and father's educational level, caste (if Hindu), rural vs urban location, state of residence, cohort (or time) effects, the age of the mother at birth and the gender and birth-order of the child hardly diminishes the Muslim effect. It is -0.021 for under-five and -0.016 for infant mortality. Girls face lower infant mortality risk but higher under-5 mortality risk, consistent with the view that the role of liquidity constraints and/or parental preferences relative to the role of nature grows with child age. Mortality risk appears to be consistently decreasing in maternal age at birth, in contrast to the U-shape noted in some other studies. Conditional upon maternal age at birth, mortality risk is increasing in birth-order, this effect being stronger for under-5 than for infant mortality.

**Omariba, Rajulton and Beaujot (2008)** had shown that the death of the immediate preceding child has a substantial and significant effect on the probability of the next child in the family dying even after adjusting for unobserved heterogeneity and all the selected factors. There is also modest, but significant, between-family variation in the probability of death. Several issues have also been demonstrated by the statistical model presented here. First, a model that ignores the correlation among siblings' survival outcomes would overestimate the effect of the death of the previous child. Second, a model that considers state dependence and unobserved heterogeneity but drops the information on firstborns would also produce biased results. Finally, in a dynamic model that examines the effects of both the death of the previous child and also includes the preceding birth intervals as a regressor, the effect of the former will attenuate.

**Houweling (2007)** showed that the location (place of residence, rural/urban) had an important effect on infant and child survival chance, once controlling the other factors. He demonstrated that place of residence was an important mediator of the relationship between economic inequality and mortality. He also observed that socio-economic inequalities in under-five mortality were often partly explained by the fact that lower socioeconomic groups tend to live in rural areas, which typically exhibit characteristics that instigate high mortality.

**Houweling, Jayasinghe and Chandola (2007)** showed that absolute inequalities in under-five mortality in Sri Lanka were very low internationally, while relative mortality inequalities were high. They also showed that despite the low overall under-five mortality levels and absolute mortality inequalities, Sri Lanka exhibited a clear mortality gradient across educational groups. Further, the high and rising relative inequalities in under-five mortality in Sri Lanka showed that the achievement of low mortality might be at the expense of increasing relative mortality inequalities between socioeconomic groups. Increasing inequalities in malnutrition and under coverage of health care, perhaps related to a strong gradient in female autonomy across educational groups, may have contributed to the rising relative under-five mortality inequalities in this country.

**Gurven *et al.* (2006)** compared age-specific mortality in remote forest and reverie regions with that in more acculturated villages and examine mortality changes among all age groups over the past fifty years and examined impacts of region, period, sex and age on mortality hazard. Villages in the remote forest and reverie regions showed 2-4 times higher mortality rates from infancy until middle adulthood than in the acculturated region.

**Rahman *et al.* (2005)** showed from the prospective study in Rajshahi district, Bangladesh that the risks of infant and child mortality were higher for children whose mother never breastfed and were not fully immunized at all. Immunization practice of children saves children from dangerous diseases. The children who are not immunized may have greater chance of being attacked by several severe diseases. The risks of infant and child mortality gradually declined as both the mother's age at marriage and their age at birth increased.

**Mittal (2005)** studied that fetal, neonatal, and post neonatal deaths at delivery are usually due to different sets of causes; these deaths are included in the categories of Maternal Care, Newborn Care, and Infant Health respectively. He also showed that there are different risk factors at different infant developmental stages and suggested that by examining the mortality at different stages of development, one can tailor the interventions to that time period.

**Davanzo *et al.* (2004)** in their study tried to find a better understanding of the effects of the lengths of inter birth intervals on infant and child mortality and on maternal mortality and morbidity in Bangladesh. They found that, compared with intervals of 3-5 years in duration, preceding inter birth intervals of less than 24 months in duration were significantly associated with higher risks of early neo-natal mortality, and that inter birth intervals of less than 36 months were significantly associated with higher risks of late neo-natal mortality, post neo-natal mortality, and child mortality. A short preceding interval also increases the risk that the index pregnancy will result in a non-live birth (particularly an induced abortion) or a pre-mature live birth. A short subsequent inter pregnancy interval was also significantly associated with a higher risk of mortality for the index child. These effects persisted when potentially confounding factors (pre maturity, breastfeeding, immunizations, and demographic and socioeconomic variables) were to be controlled.

**Klaauw and Wang (2004)** found that socio-economic and environmental characteristics have significantly different impacts on mortality rates at different ages. These are particularly important immediately after birth. The study also indicated that child mortality could be reduced substantially, particularly by improving the education of women and reducing in door air pollution caused by cooking fuels. In addition, providing access to electricity and sanitation facilities can reduce under five years' mortality rates significantly.

**Ghosh (2003)** found that the main determinants of infant and child mortality are namely demographic or biological factors such as age of the mother, mother's age at birth, breastfeeding practices, birth interval, sex of the child and immunization practices of children.

**Kishor and Parasuraman (1998)** studied bivariate comparison of infant and child mortality rates for the period 0–4 years before the survey according to mothers' employment status that revealed mothers who were employed had a 10% higher infant mortality rate and a 36% higher child mortality rate than mothers who were not employed. Male mortality increased more than female mortality if mothers work. These results were largely upheld in the multivariate analysis of births that took place 0 to 4 years before the survey. Logistic regressions were run separately for survival from 0 to 11 months and from 12 to 47 months. Controlling for relevant bio-demographic, socio-economic and individual background characteristics, the odds of dying at ages 12–47 months were significantly higher when mothers were employed; the odds of dying at ages 0–11 months were higher only if the mother was employed at home or outside the home for cash. The odds of dying did not differ by mother's employment status for female infants, but were 12% higher for males if the mother was employed than if she was not.

**Rahman *et al.* (1985)** studied the impact of environment, sanitation and crowding on infant mortality in rural Bangladesh. They found that those who do not use latrine, had significantly higher post neo-natal mortality; but they did not find any effect of environmental factors on infant mortality.

**Ali-Kabir (1984)** worked with the community level data of BFS (1976), using log-linear regression analysis and found that birth interval and birth order were the most important for infant and child mortality in Bangladesh. He also found distance of family planning clinics and primary schools, mother's education, urban/rural residence of mother were the second important factors for infant and child mortality.

**Chowdhury (1982)** found from the prospective study in rural Bangladesh that both neo-natal and post neo-natal deaths were higher for those whose mothers were illiterates. He also found that height of mothers and height of babies were negatively related to infant mortality.

**Ingrid (1981)** worked with BFS (1976) data, using multiple regression analysis and found a negative relation between birth interval and post neo-natal mortality, when the preceding child was surviving. He also found higher neo-natal mortality for males than for females and higher female post neo-natal mortality than for males.

### 1.8 Objectives of the Study

Like all other countries of the United Nations, Bangladesh is also strongly committed to achieve the MDGs by the year 2015, especially to reduce the infant (from 94 deaths per thousand live births in 1990 to 32 in 2015) and under-five mortality (from about 150 deaths per thousand live births in 1990 to 50 in 2015). In this study, an attempt would be made to identify the most important and influential covariates of infant and childhood mortality to accelerate the reduction rate of infant and under-five mortality by the year 2015.

Therefore, the specific objectives of the study would, therefore, be addressed as follows:

i. To estimate childhood mortality using indirect techniques when data classified by age and duration of marriage of mothers;

ii. To identify the covariates which have influence on infant and under-five morality;

iii. To study the life-table estimates of mortality under age five;

iv. To identify the factors related to mothers experiencing to infant and under-five mortality and to measure the contribution of each of the factors to the overall variation; and

v. To suggest what polices and remedial measures should be taken to achieve the MDGs target in infant and under-five mortality by the year 2015 in Bangladesh.

### 1.9 Organization of the Study

This study has been organized into seven chapters including different sections. These are as follows:

The **First Chapter** is introductory one, which contains of the sections such as Country Profile, Background of the Study, Infant and Childhood Mortality in Bangladesh, Millennium Development Goals (MDGs) and Reduction in Infant and Under-five Mortality in Bangladesh, Importance of the Study, Concepts and Terminology, Review of Literature, Objectives of the Study and Organization of the Study.

The **Second Chapter** is known as Data and Methodology where data sources and methodology are described in details theoretically.

The **Third Chapter** is Indirect Estimation of Childhood Mortality.

The **Fourth Chapter** is named as Covariates of Infant and Under-five Mortality.

The **Fifth Chapter** is Life Table Analysis of Infant and Under-five Mortality.

The **Sixth Chapter** is Infant and Under-five Mortality: A Discriminant Analysis and

The **Seven Chapter** is Conclusion and Policy Recommendation.

Moreover, **References** and **Annex** are included at the end of this study.

# *Chapter Two*
# *Data and Methodology*

## 2.1 Introduction

Research methodology is the philosophy of research to systematically solve the research problem. 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 research study and also to explain the findings. The present chapter is devoted to give an outline of the data source and sample size, which is used in the present study. The used methods and techniques are also mentioned and briefly described in this chapter.

## 2.2 Data Source and Sample Size

Data for the study were drawn from the Bangladesh Demographic and Health Survey (BDHS), 2004. This survey is the fourth in a series of national-level population and health surveys, conducted as a part of the global Demographic and Health Survey (DHS) program. A total of 10,811 households were selected for the sample; 10,523 were occupied, of which 10,500 were successfully interviewed, covering 361 sample points (clusters) throughout Bangladesh (122 in urban areas and 239 in the rural areas). Of the households occupied, 99.8% were successfully interviewed. In these households, 11,601 women were identified as eligible for the individual interview (i.e., ever-married and age 10-49) and interviews were completed for 11,440 or 98.6% of them. But this study is executed separately for the overall country level, rural level and urban level of Bangladesh for the ten-year period preceding the survey. So, the sample for this analysis consisted of 7427 eligible women (of whom 5004 of rural areas and 2423 of urban areas) who had at least one child before the interview. That is, an eligible woman with no child during the survey is excluded from this study. Moreover, to estimate the childhood mortality through indirect techniques, the total sample size is 8721 (of whom 5840 of rural areas and 2881 of urban areas) because an eligible woman with no child during the survey is included according to the data requirement of indirect techniques.

**2.3 Sample Design**

The sample for the 2004 BDHS covered the entire population residing in private dwellings units in the country. Administratively, Bangladesh is divided into six divisions. In turn, each division is divided into Zilas, and in turn each Zila into Upazilas. Each urban area in the Upazila is divided into wards, and into Mahallas within the ward; each rural area in the Upazila is divided into Union Parishads (UP) and into Mouzas within the UPs. The urban areas were stratified into three groups: i) Standard metropolitan areas, ii) Municipality areas, and iii) Other urban areas. These divisions allow the country as a whole to be easily separated into rural and urban areas.

For the 2001 census, sub-divisions called enumeration areas (EAs) were created based on a convenient number of dwellings units. Because sketch maps of EAs were accessible, EAs were considered suitable to use as Primary Sampling Units (PSUs) for the 2004 BDHS. In each division, the list of EAs constituted the sample frame for the 2004 BDHS survey.

A target number of completed interviews with eligible women for the 2004 BDHS was set at 10,000, based on information from the 1999-2000 BDHS. The 2004 BDHS sample is a stratified, a multistage cluster sample consisting of 361 PSUs, 122 in the urban area and 239 in the rural area. After the target sample was allocated to each group area according to urban and rural areas, the number of PSUs was calculated in terms of an average of 28 completed interviews of eligible women per PSU (or an average of 30 selected households per PSU).

Mitra and Associates conducted a household listing operation in all the sample points from 3 October 2003 to 15 December 2003. A systematic sample of 10,811 households was then selected from these lists. All ever-married women age 10-49 in the selected households were eligible respondents for the women's questionnaire. For the men's survey, 50% of the selected households were chosen through systematic sampling. Interviewers interviewed one randomly selected man, regardless of marital status, in the age group 15-54, from each of the selected households. It was expected that the sample would yield interviews with approximately 10,000 ever-married women age 10-49 and 4,400 men age 15-54.

### 2.4 Questionnaires

The BDHS used a Household Questionnaire, a Women's Questionnaire, a Men's Questionnaire, and a Community Questionnaire. The contents of these questionnaires were based on MEASURE DHS+ model questionnaire. These model questionnaires were adapted for use in Bangladesh during a series of meetings with the Technical Task Force, which consisted of representatives from NIPORT, Mitra and Associates, USAID/Dhaka, ICDDR, B's Center for Health and Population Research, Bangladesh, Pathfinder/Dhaka, and ORC Macro. Draft questionnaires were then circulated to other interested groups and were reviewed by the BDHS Technical Review Committee. The questionnaires were developed in English and then translated into and printed in Bangla. In addition, two versions of a Verbal Autopsy Questionnaire were used. One version was for neonatal deaths (0-28 days old at death) and the other was for deaths among older children (age 29 days to 5 years at death).

**2.5 Training and Fieldwork**

The BDHS Women's Questionnaire was pre-tested in September 2003 and the Men's Questionnaire was pre-tested in December 2003. For the pretest, male and female interviewers were trained at the office of Mitra and Associates. After training, the teams conducted interviews in various locations in the field under the observation of staff from Mitra and Associates and members of the Technical Task Force (TTF). Altogether, 108 Women's and 45 Men's Questionnaires were completed. Based on observations in the field and suggestions made by the pretest field teams, the TTF made revisions in the wording and translations of the questionnaires.

In November 2003, candidates for field staff positions for the main survey were recruited.

Recruitment criteria included educational attainment, maturity, ability to spend one month in training and at least four months in the field, and experience in other surveys. Training for the main survey was conducted for four weeks (1 December to 30 December 2003). Initially, training consisted of lectures on how to complete the questionnaires, with mock interviews between participants to gain practice in asking questions. Towards the end of the training course, the participants spent several days in practice interviewing in various places close to Dhaka. Trainees whose performance was considered superior were selected as supervisors and field editors.

Fieldwork for the BDHS was carried out by 12 interviewing teams. Each consisted of one male supervisor, one female field editor, five female interviewers, two male interviewers, and one logistics staff person, for a total of 120 field staff for the survey.

Mitra and Associates also fielded four quality control teams of two persons each to check on the field teams. In addition to these field control teams, NIPORT monitored fieldwork by using their quality control teams. Additionally, USAID, ORC Macro, and NIPORT monitored the fieldwork by visiting teams in the field. Fieldwork commenced on 1 January 2004 and was completed on 25 May 2004. Fieldwork was implemented in five phases.

**2.6 Data Processing**

All questionnaires for the BDHS were periodically returned to Dhaka for data processing at Mitra and Associates. The processing of the data collected began shortly after the fieldwork commenced. The processing operation consisted of office editing, coding of open-ended questions, data entry, and editing inconsistencies found by the computer programs. The data were processed on six microcomputers working in double shifts and carried out by 10 data entry operators and two data entry supervisors. The concurrent processing of the data was an advantage since the quality control teams were able to advise field teams of problems detected during the data entry. In particular, Tables were generated to check various data quality parameters. Data processing commenced on 12 January 2004 and was completed by 24 June 2004.

**2.7 Coverage of the Sample**

A total of 10,811 households were selected for the sample; 10,523 were occupied, of which 10,500 were successfully interviewed. The shortfall is primarily due to dwellings that were vacant or destroyed or in which the inhabitants had left for an extended period at the time the interviewing teams visited them. Of the households occupied, 99.8% were successfully interviewed. In these households, 11,601 women were identified as eligible for the individual interview (i.e., ever-married and age 10-

49) and interviews were completed for 11,440 or 98.6% of them. In households that were selected for inclusion in the man's survey, 4,490 eligible men age 15-54 were identified, of which 4,297 or 95.7% were interviewed.

The principal reason for non-response among eligible women and men was the failure to find them at home despite repeated visits to the household. The non-response rates for the current survey were lower than those for the 1999-2000 survey.

**2.8 Selection of the Variables**

Before performing any statistical analysis, the data needed to convert due to requirements of methods. For this, the selected data are being identified into dependent and independent groups and the original codes of these variables are further coded as follows for our own research purposes.

| Name of the variables | Type | Categories |
|---|---|---|
| **Dependent** | | |
| Infant mortality (0-11 months) | Dummy | 1=Mothers experiencing to infant mortality<br>0=Otherwise |
| Under-five mortality (0-59 months) | Dummy | 1=Mothers experiencing to under-five mortality<br>0=Otherwise |
| **Independent** | | |
| Mothers' education ($X_1$) | Dummy | 0=Illiterate<br>1=Literate |
| Age of mother at birth ($X_2$) | Dummy | 0=20-29 years<br>1=All others |
| Child's sex ($X_3$) | Dummy | 0=Male<br>1=Female |
| Is child twin? ($X_4$) | Dummy | 0=No (Single)<br>1= Yes (Multiple) |
| Source of drinking water ($X_5$) | Dummy | 0= Tube well water<br>1= All other sources |
| Toilet facility ($X_6$) | Dummy | 0=Hygienic<br>1=Non-hygienic |
| Taken T.T. injections ($X_7$) | Dummy | 0=No<br>1=Yes |
| Breastfeeding ($X_8$) | Dummy | 0=No<br>1=Yes |
| Antenatal visits ($X_9$) | Dummy | 0=No<br>1=Yes |
| After birth checked health ($X_{10}$) | Dummy | 0=No<br>1=Yes |
| Parity ($X_{11}$) | Dummy | 0=$\leq$ 2<br>1=3+ |
| Preceding birth interval ($X_{12}$) | Dummy | 0=<24 months<br>1=24+ months |

## 2.9 Methodology

Methods used in data analysis depend on the intrinsic characteristics of data. Every methodology is not suitable for analyzing every set of data. So, researchers use various methodologies. In this study, frequency distribution, bivariate analysis, multivariate analysis such as logistic regression analysis, discriminant analysis etc are used.

### 2.9.1 Frequency Distribution

When observations, discrete or continuous are available on single characteristics of a large number of individuals, it becomes necessary to condense the data as far as possible without any information of interest. If the identity of individuals, about whom a particular information is taken, is not relevant, nor the order in which the observations arise, then the first real step of condensation is to divide the observed range of variables into a suitable number of class intervals and to record the number of observations in each class. Such a table, showing the distribution of the frequencies in the different classes, is called a frequency table and the manner in which the class frequencies are distributed over the class interval is called the grouped frequency distribution, simply distribution of the variables.

### 2.9.2 Bivariate Distribution

The contingency analysis is investigated the degree of association between different phenomenon that could be useful in the analysis. At first, some simple cross tables have to construct and then examine their association. For contingency analysis, it is assumed that the hypothesis of independence or homogeneity as the null hypothesis.

The expected frequency under the null hypothesis is –

$$E_{ij} = \frac{O_{i.} * O_{.j}}{N}$$

where,

$E_{ij}$ = The expected number of respondents in the (i, j)th cell.

$O_{i.}$ = Number of respondents at the i-th row of the respective contingency table.

$O_{.j}$ = Number of respondents at the j-th column of the respective contingency table.

N = Total number of respondents.

All contingency tables are prepared on the basis of classification of variables or attributes. For each contingency table, examination of association between the components and the various segment of the components are made by computing chi-square, using the formula given by

$$\chi^2 = \sum\sum \frac{O^2_{ij}}{E_{ij}} - N$$

Which follows chi-square distribution with (r-1) (c-1) degrees of freedom (d.f.)

Where,

$O_{ij}$ and $E_{ij}$ are the observed and expected number of respondents in (i, j) th cell respectively.

### 2.9.3 Indirect Techniques

#### 2.9.3.1 Brass's Method

The Brass method of estimating child mortality is essentially a task of translating the proportions death among children ever born to women of standard age groups into a set of probabilities of dying between birth and certain exact ages. Specially, the technique converts under certain conditions, the proportions dead among children ever born in the age groups 15-19, 20-24, 25-29 etc. into conventional mortality statistics, namely, $q_1$, $q_2$, $q_3$, $q_5$,......$q_{35}$, where $q_x$ represents the probability of dying between birth and exact age x. The procedure depends on the relation between $q_1$ and $D_1$, $q_2$ and $D_2$......$q_{35}$ and $D_{35}$, where $D(i)$ is the proportion dead of children ever born to women in the ith 5-year age groups. These approximate equations are affected by differences in age patterns of mortality (Brass and Coale, 1968:88). Brass, with the use of fertility polynomial, calculated a set of multipliers by which the $D_i$ values can be converted into estimates of $q_x$. In particular, $q_x$ the probability of dying before age x is calculated using the equation

$$q_x = k_i \text{ x } D_i$$

The multipliers, $k_i$, are selected according to the value of $P_1/P_2$ and $P_2/P_3$, which are good indicators of the slope of the fertility curve at the beginning of the reproductive period. In case of Trussell method, $k_i$ is calculated by fitting regression coefficients $a_i$, $b_i$ and $c_i$ into the following equation:

$$k_i = a_i + b_i (P_1/P_2) + c_i (P_2/P_3)$$

Where, $k_i$ is defined above and $P_1$, $P_2$ and $P_3$ are the mean parities for the respective age groups 15-19, 20-24 and 25-29. The values of the coefficients $a_i$, $b_i$ and $c_i$ are given in the UN (1983).

#### 2.9.3.1.1 Estimation of Child Mortality Rates Using Data Classified by Age of Mother

**Assumptions:** The assumptions that would make this method accurate are as follows:

i. Infant and child mortality rates have been approximately constant in the recent years;

ii. The omission rates of dead children surviving children are about the same as in the reported numbers ever born;

iii. The age specific fertility has been approximately constant in the recent past and approximate form of the schedule is known;

iv. The patterns of mortality among infant and child conform approximately to the model life table; and

v. There is no powerful association between age of mother and infant mortality, and between death rates of mothers and of their children.

**Data Required**

The data required for this method are given below:

(a). The number of children ever born (CEB) classified by sex and by five-year age group of mother;

(b). The number of children surviving (or the number of dead) classified by sex and by five-year age group of mother; and

(c). The total number of women (irrespective of marital status), classified by five-year age group. Note that all women, not merely ever married women, must be considered.

**Computational Procedure**

To estimate the mortality in childhood by the Brass technique, the following steps of the computational procedure are used:

**Step 1: Calculation of Average Parity per Woman ($P_i$)**

To estimate the average parity per woman by age group of mother, we use the following formula:

$$P_i = \frac{CEB(i)}{FP(i)}$$

Where, CEB ($i$) denotes the number of children ever born (CEB) to women in age group $i$; and FP ($i$) is the total number of women in that age group, irrespective of their marital status.

**Step 2: Calculation of Proportion of Children Dead ($D_i$)**

The proportion of children dead, $D_i$, is defined as the ratio of reported children dead to reported CEB. It is calculated by using the following formula:

$$D_i = \frac{CD(i)}{CEB(i)}$$

Where, CD (i) is the number of children dead reported by women in age group i.

**Step 3: Calculation of Multipliers ($k_i$)**

The multipliers, $k_i$, required to adjust the proportion of dead, $D_i$, for the effect of the age pattern of childbearing are calculated from the ratio $P_1/P_2$ and $P_2/P_3$, by using the following equation:

$$k_i = a_i + b_i\,(P_1/P_2) + c_i\,(P_2/P_3) \qquad \text{(A)}$$

It is assumed that the West family of Model Life Tables is an adequate representation of mortality in Bangladesh, so, values of the coefficients, $a_i$, $b_i$ and $c_i$, for estimation of child mortality multipliers, Trussell variant, when data are classified by age group of mother, are taken from the bottom panel of Table 1 of Annex.

**Step 4: Calculation of Probability of Dying ($q_x$) and Probability of Surviving ($l_x$)**

Estimates of the probability of dying, $q_x$, of different values of exact age x is calculated by using the following formula:

$$q_x = k_i \times D_i$$

The probability of surviving, $l_x$, from birth to exact age x is readily obtained using the following formula:

$$l_x = 1 - q_x$$

**Step 5: Calculation of Reference Period ($t_x$)**

The UN (1983) provides a method of calculating the reference period, ($t_x$), using the regression equation:

$$t_x = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$$

Where, the coefficients $a_i$, $b_i$ and $c_i$ are taken from the bottom panel of the Table 2 of the Annex.

**2.9.3.1.2 Estimation of Child Mortality Rates Using Data Classified by Duration of Marriage**

**Assumptions:** The method follows the following assumptions:

i. Estimation of $q_2$, $q_3$, $q_4$, $q_5$, $q_{10}$ and $q_{25}$; where $q_x$ represents the probability of dying between birth and exact age $x$; as well as of the periods in which they refer in cases where a smooth change in mortality can be assumed; and

ii. Marital fertility patterns are assumed to remain constant.

**Data Required**

The data required for this method are given below:

(a). The number of children ever born classified by sex and by mother's five-year duration-of-marriage group. Duration of marriage is defined as the time elapsed since into first union, regardless of whether this union is legal;

(b). The number of children dead classified by sex and by the mother's five-year duration-of-marriage group; and

(c). The total number of ever-married women in each five-year marriage-duration group. The term "ever married" means, in this instance, having entered into at least one union.

**Computational Procedure**

The steps of the computational procedure to estimate the probability of dying ($q_x$) and probability of surviving ($l_x$) by the Brass method are described below.

**Step 1: Calculation of Average Parity per Woman ($P_i$)**

To estimate the average parity per woman by duration of marriage group of mother, we use the following formula:

$$P_i = \frac{CEB(i)}{MFP(i)}$$

Where, *CEB (i)* is the number of children ever born (CEB) reported by women belonging to duration group $i$, and MFP ($i$) is the total number of ever-married women in that duration group.

**Step 2: Calculation of Proportion of Children Dead ($D_i$)**

The Proportion of Children Dead for each duration group of mother is calculated by using the following formula:

$$D_i = \frac{CD(i)}{CEB(i)}$$

Where, CD (i) denotes the total number of children dead reported by women in duration group i

**Step 3: Calculation of Multipliers ($k_i$)**

The multipliers, $k_i$, required to adjust the proportion of dead, $D_i$, for the effect of the age pattern of childbearing are calculated from the ratio $P_1/P_2$ and $P_2/P_3$, by using the following equation:

$$k_i = a_i + b_i(P_1/P_2) + c_i(P_2/P_3) \text{..........................(B)}$$

It is assumed that the West family of model life tables is an adequate representation of mortality in Bangladesh, so, values of the coefficients, $a_i$, $b_i$ and $c_i$, for estimation of child mortality multipliers, Trussell variant, when data are classified by duration-of-marriage group of mother, are taken from the bottom panel of Table 3 of Annex.

**Step 4: Calculation of Probability of Dying ($q_x$) and Probability of Surviving ($l_x$)**

Each probability of dying before exact age x, denoted by $q_x$ is calculated by using the following formula:

$$q_x = k_i \times D_i$$

The probability of surviving denoted by $l_x$, from birth to exact age x, for each duration group is obtained by using the following formula:

$$l_x = 1 - q_x$$

**Step 5: Calculation of Reference Time ($t_x$)**

The UN (1983) provides a method of calculating $t_x$ using regression equation as:

$$t_x = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$$

Where, the coefficients $a_i$, $b_i$ and $c_i$ are taken from the bottom panel of the Table 4 of the Annex.

### 2.9.3.2 Sullivan's Method

In a modification of Brass's technique, Sullivan (1972) developed a simple linear regression equation model relating the ratios of selected pairs of $q_x$ and $D_i$ to a fertility schedule parameter. These equations give multipliers that convert the observed $D_i$ into estimates of $q_x$. The regression equation developed is of the form

$$q_x / D_i = a_i + b_i (P_2/P_3),\ i = 2,3,4.$$

Where, A and B are two constants of the regression estimated for each of the four families of the Model Life Tables and are shown in Table 5 of the Annex.

### 2.9.3.3 Trussell's Method

Trussell (1975) went on to provide multiplying factors for converting $D_i$ into $q_x$ from more extensive regression analyses than those of Sullivan. In addition, Trussell's analyses were based on the Priceton models of marital fertility. A convenient version of Trussell's model has been presented in the forthcoming manual of the UN's. The regression equation has the form of

$$q_x / D_i = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$$

Where, $P_i$ represents average parity per woman and linear regression was used to estimate values of $a_i$, $b_i$ and $c_i$ from the simultaneous proportions dead and average parities in time since first birth groups from 0 to 4 through 30 to 34. The values of $a_i$, $b_i$ and $c_i$ are shown in Table 6 of the Annex.

### 2.9.4 Logistic Regression Analysis

The logistic regression analysis is made to identify the risk factors. Cox (1958) is the pioneer of logistic regression model. Subsequently, this model was illustrated by Walker and Duncun (1967) and Cox himself (Cox, 1970). More recently, Lee (1980) and Fox (1984) have further illustrated the Cox's Model. The logistic regression model may be briefly described as follows:

Let $Y_i$ denote the dichotomous dependent variable for the ith observation and $Y_i = y_i = 1$, if the ith individual is a success and $Y_i = y_i = 0$, if the ith individual is a failure.

So that, $p_i = E\{y_i = 1 \mid X_i\} = \dfrac{1}{1+e^{-(\beta_0+\beta_1 X_i)}}$, where $X_i$ is explanatory variable and

$$1-p_i = E\{y_i = 0 / X_i\} = 1 - \frac{1}{1+e^{-(\beta_0+\beta_1 X_i)}}$$

$$= \frac{e^{-(\beta_0+\beta_1 X_i)}}{1+e^{-(\beta_0+\beta_1 X_i)}}$$

$$= \frac{1}{1+e^{(\beta_0+\beta_1 X_i)}}$$

Therefore, we can write

$$\frac{p_i}{1-p_i} = \frac{1+e^{(\beta_0+\beta_1 X_i)}}{1+e^{-(\beta_0+\beta_1 X_i)}}$$

$$= e^{(\beta_0+\beta_1 X)} \quad \text{..........................................................(1)}$$

Now if we take natural log of the equation (1) we obtain

$$L_i = \log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 X_i \quad \text{..........................................(2)}$$

Here, $\dfrac{p_i}{1-p_i}$ given in (1) is simply the odds ratio and $L_i$ given in (2) is known as log-odds.

Instead of single explanatory variable, we can count two or more explanatory variables. Let, $X_{i1}$, $X_{i2}$, ......................... $X_{ik}$ be the vector of k independent explanatory variables for the ith response. The logarithm of the ratio $p_i$ and $(l - p_i)$ gives the linear function of $X_{ij}$ and the model (2) becomes,

$$L_i = \log\left(\frac{p_i}{1-p_i}\right) = \sum_{j=o}^{k} \beta_j X_{ij} \text{.............................}(3)$$

Where, we consider $X_{i0} = 1$ and $\beta_j$ is the parameter relating to $X_{ij}$.

The function (3) is a linear function of both the variables X and the parameters β. $L_i$ is called the logit and hence the model (3) is called logistic regression model.

**Interpretation of the Parameters**

Interpretation of the parameters in logistic model is not so straight forward as in linear regression model. So, it is relevant to present a little discussion about it. Since the logit transformation, $L_i = \log\left(\frac{p_i}{1-p_i}\right)$ is linear in parameters, we can interpreter the parameters using the arguments of linear regression. Thus, the interpretation may be described as follows:

We have, $p_i = \frac{e^{\beta_0+\beta_1 X_1+........+\beta_k X_k}}{1+e^{\beta_0+\beta_1 X_1+........+\beta_k X_k}}$ is a linear in parameter.

i.e., $L_i = \log\left(\frac{p_i}{1-p_i}\right) = \beta_0 + \beta_1 X_1 + ............ + \beta_k X_k$

So, arguing analogously as in the case of linear model, we can say that $\beta_j$ (j=1,2,.........,k) represents the rate of change in $\log\left(\frac{p_i}{1-p_i}\right)$ for one unit change in $X_j$ (other variables remaining constant).

The interpretation of the parameters in logistic regression has another interesting aspect. In fact, this is the proper interpretation for the parameters of qualitative variable coefficient. To describe this, we first consider that the independent variable ($X_j$) is dichotomous. This case in not only simplest but also it gives the conceptual foundation for all other situations. The description is given below:

We have, $\log\left(\frac{p_i}{1-p_i}\right) = \beta_o + \beta_1 X_1 + \ldots\ldots\ldots\ldots + \beta_j X_j + \ldots\ldots\ldots\ldots\ldots\ldots + \beta_k X_k$

Now if $X_j$ is a dichotomous variable taking values 0 and 1, then the odds ratio 'O' (say) for $X_j = 1$ against $X_j=0$ is (keeping all other X's fixed)

$$O = \frac{p_i(Y_i = 1 \mid X, X_j = 1) \big/ \{1 - p_i(Y_i = 1 \mid X, X_j = 1)\}}{p_i(Y_i = 1 \mid X, X_j = 0) \big/ \{1 - p_i(Y_i = 1 \mid X, X_j = 0)\}}$$

$$= \frac{e^{\beta_0 + \beta_1 X_1 + \ldots\ldots\ldots + \beta_j + \ldots\ldots + \beta_k X_k}}{e^{\beta_0 + \beta_1 X_1 + \ldots\ldots\ldots + 0.\beta_j + \ldots\ldots + \beta_k X_k}}$$

$$= e^{\beta_j}$$

$$\Rightarrow \log O = \beta_j$$

So, We can directly estimate the coefficients of a logistic regression model as $\log \hat{O}$ and hence can interpreter. In a qualitative independent variable has m categories, we introduce only (m-1) dummy variables and the remaining one is taken as reference category.

**Computation of the Probability ($p_i$)**

We can compute the probability $p_i$ from the estimated odds ratio. Given a data set of X variables in equation (3), where of course of β's are estimated from fitted model, then we have,

$$\log\left(\frac{p_i}{1-p_i}\right) = c, \text{ (Some constant)}$$

$$\Rightarrow \frac{\hat{p}_i}{1-\hat{p}_i} = e^c \quad \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots(4)$$

From the equation (4), $p_i$ can be computed easily.

**Estimation of the Parameters**

In order to estimate the unknown parameters, we cannot use the standards OLS method. Because in that case we must face some special problem as non-normality of the disturbance terms, heteroscedastic variance of the disturbance terms, non-fulfillment of the axiom i.e. $0 \leq p_i = E\ (Y_i|X) \leq 1$ and questionable value of $R^2$ as a measure of goodness of fit.

To eliminate the above problem, Cox suggested the maximum likelihood estimation method in place of standard OLS method and proposed the following function:

$$L(\beta_0, \beta_1, \ldots. \beta_k) = \frac{\prod_{i=1}^{n} \exp(Y_i \sum_{j=0}^{k} \beta_j X_{ij})}{\prod_{i=1}^{n} \{1 + \exp(Y_i \sum_{j=0}^{k} \beta_j X_{ij})\}}$$

$$= \frac{\exp\{\sum_{i=1}^{n} (Y_i \sum_{j=0}^{k} \beta_j X_{ij})\}}{\prod_{i=1}^{n} \{1 + \exp(Y_i \sum_{j=0}^{k} \beta_j X_{ij})\}}$$

$$= \frac{\exp\{\sum_{j=0}^{k} \beta_j \sum_{i=1}^{n} X_{ij} Y_i\}}{\prod_{i=1}^{n} \{1 + \exp(Y_i \sum_{j=0}^{k} \beta_j X_{ij})\}}$$

$$= \frac{\exp\{\sum_{i=1}^{n} \beta_j t_j\}}{\prod_{i=1}^{n} \{1 + \exp(Y_i \sum_{j=0}^{k} \beta_j X_{ij})\}},$$

Where, $t_j = \sum_{i=1}^{n} X_{ij} Y_j, j = 0,1,\ldots\ldots.., k$

The log-likelihood function is given by

$$\log L(\beta_0, \beta_1, \ldots\ldots, \beta_k) = \sum_{j=0}^{k} \beta_j t_j - \sum_{i=1}^{n} \log\{1 + \exp(Y_i \sum_{j=0}^{k} \beta_j X_{ij})\}$$

In order to estimate the parameters of this function, the logit regression procedure of the statistical package SPSS for windows base 11.5 version may be used.

### 2.9.5 Abridged Life Table

Life tables are one form of combining mortality rates of a population at different ages into a single statistical model. They are principally used to measure the level of mortality of the population involved. One of their main advantages over other methods of measuring mortality is that they do not reflect the effects of the age distribution of an actual population and do not require the adoption of a standard population for acceptable comparisons of levels of mortality in different population.

An abridged life table contains data by intervals of 5 or 10 years of age. First, we compute cohort measures of mortality. In other words, we follow the children in our sub sample from birth and compute probabilities of dying during consecutive age intervals, using the traditional actuarial life-table method. The life-table computation uses 10 age intervals: 0 months, 1–2 months, 3–5 months, 6–8 months, 9–11 months, 12–17 months, 18–23 months, 24–35 months, 36–47 months, and 48–59 months. From these, the following commonly used measures of mortality during infancy and childhood are computed. Results are shown and discussed in Chapter 5.

| | |
|---|---|
| Neonatal mortality: | The probability of dying in the first month of life. |
| Post neonatal mortality: | The probability of dying in the 2nd through 11th month. |
| Infant mortality: | The probability of dying before the first birthday. |

Child mortality: The conditional probability of dying between the first and the fifth birthday for those who survive the first year.

Under-five mortality: The probability of dying before the fifth birthday.

By these definitions, infant mortality equals the sum of neonatal mortality and post neonatal mortality.

**2.9.6 Discriminant Analysis**

Discriminate analysis is a statistical technique used to distinguish between two or more groups or cases. Discriminate analysis seems to be originated from the study of inter group distance. The idea of inter group distance index has been presented extensively by Morant (1920) and by Mahalanobis (1930). The multivariate inter group distance has been developed by Fisher (1930) to discriminate between groups. The discrimination has been done by linear composites where each composite is linear combination of variables.

There are tow major objectives in separation of groups: (i) Description of group separation, in which linear functions (discriminant functions) of the variables are used to describe or elucidate the differences between two or more groups. The goals of discriminant analysis include identifying the relative contribution of variables to separation of the groups and finding the optimal plane on which the points can be projected to best illustrate the configuration of the groups. (ii) Prediction or allocation, in which linear or quadratic functions (classification functions) of the variables are employed to assign on individual sampling unit to one of the groups.

To study the differences among groups, linear combinations of predictor variables are formed. These linear combinations are used to identify the class of an object.

Therefore, discriminant analysis helps us to identify a class for an object by some apriori information. Sir Fisher has proposed first statistical tool to classify the objects into mutually exclusive and exhaustive groups. But the analysis starts with the objects when their groups are known in advanced. The purpose of the analysis is either to describe group differences or to predict group membership on the basis of response variable measures.

The predict or identification of group membership is done on the basis of one or more predictor or explanatory variables along with one criterion variable. The explanatory variable is categorical in nature and measured in nominal scale. Sometimes, it is dichotomous and sometimes, it is polytomous. The discriminant analysis with polytomous categorical criterion is sometimes known as predictive discriminant analysis and prediction is done by a linear combination of predictors. There are as many linear combinations as there are groups and the prediction rule enables to determine the group with which an object is identified. The group membership should be predicted accurately as per as possible.

**Scope of Discriminant Analysis**

The objective of discriminant analysis is to classify the sample objects into two or more groups. This is done with the help of linear combination of predictor or explanatory variables. The basic principle to determine the group with which an object is identified is that the misclassification error of that object is minimum. Under this assumption, the between group variance will be approximately zero if the error in classification is less or the classification is exact. The increase in error of classification leads to increase the amount of variance of any variable and the ratio of within-group sum of squares to total sum of squares will be maximum. The ratio is measured by Wilk's Lambda.

If the group means of different groups are equal. A will be 1 (one). This implies that within-group variance and the total variance are equal and the error in classification is more. Again, A=0 implies that between-group variance and total variance are equal and error in classification is less. In such a situation, the discriminant analysis provides a linear combination of explanatory variables so that it discriminates between pre-identified groups with less error. This linear combination can be represented by

$D = b' X$

Where, D is the discriminant score of order (1 x n); b is a (p x 1) vector of discriminant weight and X is the (n x p) data matrix.

In two groups of discriminant problem, the sample objects are classified with the help of a binary or indicator variable with values zero or one. One group of objects is identified by zero value of binary variable and another group of objects are identified by the value one of binary variable. Now, corresponding to this binary variable, the discriminate score $D = b' X$ is calculated using the data matrix X. The calculated discriminant score looks like the fitted multiple regression line when the binary variable is considered as dependent one. In such a situation

$Y = b' X$ is the linear probability model, where, Y is the binary variable and X is the matrix of explanatory variables.

**Assumptions Underlying Discriminant Analysis**

It has already been mentioned that the objective of the discriminant analysis is to classify the sample objects accurately on the basis of a linear combination of predictor variables. The optimality of classification depends on the assumptions of predictor variables. The optimality of classification depends on the assumption of data. The assumptions are:

i. The predictor variables follow multivariate normal distribution, and

ii. The covariate matrices of different groups of data are homogeneous.

**Form of Discriminant analysis**

The discriminant function is of the form:

$f_{km} = u_o + u_1X_{1km} + u_2X_{2km} + u_3X_{3km} + \ldots\ldots\ldots\ldots\ldots\ldots + u_pX_{pkm} \ldots\ldots\ldots\ldots$ (i)

Where, $f_{km}$= the value (score) on the canonical discriminant function for case min the group k.

$X_{1km}$ = the value on discriminant variable X, for case m in group k; and

$X_{ik}$= mean value of variable i for those case in group k.

$X_i$= mean value of variable i for all cases (grand or total mean)

$U_i$= coefficients which produce the desired characteristics in the function.

Using pooled within group's correlation matrix, correlation between independents is not perfect correlation. It is obvious, one or more of the variables may be poor discriminators, because the group means are not very different on those variables. It may happen that some of the variables have no significant contribution. A forward stepwise procedure has been considered to select the individual variable, which provides the greatest univariate discrimination.

Stepwise procedure must employ some measures of discrimination as the criterion for selection. In this analysis, we used Maximize-minimum Mahalanobis (1963) distance (D square) between the pairs of groups' centroids. Minimum tolerance value has been considered 0.001. Maximum significance of F to enter has been considered 0.05 to continue stepwise procedure of Mahalanobis distance D-square. F to remove is also a partial multivariate F statistic, but it tests the significance of the decrease in discrimination when that variable is removed from the list of variables already selected. Minimum significance of F to remove has been considered as 0.1 in stepwise method. Maximum significance of Wilk's Lambda has been considered as 1.00 and prior probability of each group is 0.5.

Another way to judge the substantive of a discriminate function is by association which summaries the degree of relatedness early childbearing and the discriminate function. A value of zero denotes no relationship at all, but larger numbers (always-positive) represent increasing degree of association with 1 being the maximum. The value of overall $\chi^2$ indicates the ultimately discriminatory variables are significant. When Fisher's approach is used, it turns out that it may be possible to determine several linear combinations for the variables.

# Chapter Three
# *Indirect Estimation of Childhood Mortality*

## 3.1 Introduction

The term "indirect" is used to describe any estimation method that depends upon models or uses consistency check, or indeed use conventional data in an unconventional way. Faced with the impossibility of obtaining reasonable measures of demographic parameters directly from the traditional data sources, demographers have developed a set of techniques that allow their indirect estimation. In this chapter, the childhood mortality rates have to be estimated when the data are classified by age, and duration of marriage.

## 3.2 Estimation of Childhood Mortality Rates Using Data Classified by Age

The proportions of children ever born (CEB) who have died are indicators of child mortality and can yield robust estimates of childhood mortality. The proportion dead among the CEB by a group of women will, therefore, depend upon the distribution of the children by length of exposure to the risk of dying (that is, upon the distribution in time of the births) and upon the mortality risks themselves. Specifically, the proportions of children dead classified by the mother's five-year age group or duration of marriage can provide estimates of the probability of dying between birth and various childhood ages. Brass (1964) was the first to develop a procedure for converting proportions dead of CEB reported by women in age groups 15-19, 20-24 etc. into estimates of the probability of dying before attaining certain exact childhood ages. Brass found that the relation between the proportion of children dead ($D_i$) and a life-table mortality measure ($q_x$) is primarily influenced by the age pattern of fertility, because it is this pattern that determines the distribution of the children of a group of women by length of exposure to the risk of dying. An important assumption made in the development of this method is that the risk of dying of a child is a function only of the age of the child and not of other factors, such as mother's age or the child's birth order. Trying to increase the flexibility of Brass's original method, Sullivan (1972) computed another set of multipliers by using least-squares regression to fit equation to data generated from observed fertility schedules and the Coale and Demeny Regional Model Life Tables (1966). Trussell (1975) estimated a third set of multipliers by the same means but using data generated from the model fertility schedules developed by Coale and Trussell (1974).

### 3.2.1 Estimation of Child Mortality Rates Using Data Classified by Age of Mother for National Level of Bangladesh

The data shown in Table 3.1 were gathered from a survey carried out in Bangladesh namely Bangladesh Demographic and Health Survey (BDHS), 2004 that are used to illustrate the Brass, Sullivan and Trussell techniques for national, rural and urban level of Bangladesh. After classifying the data on CEB by sex, a quick check of the consistency of the data is ascertained by computing the sex ratios of CEB by age of mother. Hence the complete sets of these sex ratios for the national level; rural level and urban level are showed in top, middle and bottom panel of column (7) of Table 3.1. Ideally, these sex ratios should not vary systematically with age and their values should be between 1.02 and 1.07 (United Nations, 1983). It is revealed from column (7) of Table 3.1 that the sex ratios fluctuate somewhat by age of mother but show no systematic trend and the overall sex ratio is acceptably close to the expected values of

1.05. Furthermore, since some variation of the sex ratios by age is expected because of the small sample being considered, therefore, it is concluded that this test shows no clear deficiency in the data.

**Table 3.1. Children Ever Born and Children Surviving for National, Rural and Urban Level of Bangladesh, 2004**

| Age group | Total women | Male CEB | Male Dead | Female CEB | Female Dead | Sex ratio of CEB |
|---|---|---|---|---|---|---|
| **National level** | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 15-19 | 1703 | 553 | 53 | 552 | 34 | 1.00181 |
| 20-24 | 2198 | 1908 | 163 | 1716 | 139 | 1.11189 |
| 25-29 | 1912 | 2581 | 291 | 2545 | 247 | 1.01415 |
| 30-34 | 1445 | 2628 | 333 | 2671 | 281 | 0.98390 |
| 35-39 | 857 | 2015 | 329 | 2048 | 310 | 0.98389 |
| 40-44 | 413 | 1141 | 227 | 1216 | 215 | 0.93832 |
| 45-49 | 193 | 648 | 133 | 703 | 140 | 0.92176 |
| Total | 8721 | 11474 | 1529 | 11451 | 1366 | 1.00201 |
| **Rural level** | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 15-19 | 1205 | 391 | 37 | 398 | 26 | 0.98241 |
| 20-24 | 1455 | 1325 | 106 | 1201 | 97 | 1.10325 |
| 25-29 | 1226 | 1767 | 217 | 1729 | 173 | 1.02198 |
| 30-34 | 935 | 1803 | 245 | 1843 | 212 | 0.97830 |
| 35-39 | 571 | 1446 | 243 | 1422 | 245 | 1.01688 |
| 40-44 | 296 | 858 | 171 | 905 | 154 | 0.94807 |
| 45-49 | 152 | 530 | 106 | 582 | 108 | 0.91065 |
| Total | 5840 | 8120 | 1125 | 8080 | 1015 | 1.00495 |
| **Urban level** | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 15-19 | 498 | 162 | 16 | 154 | 8 | 1.05195 |
| 20-24 | 743 | 583 | 57 | 515 | 42 | 1.13204 |
| 25-29 | 686 | 814 | 74 | 816 | 74 | 0.99755 |
| 30-34 | 510 | 825 | 88 | 828 | 69 | 0.99638 |
| 35-39 | 286 | 569 | 86 | 626 | 65 | 0.90895 |
| 40-44 | 117 | 283 | 56 | 311 | 61 | 0.90997 |
| 45-49 | 41 | 118 | 27 | 121 | 32 | 0.97521 |
| Total | 2881 | 3354 | 404 | 3371 | 351 | 0.99496 |

**Note:** 10-14 age group is included in 15-19 age group

Average parities, $P_i$, (where i=1 signifies age group 15-19; i=2 indicates age group 20-24; and so on) for male and female are calculated separately by dividing the number of male and female CEB (presenting in column (3) and (5) of Table 3.1) by the total number of women (appearing in column (2) of Table 3.1) and the complete sets of $P_i$ values for male and female are shown in top and middle panel of column (2) of Table 3.2. The values of $P_i$ for both sexes are just the sum of $P_i$ values of male and female and the results are presented in bottom panel of column (2) of that Table).

The proportion of children dead, $D_i$, for each age group of mother are computed by dividing the number of children dead of each sex (given in columns (4) and (6) of Table 3.1) by the CEB of the corresponding sex (appearing in columns (3) and (5) of that Table) and the results are shown in top and middle panel of column (3) of Table 3.2. To calculate the $D_i$ values for both sexes combined, the number of children dead of each sex have to be added and then divided by the total number of CEB (sum of male and female CEB) and the results are presented in bottom panel of column (3) of Table 3.2). Thus, $D_i(m)$ and $D_i(f)$, the proportion of male children dead and female children dead to women aged 15-19 are 0.09584 and 0.06159 respectively. From the results, it is seen that the values of $D_i$ have slightly increased between age group 25-29 and 30-34 for male, female and both sexes. These values are almost higher among women of aged 35 and above than all other ages of women, probably because the new born to women aged 35 and above are, infact, subject to higher mortality risk both mother and their new born.

The multipliers, $k_i$, required to adjust the reported proportion dead, $D_i$, for the effects of the age pattern of childbearing are calculated from the ratios $P_1/P_2$ and $P_2/P_3$ by using the estimating equation (A), described in chapter 2 and the coefficients are, for each of the four different families of model life tables in the Coale-Demeny system, listed in Table 1 in Appendix. It is assumed that the West family of model life tables is an adequate representation of mortality in Bangladesh; so, values of $a_i$, $b_i$ and $c_i$ are taken from the bottom panel of Table 1 of Appendix. The values of $P_1$, $P_2$ and $P_3$ for male, female and both sexes are shown in Table 3.2 and the full set of $k_i$ values are calculated for each sex and for both sexes separately and the results are shown in top, middle and bottom panel of column (4) of Table 3.2 respectively. As for example, the value of $k_i$ for male children of women aged 25-29 is $k_{i=3} = 0.94017$.

In case of Brass technique, the estimated values of the probabilities of dying, $q_x$, are calculated by multiplying the $k_i$ values appearing in column (4) of Table 3.2 by the corresponding proportion dead, $D_i$, given in column (3) of that Table. A complete set of $q_x$ estimates of Brass, Sullivan and Trussell are presented in columns (6), (7) and (8) respectively of Table 3.2 for each sex and both sexes combined. The results indicate that the estimates of ${}_nq_0$ increase with the increase of the age of mother for male, female and both sexes that are clearly showed in Figure 3.1.

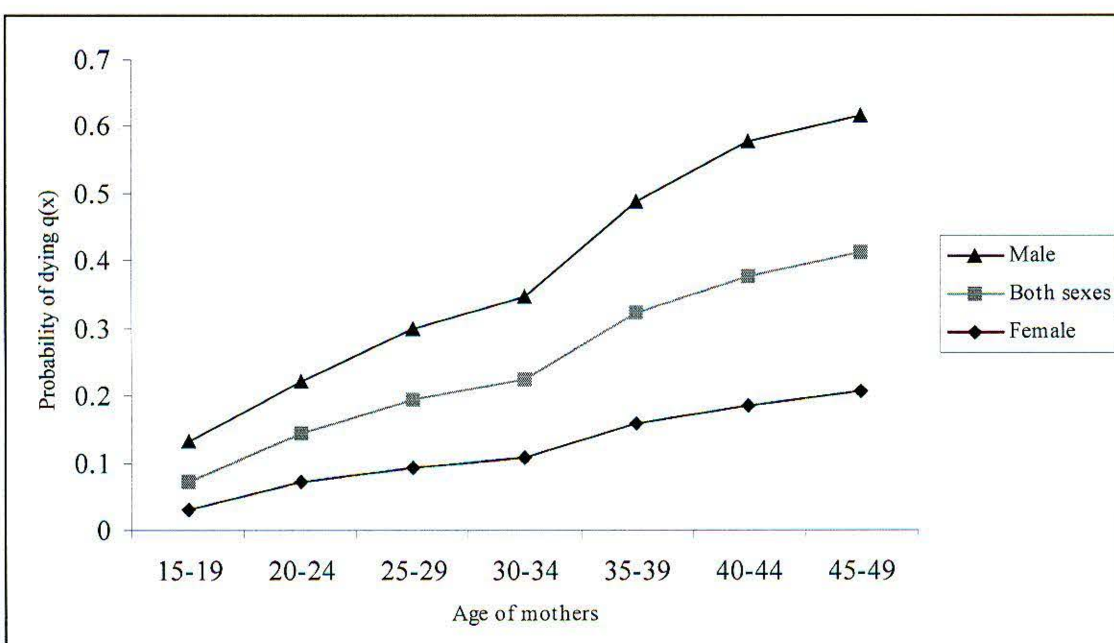


**Figure 3.1.** Patterns of child mortality using Brass technique for national level of Bangladesh

**Table 3.2. Estimates of Probabilities of Dying, Surviving and of Reference Period by Sex, Derived from Child Survival Data Classified by Age of Mother, West Model, National Level of Bangladesh, 2004**

| Sex | Age group | Average parity per woman $P_i$ | Proportion of children dead $D_i$ | Multipliers $k_i$ | Exact age | Estimates of $q_x$ | | | Probability of surviving $l_x$ | | | Reference period $t_x$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Brass | Sullivan | Trussell | Brass | Sullivan | Trussell | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| | 15-19 | 0.32472 | 0.09584 | 0.62164 | 1 | 0.05958 | - | 0.10946 | 0.94042 | - | 0.89054 | 1.89 |
| | 20-24 | 0.86806 | 0.08543 | 0.88543 | 2 | 0.07564 | 0.08139 | 0.08672 | 0.92436 | 0.91861 | 0.91328 | 3.58 |
| | 25-29 | 1.34990 | 0.11275 | 0.94017 | 3 | 0.10600 | 0.10292 | 0.11445 | 0.89400 | 0.89708 | 0.88555 | 5.63 |
| | 30-34 | 1.81869 | 0.12671 | 0.98486 | 5 | 0.12479 | 0.11629 | 0.13097 | 0.87521 | 0.88371 | 0.86903 | 7.80 |
| **Male** | 35-39 | 2.35123 | 0.16328 | 1.01543 | 10 | 0.16580 | - | 0.16641 | 0.83420 | - | 0.83359 | 10.00 |
| | 40-44 | 2.76271 | 0.19895 | 1.00681 | 15 | 0.20030 | - | - | 0.79970 | - | - | 12.40 |
| | 45-49 | 3.35751 | 0.20525 | 0.99803 | 20 | 0.20485 | - | - | 0.79515 | - | - | 15.10 |
| | | $P_1/P_2$ | | | | 0.37408 | - | 0.37408 | | | | |
| | | $P_2/P_3$ | | | | 0.64306 | 0.64306 | 0.64306 | | | | |
| | 15-19 | 0.32413 | 0.06159 | 0.46707 | 1 | 0.02877 | - | 0.07011 | 0.97123 | - | 0.92989 | 2.24 |
| | 20-24 | 0.78071 | 0.08100 | 0.87822 | 2 | 0.07114 | 0.07965 | 0.08195 | 0.92886 | 0.92035 | 0.91805 | 3.79 |
| | 25-29 | 1.33107 | 0.09705 | 0.96639 | 3 | 0.09379 | 0.09078 | 0.10028 | 0.90621 | 0.90922 | 0.89972 | 5.46 |
| | 30-34 | 1.84844 | 0.10520 | 1.01863 | 5 | 0.10716 | 0.09851 | 0.11264 | 0.89284 | 0.90149 | 0.88736 | 7.11 |
| **Female** | 35-39 | 2.38973 | 0.15137 | 1.05325 | 10 | 0.15943 | - | 0.16183 | 0.84057 | - | 0.83817 | 8.76 |
| | 40-44 | 2.94431 | 0.17681 | 1.04608 | 15 | 0.18496 | - | - | 0.81504 | - | - | 10.70 |
| | 45-49 | 3.64249 | 0.19915 | 1.03622 | 20 | 0.20636 | - | - | 0.79364 | - | - | 13.40 |
| | | $P_1/P_2$ | | | | 0.41518 | - | 0.41518 | | | | |
| | | $P_2/P_3$ | | | | 0.58653 | 0.58653 | 0.58653 | | | | |
| | 15-19 | 0.64885 | 0.07873 | 0.54745 | 1 | 0.04310 | - | 0.08978 | 0.95690 | - | 0.91022 | 2.06 |
| | 20-24 | 1.64877 | 0.08333 | 0.88236 | 2 | 0.07353 | 0.08066 | 0.08446 | 0.92647 | 0.91934 | 0.91554 | 3.68 |
| | 25-29 | 2.68096 | 0.10496 | 0.95313 | 3 | 0.10004 | 0.09698 | 0.10749 | 0.89996 | 0.90302 | 0.89251 | 5.55 |
| | 30-34 | 3.66713 | 0.11587 | 1.00140 | 5 | 0.11603 | 0.10742 | 0.12189 | 0.88397 | 0.89258 | 0.87811 | 7.46 |
| **Both sexes** | 35-39 | 4.74096 | 0.15727 | 1.03392 | 10 | 0.16260 | - | 0.16416 | 0.8374 | | 0.83584 | 9.40 |
| | 40-44 | 5.70702 | 0.18753 | 1.02600 | 15 | 0.19241 | - | - | 0.80759 | - | - | 11.60 |
| | 45-49 | 7.00000 | 0.20207 | 1.01669 | 20 | 0.20544 | - | - | 0.79456 | - | - | 14.20 |
| | | $P_1/P_2$ | | | | 0.39354 | - | 0.39354 | | | | |
| | | $P_2/P_3$ | | | | 0.61499 | 0.61499 | 0.61499 | | | | |

### 3.2.2 Estimation of Child Mortality Rates Using Data Classified by Age of Mother for Rural Level of Bangladesh

Data presented in the middle panel of Table 3.1 were used to estimate the child mortality at rural level of Bangladesh using Brass, Sullivan and Trussell techniques. For the rural areas of Bangladesh, average parities, $P_i$, for male and female are calculated separately and the complete sets of $P_i$ values for male and female are shown in top and middle panel of column (2) of Table 3.3. The values of $P_i$ for both sexes are presented in bottom panel of column (2) of that Table). The results indicate that the average parities per woman i.e. the mean number of male CEB are higher than the female CEB. It is also observed from the results that average parities are increasing with the increase of age of the mother.

The proportion of children dead, $D_i$, for each age group of mother are computed and the results are shown in top and middle panel of column (3) of Table 3.3. For both sexes combined, the calculated $D_i$ values are presented in bottom panel of column (3) of Table 3.3). Thus, $D_i(m)$ and $D_i(f)$, the proportion of male children dead and female children dead to women aged 20-24 are 0.08000 and 0.08077 respectively.

The multipliers, $k_i$, required to adjust the reported proportion dead, $D_i$, for the effects of the age pattern of childbearing, calculated using the estimating equation (A) described in chapter 2. The full sets of $k_i$ values are calculated for each sex and for both sexes separately and the results are shown in top, middle and bottom panel of column (4) of Table 3.3 respectively. As for example, the value of $k_i$ for female children of women aged 30-34 is $k_{i=4} = 1.01563$.

In case of Brass technique, the estimated values of the probabilities of dying, $q_x$, are calculated by multiplying the $k_i$ values appearing in column (4) of Table 3.3 by the corresponding proportion dead, $D_i$, given in column (3) of that Table. A complete set of $q_x$ estimates of Brass, Sullivan and Trussell are presented in columns (6), (7) and (8) respectively of Table 3.3 for each sex and both sexes combined. The results indicate that the estimates of ${}_nq_0$ increase with the increase of the age of mother for male, female and both sexes that are clearly showed in Figure 3.2.

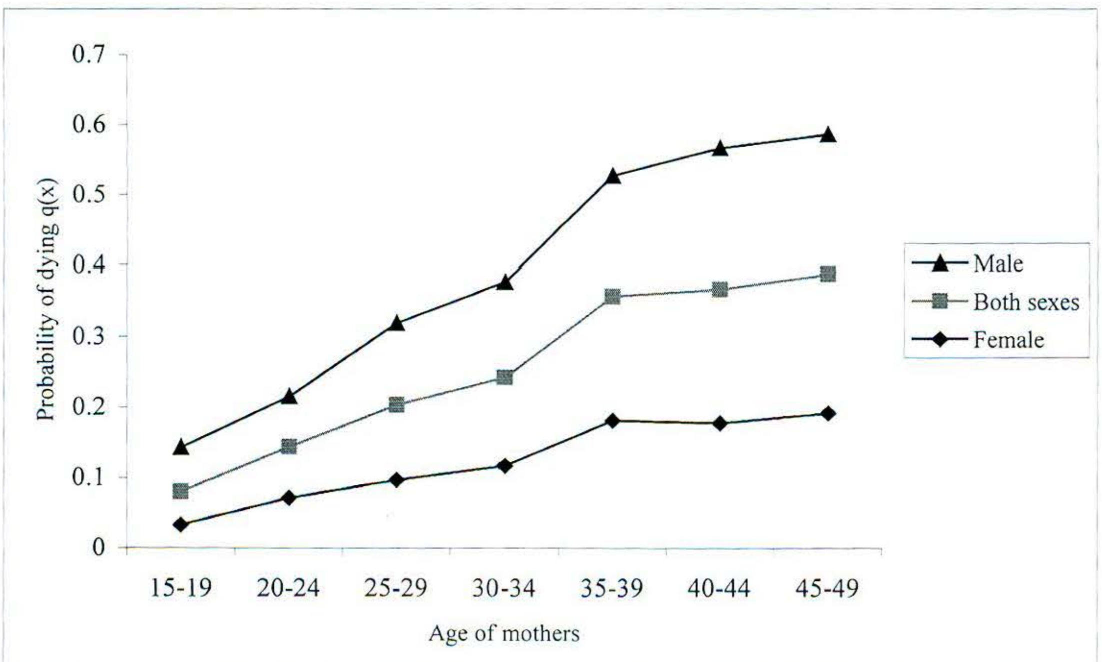


**Figure 3.2.** Patterns of child mortality using Brass technique for rural level of Bangladesh

**Table 3.3. Estimates of Probabilities of Dying, Surviving and of Reference Period by Sex, Derived from Child Survival Data Classified by Age of Mother, West Model, Rural Level of Bangladesh, 2004**

| Sex | Age group | Average parity per woman $P_i$ | Proportion of children dead $D_i$ | Multipliers $k_i$ | Exact age | Estimates of $q_x$ | | | Probability of surviving $l_x$ | | | Reference period $t_x$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Brass | Sullivan | Trussell | Brass | Sullivan | Trussell | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| | 15-19 | 0.32448 | 0.09463 | 0.66112 | 1 | 0.06256 | - | 0.10827 | 0.93744 | - | 0.89173 | 1.82 |
| | 20-24 | 0.91065 | 0.08000 | 0.89795 | 2 | 0.07184 | 0.07670 | 0.08156 | 0.92816 | 0.92330 | 0.91844 | 3.48 |
| | 25-29 | 1.44127 | 0.12281 | 0.94374 | 3 | 0.11590 | 0.11265 | 0.12518 | 0.88410 | 0.88735 | 0.87482 | 5.53 |
| | 30-34 | 1.92834 | 0.13588 | 0.98549 | 5 | 0.13391 | 0.12521 | 0.14106 | 0.86609 | 0.87479 | 0.85894 | 7.72 |
| Male | 35-39 | 2.53240 | 0.16805 | 1.01495 | 10 | 0.17056 | - | 0.17210 | 0.82944 | - | 0.82790 | 9.99 |
| | 40-44 | 2.89865 | 0.19930 | 1.00602 | 15 | 0.20050 | - | - | 0.79950 | - | - | 12.40 |
| | 45-49 | 3.48684 | 0.20000 | 0.99735 | 20 | 0.19947 | - | - | 0.80053 | - | - | 15.10 |
| | | $P_1/P_2$ | | | | 0.35632 | - | 0.35632 | | | | |
| | | $P_2/P_3$ | | | | 0.63184 | 0.63184 | 0.63184 | | | | |
| | 15-19 | 0.33029 | 0.06533 | 0.50684 | 1 | 0.03311 | - | 0.07447 | 0.96689 | - | 0.92553 | 2.15 |
| | 20-24 | 0.82543 | 0.08077 | 0.88664 | 2 | 0.07161 | 0.07947 | 0.08196 | 0.92839 | 0.92053 | 0.91804 | 3.71 |
| | 25-29 | 1.41028 | 0.10006 | 0.96595 | 3 | 0.09665 | 0.09364 | 0.10347 | 0.90335 | 0.90636 | 0.89653 | 5.42 |
| | 30-34 | 1.97112 | 0.11503 | 1.01563 | 5 | 0.11683 | 0.10777 | 0.12306 | 0.88317 | 0.89223 | 0.87694 | 7.13 |
| Female | 35-39 | 2.49037 | 0.17229 | 1.04917 | 10 | 0.18076 | - | 0.18385 | 0.81924 | - | 0.81615 | 8.87 |
| | 40-44 | 3.05743 | 0.17017 | 1.04166 | 15 | 0.17726 | - | - | 0.82274 | - | - | 10.90 |
| | 45-49 | 3.82895 | 0.18557 | 1.03196 | 20 | 0.19150 | - | - | 0.80850 | - | - | 13.60 |
| | | $P_1/P_2$ | | | | 0.40014 | - | 0.40014 | | | | |
| | | $P_2/P_3$ | | | | 0.58530 | 0.58530 | 0.58530 | | | | |
| | 15-19 | 0.65477 | 0.07985 | 0.58709 | 1 | 0.04688 | - | 0.09120 | 0.95312 | - | 0.90880 | 1.98 |
| | 20-24 | 1.73608 | 0.08036 | 0.89281 | 2 | 0.07175 | 0.07805 | 0.08175 | 0.92825 | 0.92195 | 0.91825 | 3.59 |
| | 25-29 | 2.85155 | 0.11156 | 0.95467 | 3 | 0.10650 | 0.10336 | 0.11453 | 0.89350 | 0.89664 | 0.88547 | 5.47 |
| | 30-34 | 3.89947 | 0.12534 | 1.00020 | 5 | 0.12537 | 0.11645 | 0.13207 | 0.87463 | 0.88355 | 0.86793 | 7.43 |
| Both sexes | 35-39 | 5.02277 | 0.17015 | 1.03162 | 10 | 0.17553 | - | 0.17784 | 0.82447 | - | 0.82216 | 9.44 |
| | 40-44 | 5.95608 | 0.18434 | 1.02337 | 15 | 0.18865 | - | - | 0.81135 | - | - | 11.60 |
| | 45-49 | 7.31579 | 0.19245 | 1.01420 | 20 | 0.19518 | - | - | 0.80482 | - | - | 14.40 |
| | | $P_1/P_2$ | | | | 0.37715 | - | 0.37715 | | | | |
| | | $P_2/P_3$ | | | | 0.60882 | 0.60882 | 0.60882 | | | | |

### 3.2.3 Estimation of Child Mortality Rates Using Data Classified by Age of Mother for Urban Level of Bangladesh

To estimate the child mortality at urban level of Bangladesh using Brass, Sullivan and Trussell techniques, the necessary information are presented in bottom panel of Table 3.1. Average parities, $P_i$, for the rural areas of Bangladesh are calculated separately for male and female and the complete sets of $P_i$ values are shown in top and middle panel of column (2) of Table 3.4. The values of $P_i$ for both sexes are just the sum of $P_i$ values of male and female and the results are presented in bottom panel of column (2) of that Table). The results indicate that the average parities per woman i.e. the mean number of male CEB are higher than the female CEB. It is also observed from the results that average parities are increasing with the increase of age of the mother.

The proportion of children dead, $D_i$, for each age group of mother are computed and the results are shown in top and middle panel of column (3) of Table 3.4. For both sexes combined, the values of $D_i$ of each sex have to be added and then divided by the total number of CEB (sum of male and female CEB) and the results are presented in bottom panel of column (3) of Table 3.4. Thus, $D_i(m)$ and $D_i(f)$, the proportion of male children dead and female children dead to women aged 35-39 are 0.15114 and 0.10383 respectively.

The multipliers, $k_i$, are calculated from the ratios $P_1/P_2$ and $P_2/P_3$ by using the estimating equation (A), described in chapter 2 and the coefficients are, for each of the four different families of model life tables in the Coale-Demeny system, listed in Table 1 in Appendix. The full sets of $k_i$ values are calculated for each sex and for both sexes separately and the results are shown in top, middle and bottom panel of column

(4) of Table 3.4 respectively. As for example, the value of $k_i$ for male children of women aged 15-19 is $k_{i=1} = 0.52596$.

In case of Brass technique, the estimated values of the probabilities of dying, $q_x$, are calculated by multiplying the $k_i$ values appearing in column (4) of Table 3.4 by the corresponding proportion dead, $D_i$, given in column (3) of that Table. A complete set of $q_x$ estimates of Brass, Sullivan and Trussell are presented in columns (6), (7) and (8) respectively of Table 3.4 for each sex and both sexes combined. The results indicate that the estimates of ${}_nq_0$ increase with the increase of the age of mother for male, female and both sexes that are clearly showed in Figure 3.3.

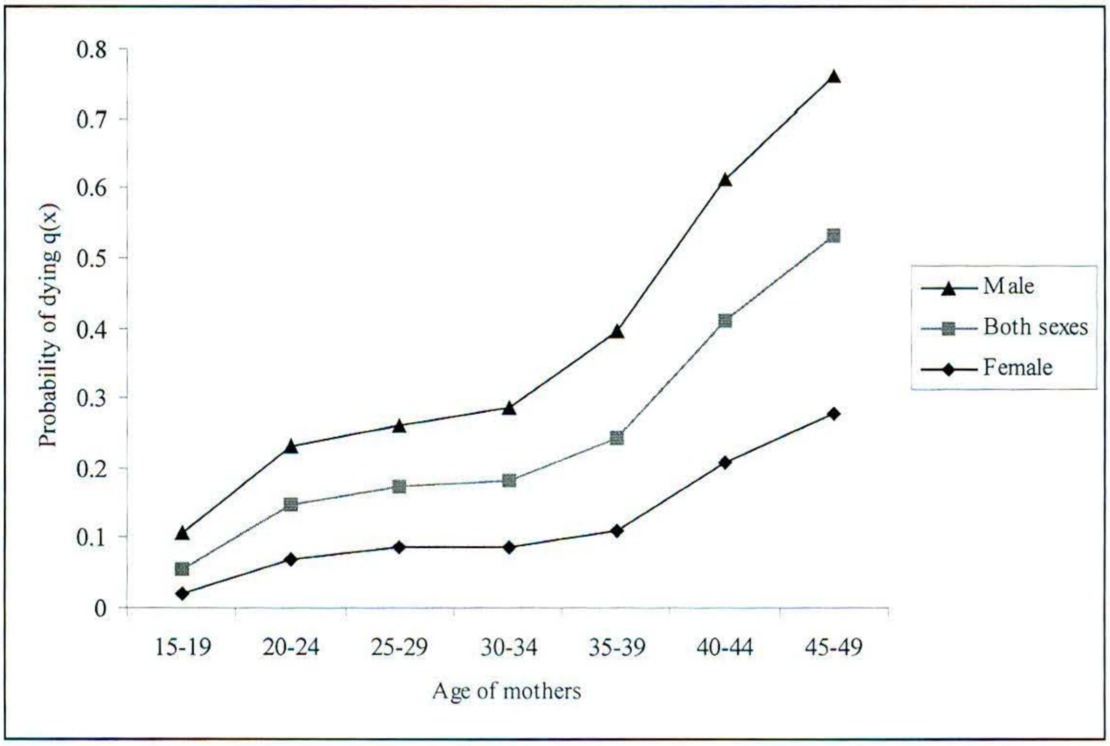


**Figure 3.3.** Patterns of child mortality using Brass technique for urban level of Bangladesh

**Table 3.4. Estimates of Probabilities of Dying, Surviving and of Reference Period by Sex, Derived from Child Survival Data Classified by Age of Mother, West Model, Urban Level of Bangladesh, 2004**

| Sex | Age group | Average parity per woman $P_i$ | Proportion of children dead $D_i$ | Multipliers $k_i$ | Exact age | Estimates of $q_x$ | | | Probability of surviving $l_x$ | | | Reference period $t_x$ |
|---|---|---|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Brass | Sullivan | Trussell | Brass | Sullivan | Trussell | |
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) | (9) | (10) | (11) | (12) |
| Male | 15-19 | 0.32530 | 0.09877 | 0.52596 | 1 | 0.05195 | - | 0.11237 | 0.94805 | - | 0.88763 | 2.08 |
| | 20-24 | 0.78466 | 0.09777 | 0.85884 | 2 | 0.08397 | 0.09219 | 0.09832 | 0.91603 | 0.90781 | 0.90168 | 3.81 |
| | 25-29 | 1.18659 | 0.09091 | 0.93513 | 3 | 0.08501 | 0.08232 | 0.09163 | 0.91499 | 0.91768 | 0.90837 | 5.83 |
| | 30-34 | 1.61765 | 0.10667 | 0.98656 | 5 | 0.10524 | 0.09726 | 0.10961 | 0.89476 | 0.90274 | 0.89039 | 7.89 |
| | 35-39 | 1.98951 | 0.15114 | 1.01979 | 10 | 0.15413 | - | 0.15318 | 0.84587 | - | 0.84682 | 9.98 |
| | 40-44 | 2.41880 | 0.19788 | 1.01197 | 15 | 0.20025 | - | - | 0.79975 | - | - | 12.20 |
| | 45-49 | 2.87805 | 0.22881 | 1.00288 | 20 | 0.22947 | - | - | 0.77053 | - | - | 14.90 |
| | | $P_1/P_2$ | | | | 0.41458 | - | 0.41458 | | | | |
| | | $P_2/P_3$ | | | | 0.66127 | 0.66127 | 0.66127 | | | | |
| Female | 15-19 | 0.30924 | 0.05195 | 0.38033 | 1 | 0.01976 | - | 0.05897 | 0.98024 | - | 0.94103 | 2.42 |
| | 20-24 | 0.69314 | 0.08155 | 0.86257 | 2 | 0.07034 | 0.08035 | 0.08204 | 0.92966 | 0.91965 | 0.91796 | 3.96 |
| | 25-29 | 1.18950 | 0.09069 | 0.96994 | 3 | 0.08796 | 0.08497 | 0.09376 | 0.91204 | 0.91503 | 0.90624 | 5.52 |
| | 30-34 | 1.62353 | 0.08333 | 1.02751 | 5 | 0.08562 | 0.07814 | 0.08969 | 0.91438 | 0.92186 | 0.91031 | 6.99 |
| | 35-39 | 2.18881 | 0.10383 | 1.06449 | 10 | 0.11053 | - | 0.11192 | 0.88947 | - | 0.88808 | 8.44 |
| | 40-44 | 2.65812 | 0.19614 | 1.05808 | 15 | 0.20753 | - | - | 0.79247 | - | - | 10.20 |
| | 45-49 | 2.95122 | 0.26446 | 1.04779 | 20 | 0.27710 | - | - | 0.72290 | - | - | 12.90 |
| | | $P_1/P_2$ | | | | 0.44614 | - | 0.44614 | | | | |
| | | $P_2/P_3$ | | | | 0.58271 | 0.58271 | 0.58271 | | | | |
| Both sexes | 15-19 | 0.63454 | 0.07595 | 0.45576 | 1 | 0.03461 | - | 0.08631 | 0.96539 | - | 0.91369 | 2.24 |
| | 20-24 | 1.47779 | 0.09016 | 0.86125 | 2 | 0.07765 | 0.08693 | 0.09070 | 0.92235 | 0.91307 | 0.90930 | 3.88 |
| | 25-29 | 2.37609 | 0.09080 | 0.95250 | 3 | 0.08649 | 0.08365 | 0.09270 | 0.91351 | 0.91635 | 0.90730 | 5.67 |
| | 30-34 | 3.24118 | 0.09498 | 1.00683 | 5 | 0.09563 | 0.08783 | 0.09991 | 0.90437 | 0.91217 | 0.90009 | 7.44 |
| | 35-39 | 4.17832 | 0.12636 | 1.04186 | 10 | 0.13165 | - | 0.13212 | 0.86835 | - | 0.86788 | 9.22 |
| | 40-44 | 5.07692 | 0.19697 | 1.03472 | 15 | 0.20381 | - | - | 0.79619 | - | - | 11.20 |
| | 45-49 | 5.82927 | 0.24686 | 1.02504 | 20 | 0.25304 | - | - | 0.74696 | - | - | 13.90 |
| | | $P_1/P_2$ | | | | 0.42938 | - | 0.42938 | | | | |
| | | $P_2/P_3$ | | | | 0.62194 | 0.62194 | 0.62194 | | | | |

## 3.3 Estimation of Childhood Mortality Rates Using Data Classified by Duration of Marriage

Duration of marriage is defined as the time elapsed since entry into first union, regardless of whether this union is legal. In certain cultures, women appear to be more likely to state duration of marriage correctly than to give correct information about their age. So, the estimation procedure based on data classified by duration of marriage may be preferred. In practice, data are often only tabulated for groups up to 15-19 or 20-24 years; coefficients for longer duration periods have been included for the sake of completeness, even though they may not be used very often. It should also be noted that in all cases, the duration categories used must span exactly five years. Data referring to an open-ended duration interval, such as 20+ (20 years or more), should not be used to estimate child mortality.

### 3.3.1 Estimation of Child Mortality Using Data Classified by Duration of Marriage for National Level of Bangladesh

To illustrate the marriage duration-based procedure for estimating mortality in childhood at national level, rural level and urban level of Bangladesh, the required data are summarized at the top, middle and bottom panel in Table 3.5 that are taken from the Bangladesh Demographic and Health Survey (BDHS), 2004. Since data for longer duration groups, spanning five years each, are not available, only data on the first five duration groups are given in that Table. The sex ratios of the reported number of children ever born (CEB) are once again examined for consistency check of the data, just as in the case in which these data are classified by age. A complete sets of these sex ratios presented in column (7) of Table 3.5 are obtained by dividing the number of male children by the corresponding number of female children. The values of these sex ratios for different marriage durations are expected to reasonably stable and to be close to 1.05 (although allowance must be made for the random variability inherent in the small numbers considered).

**Table 3.5. Children Ever Born and Children Surviving by Sex and Duration of Marriage Group of Mother of National Level, Bangladesh, 2004**

| Age group | Total women | Male | | Female | | Sex ratio of CEB |
|---|---|---|---|---|---|---|
| | | CEB | Dead | CEB | Dead | |
| **National level** | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 0-4 | 2042 | 600 | 46 | 582 | 31 | 1.03093 |
| 5-9 | 2052 | 1807 | 158 | 1699 | 129 | 1.06357 |
| 10-14 | 1781 | 2536 | 274 | 2431 | 222 | 1.04319 |
| 15-19 | 1348 | 2503 | 316 | 2533 | 266 | 0.98816 |
| 20-24 | 854 | 2057 | 336 | 2100 | 313 | 0.97952 |
| 25-29 | 393 | 1156 | 227 | 1186 | 220 | 0.97470 |
| 30-34 | 251 | 815 | 172 | 920 | 185 | 0.88587 |
| Total | 8721 | 11474 | 1529 | 11451 | 1366 | 1.00201 |
| **Rural level** | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 0-4 | 1349 | 404 | 29 | 392 | 24 | 1.03061 |
| 5-9 | 1341 | 1213 | 104 | 1143 | 89 | 1.06124 |
| 10-14 | 1177 | 1732 | 206 | 1683 | 159 | 1.02911 |
| 15-19 | 910 | 1745 | 230 | 1784 | 196 | 0.97814 |
| 20-24 | 570 | 1445 | 236 | 1422 | 234 | 1.01617 |
| 25-29 | 291 | 897 | 182 | 888 | 167 | 1.01014 |
| 30-34 | 202 | 684 | 138 | 768 | 146 | 0.89063 |
| Total | 5840 | 8120 | 1125 | 8080 | 1015 | 1.00495 |
| **Urban level** | | | | | | |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| 0-4 | 693 | 196 | 17 | 190 | 7 | 1.03158 |
| 5-9 | 711 | 594 | 54 | 556 | 40 | 1.06835 |
| 10-14 | 604 | 804 | 68 | 748 | 63 | 1.07487 |
| 15-19 | 438 | 758 | 86 | 749 | 70 | 1.01202 |
| 20-24 | 284 | 612 | 100 | 678 | 79 | 0.90265 |
| 25-29 | 102 | 259 | 45 | 298 | 53 | 0.86913 |
| 30-34 | 49 | 131 | 34 | 152 | 39 | 0.86184 |
| Total | 2881 | 3354 | 404 | 3371 | 351 | 0.99496 |

**Note:** 35-39 age group is included in 30-34 age group

Average parities, $P_i$, (the value i=1, represents marriage duration group 0-4, i=2 indicates the duration group 5-9 and so on) for male and female are calculated separately at national level in a way very similar to the step 1 of the age version and the complete sets of $P_i$ values for male and female are shown in top and middle panel of column (2) of Table 3.6. The values of $P_i$ for both sexes are just the sum of $P_i$ values of male and female and the results are presented in bottom panel of column (2) of that Table). The results indicate that the average parities per woman i.e. the mean number of male CEB are higher than the female CEB. It is also observed from the results that average parities are increasing with the increase of marriage duration of the mother.

The proportion of children dead, $D_i$, for each marriage duration group of mother is computed and the results are shown in top and middle panel of column (3) of Table 3.6. When both sexes are considered, the number of male and female dead children has to be calculated by adding the figures in columns (4) and (6) of Table 5 and then dividing by the sum of male and female CEB (columns (3) and (5) of that Table) and the results are presented in bottom panel of column (3) of Table 3.6.

The multipliers, $k_i$, are obtained by substituting the average parity ratios $P_1/P_2$ and $P_2/P_3$ and the coefficients that are listed in Table 3 in Appendix, for each of the four different families of model life tables in the Coale-Demeny system in equation (B) described in chapter 2. The values of $k_i$ calculated for each sex and for both sexes combined, are presented in top, middle and bottom panel of column (4) of Table 3.6 respectively.

The probability of dying between birth and exact age x, ($q_x$), are obtained by multiplying the proportions of children dead ($D_i$) among the ever born appearing in column (3) of Table 3.6 and the corresponding multipliers ($k_i$) given in column (4) of that Table and the estimates of $q_x$ values are presented in top, middle and bottom panel of column (6) of Table 6 for male, female and both sexes respectively and the results are also presented in Figure 3.4. From the Figure, it is observed that the probability of dying is increasing with the increase of marriage duration and the probability is higher for male than female.

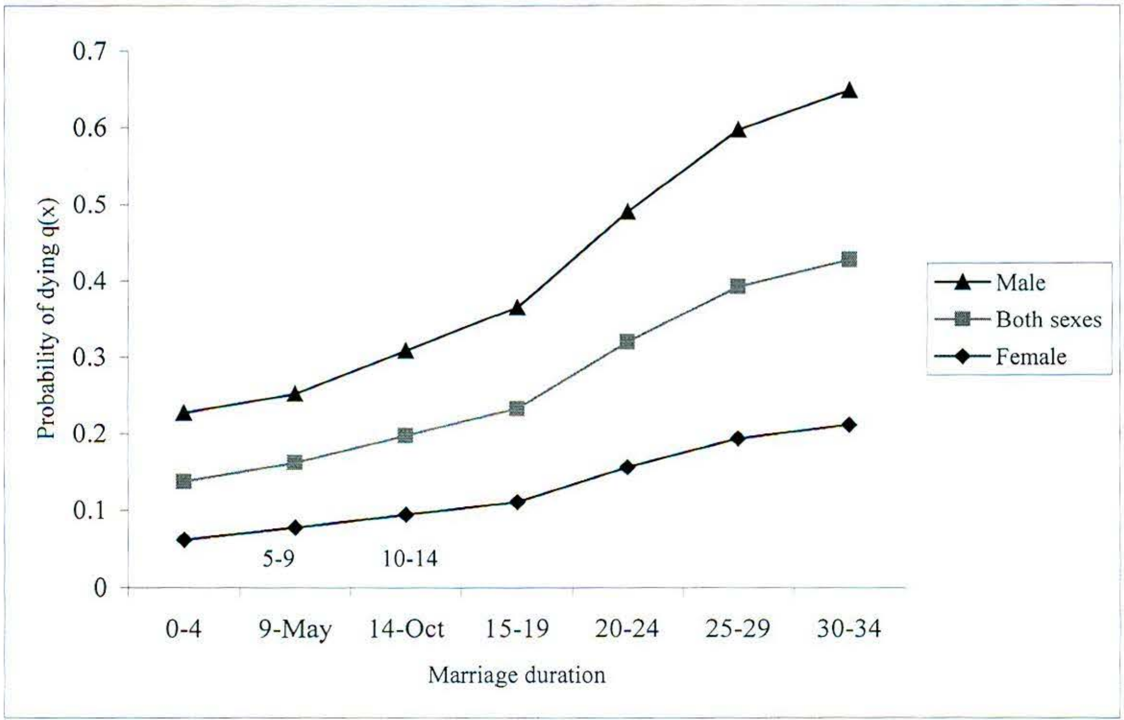


**Figure 3.4.** Patterns of child mortality when data classified by duration of marriage for national level of Bangladesh

**Table 3.6. Estimates of Probabilities of Dying, Surviving and of Reference Period by Sex, Derived from Child Survival Data Classified by Duration of Marriage, West Model, National Level of Bangladesh, 2004**

| Sex | Marriage duration | Average parity per woman $P_i$ | Proportion of children dead $D_i$ | Multipliers $k_i$ | Exact age | Estimates of $q_x$ | Probability of surviving $l_x$ | Reference period $t_x$ |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | 0-4 | 0.29383 | 0.07667 | 1.16893 | 2 | 0.08962 | 0.91038 | 1.28 |
| | 5-9 | 0.88060 | 0.08744 | 1.02863 | 3 | 0.08994 | 0.91006 | 3.21 |
| | 10-14 | 1.42392 | 0.10804 | 1.02912 | 5 | 0.11119 | 0.88881 | 5.50 |
| | 15-19 | 1.85682 | 0.12625 | 1.04953 | 10 | 0.13250 | 0.86750 | 7.93 |
| Male | 20-24 | 2.40867 | 0.16334 | 1.04265 | 15 | 0.17031 | 0.82969 | 10.50 |
| | 25-29 | 2.94148 | 0.19637 | 1.04043 | 20 | 0.20431 | 0.79569 | 13.30 |
| | 30-34 | 3.24701 | 0.21104 | 1.04705 | 25 | 0.22097 | 0.77903 | 16.30 |
| | | $P_1/P_2$ | | | | 0.33367 | | |
| | | $P_2/P_3$ | | | | 0.61844 | | |
| | 0-4 | 0.28501 | 0.05326 | 1.16271 | 2 | 0.06193 | 0.93807 | 1.30 |
| | 5-9 | 0.82797 | 0.07593 | 1.02652 | 3 | 0.07794 | 0.92206 | 3.26 |
| | 10-14 | 1.36496 | 0.09132 | 1.03347 | 5 | 0.09438 | 0.90562 | 5.47 |
| | 15-19 | 1.87908 | 0.10501 | 1.05697 | 10 | 0.11099 | 0.88901 | 7.73 |
| Female | 20-24 | 2.45902 | 0.14905 | 1.04893 | 15 | 0.15634 | 0.84366 | 10.20 |
| | 25-29 | 3.01781 | 0.18550 | 1.04444 | 20 | 0.19374 | 0.80626 | 13.10 |
| | 30-34 | 3.66534 | 0.20109 | 1.05129 | 25 | 0.21140 | 0.78860 | 16.10 |
| | | $P_1/P_2$ | | | | 0.34423 | | |
| | | $P_2/P_3$ | | | | 0.60659 | | |
| | 0-4 | 0.57884 | 0.06514 | 1.16591 | 2 | 0.07595 | 0.92405 | 1.29 |
| | 5-9 | 1.70858 | 0.08186 | 1.02761 | 3 | 0.08412 | 0.91588 | 3.23 |
| | 10-14 | 2.78888 | 0.09986 | 1.03124 | 5 | 0.10298 | 0.89702 | 5.49 |
| | 15-19 | 3.73591 | 0.11557 | 1.05317 | 10 | 0.12171 | 0.87829 | 7.83 |
| Both sexes | 20-24 | 4.86768 | 0.15612 | 1.04572 | 15 | 0.16326 | 0.83674 | 10.4 |
| | 25-29 | 5.95929 | 0.19086 | 1.04240 | 20 | 0.19895 | 0.80105 | 13.20 |
| | 30-34 | 6.91235 | 0.20576 | 1.04913 | 25 | 0.21587 | 0.78413 | 16.20 |
| | | $P_1/P_2$ | | | | 0.33879 | | |
| | | $P_2/P_3$ | | | | 0.61264 | | |

### 3.3.2 Estimation of Child Mortality Using Data Classified by Duration of Marriage for Rural Level of Bangladesh

For estimating mortality in childhood at rural level of Bangladesh through the marriage duration-based procedure, the required data are summarized in the top panel of Table 3.5 that are taken from the Bangladesh Demographic and Health Survey (BDHS), 2004. Average parities, $P_i$, for male and female are calculated separately at rural level of Bangladesh and the complete sets of $P_i$ values for male and female are shown in top and middle panel of column (2) of Table 3.7. The values of $P_i$ for both sexes are just the sum of $P_i$ values of male and female and the results are presented in bottom panel of column (2) of that Table). As for example, the average parities per woman i.e. the mean number of male CEB for the duration group 0-4 and 5-9 are 0.29948 and 0.90455 respectively.

The proportion of children dead, $D_i$, for each marriage duration group of mother at rural level of Bangladesh is computed and the results are shown in top and middle panel of column (3) of Table 3.7. When both sexes are considered, the number of male and female dead children has to be calculated and then dividing by the sum of male and female CEB and the results are presented in bottom panel of column (3) of Table 3.7. Such as, the proportions of male and female children dead for the marriage duration group 10-14 are 0.11894 and 0.09447 respectively. For both sexes, this ratio is 0.10688.

The multipliers, $k_i$, required to adjust the reported proportion dead, $D_i$, for the effects of the age pattern of childbearing, and the values of $k_i$ calculated for each sex and for both sexes combined, are presented in top, middle and bottom panel respectively of column (4) of Table 7. The values of $k_{i=1}$, i.e. for the marriage duration group 0-4 of male, female and both sexes at rural level of Bangladesh are 1.16974, 1.16312 and 1.16651 respectively.

The probability of dying between birth and exact age x, ($q_x$), for male, female and both sexes are obtained by multiplying the proportions of children dead ($D_i$) of each sex among the ever born appearing in column (3) of Table 7 and the corresponding multipliers ($k_i$) given in column (4) of that Table and the estimates of $q_x$ values are presented in top, middle and bottom panel of column (6) of Table 3.7 for male, female and both sexes respectively and the results are plotted in Figure 3.5. From the Figure, it is indicated that the probability of dying is increasing with the increase of marriage duration.

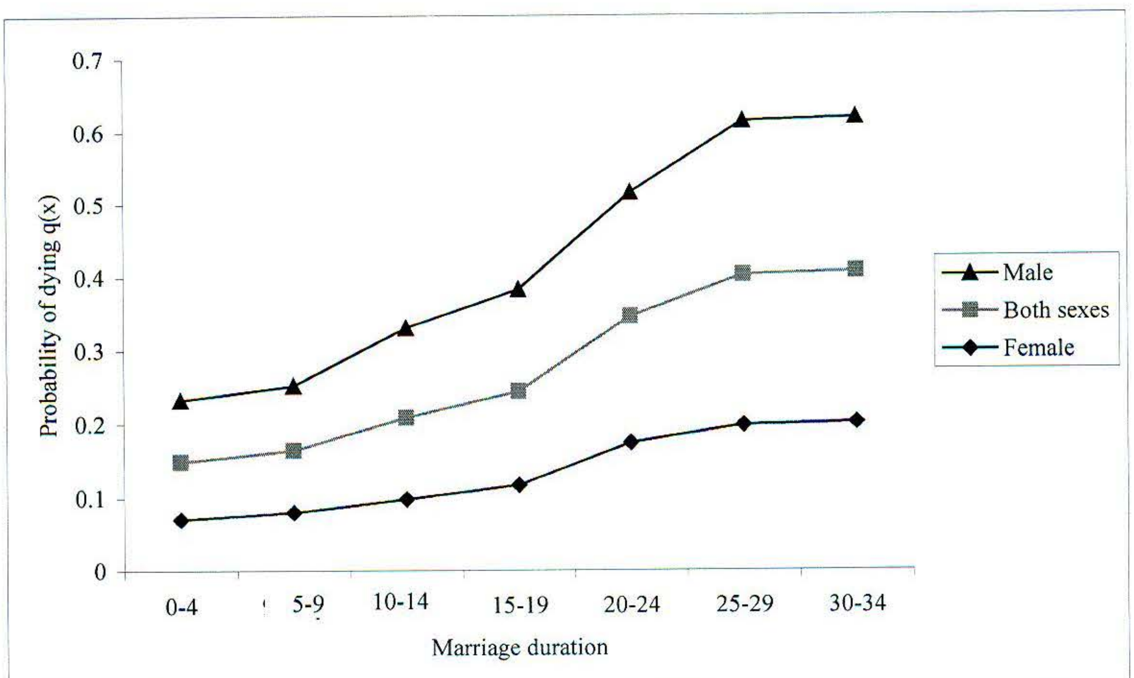


**Figure 3.5.** Patterns of child mortality when data classified by duration of marriage for rural level of Bangladesh

**Table 3.7. Estimates of Probabilities of Dying, Surviving and of Reference Period by Sex, Derived from Child Survival Data Classified by Duration of Marriage, West Model, Rural Level of Bangladesh, 2004**

| Sex | Marriage duration | Average parity per woman $P_i$ | Proportion of children dead $D_i$ | Multipliers $k_i$ | Exact age | Estimates of $q_x$ | Probability of surviving $l_x$ | Reference period $t_x$ |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | 0-4 | 0.29948 | 0.07178 | 1.16974 | 2 | 0.08396 | 0.91604 | 1.28 |
| | 5-9 | 0.90455 | 0.08574 | 1.02975 | 3 | 0.08829 | 0.91171 | 3.20 |
| | 10-14 | 1.47154 | 0.11894 | 1.03041 | 5 | 0.12256 | 0.87744 | 5.47 |
| | 15-19 | 1.91758 | 0.13181 | 1.05120 | 10 | 0.13856 | 0.86144 | 7.88 |
| Male | 20-24 | 2.53509 | 0.16332 | 1.04475 | 15 | 0.17063 | 0.82937 | 10.40 |
| | 25-29 | 3.08247 | 0.20290 | 1.04285 | 20 | 0.21159 | 0.78841 | 13.20 |
| | 30-34 | 3.38614 | 0.20175 | 1.04956 | 25 | 0.21175 | 0.78825 | 16.20 |
| | | $P_1/P_2$ | | | | 0.33108 | | |
| | | $P_2/P_3$ | | | | 0.61470 | | |
| | 0-4 | 0.29059 | 0.06122 | 1.16312 | 2 | 0.07121 | 0.92879 | 1.30 |
| | 5-9 | 0.85235 | 0.07787 | 1.02845 | 3 | 0.08009 | 0.91991 | 3.24 |
| | 10-14 | 1.42991 | 0.09447 | 1.03716 | 5 | 0.09798 | 0.90202 | 5.41 |
| | 15-19 | 1.96044 | 0.10987 | 1.06210 | 10 | 0.11669 | 0.88331 | 7.59 |
| Female | 20-24 | 2.49474 | 0.16456 | 1.05474 | 15 | 0.17357 | 0.82643 | 9.96 |
| | 25-29 | 3.05155 | 0.18806 | 1.05047 | 20 | 0.19755 | 0.80245 | 12.80 |
| | 30-34 | 3.80198 | 0.19010 | 1.05755 | 25 | 0.20104 | 0.79896 | 15.90 |
| | | $P_1/P_2$ | | | | 0.34092 | | |
| | | $P_2/P_3$ | | | | 0.59609 | | |
| | 0-4 | 0.59007 | 0.06658 | 1.16651 | 2 | 0.07767 | 0.92233 | 1.29 |
| | 5-9 | 1.75690 | 0.08192 | 1.02913 | 3 | 0.08431 | 0.91569 | 3.22 |
| | 10-14 | 2.90144 | 0.10688 | 1.03373 | 5 | 0.11049 | 0.88951 | 5.44 |
| | 15-19 | 3.87802 | 0.12071 | 1.05656 | 10 | 0.12754 | 0.87246 | 7.73 |
| Both sexes | 20-24 | 5.02982 | 0.16393 | 1.04967 | 15 | 0.17207 | 0.82793 | 10.20 |
| | 25-29 | 6.13402 | 0.19552 | 1.04662 | 20 | 0.20464 | 0.79536 | 13.00 |
| | 30-34 | 7.18812 | 0.19559 | 1.05351 | 25 | 0.20606 | 0.79394 | 16.00 |
| | | $P_1/P_2$ | | | | 0.33586 | | |
| | | $P_2/P_3$ | | | | 0.60553 | | |

### 3.3.3 Estimation of Child Mortality Using Data Classified by Duration of Marriage for Urban Level of Bangladesh

For estimating mortality in childhood at urban level of Bangladesh through the marriage duration-based procedure, the required data are summarized in the bottom panel of Table 3.5 that are taken from the Bangladesh Demographic and Health Survey (BDHS), 2004.

At urban level of Bangladesh, average parities, $P_i$, for male and female are calculated separately and the complete sets of $P_i$ values for male and female are shown in top and middle panel of column (2) of Table 3.8. The values of $P_i$ for both sexes are just the sum of $P_i$ values of male and female and the results are presented in bottom panel of column (2) of that Table). As for example, the average parities per woman for male, female and both sexes of the duration group 10-14 are 1.33113, 1.23841 and 2.56954 respectively.

The proportion of children dead, $D_i$, for each marriage duration group of mother at urban level of Bangladesh is computed and the results are shown in top and middle panel of column (3) of Table 3.8. When both sexes are considered, the number of male and female dead children has to be calculated and then dividing by the sum of male and female CEB and the results are presented in bottom panel of column (3) of Table 3.8. Such as, the proportions of male and female children dead for the marriage duration group 30-34 are 0.25954 and 0.25658 respectively. For both sexes, this ratio at urban level of Bangladesh is 0.25795.

The values of $k_i$ calculated for each sex and for both sexes combined and the results are presented in top, middle and bottom panel of column (4) of Table 3.8 respectively.

The values of $k_{i=2}$, i.e. for the marriage duration group 5-9 of male, female and both sexes at rural level of Bangladesh are 1.02635, 1.02238 and 1.02443 respectively.

For the urban level of Bangladesh, the probability of dying between birth and exact age x, ($q_x$), for male, female and both sexes are obtained by multiplying the proportions of children dead ($D_i$) of each sex among the ever born appearing in column (3) of Table 8 and the corresponding multipliers ($k_i$) given in column (4) of that Table and the estimates of $q_x$ values are presented in top, middle and bottom panel of column (6) of Table 3.8 for male, female and both sexes respectively. The results indicate that the estimate of the probability of dying increase with the increase of marriage duration for male, female and both sexes that are clearly showed in Figure 3.6.

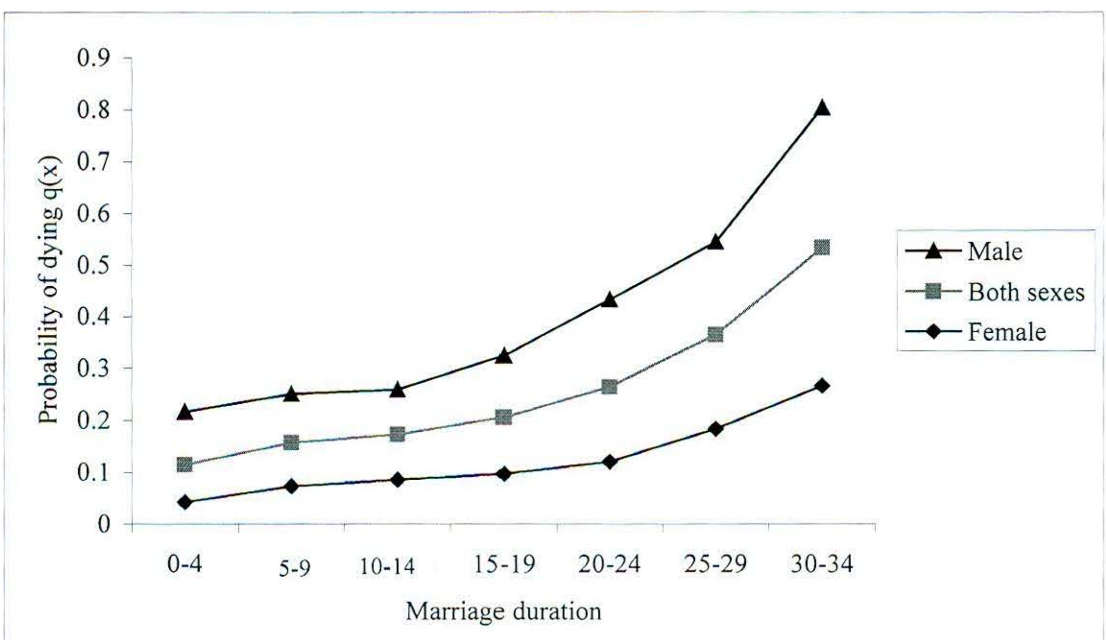


**Figure 3.6.** Patterns of child mortality when data classified by duration of marriage for urban level of Bangladesh

**Table 3.8. Estimates of Probabilities of Dying, Surviving and of Reference Period by Sex, Derived from Child Survival Data Classified by Duration of Marriage, West Model, Urban Level of Bangladesh, 2004**

| Sex | Marriage duration | Average parity per woman $P_i$ | Proportion of children dead $D_i$ | Multipliers $k_i$ | Exact age | Estimates of $q_x$ | Probability of surviving $l_x$ | Reference period $t_x$ |
|---|---|---|---|---|---|---|---|---|
| | (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | 0-4 | 0.28283 | 0.08673 | 1.16764 | 2 | 0.10127 | 0.89873 | 1.29 |
| | 5-9 | 0.83544 | 0.09091 | 1.02635 | 3 | 0.09331 | 0.90669 | 3.23 |
| | 10-14 | 1.33113 | 0.08458 | 1.02592 | 5 | 0.08677 | 0.91323 | 5.56 |
| | 15-19 | 1.73059 | 0.11346 | 1.04528 | 10 | 0.11860 | 0.88140 | 8.05 |
| Male | 20-24 | 2.15493 | 0.16340 | 1.03753 | 15 | 0.16953 | 0.83047 | 10.70 |
| | 25-29 | 2.53922 | 0.17375 | 1.03477 | 20 | 0.17979 | 0.82021 | 13.60 |
| | 30-34 | 2.67347 | 0.25954 | 1.04118 | 25 | 0.27023 | 0.72977 | 16.50 |
| | | $P_1/P_2$ | | | | 0.33854 | | |
| | | $P_2/P_3$ | | | | 0.62762 | | |
| | 0-4 | 0.27417 | 0.03684 | 1.16241 | 2 | 0.04282 | 0.95718 | 1.30 |
| | 5-9 | 0.78200 | 0.07194 | 1.02238 | 3 | 0.07355 | 0.92645 | 3.29 |
| | 10-14 | 1.23841 | 0.08422 | 1.02471 | 5 | 0.08630 | 0.91370 | 5.62 |
| | 15-19 | 1.71005 | 0.09346 | 1.04467 | 10 | 0.09763 | 0.90237 | 8.09 |
| Female | 20-24 | 2.38732 | 0.11652 | 1.03520 | 15 | 0.12062 | 0.87938 | 10.70 |
| | 25-29 | 2.92157 | 0.17785 | 1.03045 | 20 | 0.18327 | 0.81673 | 13.70 |
| | 30-34 | 3.10204 | 0.25658 | 1.03676 | 25 | 0.26601 | 0.73399 | 16.60 |
| | | $P_1/P_2$ | | | | 0.35060 | | |
| | | $P_2/P_3$ | | | | 0.63145 | | |
| | 0-4 | 0.55700 | 0.06218 | 1.16511 | 2 | 0.07245 | 0.92755 | 1.29 |
| | 5-9 | 1.61744 | 0.08174 | 1.02443 | 3 | 0.08374 | 0.91626 | 3.26 |
| | 10-14 | 2.56954 | 0.08441 | 1.02533 | 5 | 0.08655 | 0.91345 | 5.59 |
| | 15-19 | 3.44064 | 0.10352 | 1.04499 | 10 | 0.10818 | 0.89182 | 8.07 |
| Both sexes | 20-24 | 4.54225 | 0.13876 | 1.03641 | 15 | 0.14381 | 0.85619 | 10.70 |
| | 25-29 | 5.46078 | 0.17594 | 1.03268 | 20 | 0.18169 | 0.81831 | 13.60 |
| | 30-34 | 5.77551 | 0.25795 | 1.03904 | 25 | 0.26802 | 0.73198 | 16.60 |
| | | $P_1/P_2$ | | | | 0.34437 | | |
| | | $P_2/P_3$ | | | | 0.62947 | | |

# Chapter Four

# Covariates of Infant and Under-five Mortality

## 4.1 Introduction

Mortality has been declining all over the world, partly as a result of advances in medical knowledge and technology as well as improvement in living conditions. For both biological and behavioral reasons, mortality depends greatly on the age and sex of individuals (United Nations Secretariat, 1988).

Infant and under-five mortality are determined by both the biological endowment of children at birth and their environment after birth. In developing countries, background characteristics such as mother's literacy, urban/rural residence, and household economic status are likely to affect a child's condition at birth as well as its environment, thus affecting infant and child mortality (Hobcraft, McDonald and Rutstein, 1984; Mosley and Chen, 1984; United Nations, 1985; 1991; 1998). It is to examine the effect of child's sex on infant and under-five mortality to see whether son preference results in sex differentials in mortality in Bangladesh are different from the general pattern observed in most other populations. Some characteristics of children are related to mother's fertility behavior, such as mother's age at childbirth, child's birth order, and previous and following birth intervals. Careful monitoring of mother's health and growth of the fetus during pregnancy can identify potential complications during pregnancy, thus improving child survival after birth. Mother's tetanus immunization during pregnancy can sharply reduce risks of mortality due to neonatal tetanus. Also, timely check-ups of mother and baby after birth can improve survival chances of children.

In this chapter, it is tried to identify the covariates of infant and under-five mortality using some well known statistical tools such bivariate analysis, chi square test and logistic regression approach. It is also tried to prove the wroth of the logistic regression model using corrected classification rate (CCR).

**4.2 Background Characteristics of the Respondents**

Table 4.1 revealed the background information for total ever-married women of ten-year period preceding the survey who lived at rural and urban areas of Bangladesh as well as at the national level.

According to the information, about 37.4% women from national level are illiterate. The illiteracy among rural women (40.9%) is still higher than the urban women (30.1%). About 52.1% of rural women and 57.0% of urban women already become a mother of one or more child(ren) when their age was 20-29 years. This figure is 53.7% for national level. The percentages of male children are more than the female in all the three cases of rural, urban and national level of Bangladesh. Twin births to women most often seem to be dangerous both for mother and the new born. The study results indicate that 0.9% of national level women, 0.8% of rural women, and 1.2% of urban women gave twin births. Tube well as a source of pure drinking water is very much popular to the people of Bangladesh. From the results of Table 4.1, it is observed that 88.4% of the respondents are using tube well water to drink. The results also indicate that about 95.0% of rural respondents and about 75.0% of urban respondents fully use tube well as their source of drinking water. The Government of Bangladesh, in consultation with the coalition partners declared the target for achieving 100% sanitation in Bangladesh by 2010 as against MDG and WSSD (Ahmed and Siddiqi, 2004). From Table 4.1, it is observed that 38.9% of all women, 44.0% of rural women, and 28.4% of urban women are not accessed to sanitary latrine facilities. Tetanus Toxoid (TT) vaccine is given to women during their childbearing age (15-49) to protect them from tetanus during their whole reproductive life and their newborns from neonatal tetanus. From the Table 4.1, it is seen that the proportion of women who have received TT injection is 89.3%, 88.1%, and 91.8% respectively for national, rural, and urban level of Bangladesh.

Breast milk is the best and most useful food for the children. Arifeen (2008) found out using the BDHS data that the proportion of newborns who started on breast milk within one hour of birth has increased from 9.0% in 1993 to 24.0% in 2004 (data not yet available from the BDHS, 2007). He also showed that the median duration of breastfeeding has remained unchanged at about 32 months, and there has been absolutely no change in rates of exclusive breastfeeding. But the results of this study indicate that more or less 30.0% of the respondents do not breast feed their child.

If do not feel any life threatening risk, the people of Bangladesh is not properly habituated with the antenatal visits and also with the health check up of mothers and the new born after the birth taken place to qualified doctors. The results of this study indicate that about 30.5% of total women, 37.1% of rural women and 17.0% of urban women do not go for antenatal visit to doctor during their pregnancy. On the other hand, 50.4% of total women, 55.2% of rural women, and 40.6% of urban women do not check their health after the birth. The couple having 1-2 children is to be considered generally as ideal family in Bangladesh. Table 4.1 shows that only 49.2 of total women, 46.7% of rural women and 54.5% of urban women have the child 1-2. The rest of them are having 3 and more children. Interval between two births have direct effect on both mothers' and child's health condition. From Table 4.1, it is observed that 11.6% of the respondents gave birth within the interval of <24 months.

**Table 4.1. Background Characteristics of All Ever-married Women**

| Selected variables | National level | | Rural level | | Urban level | |
|---|---|---|---|---|---|---|
| | n | % | n | % | n | % |
| **Mothers' education** | | | | | | |
| Illiterate | 2778 | 37.4 | 2048 | 40.9 | 730 | 30.1 |
| Literate | 4649 | 62.6 | 2956 | 59.1 | 1693 | 69.9 |
| **Age of mother at birth** | | | | | | |
| 20-29 years | 3986 | 53.7 | 2605 | 52.1 | 1381 | 57.0 |
| All other aged | 3441 | 46.3 | 2399 | 47.9 | 1042 | 43.0 |
| **Child's sex** | | | | | | |
| Male | 3816 | 51.4 | 2556 | 51.1 | 1260 | 52.0 |
| Female | 3611 | 48.6 | 2448 | 48.9 | 1163 | 48.0 |
| **Is child twin?** | | | | | | |
| Single | 7357 | 99.1 | 4963 | 99.2 | 2394 | 98.8 |
| Multiple | 70 | 0.9 | 41 | 0.8 | 29 | 1.2 |
| **Source of drinking water** | | | | | | |
| Tube well water | 6566 | 88.4 | 4740 | 94.7 | 1826 | 75.4 |
| All other sources | 861 | 11.6 | 38 | 0.8 | 558 | 23.0 |
| **Toilet facility** | | | | | | |
| Hygienic | 4539 | 61.1 | 2803 | 56.0 | 1736 | 71.6 |
| Un-hygienic | 2888 | 38.9 | 2201 | 44.0 | 687 | 28.4 |
| **Taken T.T. injections** | | | | | | |
| No | 796 | 10.7 | 597 | 11.9 | 199 | 8.2 |
| Yes | 6631 | 89.3 | 4407 | 88.1 | 2224 | 91.8 |
| **Breastfeeding** | | | | | | |
| No | 2239 | 30.1 | 1440 | 28.8 | 799 | 33.0 |
| Yes | 5188 | 69.9 | 3564 | 71.2 | 1624 | 67.0 |
| **Antenatal visits** | | | | | | |
| No | 2265 | 30.5 | 1854 | 37.1 | 411 | 17.0 |
| Yes | 5162 | 69.5 | 3150 | 62.9 | 2012 | 83.0 |
| **After birth checked health** | | | | | | |
| No | 3746 | 50.4 | 2762 | 55.2 | 984 | 40.6 |
| Yes | 3681 | 49.6 | 2242 | 44.8 | 1439 | 59.4 |
| **Parity** | | | | | | |
| 1-2 | 3657 | 49.2 | 2336 | 46.7 | 1321 | 54.5 |
| 3+ | 3770 | 50.8 | 2668 | 53.3 | 1102 | 45.5 |
| **Preceding birth interval** | | | | | | |
| <24 months (r) | 860 | 11.6 | 578 | 11.6 | 282 | 11.6 |
| 24+ months | 4747 | 63.9 | 3568 | 65.3 | 1479 | 61.0 |
| Have a child | 1820 | 24.5 | 1158 | 23.1 | 662 | 27.3 |
| Total | 7427 | 100.0 | 5004 | 100.0 | 2423 | 100.0 |

### 4.3 Bivariate Analysis: A Chi-square Test Approach

Although the infant and under-five mortality are declining gradually in Bangladesh, there are significant variations observed in these mortality among rural and urban women with different selected background characteristics. To see the extent of association between infant and under-five mortality and various selected background characteristics across the country and rural-urban level in Bangladesh, a well-known statistical tool namely- Pearson Chi-square test procedure is used and the results of the association are presented in Table 4.2.

It is revealed from the results that the infant and under-five mortality are statistically and significantly associated with mothers' education, age of mother at birth, is child twin?, toilet facility, T.T. injections, breastfeeding, antenatal visits during pregnancy, after birth checked health, parity and preceding birth interval. Among all the selected variables, child's sex and source of drinking water are not significantly associated with both the infant and under-five mortality.

**Table 4.2. Association (Pearson Chi-square) between Background Characteristics and Infant and Under-five Mortality**

| Background characteristics | National level | | Rural level | | Urban level | |
|---|---|---|---|---|---|---|
| | Infant mortality | Under 5 mortality | Infant mortality | Under 5 mortality | Infant mortality | Under 5 mortality |
| **Mothers' education** | 42.178 | 55.651 | 19.910 | 29.960 | 26.255 | 27.267 |
| Significant level | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Age of mother at birth** | 21.459 | 25.346 | 12.218 | 17.248 | 9.622 | 7.757 |
| Significant level | 0.000 | 0.000 | 0.000 | 0.000 | 0.001 | 0.004 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Child's sex** | 0.897 | 0.047 | 0.950 | 0.226 | 0.066 | 0.096 |
| Significant level | 0.343 | 0.828 | 0.330 | 0.342 | 0.441 | 0.417 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Is child twin?** | 96.024 | 85.412 | 49.719 | 46.599 | 46.768 | 40.294 |
| Significant level | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Source of drinking water** | 3.064 | 2.297 | 2.019 | 1.363 | 1.447 | 2.080 |
| Significant level | 0.053 | 0.130 | 0.155 | 0.154 | 0.141 | 0.095 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Toilet facility** | 7.737 | 13.873 | 2.573 | 5.884 | 7.489 | 9.082 |
| Significant level | 0.005 | 0.000 | 0.064 | 0.009 | 0.005 | 0.002 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Taken T.T. injections** | 13.545 | 11.340 | 8.929 | 7.975 | 4.815 | 3.034 |
| Significant level | 0.000 | 0.001 | 0.003 | 0.005 | 0.030 | 0.066 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Breastfeeding** | 285.122 | 321.014 | 210.932 | 244.271 | 76.677 | 81.265 |
| Significant level | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 | 0.000 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Antenatal visits** | 7.222 | 3.846 | 3.159 | 0.654 | 6.249 | 5.768 |
| Significant level | 0.007 | 0.050 | 0.046 | 0.229 | 0.012 | 0.015 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **After birth checked health** | 3.725 | 9.881 | 5.184 | 14.397 | 0.014 | 0.044 |
| Significant level | 0.054 | 0.002 | 0.014 | 0.000 | 0.498 | 0.460 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Parity** | 10.536 | 21.248 | 4.652 | 13.716 | 6.777 | 7.112 |
| Significant level | 0.001 | 0.000 | 0.018 | 0.000 | 0.006 | 0.005 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |
| **Preceding birth interval** | 5.047 | 7.013 | 6.196 | 6.921 | 0.140 | 0.720 |
| Significant level | 0.025 | 0.008 | 0.012 | 0.008 | 0.405 | 0.240 |
| Degrees of freedom | 1 | 1 | 1 | 1 | 1 | 1 |

### 4.4 Multivariate Analysis: A Logistic Regression Approach

Bivariate association often does not necessarily imply a significant causal relationship. Therefore, a multivariate approach namely logistic (logit) regression model was applied (Gujarati, 2008) to determine which factors best explain and predict infant and under-five mortality in Bangladesh. Since child's sex and source of drinking water do not show any significant association with infant and under-five mortality that are already clear from section 4.3 and Table 4.2, therefore, these two variables are excluded in performing the logistic regression analysis. The results in terms of odds ratio that are calculated for each category of the categorical variables, presented in Table 4.3.

The education of mother has a distinct influence on infant and under-five mortality. Giashuddin and Kabir (2008) showed that children of mothers with no education had 1.85 (95 % CI 1.54-2.21) times risk of dying before completing one year than children of mothers have at least secondary education. From Table 4.3, it is apparent that education of mother is the most important factor, affecting the infant and under-five mortality. Large and statistically significant differences are also observed at national level, despite having controlled for other variables. Considering the illiterate mothers as reference category, the relative odds ratio of literate mothers is found to be 0.753 and 0.753 at national level, to be 0.805 and 0.770 at rural level and to be 0.643 and 0.723 at urban level of Bangladesh for infant and under-five mortality respectively. This indicates that the literate mothers of national level are 0.753 and 0.753 times less likely to face infant and under-five mortality as compared to illiterate mothers. These are 0.805 and 0.770 times less for rural mothers, and 0.643 and 0.723 times less for urban mothers. But the results of rural and urban areas are not statistically significant.

The results also indicate when the level of education increased, the incidence of infant and under-five mortality decreased. Because an educated mother is perceived to be able to provide proper care of her health and her child.

Age of mother at birth is another highly significant factor, influencing the level of infant and under-five mortality both at national, rural, and urban level of Bangladesh. Ascadi and Zhonson (1986) indicated that the risk of dying is higher for infants born to mothers who were closer to the lower or upper limits of the reproductive periods than to those who were in the prime of their childbearing periods. The logistic coefficients of this study indicate that the highest occurrence of infant and under-five mortality is among mother whose age at birth was below 20 years and/or above 30 years. It is evident that the risk of infants and under-five mortality born to mothers who are less than 20 years and/or 30 or more years of age are 1.601 and 1.645 times higher at risk of dying at national level, 1.574 and 1.686 times higher at rural level and 1.754 and 1.614 times higher at urban level respectively than the mothers who are 20-29 years of age (reference category).

Child is twin or not is found to be another significant factor, affecting the infant and under-five mortality. The relative odds ratio corresponding to the twin birth for infant and under-five mortality at national level are 7.523 and 6.558; at rural and urban level, these ratios are 8.027 and 7.133; and 6.320 and 5.559 respectively. It indicates that the infant and under-five mortality in case of twin birth at national level are 7.523 and 6.558 times higher; at rural level and urban level, 8.027 and 7.133 times; and 6.320 and 5.559 times respectively higher than that of the reference category (single birth).

Rahman *et al.* (1985) studied the impact of sanitation on infant mortality in rural Bangladesh and they found that those who did not use latrine had significantly higher post neo-natal mortality. From the results of this study, it is observed that the types of toilet facility have an effect on the infant and under-five mortality, with mothers having un-hygienic toilet facility being higher risk of infant and under-five mortality, but this effect is also not statistically significant.

Tetanus Toxoid (TT) vaccines are given to both the mother and their newborn to protect them from the life threatening disease namely tetanus. Tetanus is a fatal disease caused by unhygienic conditions at birth. It is one of the major reasons of neonatal mortality in developing countries (Stanfield and Galazha, 1984). The regression coefficients of taken T.T. injection are calculated and the results show the negative and significant effect on infant and under-five mortality. The relative odds ratio at national, rural and urban level for infant and under-five mortality corresponding to the mothers who take T.T. injection is 0.553 and 0.558; 0.536 and 0.518; and 0.613 and 0.707 respectively. These indicate that the risk of infant and under-five mortality among mothers who take T.T. injection are 0.553 and 0.558 times lower at national level, 0.536 and 0.518 times lower at rural level, and 0.613 and 0.707 times lower at urban level than the mothers who do not take this injection.

Breastfeeding could potentially be a confounding factor, since it affects both child survival and the length of the birth interval. It combats against infectious diseases and gives protection against diarrhoeal disease, which is one of the major killers of child in many developing countries (Wyon and Gordon, 1997). In this study, it is seen that breastfeeding has negative and statistically significant effect on infant and under-five mortality both at rural, urban, and national level of Bangladesh. The results indicate that the mothers who are feeding child their breast milk have 0.008 and 0.014 times lower risk of mortality during their infancy as well as their childhood period. The results also indicate that the mothers of rural and urban level who are feeding child their breast milk have lower risk of mortality than the mothers who are not feeding the breast milk. In case of breastfeeding practices, the risk of mortality among infant and under-five is higher in urban areas as compared with rural areas.

Antenatal care is an umbrella term used to describe the medical procedures and pregnancy related health care provided by doctor or a health worker in a medical center or at home. The overall aim of antenatal care is to produce healthy mother baby at the end of pregnancy (Rahman, Parkurst and Normand, 2003). Visits to doctors during pregnancy period and after the birth taken place are also the significant factors, affecting both the infant and under-five mortality. From the results, it is clear that at national level, the infant and under-five mortality are 0.148 and 0.176 times lower among mother who go for antenatal visits during pregnancy. It is also found that the likelihood of infant and under-five mortality both at rural and urban level of Bangladesh is lower among those mothers who go for antenatal visits during pregnancy. At the same time, it is also observed that the mothers who go for checked their health after the birth has taken place, the infant and under-five mortality are also lower among those, irrespective of the residence of rural and urban areas of Bangladesh.

**Table 4.3. Odds Ratio of Infant and Under-five Mortality on Some Selected Background Characteristics**

| Background characteristics | National level | | Rural level | | Urban level | |
|---|---|---|---|---|---|---|
| | Infant | Under 5 | Infant | Under 5 | Infant | Under 5 |
| | Odds ratio $[Exp(\beta)]$ | Odds ratio $[Exp(\beta)]$ | Odds ratio $[Exp(\beta)]$ | Odds ratio $[Exp(\beta)]$ | Odds ratio $[Exp(\beta)]$ | Odds ratio $[Exp(\beta)]$ |
| **Mothers' education** | | | | | | |
| Illiterate(r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Literate | $0.753^{***}$ | $0.753^{**}$ | 0.805 | 0.770 | 0.643 | $0.723^{*}$ |
| **Age of mother at birth** | | | | | | |
| 20-29 years (r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| All other aged | $1.601^{*}$ | $1.645^{**}$ | $1.574^{**}$ | $1.686^{*}$ | $1.754^{**}$ | $1.614^{**}$ |
| **Is child twin?** | | | | | | |
| Single(r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Multiple | $7.523^{*}$ | $6.558^{*}$ | $8.027^{*}$ | $7.133^{*}$ | $6.320^{*}$ | $5.559^{*}$ |
| **Toilet facility** | | | | | | |
| Hygienic (r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Un-hygienic | 1.034 | 1.162 | 0.878 | 1.025 | 1.525 | $1.595^{**}$ |
| **Taken T.T. injections** | | | | | | |
| No (r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Yes | $0.553^{**}$ | $0.558^{*}$ | $0.536^{**}$ | $0.518^{*}$ | 0.613 | 0.707 |
| **Breastfeeding** | | | | | | |
| No (r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Yes | $0.008^{*}$ | $0.014^{*}$ | $0.006^{*}$ | $0.011^{*}$ | $0.011^{*}$ | $0.017^{*}$ |
| **Antenatal visits** | | | | | | |
| No (r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Yes | $0.148^{*}$ | $0.176^{*}$ | $0.085^{*}$ | $0.105^{*}$ | $0.295^{*}$ | $0.336^{*}$ |
| **After birth checked health** | | | | | | |
| No (r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| Yes | $0.134^{*}$ | $0.213^{*}$ | $0.196^{*}$ | $0.319^{*}$ | $0.082^{*}$ | $0.113^{*}$ |
| **Parity** | | | | | | |
| 1-2(r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 3+ | 1.318 | $1.476^{**}$ | 1.291 | $1.553^{**}$ | 1.440 | 1.389 |
| **Preceding birth interval** | | | | | | |
| <24 months (r) | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 | 1.000 |
| 24+ months | 0.740 | $0.709^{**}$ | $0.641^{**}$ | $0.650^{**}$ | 1.007 | 0.842 |
| Constant | 5.100 | 3.245 | 6.894 | 4.082 | 2.820 | 2.134 |

**Note:** (r) indicates reference category.
**Significance level:** * $p< 0.01$, ** $p< 0.05$ and *** $p< 0.1$

Preceding birth interval, subsequent pregnancy and breastfeeding duration each have an independent influence on early mortality risk. Women with short intervals between two pregnancies have insufficient time to store their nutritional reserves, a situation which is thought to adversely affect fetal growth. Maternal depletion is often cited as the primary mechanism, responsible for the adverse effects of short birth interval. Considering the preceding birth interval of <24 months as reference category, the relative odds ratio corresponding to the preceding birth interval of 24+ months is 0.740 and 0.709 for infant and under-five mortality at national level. For rural and urban level, these figures are 0.641 and 0.650, and 1.007 and 0.842 respectively. This means that the risk of infant and under-five mortality is lower among the mother given birth after the 24 months of duration than the reference category.

### 4.5 Measuring of the Worth of the Model

There are various statistics that have been proposed for assessing the worth of a logistic regression model, analogous to those that are used in linear regression. Hence, one of the proposed statistics is given below:

#### 4.5.1 Correct Classification Rate (CCR)

The value of any goodness-of-fit statistic is highly dependent on the number of classes that are used and the statistical significance of the statistic is also dependent to some extent on the number of classes. This clearly mitigates somewhat against their use as a measure of the quality of fit. We might also criticize any statistic that is a function of the $P_i$ when Y is binary. That is, each $P_i$ and its closeness to $Y_i$ depend on more than the worth of the model. If our object is to predict whether a subject will or will not have the attribute of interest, a more meaningful measure of the worth of the model would be the percentage of subjects in the data set that classified correctly. Accordingly, we will use the correct classification rate (CCR) as a measure of the fit of the model. In order to find the CCR, the following Table 4.4 and 4.5 is used for infant mortality and Table 4.6 and 4.7 is used for under-five mortality model.

**Table 4.4. Observed Classification Table [i, ii] for Infant Mortality**

| For national level | | | | |
|---|---|---|---|---|
| Infant mortality | | Predicted | | Percentage correct |
| | | No | Yes | |
| Observed | No | 5401 | 0 | 100.0 |
| | Yes | 206 | 0 | 0.0 |
| | Overall percentage | | | 96.3 |
| **For rural level** | | | | |
| Infant mortality | | Predicted | | Percentage correct |
| | | No | Yes | |
| Observed | No | 3708 | 0 | 100.0 |
| | Yes | 138 | 0 | 0.0 |
| | Overall percentage | | | 96.4 |
| **For urban level** | | | | |
| Infant mortality | | Predicted | | Percentage correct |
| | | No | Yes | |
| Observed | No | 1693 | 0 | 100.0 |
| | Yes | 68 | 0 | 0.0 |
| | Overall percentage | | | 96.1 |

i. Constant is included in the model
ii. The cut value is 0.5

**Table 4.5. Predicted Classification Table [i] for Infant Mortality**

| For national level | | | | |
|---|---|---|---|---|
| Infant mortality | | Predicted | | Percentage correct |
| | | No | Yes | |
| Observed | No | 5390 | 11 | 99.8 |
| | Yes | 170 | 36 | 17.5 |
| | Overall percentage | | | 96.8 |
| **For rural level** | | | | |
| Infant mortality | | Predicted | | Percentage correct |
| | | No | Yes | |
| Observed | No | 3700 | 8 | 99.8 |
| | Yes | 110 | 28 | 20.3 |
| | Overall percentage | | | 96.9 |
| **For urban level** | | | | |
| Infant mortality | | Predicted | | Percentage correct |
| | | No | Yes | |
| Observed | No | 1691 | 2 | 99.9 |
| | Yes | 57 | 11 | 16.2 |
| | Overall percentage | | | 96.6 |

i. The cut value is 0.5

**Table 4.6. Observed Classification Table [i, ii] for Under-five Mortality**

**For national level**

| Infant mortality | | Predicted: No | Predicted: Yes | Percentage correct |
|---|---|---|---|---|
| Observed | No | 5352 | 0 | 100.0 |
| | Yes | 255 | 0 | 0.0 |
| | Overall percentage | | | 95.5 |

**For rural level**

| Infant mortality | | Predicted: No | Predicted: Yes | Percentage correct |
|---|---|---|---|---|
| Observed | No | 3668 | 0 | 100.0 |
| | Yes | 178 | 0 | 0.0 |
| | Overall percentage | | | 95.4 |

**For urban level**

| Infant mortality | | Predicted: No | Predicted: Yes | Percentage correct |
|---|---|---|---|---|
| Observed | No | 1684 | 0 | 100.0 |
| | Yes | 77 | 0 | 0.0 |
| | Overall percentage | | | 95.6 |

i. Constant is included in the model
ii. The cut value is 0.5

**Table 4.7. Predicted Classification Table [i] for Under-five Mortality**

**For national level**

| Infant mortality | | Predicted: No | Predicted: Yes | Percentage correct |
|---|---|---|---|---|
| Observed | No | 5342 | 10 | 99.8 |
| | Yes | 217 | 38 | 14.9 |
| | Overall percentage | | | 96.0 |

**For rural level**

| Infant mortality | | Predicted: No | Predicted: Yes | Percentage correct |
|---|---|---|---|---|
| Observed | No | 3661 | 7 | 99.8 |
| | Yes | 145 | 33 | 18.5 |
| | Overall percentage | | | 96.0 |

**For urban level**

| Infant mortality | | Predicted: No | Predicted: Yes | Percentage correct |
|---|---|---|---|---|
| Observed | No | 1682 | 2 | 99.9 |
| | Yes | 66 | 11 | 14.3 |
| | Overall percentage | | | 96.1 |

i. The cut value is 0.5

If the threshold or cut value is to be considered as 0.5 then from Table 4.5, it is observed that CCR for infant mortality model is 96.8 at national level, 96.9 at rural level and 96.6 at urban level. At the same time, from Table 4.7, it is seen that CCR for under-five mortality model is 96.0 at national level, 96.0 at rural level and 96.1 at urban level. A model that affords better classification should be judged superior by a goodness-of-fit test. That is, a higher proportion of CCR indicates that the used logistic model is working well. Therefore, the models can be used for the significance prediction about the infant and under-five mortality at national, rural, and urban level of Bangladesh.

# *Chapter Five*
# *Life Table Analysis of Infant and Under-five Mortality*

## 5.1 Introduction

The life table gives the life history of a hypothetical group or cohort as it is gradually diminished by deaths. It is a conventional method of expressing the most fundamental and essential facts about the age distribution of mortality in a tabular form and is a powerful tool for measuring the probability of life and deaths of various age sectors. It is clearly designed essentially to measure mortality but it is also used by a variety of specialists in different branches. It is used by actuarial sciences, demographers, economists, sociologists, public health workers, geographers and many others in studies of longevity, fertility, migration, population renew and population growth as well as in making estimates and projections of population size, distribution and characteristics. It is also used in the studies of widowhood, orphanhood, length of married life, length of working life and length of disability free life.

This chapter gives commonly used indicators of mortality before age five, based on cohort life-table computations, as basic measures of infant and under-five mortality. Cohort life tables are computed by following the children in our sub sample from birth and computing the probabilities of dying during consecutive age intervals, using the traditional actuarial life-table method. The life-table computation uses age intervals of 0 months, 1–2 months, 3–5 months, 6–8 months, 9–11 months, 12–17 months, 18–23 months, 24–35 months, 36–47 months, and 48–59 months. We first calculate probabilities of survival (l(x) values in conventional life-table notation) at ages 1, 3, 6, 9, 12, 18, 24, 36, 48, and 60 months in terms of the number of survivors per 1,000 births (i.e., the life table radix, l(0), is set to 1,000). Age-specific cohort mortality measures (deaths per 1,000) can then be computed from these probabilities of survival as follows:

Neonatal mortality: $1{,}000 - l(1)$

Post neonatal mortality: $l(1) - l(12)$

Infant mortality: $1{,}000 - l\,(12)$

Child mortality: $1{,}000 * [l(12) - l(60)] / l(12)$

Under-five mortality: $1{,}000 - l\,(60)$

In this chapter, abridged life tables have been constructed using the number of deaths ($_xd_n$) in the interval x to (x + n) based for the overall country level, rural level, urban level, male child, female child, literate mother, illiterate mother, rural male child, rural female child, urban male child, urban female child, currently working and currently not working mothers. It is to be noted that life tables, described in this chapter, are called single decrement life tables as well as period life tables too.

### 5.2 Patterns of Survival Function ($l_x$) at Exact Age x

The number of persons living at the beginning of the indicated age x out of the total number of births assumed as the radix of the table for the overall country level, male child, female child, literate mother, illiterate mother, currently not working mother, working mother, rural areas, urban areas, rural male child, rural female child, urban male child and urban female child have been calculated to selected ages and the results are presented in Table 5.1. To see the trends and patterns, these surviving functions have been plotted in the graph paper and depicted in Figure 5.1, Figure 5.2, Figure 5.3, and Figure 5.4.

**Table 5.1. Survival Function ($l_x$) to the Selected Age**

| Age in months | Number of persons living at the beginning of the indicated age x ($l_x$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | National level | | | | | | |
| | Country level | Male child | Female child | Literate mother | Illiterate mother | Not working mother | Working mother |
| 0 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 1-2 | 835 | 912 | 923 | 921 | 914 | 880 | 955 |
| 3-5 | 787 | 883 | 904 | 905 | 882 | 843 | 944 |
| 6-8 | 751 | 864 | 887 | 885 | 866 | 817 | 934 |
| 9-11 | 733 | 855 | 878 | 882 | 851 | 807 | 926 |
| 12-17 | 725 | 851 | 874 | 879 | 846 | 801 | 924 |
| 18-23 | 714 | 847 | 867 | 875 | 839 | 794 | 920 |
| 24-35 | 702 | 839 | 863 | 869 | 833 | 784 | 918 |
| 36-47 | 686 | 834 | 852 | 862 | 824 | 773 | 913 |
| 48-59 | 677 | 831 | 846 | 858 | 819 | 766 | 911 |
| 60 | 669 | 828 | 841 | 857 | 812 | 764 | 905 |

| Age in months | Rural areas | Urban areas | Rural male child | Rural female child | Urban male child | Urban female child |
|---|---|---|---|---|---|---|
| 0 | 1000 | 1000 | 1000 | 1000 | 1000 | 1000 |
| 1-2 | 888 | 947 | 940 | 948 | 972 | 975 |
| 3-5 | 855 | 932 | 922 | 933 | 961 | 971 |
| 6-8 | 834 | 917 | 909 | 925 | 955 | 962 |
| 9-11 | 822 | 911 | 903 | 919 | 952 | 959 |
| 12-17 | 815 | 910 | 899 | 916 | 952 | 958 |
| 18-23 | 805 | 909 | 895 | 910 | 952 | 957 |
| 24-35 | 794 | 908 | 888 | 906 | 951 | 957 |
| 36-47 | 784 | 902 | 884 | 900 | 950 | 952 |
| 48-59 | 775 | 902 | 881 | 894 | 950 | 952 |
| 60 | 770 | 899 | 879 | 891 | 949 | 950 |

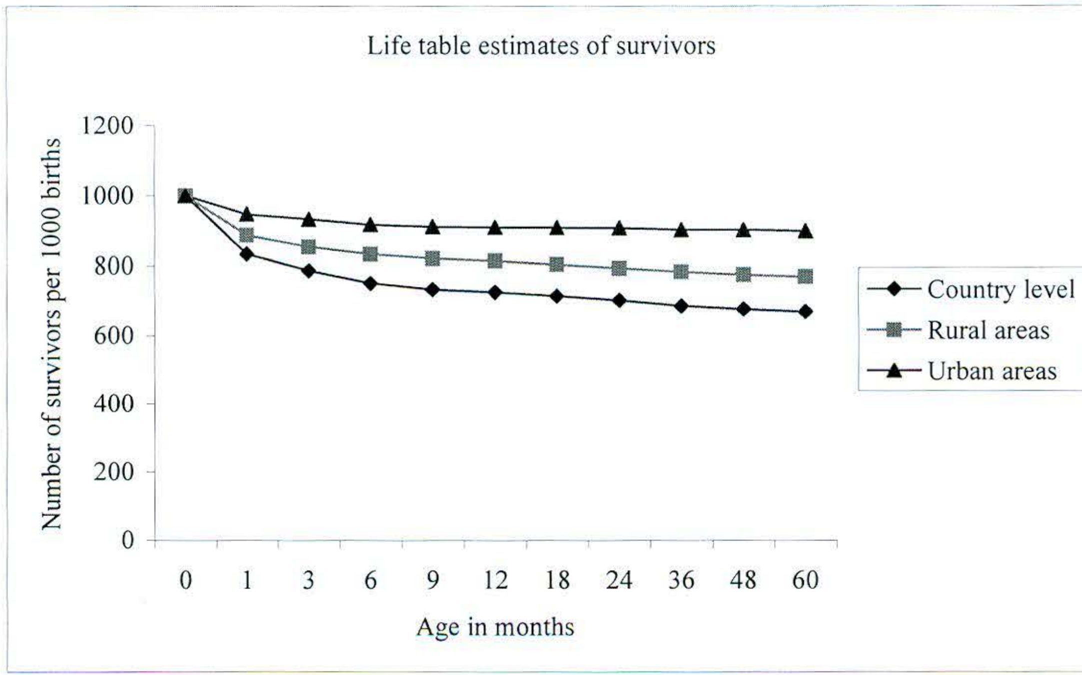


**Figure 5.1.** The number of survivors for the overall country level, rural level and urban level

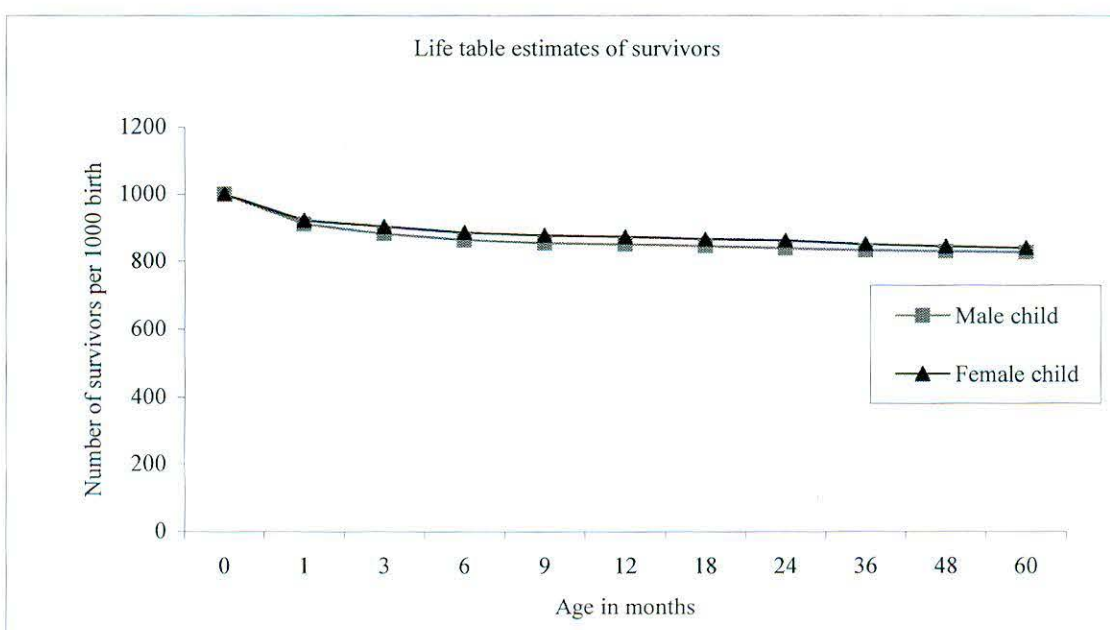


**Figure 5.2.** The number of survivors for the male and female child

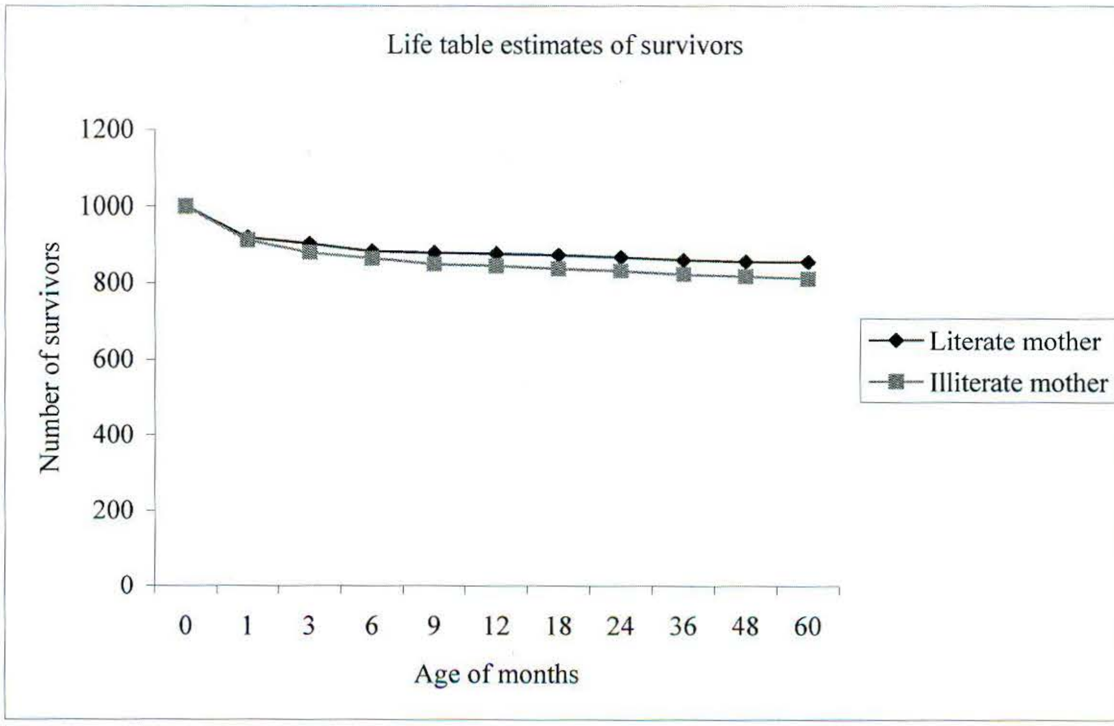


**Figure 5.3.** The number of survivors for the literate and illiterate mothers

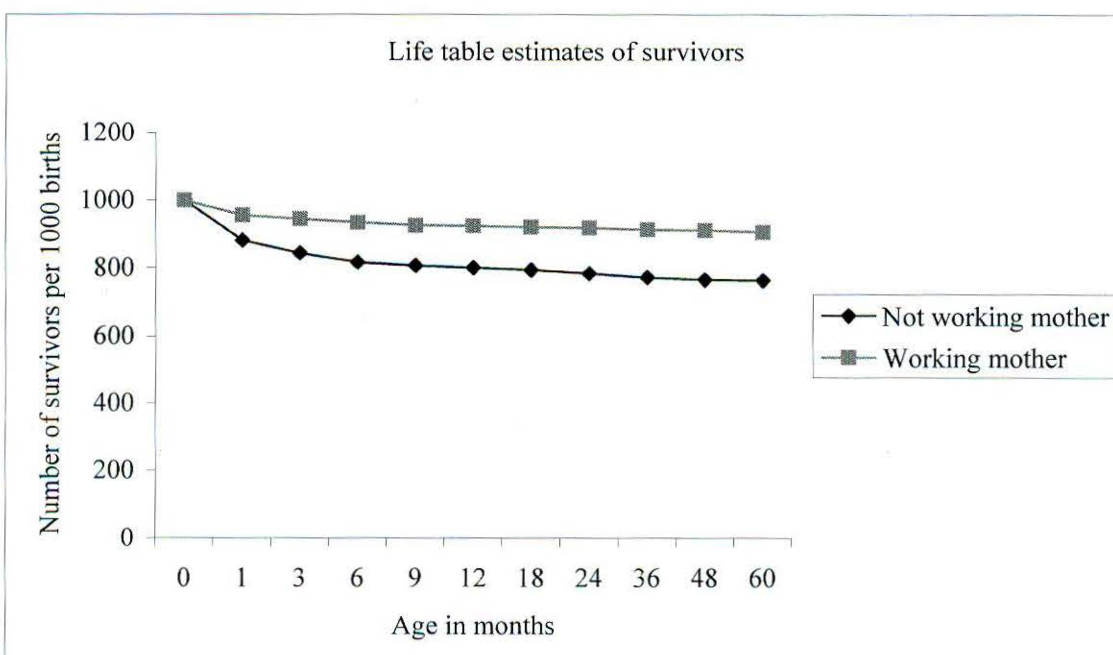


**Figure 5.4.** The number of survivors for the not working and working mothers

The age pattern of mortality varies due to the level of mortality. The results showed that the mortality differences between rural and urban areas are much larger at older ages than at younger ages. In both the rural and urban areas of Bangladesh, the survival function decreases steeply throughout the period and these changes are little after the neonatal period. This is as expected because many of the risks of post neonatal and child mortality can be reduced by improvements in environment and health-care behavior, whereas many risks of neonatal mortality have genetic origins and are difficult to reduce.

### 5.3 Patterns of the Probability of Dying between Age x to (x+n) (${}_nq_x$)

The proportions of the persons in the cohort alive at the beginning of an indicated age x who will die before reaching the end of the age (x+n) have been calculated for the overall country level, male child, female child, literate mothers, illiterate mothers, currently not working mothers, working mothers, rural areas, urban areas, rural male child, rural female child, urban male child and urban female child and the results are presented in Table 5.2.

To observe the patterns of it for the overall country level, rural areas and urban areas have been plotted in the graph paper and depicted in Figure 5.5. From the figure, it is seen that the ${}_nq_x$ function are decreasing with the increase of age. The pattern of the probability of dying of rural areas is higher due to ages than that of the urban areas of Bangladesh.

In case of male and female child, the results are plotted in Figure 5.6 and it is seen that the probability of dying is higher in rural areas than the urban areas. The graph of ${}_nq_x$ is higher for illiterate mothers than the literate (Figure 5.7) and in case of currently not working and working mothers, it is seen that the probability of dying of not working mothers is more among than the working mothers (Figure 5.8).

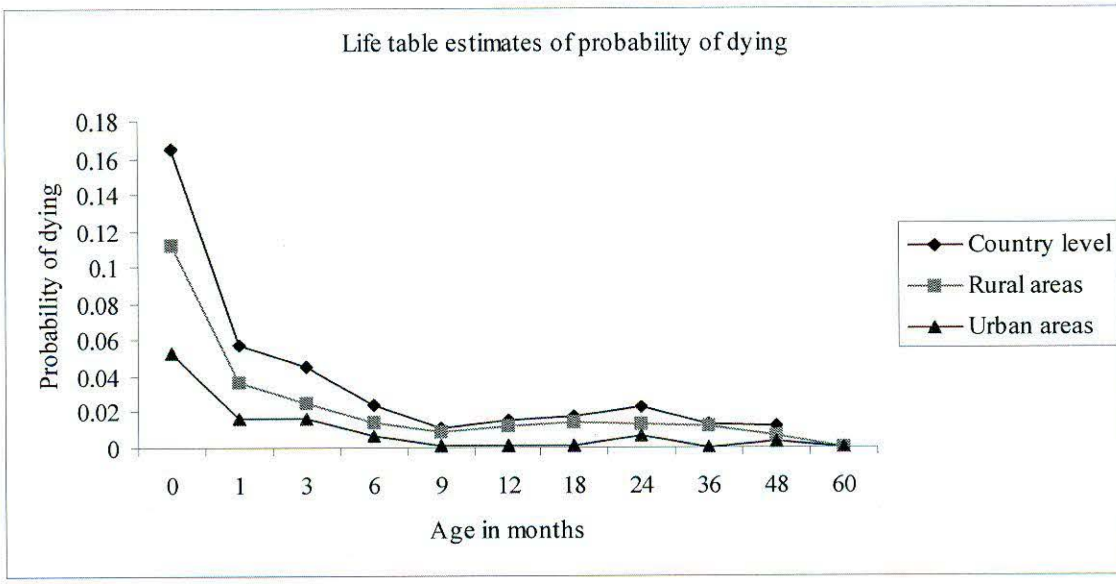


**Figure 5.5.** The probability of dying for the overall country level, rural level and urban level

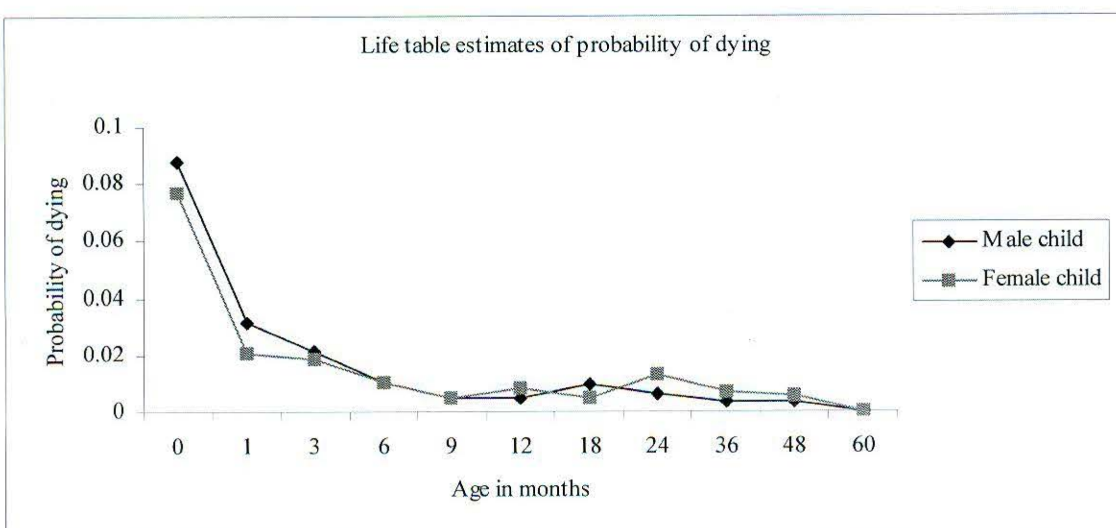


**Figure 5.6.** The probability of dying for the male and female child

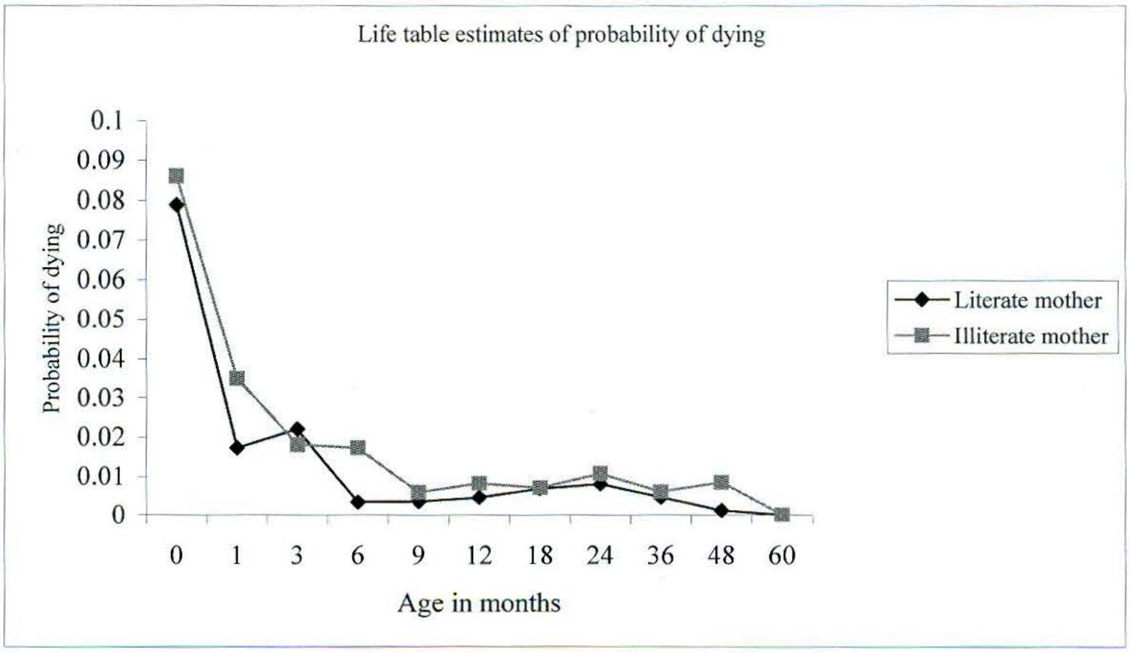


**Figure 5.7.** The probability of dying for the illiterate and literate mothers

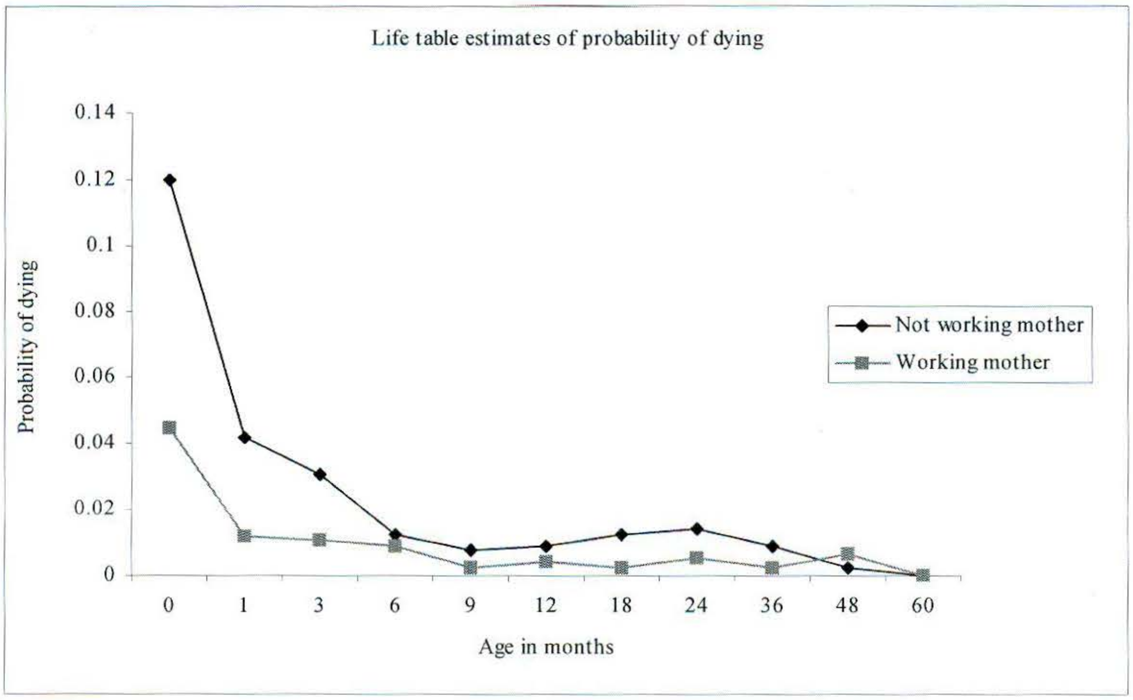


**Figure 5.8.** The probability of dying for the currently not working and working mothers

**Table 5.2. Probability of Dying between Age x to (x+n) ($_nq_x$)**

| Age in months | Probability of dying at age x to (x+n) ($_nq_x$) | | | | | | |
|---|---|---|---|---|---|---|---|
| | National level | | | | | | |
| | Country level | Male child | Female child | Literate mother | Illiterate mother | Not working mother | Working mother |
| 0 | 0.16500 | 0.08800 | 0.07700 | 0.07900 | 0.08600 | 0.12000 | 0.04500 |
| 1-2 | 0.05749 | 0.03180 | 0.02059 | 0.01737 | 0.03501 | 0.04205 | 0.01152 |
| 3-5 | 0.04574 | 0.02152 | 0.01881 | 0.02210 | 0.01814 | 0.03084 | 0.01059 |
| 6-8 | 0.02397 | 0.01042 | 0.01015 | 0.00339 | 0.01732 | 0.01224 | 0.00857 |
| 9-11 | 0.01091 | 0.00468 | 0.00456 | 0.00340 | 0.00588 | 0.00743 | 0.00216 |
| 12-17 | 0.01517 | 0.00470 | 0.00801 | 0.00455 | 0.00827 | 0.00874 | 0.00433 |
| 18-23 | 0.01681 | 0.00945 | 0.00461 | 0.00686 | 0.00715 | 0.01259 | 0.00217 |
| 24-35 | 0.02279 | 0.00596 | 0.01275 | 0.00806 | 0.01080 | 0.01403 | 0.00545 |
| 36-47 | 0.01312 | 0.00360 | 0.00704 | 0.00464 | 0.00607 | 0.00906 | 0.00219 |
| 48-59 | 0.01182 | 0.00361 | 0.00579 | 0.00117 | 0.00855 | 0.00261 | 0.00659 |
| 60 | - | - | - | - | - | - | - |

| Age in months | Rural areas | Urban areas | Rural male child | Rural female child | Urban male child | Urban female child |
|---|---|---|---|---|---|---|
| 0 | 0.11200 | 0.05300 | 0.06000 | 0.05200 | 0.02800 | 0.02500 |
| 1-2 | 0.03716 | 0.01584 | 0.01915 | 0.01582 | 0.01132 | 0.00410 |
| 3-5 | 0.02456 | 0.01609 | 0.01410 | 0.00857 | 0.00624 | 0.00927 |
| 6-8 | 0.01439 | 0.00654 | 0.00660 | 0.00649 | 0.00314 | 0.00312 |
| 9-11 | 0.00852 | 0.00110 | 0.00443 | 0.00326 | 0 | 0.00104 |
| 12-17 | 0.01227 | 0.00110 | 0.00445 | 0.00655 | 0 | 0.00104 |
| 18-23 | 0.01366 | 0.00110 | 0.00782 | 0.00440 | 0.00105 | 0 |
| 24-35 | 0.01259 | 0.00661 | 0.00450 | 0.00662 | 0.00105 | 0.00522 |
| 36-47 | 0.01148 | 0 | 0.00339 | 0.00667 | 0 | 0 |
| 48-59 | 0.00645 | 0.00333 | 0.00227 | 0.00336 | 0.00105 | 0.00210 |
| 60 | - | - | - | - | - | - |

**Note:** $q_x=d_x/l_x$

## 5.4 Patterns of Life Expectancy ($e_x$) at Exact Age x

The expectation of life ($e_x$) at exact age x have been calculated corresponding to the selected ages for the overall country level, male child, female child, literate mother, illiterate mother, currently not working mother, working mother, rural areas, urban areas, rural male child, rural female child, urban male child and urban female child and the results are presented in Table 5.3. The results indicate that the life expectancy is higher for male child, literate mothers and currently working mothers than the female child, illiterate mothers and currently not working mothers respectively. To see the patterns, these expectation of life at exact age x have been plotted in the graph paper and depicted in Figure 5.9 and Figure 5.10. From these figures, it is seen that the expectation of life for all the mentioned indicators exhibit same but traditional pattern. The expectation of life at birth for the overall country level is 42.37, for the male child is 50.62, for the female child is 51.96, for the literate mother is 52.24, for illiterate mother is 42.38, for currently not working mother is 47.25, for working mother is 55.12, for rural area is 47.89, for urban area is 54.49, for rural male child is 53.50, for rural female child is 54.39, for urban male child is 57.12 and for urban female child is 57.36 respectively. It is observed that the pecks of the curves of the expectation of life are showing increasing up to 1-2 age group and then start to decline with passing of time. It is also observed that the expectation of life are gradually increasing in the age interval [0, 5] and smoothly decreasing in the age interval [6, 59] for the overall country level and rural area of Bangladesh. But for the urban area, the expectancy of life are increasing in the age interval [0, 2] and smoothly decreasing in the age interval [3, 59]. It is also found that the maximum life expectancy for the overall country level and rural area are 50.66 and 52.89 respectively in the same age 3 months whereas it is 56.51 for the urban area in the age 1 month.

**Table 5.3. Expectation of Life at Exact Age x**

| Age in months | Life expectancy ($e_x$) at exact age x | | | | | | |
|---|---|---|---|---|---|---|---|
| | National level | | | | | | |
| | Country level | Male child | Female child | Literate mother | Illiterate mother | Not working mother | Working mother |
| 0 | 42.37350 | 50.62540 | 51.96410 | 52.23770 | 50.13580 | 47.25200 | 55.12150 |
| 1-2 | 49.68743 | 54.48136 | 55.27411 | 55.69273 | 53.82495 | 52.65455 | 56.70471 |
| 3-5 | 50.65693 | 54.23783 | 54.41482 | 54.65967 | 53.74150 | 52.92171 | 55.35381 |
| 6-8 | 50.01332 | 52.39757 | 52.42897 | 52.86102 | 51.70670 | 51.55814 | 52.93041 |
| 9-11 | 48.20464 | 49.93333 | 49.95103 | 50.03571 | 49.59166 | 49.17844 | 50.37473 |
| 12-17 | 45.72000 | 47.16099 | 47.17277 | 47.20137 | 46.87589 | 46.53558 | 47.48052 |
| 18-23 | 40.37815 | 41.36954 | 41.52941 | 41.40343 | 41.24195 | 40.91940 | 41.67391 |
| 24-35 | 35.01709 | 35.73540 | 35.70800 | 35.66858 | 35.51741 | 35.40306 | 35.75817 |
| 36-47 | 23.69388 | 23.91367 | 24.09155 | 23.90951 | 23.83981 | 23.82147 | 23.92114 |
| 48-59 | 11.92910 | 11.97834 | 11.84028 | 11.99301 | 11.94872 | 11.98433 | 11.96048 |
| 60 | - | - | - | - | - | - | - |

| Age in months | Rural areas | Urban areas | Rural male child | Rural female child | Urban male child | Urban female child |
|---|---|---|---|---|---|---|
| 0 | 47.88660 | 54.48690 | 53.50050 | 54.38610 | 57.12490 | 57.36200 |
| 1-2 | 52.88851 | 56.51954 | 55.89628 | 56.35285 | 57.76183 | 57.82513 |
| 3-5 | 52.89123 | 55.41309 | 54.96800 | 55.24277 | 56.41155 | 56.05922 |
| 6-8 | 51.18525 | 53.29498 | 52.73267 | 52.70757 | 53.75654 | 53.56965 |
| 9-11 | 48.91058 | 50.63611 | 50.07309 | 50.04189 | 50.92122 | 50.73253 |
| 12-17 | 46.31779 | 47.69011 | 47.28921 | 47.20087 | 47.92122 | 47.78392 |
| 18-23 | 40.85590 | 41.73927 | 41.48715 | 41.49231 | 41.92122 | 41.83072 |
| 24-35 | 35.38035 | 35.78194 | 35.79054 | 35.66225 | 35.96215 | 35.83072 |
| 36-47 | 23.75510 | 23.98004 | 23.92534 | 23.86000 | 23.99368 | 23.98739 |
| 48-59 | 11.96129 | 11.98004 | 11.98638 | 11.97987 | 11.99368 | 11.98739 |
| 60 | - | - | - | - | - | - |

**Note:** $e_x = T_x / l_x$

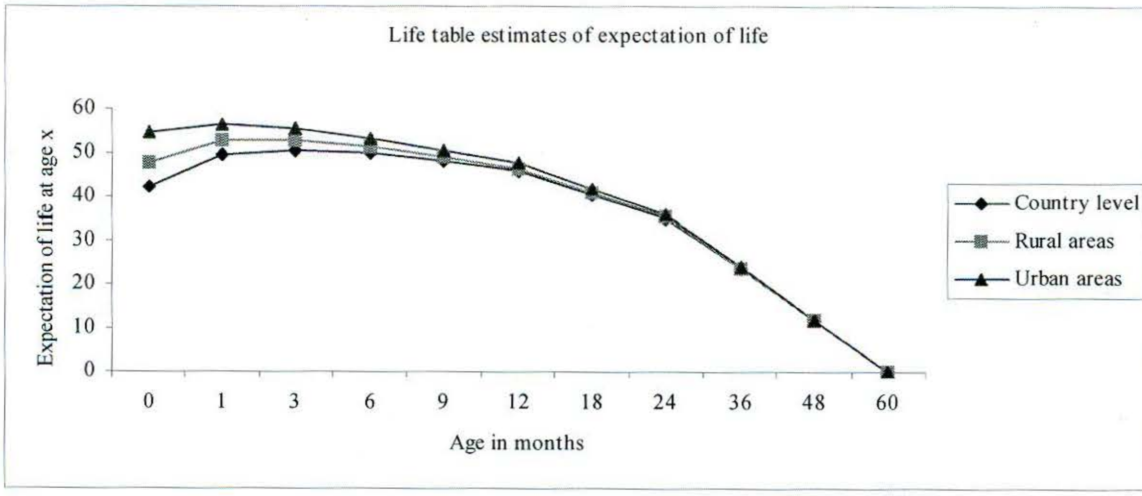


**Figure 5.9.** The life expectancy for the overall country level, rural level and urban level

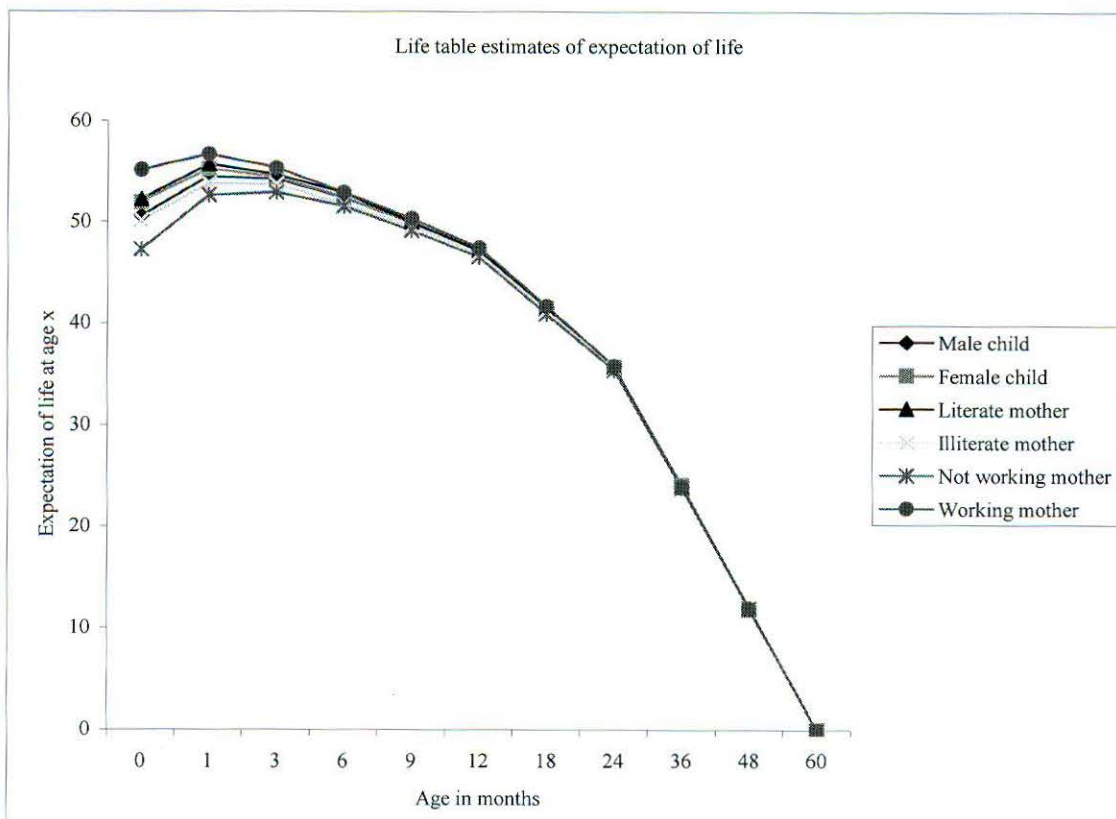


**Figure 5.10.** The life expectancy for the male, female, literate, illiterate, working and not working mohers

### 5.5 Patterns of Life Table Age Specific Death Rates (ASDRs)

The life table age specific death rates for the overall country level, male child, female child, literate mother, illiterate mother, currently not working mother, working mother, rural areas, urban areas, rural male child, rural female child, urban male child and urban female child have been calculated to selected ages and the results are presented in Table 5.4. The results indicate that the age specific death rates are higher among female child than the male child. But these rates are lower among the literate mothers than the illiterate mothers.

To see the patterns of it for the overall country level, rural and urban areas of Bangladesh have been plotted in the graph paper and depicted in Figure 5.11. From the figure, it is seen that the age specific death rates are high for the overall country level and it is low in urban areas than the rural areas. The age specific death rates are also seen to be higher among urban male child than the rural male child. These rates are also seen higher among illiterate and not working mother than the literate and working mother (Table 5.4).

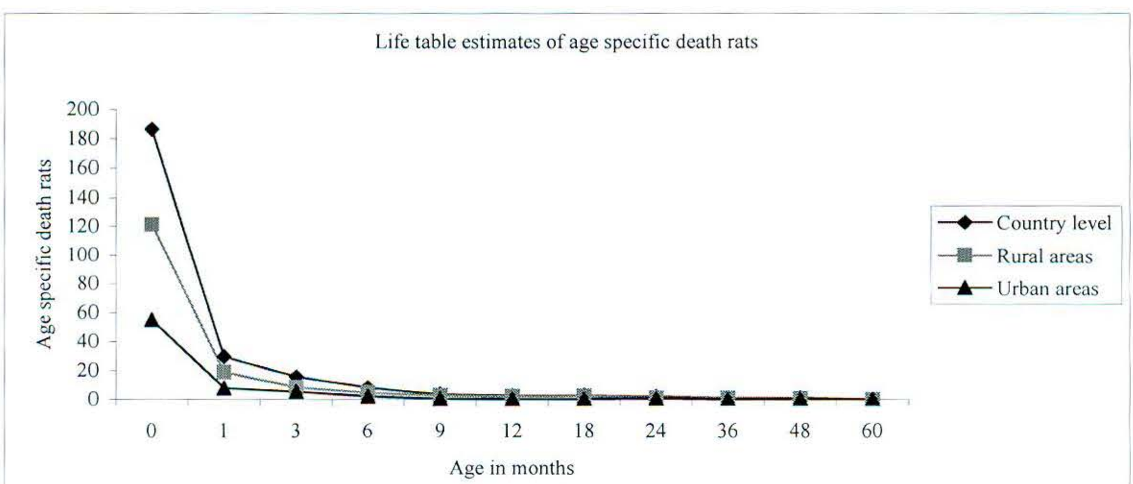


**Figure 5.11.** Age specific death rats (ASDRs) for the overall country level, rural level and urban level

**Table 5.4. Life Table Age Specific Death Rates (ASDRs)**

| Age in months | Age specific death rates | | | | | | |
|---|---|---|---|---|---|---|---|
| | National level | | | | | | |
| | Country level | Male child | Female child | Literate mother | Illiterate mother | Not working mother | Working mother |
| 0 | 186.546 | 93.7766 | 81.3867 | 83.6244 | 91.5088 | 131.004 | 46.4636 |
| 1-2 | 29.5931 | 16.1560 | 10.3996 | 8.76232 | 17.8174 | 21.4742 | 5.79252 |
| 3-5 | 15.6047 | 7.25052 | 6.32794 | 7.44879 | 6.10221 | 10.4418 | 3.54988 |
| 6-8 | 8.08625 | 3.49040 | 3.39943 | 1.13186 | 5.82411 | 4.10509 | 2.86738 |
| 9-11 | 3.65798 | 1.56311 | 1.52207 | 1.13572 | 1.96425 | 2.48756 | 0.72072 |
| 12-17 | 2.54807 | 0.78524 | 1.34023 | 0.76017 | 1.38477 | 1.46290 | 0.72307 |
| 18-23 | 2.82486 | 1.58165 | 0.77071 | 1.14679 | 1.19617 | 2.11238 | 0.36271 |
| 24-35 | 1.92123 | 0.49811 | 1.06900 | 0.67398 | 0.90525 | 1.17748 | 0.45512 |
| 36-47 | 1.10051 | 0.30030 | 0.58275 | 0.38760 | 0.50720 | 0.75807 | 0.18275 |
| 48-59 | 0.99059 | 0.30139 | 0.48876 | 0.09718 | 0.71531 | 0.21786 | 0.55066 |
| 60 | - | - | - | - | - | - | - |

| Age in months | Rural areas | Urban areas | Rural male child | Rural female child | Urban male child | Urban female child |
|---|---|---|---|---|---|---|
| 0 | 121.528 | 55.0421 | 62.6305 | 53.9643 | 28.5598 | 25.4453 |
| 1-2 | 18.9329 | 7.98297 | 9.66702 | 7.97448 | 5.69064 | 2.05550 |
| 3-5 | 8.28893 | 5.40833 | 4.7333 | 2.87047 | 2.08768 | 3.10398 |
| 6-8 | 4.83092 | 2.18818 | 2.20751 | 2.16920 | 1.04877 | 1.04112 |
| 9-11 | 2.85074 | 0.36610 | 1.47984 | 1.08992 | 0 | 0.34777 |
| 12-17 | 2.05761 | 0.18325 | 0.74322 | 1.09529 | 0 | 0.17406 |
| 18-23 | 2.29310 | 0.18345 | 1.30866 | 0.73421 | 0.17516 | 0 |
| 24-35 | 1.05619 | 0.55249 | 0.37622 | 0.55371 | 0.08767 | 0.43653 |
| 36-47 | 0.96216 | 0 | 0.28329 | 0.55741 | 0 | 0 |
| 48-59 | 0.53937 | 0.27762 | 0.18939 | 0.28011 | 0.08777 | 0.17525 |
| 60 | - | - | - | - | - | - |

**Note:** ASDRs=$d_x/L_x$

### 5.6 Life Table Estimates of Mortality

Table 5.5 shows the mortality for selected age intervals estimated by abridged life tables for Bangladesh and for other characteristics. Under-five mortality is quite high in Bangladesh as a whole during the ten-year period before the survey, 331 per 1000 live births are estimated to have died before age five. Among the selected characteristics, estimated under-five mortality is higher among not working mother, followed by rural areas, illiterate mothers, male child, female child and so on. Figure 5.12 shows the estimated infant (0-11 months) and child (12-59 months) mortality for Bangladesh and for the other selected characteristics.

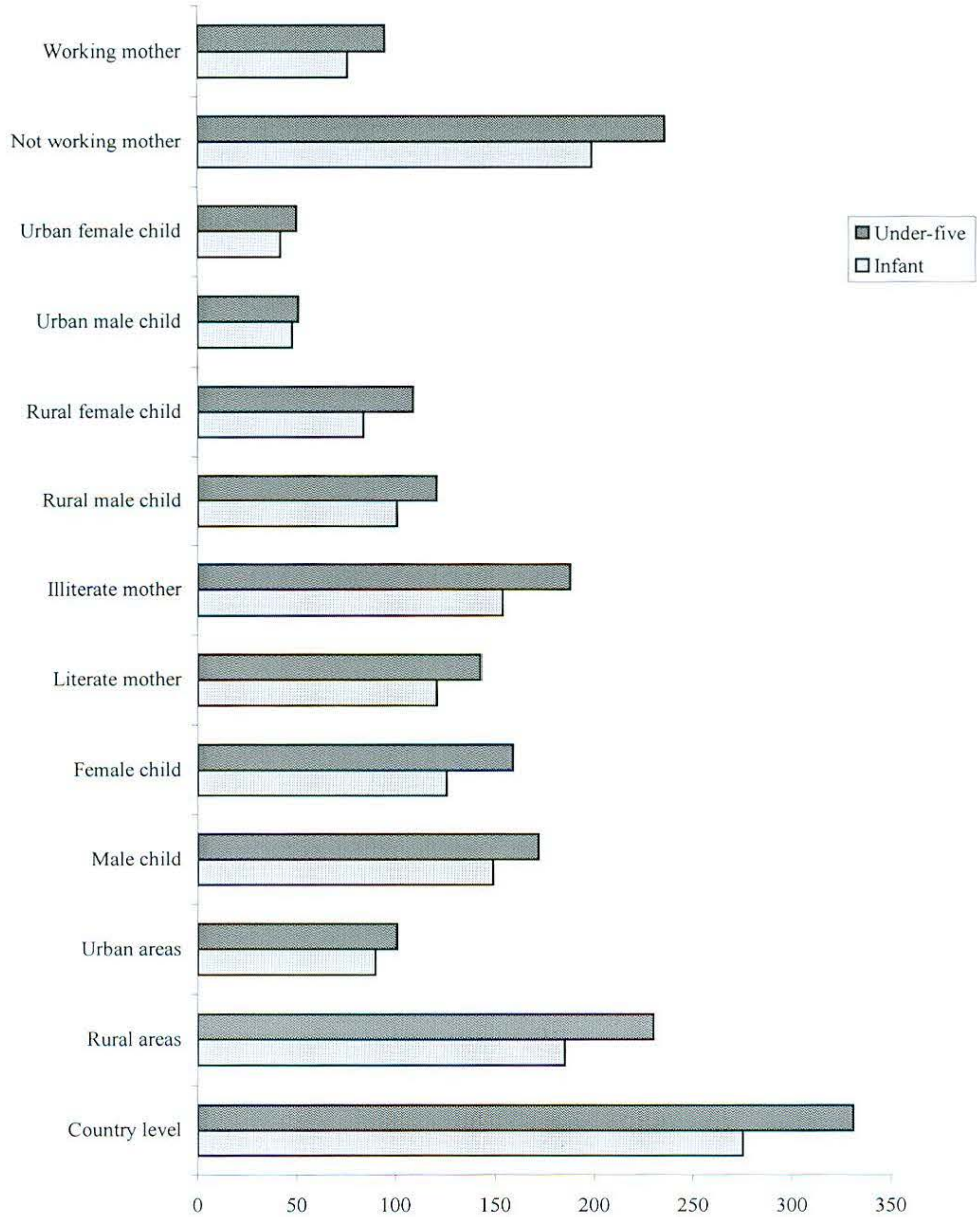


**Figure 5.12.** Life table estimates of infant and under-five mortality

**Table 5.5. Life Table Estimates of Mortality for Selected Age Intervals, for Births during the Ten Years Preceding the Survey**

| Areas | Neonatal | Post neonatal | Infant | Child | Under 5 |
|---|---|---|---|---|---|
| Country level | 165 | 110 | 275 | 77.24138 | 331 |
| Rural areas | 112 | 73 | 185 | 55.21472 | 230 |
| Urban areas | 53 | 37 | 90 | 12.08791 | 101 |
| Male child | 88 | 61 | 149 | 27.02703 | 172 |
| Female child | 77 | 49 | 126 | 37.75744 | 159 |
| Literate mother | 79 | 42 | 121 | 25.02844 | 143 |
| Illiterate mother | 86 | 68 | 154 | 40.18913 | 188 |
| Rural male child | 60 | 41 | 101 | 22.24694 | 121 |
| Rural female child | 52 | 32 | 84 | 27.29258 | 109 |
| Urban male child | 28 | 20 | 48 | 3.151261 | 51 |
| Urban female child | 25 | 17 | 42 | 8.350731 | 50 |
| Not working mother | 120 | 79 | 199 | 46.19226 | 236 |
| Working mother | 45 | 31 | 76 | 20.56277 | 95 |

# Chapter Six

# Infant and Under-five Mortality: A Discriminant Analysis

## 6.1 Introduction

Infant and under-five mortality have been recognized as an excellent summary index of the level of living and socio-economic development in any region as well as sub-region of any country. Reduction in infant and under-five mortality is a major goal of the strategy to achieve health for all and an important indicator of the successful implementation of the Poverty Reduction Strategy Paper (PRSP) because the level of infant and under-five mortality is a consequence of broad range of Government interventions. In this chapter, it is discussed and compared the different covariates of infant and under-five mortality in the context of overall country level, urban level and rural level of Bangladesh using discriminant analysis.

The dependent variable in multiple regression analysis is assumed to be normally distributed, whereas the binary variable in discriminant analysis does not follow any statistical distribution. The explanatory variables in discriminant analysis do not follow any statistical distribution but the explanatory variables in discriminant analysis follow multivariate normal distribution. The objective of regression analysis is to predict response variable on the basis of predictors, whereas the objective of discriminant analysis is to classify the sample objects with minimum classification error through linear combinations of predictors.

Discriminant analysis seems to be originated from the study of inter group distance. To study the differences among groups, linear combinations of predictor variables are formed. These linear combinations are used to identify the class of an object. Therefore, discriminant analysis helps us to identify a class for an object by some apriori information.

The discriminant function is of the form (Rao, 1965):

$$Z = l_1 x_1 + l_2 x_2 + \dots\dots\dots\dots\dots\dots\dots\dots + l_k x_k$$

The coefficients $l_k$ are determined so as to maximize the quantity

$$(\Sigma l_i \partial_i)^2 - \Sigma\Sigma l_i l_j \partial_{ij}$$

Where $\partial_i = \mu_{1i} - \mu_{2i}$

$\mu_{1i}$ and $\mu_{2i}$ being the mean values of the ith variable under the two populations.

**6.2 Discriminant Analysis of Infant and Under-five Mortality**

Table 6.1 shows the Wilk's Lambda values corresponding to the p-values for the overall country level, rural level and for the urban level of Bangladesh. In this analysis, out of ten variables, the stepwise procedure has picked up the set of six and eight variables respectively for the infant and under-five mortality in case of the overall country level; the set of seven and six variables both for infant and under-five mortality in case of rural and urban level of Bangladesh respectively. In other words, this set consists of the variables that best discriminate the two groups- (i) mothers experiencing to infant mortality or not and (ii) mothers experiencing to under-five mortality or not. It is also observed that the discriminant solution is statistically significant.

The importance of the variables in discriminant analysis can be studied using the technique suggested by Huberty (1994). The most important variable is the one for which it provides the largest Wilk's Lambda. The second most important variable is the one for which the Wilk's Lambda value is the second largest one. Thus, the variables are ranked according to their importance depending on the ranks of the Lambda values and presented in Table 6.1.

From the results, it is observed that breastfeeding is the most important variable in discriminating both the two groups of mother, i. e. mothers experiencing to infant mortality or not; and mothers experiencing to under-five mortality or not for those who are residing among the overall country level, rural level and urban level of Bangladesh. Because breastfeeding provides the largest Wilk's Lambda values.

For the overall country level, the second most important variable is antenatal visits which is discriminating the mothers experiencing to infant mortality or not, followed by is child twin?, after birth checked health, taken T.T. injections and age of mother at birth. But in discriminating the mothers experiencing to under-five mortality or not, the second important variable is also antenatal visits, followed by is child twin?, after birth checked health, age of mother at birth, taken T.T. injections, mothers' education and preceding birth interval.

If it is looked at the results of the rural level of Bangladesh, it is seen that the second important variable in discriminating both the selected groups of mother is antenatal visits, followed by is child twin?, after birth checked health, taken T.T. injections, age of mother at birth and preceding birth interval.

**Table 6.1. Results Showing Wilk's Lambda and P-values for the Predictor Variables**

| Level | Variable | Lambda values | P-value |
|---|---|---|---|
| Overall country level | **Infant mortality** | | |
| | Breastfeeding | 0.971 | 0.000 |
| | Antenatal visits | 0.955 | 0.000 |
| | Is child twin? | 0.942 | 0.000 |
| | After birth checked health | 0.933 | 0.000 |
| | Taken T.T. injections | 0.931 | 0.000 |
| | Age of mother at birth | 0.929 | 0.000 |
| | **Under-five mortality** | | |
| | Breastfeeding | 0.966 | 0.000 |
| | Antenatal visits | 0.951 | 0.000 |
| | Is child twin? | 0.940 | 0.000 |
| | After birth checked health | 0.934 | 0.000 |
| | Age of mother at birth | 0.931 | 0.000 |
| | Taken T.T. injections | 0.928 | 0.000 |
| | Mothers' education | 0.927 | 0.000 |
| | Preceding birth interval | 0.927 | 0.000 |
| Rural level | **Infant mortality** | | |
| | Breastfeeding | 0.970 | 0.000 |
| | Antenatal visits | 0.950 | 0.000 |
| | Is child twin? | 0.939 | 0.000 |
| | After birth checked health | 0.929 | 0.000 |
| | Taken T.T. injections | 0.926 | 0.000 |
| | Age of mother at birth | 0.925 | 0.000 |
| | Preceding birth interval | 0.924 | 0.000 |
| | **Under-five mortality** | | |
| | Breastfeeding | 0.963 | 0.000 |
| | Antenatal visits | 0.945 | 0.000 |
| | Is child twin? | 0.935 | 0.000 |
| | After birth checked health | 0.929 | 0.000 |
| | Taken T.T. injections | 0.926 | 0.000 |
| | Age of mother at birth | 0.923 | 0.000 |
| | Preceding birth interval | 0.922 | 0.000 |
| Urban level | **Infant mortality** | | |
| | Breastfeeding | 0.973 | 0.000 |
| | Is child twin? | 0.957 | 0.000 |
| | After birth checked health | 0.944 | 0.000 |
| | Age of mother at birth | 0.937 | 0.000 |
| | Taken T.T. injections | 0.933 | 0.000 |
| | Mothers' education | 0.930 | 0.000 |
| | **Under-five mortality** | | |
| | Breastfeeding | 0.971 | 0.000 |
| | Is child twin? | 0.958 | 0.000 |
| | After birth checked health | 0.946 | 0.000 |
| | Age of mother at birth | 0.941 | 0.000 |
| | Antenatal visits | 0.936 | 0.000 |
| | Toilet facility | 0.934 | 0.000 |

For the urban level of Bangladesh, the first, second, third and fourth important variables in discriminating both the selected groups of mother are the breastfeeding, is child twin?, after birth checked health and age of mother at birth respectively. But the fifth and sixth important variables are taken T.T. injections and mothers' education respectively in discriminating the groups of mother experiencing to infant mortality or not, whereas antenatal visits and toilet facility are the fifth and sixth important variable in discriminating the other groups of mother i. e. mothers experiencing to under-five mortality or not.

The importance of the set of variables that have been picked up from the stepwise procedure is also observed from the study of the standardized canonical discriminant function coefficients. The analytical results are also shown in Table 6.2.

**Table 6.2. Canonical Discriminant Function Coefficients for the Predictor Variables**

| Level | Variables | Unstandardized coefficients | Standardized coefficients |
|---|---|---|---|
| Overall country level | **Infant mortality** | | |
| | Breastfeeding ($x_6$) | 2.536 | 1.179 |
| | Antenatal visits ($x_7$) | 0.772 | 0.361 |
| | Is child twin? ($x_3$) | -4.176 | -0.434 |
| | After birth checked health ($x_8$) | 1.014 | 0.507 |
| | Taken T.T. injections ($x_5$) | 0.614 | 0.199 |
| | Age of mother at birth ($x_2$) | -0.360 | -0.175 |
| | Constant | -3.058 | |
| | **Under-five mortality** | | |
| | Breastfeeding ($x_6$) | 2.431 | 1.127 |
| | Antenatal visits ($x_7$) | 0.697 | 0.326 |
| | Is child twin? ($x_3$) | -3.810 | -0.396 |
| | After birth checked health ($x_8$) | 0.818 | 0.409 |
| | Age of mother at birth ($x_2$) | -0.413 | -0.201 |
| | Taken T.T. injections ($x_5$) | 0.580 | 0.189 |
| | Mothers' education ($x_1$) | 0.231 | 0.114 |
| | Preceding birth interval ($x_{10}$) | 0.277 | 0.100 |
| | Constant | -3.157 | |
| Rural level | **Infant mortality** | | |
| | Breastfeeding ($x_6$) | 2.758 | 1.265 |
| | Antenatal visits ($x_7$) | 0.897 | 0.436 |
| | Is child twin? ($x_3$) | -4.055 | -0.399 |
| | After birth checked health ($x_8$) | 1.099 | 0.546 |
| | Taken T.T. injections ($x_5$) | 0.548 | 0.186 |
| | Age of mother at birth ($x_2$) | -0.256 | -0.126 |
| | Preceding birth interval ($x_{10}$) | 0.329 | 0.118 |
| | Constant | -3.535 | |
| | **Under-five mortality** | | |
| | Breastfeeding ($x_6$) | 2.691 | 1.230 |
| | Antenatal visits ($x_7$) | 0.844 | 0.411 |
| | Is child twin? ($x_3$) | -3.803 | -0.374 |
| | After birth checked health ($x_8$) | 0.887 | 0.440 |
| | Taken T.T. injections ($x_5$) | 0.579 | 0.197 |
| | Age of mother at birth ($x_2$) | -0.379 | -0.186 |
| | Preceding birth interval ($x_{10}$) | 0.349 | 0.125 |
| | Constant | -3.358 | |
| Urban level | **Infant mortality** | | |
| | Breastfeeding ($x_6$) | 1.984 | 0.945 |
| | Is child twin? ($x_3$) | -4.073 | -0.469 |
| | After birth checked health ($x_8$) | 0.935 | 0.462 |
| | Age of mother at birth ($x_2$) | -0.579 | -0.277 |
| | Taken T.T. injections ($x_5$) | 0.929 | 0.269 |
| | Mothers' education ($x_1$) | 0.453 | 0.217 |
| | Constant | -2.655 | |
| | **Under-five mortality** | | |
| | Breastfeeding ($x_6$) | 2.085 | 0.992 |
| | Is child twin? ($x_3$) | -3.902 | -0.449 |
| | After birth checked health ($x_8$) | 0.816 | 0.404 |
| | Age of mother at birth ($x_2$) | -0.548 | -0.263 |
| | Antenatal visits ($x_7$) | 0.683 | 0.268 |
| | Toilet facility ($x_4$) | -0.460 | -0.212 |
| | Constant | -1.943 | |

The magnitude of the coefficients indicates the importance of the variables in discriminating among the selected groups of mother (Blackith and Reyment, 1971). From the results, it is indicated that breastfeeding is the most important one of the variables, which has already been observed from the results of Table 6.1.

The fitted discriminant functions turn to be:

For the infant mortality of overall country level:

$$Z = -0.175X_2 - 0.434X_3 + 0.199X_5 + 1.179X_6 + 0.361X_7 + 0.507X_8 \ldots\ldots\ldots\ldots\ldots \text{(i)}$$

For the under-five mortality of overall country level:

$$Z = 0.114X_1 - 0.201X_2 - 0.396X_3 + 0.189X_5 + 1.127X_6 + 0.326X_7 + 0.409X_8 + 0.100X_{10} \ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots\ldots \text{(ii)}$$

For the infant mortality of rural level:

$$Z = -0.126X_2 - 0.399X_3 + 0.186X_5 + 1.265X_6 + 0.436X_7 + 0.546X_8 + 0.118X_{10} \ldots \text{(iii)}$$

For the under-five mortality of rural level:

$$Z = -0.186X_2 - 0.374X_3 + 0.197X_5 + 1.230X_6 + 0.411X_7 + 0.440X_8 + 0.125X_{10} \ldots. \text{(iv)}$$

For the infant mortality of urban level:

$$Z = 0.217X_1 - 0.277X_2 - 0.469X_3 + 0.269X_5 + 0.945X_6 + 0.462X_8 \ldots\ldots\ldots\ldots\ldots\ldots \text{(v)}$$

For the under-five mortality of urban level:

$$Z = -0.263X_2 - 0.449X_3 - 0.212X_4 + 0.992X_6 + 0.268X_7 + 0.404X_8 \ldots\ldots\ldots\ldots\ldots. \text{(vi)}$$

From the above discriminant function mentioned in equation (i), it is indicated that the more and frequent breastfeeding practices among the respondents; the regular visits of the respondents to doctors during the antenatal period, the widespread practition among mothers to go for a doctor for checking their health after the birth taken place and the more frequency of the respondents taken all doses of T.T. injections at the scheduled time, the higher the discriminant score. The function also reveals that a small number and less familiar of twin child during the maternal delivery of the respondents and less effect of the mothers' age at the time of the birth, would contribute to high values of Z.

From the above discriminant function mentioned in equation (ii), it is revealed that the more and frequent breastfeeding practices among the respondents; the regular visits of the respondents to doctors during the antenatal period, the widespread practition among mothers to go for a doctor for checking their health after the birth taken place, the more frequency of the respondents taken all doses of T.T. injections at the scheduled time, the more the literacy among the respondents and the more the tendency of respondents to space birth by intervals at least 24 months, the more the discriminant score. The function also reveals that the smallest amount and less familiar of twin child during the maternal delivery of the respondents and less effect of the mothers' age at the time of the birth, would contribute to high values of Z.

From the above discriminant function mentioned in equation (iii) and (iv), it is indicated that the more and frequent breastfeeding practices among the respondents; the regular visits of the respondents to doctors during the antenatal period, the widespread practition among mothers to go for a doctor for checking their health after the birth taken place, the more frequency of the respondents in taking all doses of T.T. injections at the scheduled time and the more the literacy among the respondents and the more the tendency of respondents to space birth by intervals at least 24 months, the more the discriminant score for the both selected groups of mother experiencing to infant mortality or not and to under-five mortality at the rural level of Bangladesh. The function also indicates that the fewer amounts and less familiar of twin child during the maternal delivery of the respondents and the less effect of the mothers' age at the time of the birth, would contribute to high values of discriminant score.

From the above discriminant function mentioned in equation (v), it is observed that the more and frequent breastfeeding practices among the respondents; the widespread practition among mothers to go for a doctor for checking their health after the birth taken place, the more frequency of the respondents in taking all doses of T.T. injections at the scheduled time and the more the literacy among the respondents, the more the discriminant score for the groups of mother experiencing to infant mortality or not at the urban level of Bangladesh. The function also reveals that the fewer amounts and less familiar of twin child during the maternal delivery of the respondents and the less effect of the mothers' age at the time of the birth, would contribute to high values of discriminant score.

From the above discriminant function mentioned in equation (vi), it is showed that the more and frequent breastfeeding practices among the respondents; the widespread practition among mothers to go for a doctor for checking their health after the birth taken place and the regular visits of the respondents to doctors during the antenatal period, the more the discriminant score for the groups of mother experiencing to under-five mortality or not at the urban level of Bangladesh. The function also reveals that a small number and less familiar of twin child during the maternal delivery of the respondents, the less effect of the mothers' age at the time of the birth and the unavailability of hygienic toilet facility in the household, would contribute to high values of discriminant score.

**Table 6.3. Test of Significance and the Related Results of Discriminant Function**

| | Function | Eigen-value $\lambda$ | Percentage of variation | Canonical correlation coefficient | Wilk's Lambda $\Lambda$ | Degrees of freedom | Chi-square $(\chi^2)$ | P-value |
|---|---|---|---|---|---|---|---|---|
| Overall country level | Infant mortality | 0.077 | 100.0 | 0.267 | 0.929 | 6 | 414.187 | 0.000 |
| | Under-five mortality | 0.079 | 100.0 | 0.271 | 0.927 | 8 | 426.469 | 0.000 |
| Rural level | Infant mortality | 0.082 | 100.0 | 0.275 | 0.924 | 7 | 302.617 | 0.000 |
| | Under-five mortality | 0.084 | 100.0 | 0.279 | 0.922 | 7 | 311.247 | 0.000 |
| Urban level | Infant mortality | 0.076 | 100.0 | 0.265 | 0.930 | 6 | 128.192 | 0.000 |
| | Under-five mortality | 0.071 | 100.0 | 0.257 | 0.934 | 6 | 120.445 | 0.000 |

It is seen that the discriminant function is statistically significant and also revealed that the function discriminates well (i.e. the function can explain about 100.0% of the variation in discriminating) between two selected groups of mothers for the overall country level, rural level and urban level of Bangladesh. The size of eigen value (0.077 for the infant mortality and 0.079 for the under-five mortality of overall country level; 0.082 for the infant mortality and 0.084 for the under-five mortality of rural level, and 0.076 for the infant mortality and 0.071 for the under-five mortality of urban level) is related to the discriminating power of the function. These values indicate that discrimination between two groups of variables is present. Another way to judge the substantive utility of discriminant function is the examination of the canonical correlation coefficients (0.267 for the infant mortality and 0.271 for the under-five mortality of overall country level, 0.275 for the infant mortality and 0.279 for the under-five mortality of rural level; and 0.265 for the infant mortality and 0.257 for the under-five mortality of urban level) which is a measure of association that summarizes the degree of relatedness between the selected groups of mother and the discriminant function. A value of zero indicates that there exists no discrimination at all, but the large number (always positive) indicates the increasing degrees of association with one being the maximum.

# Chapter Seven

# Conclusion and Policy Recommendation

## 7.1 Introduction

Bangladesh is the most densely populated country in the world, excluding city-states such as Hong Kong and Singapore. The country has a population of about 147.3 million, with a corresponding population density of more than 920 persons per square kilometer, making it the eighth most populous country in the world (PRB, 2008). The main characteristics of Bangladesh have been presented in the first chapter in section 1.1. A healthy and sound developed generation can go in front of prosperity and hallucination. So, for ensuring the proper grown up of the newborn baby through the achievement of PRSP and declaration of MDGs goals and targets in infant and under-five mortality, an attempt has been made for "A Study on Infant and Under-five Mortality in Bangladesh" using the data provided by BDHS, 2004 for the national level, rural level and urban level of Bangladesh separately, including those eligible woman having one or more child(ren) during the ten-year period preceding the survey.

## 7.2 Findings of the Study

The results of this study have already been discussed in the subsequence sections of different chapters. The major findings of this study are being summarized as follows:

Using the above-mentioned data, childhood mortality has been estimated through indirect techniques (Brass, Sullivan and Trussell method) for the national level, rural level and urban level of Bangladesh separately when data are classified by age and duration of marriage group of mothers and the results are included in chapter three.

From the results, it is revealed that the sex ratios of CEB by age group of mother do not expose any irregularities that could not be explained by the small numbers involved in most cases. The average parities and the proportions of dead children reported by women of each age group increase rapidly with age of mother, especially from ages 30-34 to ages 45-49. The very rapid increase in the proportions of dead with age of mother suggests that a combination of effects is in operation, that is, there is an increasingly longer average exposure to the risk of dying of the children and considerably higher child mortality from ten years before the survey. In case of Brass method, the probabilities of dying are increasing with the increasing of age of mothers. In case of Sullivan method, the same patterns are followed except for male and both sexes of urban level of Bangladesh. The probability of dying is low in the age group 20-24 for male of national and rural level and in the age group 25-29 of urban level when it is calculated through Trussell method.

As in the case of the age-based analysis, the childhood mortality has also been estimated when data are classified by duration of marriage of mothers. From the results, it is indicated that the sex ratios at birth of children CEB are closer to the expected value of 1.05. The average parities are increasing monotonically with the duration of marriage and the proportions of children dead are also increasing with marital duration. From the results of estimated mortality levels for the national level, rural level and urban level, it is observed that the probability of dying is increasing with the increase of marital duration, but for the urban level of male, these probabilities are decreasing from the marital duration 0-4 to 10-14 and then again increasing up to the last marital duration group.

The effects of the covariates on infant and under-five mortality in Bangladesh have been examined in this study through the well-known statistical tools such as Pearson chi-square test approach and logistic (logit) regression analysis and the results are showed in chapter four. The results of Pearson chi-square test indicates that except the two variables (child's sex and sources of drinking water), all other variables (such as mothers' education, age of mother at birth, is child twin?, toilet facility, T.T. injections, breastfeeding, antenatal visits during pregnancy, after birth checked health, parity and preceding birth interval) are statistically and significantly associated with the infant and under-five mortality. Among all the twelve variables that are selected for chi-square test approach, since the two variables have no any statistically significant effect, these two variables are excluded in logistic regression analysis. The results of logistic regression analysis using the remaining ten variables also showed in Table 4.3 of chapter four for the national level, rural level and urban level of Bangladesh separately. From the results, it is revealed that the literate mothers of national level, rural level and urban level are less likely to face infant and under-five mortality as compared to illiterate mothers. But the results of rural and urban areas are not statistically significant. The highest occurrence of infant and under-five mortality is among mother whose age at birth was below 20 years and/or above 30 years. Twin child during birth is found to be another significant factor, affecting the infant and under-five mortality more than five times than the single birth. The covariates such as breastfeeding, antenatal visits and after birth checked health are highly significant ($p < 0.01$) factors, affecting infant and under-five mortality. The impact of toilet facility on infant and under-five mortality, except for under-five mortality of urban level, is not statistically significant.

The abridged life tables have been constructed using the number of deaths (${}_xd_n$) in the interval x to (x + n) based for the overall country level, rural level, urban level, male child, female child, literate mother, illiterate mother, rural male child, rural female child, urban male child, urban female child, currently working and currently not working mothers and the results are presented in chapter five. From the results, it is found that the probability of dying is higher in rural areas, male child and illiterate mothers than the urban areas, female child and literate mothers respectively. The results also indicate that the life expectancy of the child under age five is higher for literate mothers, working mothers and for female child at national level of Bangladesh than the illiterate mothers, not working mothers and male child respectively. Again the life expectancy of the urban child is higher than the rural child (Table 5.3). The life table estimates show that the age specific death rate (ASDR) among illiterate mothers, not working mothers and rural areas is higher than the literate mothers, working mothers and urban areas (Table 5.4).

To classify the sample objects accurately on the basis of a linear combination of predictor variables, the discriminant analysis has been being performed for the national level, rural level and urban level of Bangladesh separately and the results are included in chapter six. The stepwise procedure has been picked up and only the significant variables are ranked according to the rank of the Wilk's Lambda values (Table 6.1). From the results of Table 6.1, it is clear that breastfeeding is the most important variables among all the ranked variables. Again the canonical discriminant function coefficients (unstandardized and standardized) for the predictor variables have also been calculated (Table 6.2) and the results are almost similar with the results getting from the ranked of the Wilk's Lambda, that is, breastfeeding has the highest coefficient among all the selected variables. Also from the related results of discriminant function (Table 6.3), it is observed that the discriminant function is statistically significant and discriminates well between two selected groups of mothers (i.e. mothers experiencing to infant mortality or not and mothers experiencing to under-five mortality or not) for the overall country level, rural level and urban level of Bangladesh.

### 7.3 Policy Implications

From the above discussion of the findings of the study, the following policy implications seem to emerge:

i. Births should be reduced to very young mothers (<20 years) to postponement of premature birth, unwanted pregnancies, unstable marital union, and to older mothers (30+ years) to avoid pregnancy complications due to reduction reproduction capacity and other biological factors to higher pregnancy order.

ii. The findings of this study show that at the highest risk of infant and under-five mortality are the ones whose mothers have no education (illiterate), taken no T. T. injections, do not breastfeed and after birth do not go for checking their health. So, the provision of quality education to all especially to females at least up to primary level and planned urbanization should be ensured. Because these can, in turn, reduce the risk of mortality of mothers and her newborn baby.

iii. Higher order births should be decreased and births to space by intervals of at least 24 months should be encouraged. Children with higher birth order and preceding birth interval less than 24 months have a higher probability of death. Because maternal depletion is often cited as the primary mechanism, responsible for the adverse effects of frequent birth with short interval.

iv. Since the life expectancy at age x is higher for literate mothers than illiterate, for working mothers than not working mothers, for urban areas than rural areas, therefore, in order to reduce the infant and under-five mortality, the socio-economic status should be enhanced through proper education, employment and planned urbanization.

v. Last but not least, Government should take proper initiatives through information, education and communication (IEC) campaigns so that the country may able to attain the MDGs by the year 2015.

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**Table 1. Coefficients for Estimation of Child Mortality Multipliers, Trussell Variant, When Data Classified by Age of Mothers**

| Mortality model | Age group | Index i | Mortality ratio* $q_x/D_i$ | Coefficients $a_i$ | $b_i$ | $c_i$ |
|---|---|---|---|---|---|---|
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| North | 15-19 | 1 | $q_1/D_1$ | 1.1119 | -2.9287 | 0.8507 |
| | 20-24 | 2 | $q_2/D_2$ | 1.2390 | -0.6865 | -0.2745 |
| | 25-29 | 3 | $q_3/D_3$ | 1.1884 | 0.0421 | -0.5156 |
| | 30-34 | 4 | $q_5/D_4$ | 1.2046 | 0.3037 | -0.5656 |
| | 35-39 | 5 | $q_{10}/D_5$ | 1.2586 | 0.4236 | -0.5898 |
| | 40-44 | 6 | $q_{15}/D_6$ | 1.2240 | 0.4222 | -0.5456 |
| | 45-49 | 7 | $q_{20}/D_7$ | 1.1772 | 0.3486 | -0.4624 |
| South | 15-19 | 1 | $q_1/D_1$ | 1.0819 | -3.0005 | 0.8689 |
| | 20-24 | 2 | $q_2/D_2$ | 1.2846 | -0.6181 | -0.3024 |
| | 25-29 | 3 | $q_3/D_3$ | 1.2223 | 0.0851 | -0.4704 |
| | 30-34 | 4 | $q_5/D_4$ | 1.1905 | 0.2631 | -0.4487 |
| | 35-39 | 5 | $q_{10}/D_5$ | 1.1911 | 0.3152 | -0.4291 |
| | 40-44 | 6 | $q_{15}/D_6$ | 1.1564 | 0.3017 | -0.3958 |
| | 45-49 | 7 | $q_{20}/D_7$ | 1.1307 | 0.2596 | -0.3538 |
| East | 15-19 | 1 | $q_1/D_1$ | 1.1461 | -2.2536 | 0.6259 |
| | 20-24 | 2 | $q_2/D_2$ | 1.2231 | -0.4301 | -0.2245 |
| | 25-29 | 3 | $q_3/D_3$ | 1.1593 | 0.0581 | -0.3479 |
| | 30-34 | 4 | $q_5/D_4$ | 1.1404 | 0.1991 | -0.3487 |
| | 35-39 | 5 | $q_{10}/D_5$ | 1.1540 | 0.2511 | -0.3506 |
| | 40-44 | 6 | $q_{15}/D_6$ | 1.1336 | 0.2556 | -0.3428 |
| | 45-49 | 7 | $q_{20}/D_7$ | 1.1201 | 0.2362 | -0.3268 |
| West | 15-19 | 1 | $q_1/D_1$ | 1.1415 | -2.7070 | 0.7663 |
| | 20-24 | 2 | $q_2/D_2$ | 1.2563 | -0.5381 | -0.2637 |
| | 25-29 | 3 | $q_3/D_3$ | 1.1851 | 0.0633 | -0.4177 |
| | 30-34 | 4 | $q_5/D_4$ | 1.1720 | 0.2341 | -0.4272 |
| | 35-39 | 5 | $q_{10}/D_5$ | 1.1865 | 0.3080 | -0.4452 |
| | 40-44 | 6 | $q_{15}/D_6$ | 1.1746 | 0.3314 | -0.4537 |
| | 45-49 | 7 | $q_{20}/D_7$ | 1.1639 | 0.3190 | -0.4435 |

Estimation equations:
$k_i = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$
$q_x = k_i \times D_i$

*The ratio of the probability of dying to proportion of children dead. The ratio is set equal to the multiplier $k_i$.

**Source:** United Nations (1983), Manual X, Page 77.

**Table 2. Coefficients for Estimation of the Reference Period, $(t_x)^*$, to Which the Values of $q_x$ Estimated from Data Classified by Age Refer**

| Mortality model | Age group | Index | Age | Parameter estimates | Coefficients | | |
|---|---|---|---|---|---|---|---|
| | | i | x | | $a_i$ | $b_i$ | $c_i$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | 15-19 | 1 | 1 | $q_1$ | 1.0921 | 5.4732 | 1.9672 |
| | 20-24 | 2 | 2 | $q_2$ | 1.3207 | 5.3751 | 0.2133 |
| | 25-29 | 3 | 3 | $q_3$ | 1.5996 | 2.6268 | 4.3701 |
| **North** | 30-34 | 4 | 5 | $q_5$ | 2.0779 | -1.7908 | 9.4126 |
| | 35-39 | 5 | 10 | $q_{10}$ | 2.7705 | -7.3403 | 14.9352 |
| | 40-44 | 6 | 15 | $q_{15}$ | 4.1520 | -12.2448 | 19.2349 |
| | 45-49 | 7 | 20 | $q_{20}$ | 6.9650 | -13.9160 | 19.9542 |
| | 15-19 | 1 | 1 | $q_1$ | 1.0900 | 5.4443 | -1.9721 |
| | 20-24 | 2 | 2 | $q_2$ | 1.3079 | 5.5568 | 0.2021 |
| | 25-29 | 3 | 3 | $q_3$ | 1.5173 | 2.6755 | 4.7471 |
| **South** | 30-34 | 4 | 5 | $q_5$ | 1.9399 | 2.2739 | 10.3876 |
| | 35-39 | 5 | 10 | $q_{10}$ | 2.6157 | -8.4819 | 16.5153 |
| | 40-44 | 6 | 15 | $q_{15}$ | 4.0794 | -13.8308 | 21.1866 |
| | 45-49 | 7 | 20 | $q_{20}$ | 7.1796 | -15.3880 | 21.7892 |
| | 15-19 | 1 | 1 | $q_1$ | 1.0959 | 5.5864 | -1.9949 |
| | 20-24 | 2 | 2 | $q_2$ | 1.2921 | 5.5897 | 0.3631 |
| | 25-29 | 3 | 3 | $q_3$ | 1.5021 | 2.4692 | 5.0927 |
| **East** | 30-34 | 4 | 5 | $q_5$ | 1.9347 | -2.6419 | 10.8533 |
| | 35-39 | 5 | 10 | $q_{10}$ | 2.6197 | -8.9693 | 17.0981 |
| | 40-44 | 6 | 15 | $q_{15}$ | 4.1317 | -14.3550 | 21.8247 |
| | 45-49 | 7 | 20 | $q_{20}$ | 7.3657 | -15.8083 | 22.3005 |
| | 15-19 | 1 | 1 | $q_1$ | 1.0970 | 5.5628 | -1.9956 |
| | 20-24 | 2 | 2 | $q_2$ | 1.3062 | 5.5677 | 0.2962 |
| | 25-29 | 3 | 3 | $q_3$ | 1.5305 | 2.5528 | 4.8962 |
| **West** | 30-34 | 4 | 5 | $q_5$ | 1.9991 | -2.4261 | 10.4282 |
| | 35-39 | 5 | 10 | $q_{10}$ | 2.7632 | -8.4065 | 16.1787 |
| | 40-44 | 6 | 15 | $q_{15}$ | 4.3468 | -13.2436 | 20.1990 |
| | 45-49 | 7 | 20 | $q_{20}$ | 7.5242 | -14.2013 | 20.0162 |

Estimation equation:
$t_x = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$

*The number of years prior to the survey.

**Source:** United Nations (1983), Manual X, Page 78.

**Table 3. Coefficients for Estimation of Child Mortality Multipliers, Trussell Variant, When Data Classified by Duration of Marriage of Mothers**

| Mortality model | Age group | Index | Mortality ratio* | Coefficients | | |
|---|---|---|---|---|---|---|
| | | $i$ | $q_x / D_i$ | $a_i$ | $b_i$ | $c_i$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| North | 0-4 | 1 | $q_1/D_1$ | 1.2615 | -0.5340 | 0.1252 |
| | 5-9 | 2 | $q_2/D_2$ | 1.1957 | -0.4103 | -0.0930 |
| | 10-14 | 3 | $q_3/D_3$ | 1.3067 | -0.0103 | -0.4618 |
| | 15-19 | 4 | $q_5/D_4$ | 1.4701 | 0.1763 | -0.7268 |
| | 20-24 | 5 | $q_{10}/D_5$ | 1.5039 | 0.0039 | -0.7071 |
| | 25-29 | 6 | $q_{15}/D_6$ | 1.4798 | -0.2487 | -0.5582 |
| | 30-34 | 7 | $q_{20}/D_7$ | 1.4373 | -0.2317 | -0.5047 |
| South | 0-4 | 1 | $q_1/D_1$ | 1.3103 | -0.5856 | 0.1367 |
| | 5-9 | 2 | $q_2/D_2$ | 1.2309 | -0.3463 | -0.1073 |
| | 10-14 | 3 | $q_3/D_3$ | 1.2774 | 0.0336 | -0.3787 |
| | 15-19 | 4 | $q_5/D_4$ | 1.3493 | 0.1366 | -0.5403 |
| | 20-24 | 5 | $q_{10}/D_5$ | 1.3592 | -0.0315 | -0.4944 |
| | 25-29 | 6 | $q_{15}/D_6$ | 1.3532 | -0.1978 | -0.4099 |
| | 30-34 | 7 | $q_{20}/D_7$ | 1.3498 | -0.1663 | -0.4131 |
| East | 0-4 | 1 | $q_1/D_1$ | 1.2299 | -0.3998 | 0.0910 |
| | 5-9 | 2 | $q_2/D_2$ | 1.1611 | -0.2451 | -0.0797 |
| | 10-14 | 3 | $q_3/D_3$ | 1.2036 | 0.0171 | -0.2992 |
| | 15-19 | 4 | $q_5/D_4$ | 1.2773 | 0.1015 | -0.4276 |
| | 20-24 | 5 | $q_{10}/D_5$ | 1.3014 | -0.0219 | -0.4195 |
| | 25-29 | 6 | $q_{15}/D_6$ | 1.3160 | -0.1630 | -0.3751 |
| | 30-34 | 7 | $q_{20}/D_7$ | 1.3287 | -0.1523 | -0.3925 |
| West | 0-4 | 1 | $q_1/D_1$ | 1.2584 | -0.4683 | 0.1080 |
| | 5-9 | 2 | $q_2/D_2$ | 1.1841 | -0.3006 | -0.0892 |
| | 10-14 | 3 | $q_3/D_3$ | 1.2446 | 0.0131 | -0.3555 |
| | 15-19 | 4 | $q_5/D_4$ | 1.3353 | 0.1157 | -0.5245 |
| | 20-24 | 5 | $q_{10}/D_5$ | 1.3875 | -0.0193 | -0.5472 |
| | 25-29 | 6 | $q_{15}/D_6$ | 1.4227 | -0.1954 | -0.5127 |
| | 30-34 | 7 | $q_{20}/D_7$ | 1.4432 | -0.1977 | -0.5339 |

Estimation equations:
$k_i = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$
$q_x = k_i \times D_i$

* The ratio of the probability of dying to proportion of children dead. The ratio is set equal to the multiplier $k_i$.

**Source:** United Nations (1983), Manual X, Page 82.

**Table 4. Coefficients for Estimation of the Reference Period, $(t_x)^*$, to Which the Values of $q_x$ Estimated from Data Classified by Duration of Marriage Refer**

| Mortality model | Age group | Index | Age | Parameter estimates | Coefficients | | |
|---|---|---|---|---|---|---|---|
| | | i | x | | $a_i$ | $b_i$ | $c_i$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) | (8) |
| | 0-4 | 1 | 2 | $q_2$ | 1.0311 | 1.3149 | -0.3282 |
| | 5-9 | 2 | 3 | $q_3$ | 1.6964 | 4.2147 | -0.0160 |
| | 10-14 | 3 | 5 | $q_5$ | 1.4285 | 3.2687 | 4.4073 |
| **North** | 15-19 | 4 | 10 | $q_{10}$ | -0.0753 | -1.0800 | 12.9281 |
| | 20-24 | 5 | 15 | $q_{15}$ | -1.9749 | -3.4773 | 21.3318 |
| | 25-29 | 6 | 20 | $q_{20}$ | -2.1888 | 0.6124 | 23.9376 |
| | 30-34 | 7 | 25 | $q_{25}$ | 0.9613 | 4.4416 | 21.4661 |
| | 0-4 | 1 | 2 | $q_2$ | 1.0202 | 1.3064 | -0.3297 |
| | 5-9 | 2 | 3 | $q_3$ | 1.6601 | 4.5105 | -0.0335 |
| | 10-14 | 3 | 5 | $q_5$ | 1.2146 | 3.4684 | 4.9524 |
| **South** | 15-19 | 4 | 10 | $q_{10}$ | -0.6454 | -1.6045 | 14.6773 |
| | 20-24 | 5 | 15 | $q_{15}$ | -2.9104 | -4.1352 | 24.0072 |
| | 25-29 | 6 | 20 | $q_{20}$ | -3.1641 | 1.2106 | 26.3515 |
| | 30-34 | 7 | 25 | $q_{25}$ | 0.4456 | 5.6384 | 23.2565 |
| | 0-4 | 1 | 2 | $q_2$ | 1.0380 | 1.4213 | -0.3545 |
| | 5-9 | 2 | 3 | $q_3$ | 1.6441 | 4.7042 | 0.0642 |
| | 10-14 | 3 | 5 | $q_5$ | 1.1068 | 3.3032 | 5.4464 |
| **East** | 15-19 | 4 | 10 | $q_{10}$ | -0.8678 | -1.9683 | 15.5187 |
| | 20-24 | 5 | 15 | $q_{15}$ | -3.2154 | -4.1123 | 24.8624 |
| | 25-29 | 6 | 20 | $q_{20}$ | -3.3885 | 1.6746 | 26.9798 |
| | 30-34 | 7 | 25 | $q_{25}$ | 0.4716 | 5.8775 | 23.7246 |
| | 0-4 | 1 | 2 | $q_2$ | 1.0349 | 1.3714 | -0.3390 |
| | 5-9 | 2 | 3 | $q_3$ | 1.6654 | 4.5855 | 0.0233 |
| | 10-14 | 3 | 5 | $q_5$ | 1.2109 | 3.3291 | 5.1402 |
| **West** | 15-19 | 4 | 10 | $q_{10}$ | -0.5370 | -1.7679 | 14.6370 |
| | 20-24 | 5 | 15 | $q_{15}$ | -2.4694 | -3.9194 | 23.0999 |
| | 25-29 | 6 | 20 | $q_{20}$ | -2.2107 | 1.3059 | 24.4479 |
| | 30-34 | 7 | 25 | $q_{25}$ | 1.7815 | 5.1415 | 20.6725 |

Estimation equation:
$t_x = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$

*The number of years prior to the survey.

**Source:** United Nations (1983), Manual X, Page 83.

**Table 5. Coefficients for Estimation of Child Mortality by Sullivan Method, When Data Classified by Age of Mothers**

| Mortality model | Age group | Index | Mortality ratio | Coefficients | |
|---|---|---|---|---|---|
| | | i | $q_x / D_i$ | $a_i$ | $b_i$ |
| (1) | (2) | (3) | (4) | (5) | (6) |
| North | 20-24 | 2 | $q_2/D_2$ | 1. 30 | -0.63 |
| | 25-29 | 3 | $q_3/D_3$ | 1. 17 | -0.50 |
| | 30-34 | 4 | $q_5/D_4$ | 1. 15 | -0.42 |
| South | 20-24 | 2 | $q_2/D_2$ | 1.33 | -0.61 |
| | 25-29 | 3 | $q_3/D_3$ | 1.20 | -0.44 |
| | 30-34 | 4 | $q_5/D_4$ | 1.14 | -0.32 |
| East | 20-24 | 2 | $q_2/D_2$ | 1.26 | -0.44 |
| | 25-29 | 3 | $q_3/D_3$ | 1.14 | -0.33 |
| | 30-34 | 4 | $q_5/D_4$ | 1.11 | -0.26 |
| West | 20-24 | 2 | $q_2/D_2$ | 1. 30 | -0.54 |
| | 25-29 | 3 | $q_3/D_3$ | 1. 17 | -0.40 |
| | 30-34 | 4 | $q_5/D_4$ | 1. 13 | -0.33 |

Estimation equation:
$q_x / D_i = a_i + b_i(P_2/P_3)$, $i = 2,3,4$

**Source:** United Nations (1983), Four Families of Model Life Tables, Page 77.

**Table 6. Coefficients for Estimation of Child Mortality by Trussell Method, When Data Classified by Age of Mothers**

| Mortality model | Age group | Index | Mortality ratio | Coefficients | | |
|---|---|---|---|---|---|---|
| | | i | $q_x / D_i$ | $a_i$ | $b_i$ | $c_i$ |
| (1) | (2) | (3) | (4) | (5) | (6) | (7) |
| | 15-19 | 1 | $q_1/D_1$ | 1.1809 | -0.0787 | -0.0182 |
| | 20-24 | 2 | $q_2/D_2$ | 1.1298 | -0.1609 | -0.0746 |
| **North** | 25-29 | 3 | $q_3/D_3$ | 1.2037 | -0.0107 | -0.2856 |
| | 30-34 | 4 | $q_5/D_4$ | 1.2933 | 0.0987 | -0.4629 |
| | 35-39 | 5 | $q_{10}/D_5$ | 1.3240 | 0.1557 | -0.5678 |
| | 15-19 | 1 | $q_1/D_1$ | 1.1697 | -0.1431 | 0.0034 |
| | 20-24 | 2 | $q_2/D_2$ | 1.1337 | -0.2625 | -0.0859 |
| **South** | 25-29 | 3 | $q_3/D_3$ | 1.2977 | -0.0416 | -0.4335 |
| | 30-34 | 4 | $q_5/D_4$ | 1.4860 | 0.1566 | -0.7602 |
| | 35-39 | 5 | $q_{10}/D_5$ | 1.5278 | 0.2619 | -0.9135 |
| | 15-19 | 1 | $q_1/D_1$ | 1.2023 | -0.1322 | -0.0022 |
| | 20-24 | 2 | $q_2/D_2$ | 1.1669 | -0.1911 | -0.0943 |
| **East** | 25-29 | 3 | $q_3/D_3$ | 1.2501 | -0.0003 | -0.3383 |
| | 30-34 | 4 | $q_5/D_4$ | 1.3243 | 0.1220 | -0.5121 |
| | 35-39 | 5 | $q_{10}/D_5$ | 1.3279 | 0.1701 | -0.5770 |
| | 15-19 | 1 | $q_1/D_1$ | 1.1882 | -0.1063 | -0.0098 |
| | 20-24 | 2 | $q_2/D_2$ | 1.1410 | -0.1953 | -0.0822 |
| **West** | 25-29 | 3 | $q_3/D_3$ | 1.2417 | -0.0231 | -0.3390 |
| | 30-34 | 4 | $q_5/D_4$ | 1.3631 | 0.1104 | -0.5766 |
| | 35-39 | 5 | $q_{10}/D_5$ | 1.4240 | 0.1934 | -0.7420 |

Estimation equation:
$q_x / D_i = a_i + b_i(P_1/P_2) + c_i(P_2/P_3)$

**Source:** United Nations (1983), Four Families of the Model Life Tables, Page 77.