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# Modelling of Nutritional Status of Ever-Married Women in Bangladesh

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

**By**
**Md. Kamruzzaman**

**University of Rajshahi**
**April, 2015**

**Department of Statistics**
**University of Rajshahi**
**Bangladesh**

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**Under the supervision of**

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**University of Rajshahi**
**April, 2015**

**Department of Statistics**
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Dedicated
to
My Parents

# CERTIFICATE

We are pleased to certify that the dissertation entitled **“Modelling of Nutritional Status of Ever-Married Women in Bangladesh”** is the original work of **Md. Kamruzzaman** and to the best of our knowledge; this is the candidate’s own achievement and is not a conjoint work. He has completed this dissertation under our direct guidance and supervision.

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

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

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# DECLARATION

I do hereby declare that the dissertation entitled **“Modelling of Nutritional Status of Ever-Married Women in Bangladesh”** submitted to the Department of Statistics, University of Rajshahi for the degree of **Doctor of Philosophy** in Statistics is exclusive my own and original work carried out under the supervision of **Professor Dr. Md. Golam Hossain, Professor Dr. Md. Nurul Islam** and **Professor Samad Abedin,** Department of Statistics, University of Rajshahi, Bangladesh. I didn’t submit any part of this thesis to other Universities or Institutes for getting any degree, diploma or for other similar purposes.

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University of Rajshahi — Md. Kamruzzaman

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# ABSTRACT

The change in nutritional status plays an important role in the course of a person's health. Body mass index (BMI) is measure of body fat based on height and weight of a person and it is used to screen for weight categories that may lead to health problems. The first main objective of this thesis was to observe the presence of secular trends in nutritional status of Bangladeshi married women over time. A total of 45,572 Bangladeshi non-pregnant married women in reproductive age were used in this study with average age 30.11±9.04 years. The secondary cross-sectional data used in this study was extracted from Bangladesh Demographic and Health Survey (BDHS) and they collected data from Bangladeshi ever-married women using multistage stratified cluster sampling. The last five rounds (1996-97, 1999-2000, 2004, 2007 and 2011) BDHS measured height and weight from their selected sample, the data was derived from the measurement years 1996-97 to 2011. Descriptive statistics, Analysis of variance (ANOVA) and linear regression analysis were used in this study.

The mean value of BMI of Bangladeshi non-pregnant married women was 20.65±3.67 kg/$m^2$ with height and weight were 150.60±5.44 cm and 46.93±9.24 kg, respectively. Using ANOVA, height, weight and BMI showed significant ($p<0.001$) differences among the measurement year cohorts from 1996-97 to 2011. The increasing tendency in height, weight and BMI of Bangladeshi married women in reproductive age were showed during the measurement years from 1996-97 to 2011. The sample was divided into 40 groups according their birth year cohorts from 1955 to 1995. ANOVA also demonstrated that the variation of height, weight and BMI were significant ($p<0.001$) among the birth year cohorts from 1955 to 1995. The slope of linear regression demonstrated that an increasing tendency in BMI was found among birth year cohorts from 1955 to 1971, but a decreasing tendency was observed during the birth year cohorts from 1972 to 1995. In this study found that more than 50% women were normal weight and a remarkable number of married women (31.4%) were underweight. More than 10% women were overweight and only 2.1% were obese among non-pregnant Bangladeshi married women. It was found that the proportion of underweight women has been increasing and the opposite direction also observed for the number of obese in those born during the last 40 years of the study period (1955 to 1995). Underweight can be considered as the major health problems of Bangladeshi married women and requires attention.

The second objective of the thesis was to investigate the influencing factors of body mass index among Bangladeshi married women. Hierarchy data was used in this study that was collected by Bangladesh Demographic and Health Survey-2011 (BDHS-2011) using multistage stratified cluster sampling. Usually, large-scale survey for public health, demography and sociology follow a hierarchical data structure as the surveys are based on multistage stratified cluster sampling. The appropriate approach to analyzing such survey data is therefore based on nested sources of variability which come from different levels of the hierarchy. The single level statistical model is not appropriate for analyzing such kind of data set. Multilevel (two level) linear regression was utilized in the present study to remove the cluster effect for each outcome.

The mean BMI of Bangladeshi married women in reproductive age was 21.60±3.86 $kg/m^2$ with height and weight was 150.92 ±5.36 cm and 49.28 ± 9.69 kg, respectively. The prevalence of underweight, normal weight, overweight and obese were 22.8%, 59.1%, 14.9% and 3.2%, respectively of Bangladeshi non-pregnant married women in reproductive age for BDHS-2011 data set. Analysis of variance (ANOVA) demonstrated that the BMI of Bangladeshi non-pregnant married women in reproductive age was significantly different among respondents' and her husbands' education level ($p<0.001$) and wealth index ($p<0.001$). The t-test showed that the differences of BMI was significant between (i) urban and rural ($p<0.001$), (ii) watching television, yes and no (($p<0.001$), (iii) currently breastfeeding, yes and no ($p<0.001$), (iv) currently use contraceptive, yes and no ($p<0.05$), (v) living with husband, yes and no ($p<0.01$) and (v) currently working status ($p<0.05$). Person's correlation coefficients exhibited that respondent's age, age at first marriage and age at first birth were significantly ($p<0.001$) positively related with BMI of married women in reproductive age, and there was a negative association between number of ever born children and BMI ($p<0.001$). Two level regression model demonstrated that age and age at first marriage of women were positively ($p<0.01$) related with their BMI. Parity was negatively related with women's BMI. BMI was especially less pronounced among non-pregnant married women who came from rural, uneducated, uneducated husband, came from poor family, house wife, currently not use contraceptive and currently not breastfeeding.

Under-nutrition is considered as a major health problems in Bangladesh especially of married women. Government and non-government organization of Bangladesh should take step to increase people education level and improve economic condition for removing under-nutrition among married women.

The third and final main objective of this thesis was to quantify the prevalence of anemia and assessed how various nutritional, socio-economic and demographic factors associated with anemia among non-pregnant women in Bangladesh. Anemia is one of the most common and global public health problems. Highly prevalence of anemia was found among women of reproductive age in the world especially in developing countries. Study on anemia among Bangladeshi non-pregnant married women is poorly documented. Cross-sectional data were used in this study. Data was extracted from

Bangladesh Demographic and Health Survey (BDHS) 2011. The nationally representative sample (5,293 married women) was selected by multistage stratified cluster sampling and data was collected from July 8, 2011 to December 27, 2011. Multilevel (two level) logistic regression analysis was done in this study. The prevalence of anemia among Bangladeshi married women was more than 41% and among anemic women, 35.5% was mild, 5.6% and only 0.2% were moderate and severe anemic respectively. Chi-square ($\chi^2$-test) test was utilized in this study for selecting independent factors for multilevel logistic regression analysis.

$\chi^2$-test demonstrated that residence ($p<0.001$), respondents' and her husbands' education levels ($p<0.001$), currently breastfeeding ($p<0.001$), currently amenorrhea ($p<0.001$), currently use contraceptive ($p<0.001$), toilet facility ($p<0.01$), religion ($p<0.001$), wealth index ($p<0.001$), BMI ($p<0.001$), age group ($p<0.001$), number of ever born children ($p<0.001$) were significantly associated with anemia. The two level logistic regression model demonstrated that women who were currently breastfeeding and amenorrhea had more likely ($p<0.01$) to get anemia than their counterparts. Underweight women had a higher chance ($p<0.01$) to get anemia than normal weight, overweight and obese. Uneducated women were more likely to get anemia ($p<0.01$) than secondary and higher educated. Anemia was especially less pronounced among non-pregnant women who are currently use contraceptive ($p<0.05$), Muslim ($p<0.01$) and came from rich family ($p<0.01$). Moreover, women who were 30-49 years old had more likely to get anemia than younger ($p<0.01$).

Under-nutrition is most important predictor for anemia among Bangladeshi married women and undernourished women are living under poor condition. Government of Bangladesh should take appropriate initiative to improve economic condition for removing anemia among married women.

# *CHAPTER ONE*

## General Introduction

## 1.1 Introduction

Modelling is nothing but to establish the relationship between dependent and independent variable(s) through some way whether graphically or mathematically. Our approach will be described the relationship through some functional form. Regression methods have become an integral component of any data analysis, concerned with describing this relationship.

Nutritional status is the state of a person's health in terms of the nutrients in his/her diet. Nutritional status is a global term that encompasses a number of specific components from nutritional assessments. Nutritional assessment is a comprehensive approach to define nutritional status using medical, nutrition and medication histories, physical examination, anthropometric measurement, and laboratory data. Body mass index (BMI) is an essentially based on a person's weight and height and is considered an indirect measure of nutritional status. The change in nutritional status plays an important role in the course of a person's health. Therefore, BMI can be used as an indicator for health status, and association with some diseases can be expected. So, BMI is a good indicator of nutritional status in a population. A BMI value $\geq 30$ kg/m$^2$ has been shown to be a risk factor for hypertension, heart disease, diabetes mellitus, cardiovascular disease, gall bladder disease and various types of cancer. On the other hand, a low BMI (underweight BMI$\leq 18.5$ kg/m$^2$) has been associated with a higher risk of hip fracture in women (Gnudi et al., 2009; Morin et al., 2009). Low birth weight and higher mortality rate has also been associated with a low BMI in pregnant mothers (Hosegood & Campbell, 2003). The patterns in the level of public health in a community could be ameliorated with changes in BMI over time. Comparison of BMI over time may also provide useful information about changes in the general environment of a given population. Information on the prevalence of anemia can also be useful for the development of health intervention programs designed to prevent and control anemia. These are the particularly important for developing countries where health and medically related reforms are being actively implemented.

Now a days the term 'trend / secular change' is being used to describe a wide variety of traits showing non-random or systematic changes with time in stature, weight, BMI, head and face dimensions of adults in successive generations living in local geographical regions (Tobias and Netscher, 1977). With respect to the direction of such secular changes, there are two types: (1) positive secular changes and (2) negative secular changes. The secular trends of increasing BMI have been observed in many Western countries (Flegal et al., 1988; Shah et al., 1991; Gullinford et al., 1992; Lahti-Koski et al., 2001; Lysens & Vansant, 2001; Bielicki et al., 2001; Mascie-Taylor & Goto, 2007; Walls et al., 2010). The phenomenon of negative secular trends in BMI has been reported in a Glasgow alumni cohort (Okasha et al., 2003). An increasing tendency towards this negative secular trend has also been found in Vietnam (Khan et al., 2010), China (Chen & Ji, 2009), Kuwait (Al-Isa, 1997) and Japan (Yanai et al., 1997). A decreasing tendency in BMI have been observed in female populations using only 2007 BDHS data (Hossain et al., 2012) and also for the university female students (Hossain et al., 2012) in Bangladesh. An examination of these trends in BMI is of special importance for married women in developing countries.

BMI is an internationally used measure of obesity. Relationship between BMI and socio-demographic factors for other population have been described elsewhere (Tavani et al., 1994; Brener et al., 2004; Ali and Lindstrom, 2006; Morin et al., 2009; Okoh, 2013; Hou et al., 2014; Sundararajan et al., 2014). In Bangladesh, researchers have investigated the relationship of BMI with mortality (Hosegood & Campbell, 2003; Pierce et al., 2010) and socio-economic and demographic factors (Pryer et al., 2003; Shafique et al., 2007; Khan and Kraemer, 2009) and socio-demographic factors (Hossain et al., 2012) in female populations, and socio-demographic factors (Hossain et al., 2012) in university female students. In realizing the existence of this cause and effect relationship, efforts are currently underway to correct the underlying problems that resulted in a low BMI. Similarly, actions should also be taken for married women considering that this population contributes to the nation's workforce and therefore its productivity. Due to the unique problems experienced by married women e.g. increased family responsibility and financial commitment, it is important to investigate the relationship between the BMI of married women and important factors such as age, age at first marriage, age at first birth, number of ever born children, wealth index, currently use contraceptive, currently breastfeeding and watching television, in order to ensure corrective measures can be undertaken.

Low level of hemoglobin in the blood, as evidenced by fewer numbers of functioning red blood cells is called anemia. Hemoglobin in red blood cells is an oxygen-carrying protein that binds oxygen through its iron component. Hemoglobin transports oxygen to most cells in the body for the generation of energy. When hemoglobin levels are low less oxygen reaches the cells to support the body's activities. There are multiple causes of anemia, of which iron deficiency is the most common. Other important causes include folate deficiency, malaria, AIDS, hemoglobinopathies including thalassaemia, and parasitic infections. Anemia affects the lives of people throughout the life cycle, however, it is usually most prevalent and severe in preschool children and pregnant women, whose iron requirements for growth and reproduction are relatively highest (DeMaeyer and Adiels-Tegman, 1985). Anemia is an important global public health problem among women (Benoist et al., 2008). Anemia in reproductive aged women has been associated with numerous morbidities including miscarriage (Szerafin and Jako, 2010), preterm delivery (Scholl et al., 1992), abruption placenta (Arnold et al., 2009) and low birth weight (Rasmussen, 2001). It is also related to higher risk of prenatal and maternal mortality (Lee et al, 2006; Mulayim et al., 2008; Brabin et al., 2001). In addition, anemic individuals have generally more infectious diseases (Ndyomugyenyi et al., 2008) and will have lower physical and work capacity (Scholz et al., 1997). Center for Disease Control and Prevention (CDCP) of United States has identified anemia as an important indicator for general health among non-pregnant women, and recommended that all non-pregnant women should check their hemoglobin level every 5-10 years throughout their childbearing age (CDC, 1998). In developing countries, married women are often responsible for maintaining the family, and many are also contributing towards the workforce and productivity of the nation. Study on prevalence of anemia among married women is very useful for the authorities to evaluate the status of general health and plan remedial measures that can be effectively target groups or population at risk. So, it is important to investigate the prevalence of anemia among non-pregnant married women of reproductive age of Bangladesh and explore important socio-demographic factors that may be associated with this condition.

## 1.2 Objectives

The objectives of the study are as follows:

**a) Broad objective:** The overall objective of this thesis is to modelling of nutritional status among Bangladeshi non-pregnant married women in reproductive age.

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

i) To investigate the nutritional status (BMI) of Bangladeshi non-pregnant married women in reproductive age and observe the trend in BMI over time.

ii) To identify the effect of socio-economic and demographic factors on BMI of Bangladeshi non-pregnant married women of reproductive age.

iii) To investigate the prevalence of anemia among non-pregnant married women of reproductive age of Bangladesh and explore important socio-demographic factors that may be associated with this condition.

## 1.3 Organization of the thesis

This thesis is organized into six chapters as follows:

Chapter 1 contains the "general introduction" about whole of our study, and objectives and organization of the thesis.

Chapter 2 describes "data and methods" which contains introduction, sources of data, respondents' selection, study design and sampling, questionnaire, data collection, data processing, quality of the data, methodology, history of multilevel analysis, developing a multilevel model, multilevel multivariate/multiple regression model and multilevel multivariate/multiple logistic regression model.

Chapter 3 describes the "secular trends in nutritional status (BMI) of Bangladeshi non-pregnant married women of reproductive age over four decades" which contains introduction, review of literatures, materials and methods, results, discussions and conclusions.

Chapter 4 describes the "effect of socio-economic and demographic factors on BMI of Bangladeshi non-pregnant married women of reproductive age: multilevel linear regression analysis”. This chapter contains introduction, review of literatures, materials and methods, results, discussions and conclusions.

Chapter 5 describes the “prevalence and associated factors of anemia among non-pregnant women of reproductive age in Bangladesh: multilevel logistic regression analysis”. This chapter presents introduction, review of literatures, materials and methods, results, discussions and conclusions.

Chapter 6 contains the concluding remarks and guideline of future perspectives based on the findings from the present study.

# *CHAPTER TWO*

## Data and Methods

## 2.1 Introduction

Data is a collection of facts, such as numbers, words, measurements, observations or even just descriptions of things. Research data is defined as recorded accurate material commonly kept by and accepted in the scientific community as necessary to validate research findings; although the majority of such data is created in digital format, all research data is included irrespective of the format in which it is created. According to the source of data, it can be classified into two classes; (i) Primary data and (ii) Secondary data. Primary data are collected by the investigator conducting the research. Secondary data, by contrast, is collected by someone other than the user. Common sources of secondary data for social science include censuses, organizational records and data collected through qualitative methodologies or qualitative research. In the present study, secondary data was used that was extracted from Bangladesh Demographic and Health Survey (BDHS).

Knowledge about methodology will provide us with a place to hang our statistics. In other words, statistics are not numbers that just appear out of now here. Rather, the numbers (data) are generated out of research. Statistics are merely a tool to help us answer research questions. As such, an understanding of methodology will facilitate our understanding of basic statistics. The process of developing a mathematical model is termed mathematical modeling. A mathematical model is a description of a system using mathematical concepts and language. Its can help students understand and explore the meaning of equations or functional relationships. A statistical model embodies a set of assumptions concerning the generation of the observed data, and similar data from a larger population. A model represents, often in considerably idealized form, the data-generating process.

Two statistical models are nested if the first model can be transformed into the second model by imposing constraints on the parameters of the first model. In the current study, multilevel regression was used for analysis the nested data that was derived from BDHS-2011.

BDHS used multistage stratified cluster sampling for selecting household from different enumeration areas (EAs). Step by step the sampling technique, survey design, questionnaire, survey instruments, measuring system and quality control were used by BDHS for collecting information from Bangladeshi married women have been described in below. The multilevel linear and logistic regressions also have been described in below.

## 2.2 Materials

### 2.2.1 Sources of data

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

### 2.2.2 Respondents' selection

In statistics, population is an aggregate of the elements possessing certain characteristics of interest in particular investigation, but in demography/health statistics population means the human beings. In the current study, the effect of socio-economic, demographic and behavioral factors on nutritional status and anemia among Bangladeshi married women in reproductive age were investigated using data collected by Bangladesh Demographic and Health Survey-2011 (BDHS-2011), a national-level survey where various districts of Bangladesh were represented. We identified married women in the reproductive age of 15-49 years within the sample population. The sample population of this study consisted of 17,842 married currently non-pregnant Bangladeshi women. Socio-economic, demographic, anthropometric, health and lifestyle information from 17,842 ever-married Bangladeshi women were collected from July 8, 2011 to December 27, 2011. The sampling technique, survey design, survey instruments, measuring system and quality control etc. had been described elsewhere (NIPORT, 2013). For analysis of trends in BMI over time, data from previous BDHS surveys conducted in 1996-1997, 1999-2000, 2004, 2007 were included for analysis. The sample units consisted of 59,949 Bangladeshi married non-pregnant women in reproductive age conducted in 1996-1997, 1999-2000, 2004, 2007 and 2011 by BDHS. Again the sampling technique, survey design, survey instruments, measuring system and quality control etc. of conducted years for 1996-1997 to 2007 had been described elsewhere (NIPORT, 2009 and NIOPRT, 2005).

### 2.2.3 Study design and sampling

The BDHS-2011 sample was represented with the various districts of Bangladesh and covers the entire population residing in non-institutional dwelling units in the country.

The survey used as a sampling frame according to the list of EAs prepared for the 2011 Population and Housing Census, provided by the Bangladesh Bureau of Statistics (BBS). The primary sampling unit (PSU) for the survey was an EA that was created to have an average of about 120 households.

Bangladesh has seven administrative divisions namely Barisal, Chittagong, Dhaka, Khulna, Rajshahi, Rangpur and Sylhet. Each division was subdivided into zilas, and each zila into upazilas. Each urban area in an upazila was divided into wards, and into mahallas within a ward, on the other hand, a rural area in the upazila was divided into union parishads (UP) and mouzas within a UP.

Each division was stratified into urban and rural areas. The urban areas of each division were further stratified into two strata namely (i) city corporations and (ii) other than city corporations because Rangpur Division had no city corporations, a total of 20 sampling strata were created. BDHS has used two-stage stratified sample of households. Samples of EAs were selected independently in each stratum in two stages. At the first stage of sampling, 600 EAs were selected with probability proportional to the EA size, with 207 clusters in urban areas and 393 in rural areas. At the second stage was used to select households (fixed 30) from each unit. With this design, the survey selected 18,000 residential households, which were expected to result in completed interviews with about 18,000 ever-married women, 6,210 in urban areas and 11,790 in rural areas. The sample was expected to result in about 18,072 completed interviews with ever-married women age 12-49; 6,426 in urban areas and 11,646 in rural areas (NIOPRT, 2013).

### 2.2.4 Questionnaire

The household questionnaire for adult individuals has been recorded by BDHS:

- Height and weight measurements
- Anemia test results
- Measurements of blood pressure and blood glucose

The woman's especially questionnaire has been used for collect information from ever-married women age 12-49. Women were asked questions on the following topics:

- Some common personal characteristic of the respondents such as age, sex, education, religion, occupation, etc.
- Reproductive history
- Use and source of family planning methods
- Antenatal, delivery, postnatal, and newborn care
- Breastfeeding and infant feeding practices
- Child immunizations and childhood illnesses
- Marriage
- Fertility preferences
- Husband's background and work status
- Awareness of AIDS and other sexually transmitted infections
- Food security

### 2.2.5 Data collection

Training of field workers, interviewers, field supervisors and observers for collecting information of BDHS surveys have been mentioned in NIPORT (2013; 2009 and 2005). Data quality was ensured through four quality control teams, each comprised of one male and one female staff person. In addition, NIPORT monitored fieldwork by using extra quality control teams. Data quality was also monitored through field check tables generated concurrently with data processing. This was an advantage because the quality control teams were able to advise field teams of problems detected during data entry. In particular, tables were generated to check various data quality parameters. Fieldwork was also monitored through visits by representatives from USAID, ICF International, and NIPORT (NIOPRT, 2013).

Data Collection Methodology (DCM) is a team of survey methodologists specializing in the use of qualitative and quantitative research methods to enhance quantitative enquiry and promote good practice. DCM offers expertise in the development, testing and evaluation of survey data collection instruments including self-completion forms, record-keeping diaries and questionnaires administered by interviewers (on paper, by computer-assisted telephone interviewing (CATI) or computer-assisted personal interviewing (CAPI)). DCM also conducts in-depth studies to explore concepts and themes relating to the design of data collection instruments, or relating to more general survey and statistical matters. Where possible, DCM aims to contribute to the theoretical development of survey methods. The qualitative methods DCM applies include focus groups, in-depth interviews, behavior coding, cognitive question testing and expert reviews of survey questions and documentation. Quantitative techniques to aid questionnaire evaluation were also used. DCM has been part of the methodology directorate of the Office for National Statistics (ONS). DCM was formerly known as Qualitative Methods Applied to Surveys (QMAS). Clients of DCM include other areas of ONS, other government departments, local authorities, academic institutions and charities. DCM is not normally able to work for clients in the private sector or for private individuals such as students. The data should be collected keeping in view the objectives of the study of the BDHS data. The editing of the completed questionnaire helped in mending and recording errors or eliminating data that are obviously erroneous and inconsistent. All kind of mistakes have been corrected where it was found in questionnaire and all answers have been observed carefully. As a result there is no irreverent information. The tendency should not collect too many data, but the important one and some of which are never subsequently examined and analysis. In this survey the method of especially collect from BDHS data used. The enumerators were mainly respondents to collect information and recorded them properly. Attention was given to recorded factual and true statement made by the respondents. In any survey enumerators' role is the most significance with respect to coverage and reliability of data collection. The success and failure of the enumerators in eliciting relevant respondents is largely and exclusively dependent on efficiency, capability and responsibility.

### 2.2.6 Data processing

The completed BDHS-2011 questionnaires were periodically sent to Dhaka for data processing at Mitra and Associates offices. The data processing began shortly after the start of fieldwork. Data processing consisted of office editing, coding of open-ended questions, data entry, and editing inconsistencies found by the computer program. The data were processed by 16 data entry operators and two data entry supervisors. Data processing commenced on July 23, 2011 and ended on January 15, 2012. Data processing was carried out using the Census and Survey Processing System (CSPro), a joint software product of the U.S. Census Bureau, ICF International, and Serpro S.A.

### 2.2.7 Quality of the data

Any kind of research finding based on the survey data mainly depends primarily on the reliability of the data. From various socio-economic and demographic points of view Bangladesh is an underdeveloped country. Due to very low literacy rate, citizens are not conscious about the importance of providing correct information's in census and survey. Because of these, various errors are included in any survey data, such as, age heaping, miss-reporting, digit preference, etc, in case of retrospective surveys. Some of the respondents, especially women also refuse in giving information totally and partially due to religious and social superstition. Although the standard in terms of organization, co-ordination, supervisors and intensive training of the interviews and the associated field supervisors and editors, BDHS is expected to result in better quality of data, there is obvious need for an assessment of the quality of data to prove the validity of the finding of the study. Software and technical support of BDHS data have been described in NIPORT (2013).

## 2.3 Methodology

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

### 2.3.1 History of multilevel analysis

Multilevel analysis is a relatively new statistical technique in social science research, although its roots can be traced back to classical sociological studies, especially Durkheim’s study of suicide. Durkheim sought the causes of suicide, a very personal and individual phenomenon, in the social contexts of the individual. Multilevel analysis can be viewed as a modern way of addressing research questions concerning how outcomes at the individual level can be seen as the result of the interplay between individual and contextual factors.

The first step towards modern multilevel analysis was the rise of contextual analysis in the USA in the 1940s. Contextual analysis was introduced as a critique of the dominant micro-perspective in American sociology. Contextual analysis became more established in the 1960s, the statistical techniques became more sophisticated and conceptual progress was made. Larzarsfeld’s (Larzarsfeld, 1959) concept of contextual propositions, Larzarsfeld and Menzel’s (Larzarsfeld & Menzel, 1961) typology of variables by levels and Blau’s (Blau, 1960) concept of structural effects were the most influential contributions.

Around 1970, contextual analysis was heavily criticized by Hauser. He maintained that most alleged contextual effects lacked substance and were artefacts of inadequately specified individual-level models. Instead, the ‘contextual effects’ were grouped individual effects. He used the term contextual fallacy to describe this phenomenon (Hauser, 1970).

From the end of the 1970s, the crucial steps in developing multilevel analysis took place in school research. Educational data had mainly been analyzed at the individual level, ignoring the schools. An innovative step was to analyze each school separately. The dependent variable could be an outcome variable such as the score in a mathematics test with explanatory variables at the individual level, such as gender and parents' socioeconomic status. Estimating identical regression models for each school would yield a set of intercepts and regression coefficients that could show systematic variation by schools. This led to the slopes-as-outcomes approach. The slopes (regression coefficients) were seen as dependent variables in a school-level analysis, with explanatory variables at the school level. This approach can be viewed as a two-stage multiple regression design.

In the 1980s, several variations of multilevel models were developed to avoid the statistical problems of the two-stage design. In Chicago, a group of researchers developed the HLM software for simultaneous estimation of 'hierarchical linear models' with two levels (Raudenbush and Bryk, 2002). In London, another groups of educational researchers developed another software program for multilevel analysis, now known as Mlwin (Goldstein, 1995).

Multilevel models deal with the analysis of data where observations are nested within groups. Social, behavioral and even economic data often have a hierarchical structure. A frequently cited example is in education, where students are grouped in classes. Classes are grouped in schools, schools in school districts, etc. We thus have variables describing individuals, but the individuals may be grouped into larger or higher-order units.

Multilevel model is widely used in various fields such as, in educational research or geographical research, to estimate separately the variance between pupils within the same school, and the variance between schools. In psychological applications, the multiple levels are items in an instrument, individuals, and families. In sociological applications, multilevel models are used to examine individuals embedded within regions or countries. In organizational psychology research, data from individuals must often be nested within teams or other functional units and so on.

### 2.3.2 Developing a multilevel model

Multilevel approach is a well-developed statistical technique. Very little health related research has been conducted using this methodology. It provides the advantages over the single level analyses as only this methodology have introduced the hierarchical effects of variation besides the fixed effects and the random effects due to responses.

**Assumptions**

Multilevel models have the same assumptions as other major general linear models (e.g., ANOVA, regression), but some of the assumptions are modified for the hierarchical nature of the design (i.e., nested data).

**Linearity:** The assumption of linearity states that there is a rectilinear (straight-line, as opposed to non-linear or U-shaped) relationship between variables.

**Normality:** The assumption of normality states that the error terms at every level of the model are normally distributed.

**Homoscedasticity:** The assumption of homoscedasticity, also known as homogeneity of variance, assumes equality of population variances.

**Independence of observations:** Independence is an assumption of general linear models, which states that cases are random samples from the population and that scores on the dependent variable are independent of each other.

**Modification of Assumptions**

The assumptions of linearity and normality do not pose any problems for multilevel models, and are thus retained. However, the assumptions of homoscedasticity and independence of observations must be adapted in order to proceed with this type of analysis. The latter two assumptions pose several problems. First, units of observations in the same group are more similar than those in different groups. Second, while groups are independent of each others, observations within a group share values on variables, and thus, they are not independent. However, one advantage of employing multilevel models over other types of analyses is that independence is not required, because it is violated at each level of the analysis. Additionally, multilevel models are designed to deal with this intraclass correlation, which assumes that data from the same context are more similar than data from different contexts. Multilevel modelling analysis serves to measure the variability within contexts.

#### 2.3.2.1 Multilevel multivariate/multiple regression model

In order to maintain the adequacy and to achieve the accuracy in the interpretation, it is logical to examine the relative importance of each independent variable simultaneously by some multivariate methods. There are wide varieties of multivariate statistical techniques that can be used appropriately under the certain circumstances. Since in our study, the outcome variable (BMI) is continuous and there are wide number of independent continuous variables also, the appropriate model to be fit is the ‘multivariate/multiple regression model’.

According to our purpose, besides the random variations due to the response it is needed to include the hierarchical effects of the selected variables in the model. As such, our approach will be to define a regression model that will include all these effects of hierarchies. Thus we are to construct a ‘multilevel multiple regression model’.

Let Y be the response variable, and X be the independent variable. Then the regression equation for the $i$ th individual is written as:

$$Y_i = \beta_0 + \beta_1 X_i + e_i \qquad (1)$$

$\beta_0$ be the intercept, it shows where the regression line meets the vertical axis. Slope $\beta_1$, be the rate of increase of the dependent variable due to unit increase of the independent variable. And $e_i$ be the random error term, which is the difference between the estimated and the observed value of the response variable for the $i$th observation. It is termed as a residual because it is that part of the $Y_i$, which is not predicted or remained, unexplained by the regression relationship in equation (1). The interpretation is to be given to all these three measurers, $\beta_0$, $\beta_1$ and $e_i$. This is the basic model, which is used to describe the single level relationship between response and explanatory variables.

Turning now to the multilevel case; let pupils are distributed in different clusters and let the clusters are regarded as a random sample of all clusters, we can express the relationships for $i$th individual in the $j$th cluster as:

$$Y_{ij} = \beta_{0j} + \beta_1 X_{ij} + e_{ij} \qquad (2)$$

In general, wherever an item has an $ij$ subscript it varies from pupil to pupil within a cluster. Where an item has a $j$ subscript only it varies across clusters but has the same value for all the pupils within a cluster. And where an item has neither subscript it is constant across pupils and clusters. Therefore, $X_{ij}$ and $Y_{ij}$ are the values of the independent and dependent variables for pupil $i$ in cluster $j$ respectively. $\beta_{0j}$ is the regression intercept for the $j$th cluster. $\beta_1$ is the regression slope, which is assumed to be constant across all clusters, and $e_{ij}$ is the individual-level residual for the $i$th pupil in the $j$th cluster. Thus, $e_{ij} \equiv Y_{ij} - \hat{Y}_{ij}$. In a multilevel analysis the level-2 groups, in this case clusters, are treated as a random sample. The equation (2) is therefore, re-expressed as

$$Y_{ij} = \beta_0 + \beta_1 X_{ij} + u_{0j} + e_{ij} \qquad (3)$$

where, $u_{0j} \equiv \beta_{0j} - \beta_0$ is the departure of the $j$ th cluster's actual intercept from the value $\beta_0$ predicted for all clusters. It is thus a level-2 residual. $\beta_0$ is indicating that it is constant across all clusters; $u_{0j}$ is specific to cluster $j$, but is the same for all individuals in that cluster. In this equation, both $u_{0j}$ and $e_{ij}$ are random quantities, whose means are equal to zero. We assumed that, being at different levels, these variables are uncorrelated and we further assume that they follow a normal distribution. It is sufficient, therefore, to estimate their variances, $\sigma_u^2$ and $\sigma_e^2$. The quantities $\beta_0$ and $\beta_1$ are common to all members of the population; they are thus not random but fixed, and will need to be estimated.

It is the existence of the two random variables $u_{0j}$ and $e_{ij}$ in equation (3), which makes it out as a multilevel (2-level) model. The variances $\sigma_u^2$ and $\sigma_e^2$ are referred to as random parameters of the model.

So, the multilevel linear model having $k$ explanatory variables and two levels, *viz*., clusters and individuals, can be stated as under,

$$Y_{ij} = (\beta_0 + \sum_{h=1}^{k} \beta_h X_{hij}) + (u_{0j} + e_{ij}) \qquad (4)$$

where, $h$ =independent variable identity, varies from 1 to $k$.

$i$ =respondent's identity.

$j$ =cluster level identity.

$\beta_0$ =intercept or the overall mean.

$\beta_h$ =the regression coefficient for $h$ th variable.

$Y_{ij}$ =response of the $i$ th individual in the $j$ th cluster.

$X_{hij}$ =response for the $h$ th variable of $i$ th respondent in the $j$ th cluster.

$e_{ij}$ =residual for $i$ th respondent in the $j$ th cluster.

$u_{0j}$ =residual for the $j$ th cluster= $\beta_{0j} - \beta_0$

This is the 'multilevel (two-level) multivariate/multiple regression model' where the first parenthesis contains the fixed part and the next parenthesis contains the residual part of the model.

**2.3.2.2 Multilevel multivariate/multiple logistic regression model**

In order to maintain the adequacy and to achieve the accuracy in the interpretation, it is logical to examine the relative importance of each independent variable simultaneously by some multivariate methods. There are wide varieties of multivariate statistical techniques that can be used appropriately under the certain circumstances. Since in our study, the outcome variable (anemia) is binary or dichotomous and there are wide number of independent dichotomous variables also, the appropriate model to be fit is the 'multivariate/multiple logistic regression model'. According to our purpose, besides the random variations due to the response it is needed to include the hierarchical effects of the selected variables in the model. As such, our approach will be to define a regression model that will include all these effects of hierarchies. Thus we are to construct a 'multilevel multiple logistic regression model'.

As we know that the logistic regression is applied to the fields where response variable is discrete or binary or dichotomous. That is when the dependent variable can have only two values, e.g., an event occurring or not occurring. This does not require any distributional assumptions concerning explanatory variables. This model can be successfully used in the field of discriminate analysis. The logistic regression model can be used not only to identify risk factors but also to predict the probability of success. The general logistic regression model expresses a qualitative dependent variable as a function of several independent variables, both qualitative and quantitative.

Let $Y_i$ denote the dependent variable for the $i$th observation and $Y_i$=1 if the $i$th individual is a success, and $Y_i$=0 if the $i$th individual is a failure. Suppose that for each of the individuals $k$ independent variables $X_{i1}, X_{i2},..., X_{ik}$ are measured. These variables can be either qualitative or quantitative. In this model, the dependence of the probability of success and failure on independent variables is assumed to be respectively as:

$$P(Y_i = 1) = \pi(x) = \frac{1}{1 + \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k)} \text{ and}$$

$$P(Y_i = 0) = 1 - \pi(x) = \frac{\exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k)}{1 + \exp(\beta_0 + \beta_1 x_1 + \beta_2 x_2 + ... + \beta_k x_k)}$$

where, $\pi(x) = E(Y \mid X)$ and is read as the expected value of Y (outcome variable) given the value X (the independent variable). For the dichotomous data this ranges between 0 and 1. Thus, for the dichotomous data the value of the outcome variable given X as $Y = \pi(x) + \varepsilon$. Here the quantity $\varepsilon$ may assume one of the two possible values. If Y=1 then $\varepsilon = 1 - \pi(x)$ with probability $\pi(x)$, and if Y=0 then $\varepsilon = -\pi(x)$ with probability $1 - \pi(x)$. Thus $\varepsilon$ has the distribution with mean zero and variance $\pi(x)(1 - \pi(x))$. That is the conditional distribution of the outcome variable follows a binomial distribution with probability, given by the conditional mean, $\pi(x)$.

The logarithm of the ratio of $\pi(x)$ and $1-\pi(x)$ turns out to be a simple linear function of $X_{ij}$. The transformation of $\pi(x)$ is the logit transformation. This transformation if defined, in terms of $\pi(x)$, as follows:

$$\text{g(x)=logit(}\pi(x)\text{)} = \ln\left[\frac{\pi(x)}{1-\pi(x)}\right]$$

$$= \beta_0 + \beta_1 X_1 + \beta_2 X_2 + ... + \beta_k X_k = \beta_0 + \sum_{j=1}^{k} \beta_j X_{ij}$$

The importance of this transformation is that g(x) has many of the desirable properties of a linear regression model. The logit, is the logarithm of the odds of success, that is, the logarithm of the ratio of the probability of success to the probability of failure.

Logistic regression procedure is also proposed for the hierarchical data analysis for study data with group structure and a binary response variable. The group structure is defined by the presence of micro observations embedded within contexts (macro observations), and specification is at both of these levels. At the first level (micro level), the usual logistic regression model is defined for each context. The same regressors are used in each context, but the micro regression coefficients (intercept term) are to vary over contexts. At the second level, the micro coefficients are treated as functions of macro regressors.

The two-level model obtained in equation (4) is a multilevel linear regression model. Hence it will not be able to interpret the data which is binary in nature. Now we will combine the idea of logit model and the 2-level model. Hence obtain the 2-level logistic regression model.

Anemia is allowed to vary between clusters. In the level-1, let $Y_{ij}$ be the dichotomous value (0 or 1) of the $i$th pupil in the $j$th cluster and let $\pi_{ij}$ is the probability of anemia, and then the 2-level logistic regression model is as follows:

$$\text{logit}(\pi_{ij}) = \log\left(\frac{\pi_{ij}}{1-\pi_{ij}}\right) = \beta_0 + \sum_{h=1}^{k}\beta_h X_{hij} + u_{0j} + e_{ij} \tag{5}$$

where, $\pi_{ij} = \dfrac{\exp\left(\beta_0 + \sum_{h=1}^{k}\beta_h X_{hij} + u_{0j}\right)}{1+\exp\left(\beta_0 + \sum_{h=1}^{k}\beta_h X_{hij} + u_{0j}\right)}$.

So the full model of 'multilevel logistic regression' can be written as

$$Y_{ij} = \pi_{ij} + e_{ij} = \frac{\exp\left(\beta_0 + \sum_{h=1}^{k}\beta_h X_{hij} + u_{0j}\right)}{1+\exp\left(\beta_0 + \sum_{h=1}^{k}\beta_h X_{hij} + u_{0j}\right)} + e_{ij} \tag{6}$$

The right hand side of the equation (6) is non-linear both in the fixed and in the higher level of random parameter.

In this equation $u_{0j}$ is random variable which follows $N(0,\sigma_u^2)$ across level-2. In addition, $e_{ij}$ is assumed to have the binomial distribution with mean $\pi_{ij}$ and variance $\pi_{ij}(1-\pi_{ij})$.

# *CHAPTER THREE*

## Secular Trends in Nutritional Status (BMI) of Bangladeshi Non-Pregnant Married Women of Reproductive Age Over Four Decades

## 3.1 Introduction

Nutritional status for a population is measured by body mass index. The change in nutritional status plays an important role in the course of a person's health. Therefore, BMI can be used as an indicator for health status, and association with some diseases can be expected. The high prevalence of overweight ($25 \le BMI < 30$) and obesity ($BMI \ge 30$) of a population has been shown to be a risk factor for hypertension, heart disease, diabetes mellitus, cardiovascular disease, gall bladder disease and various types of cancer. On the other hand, a low BMI (underweight BMI<18.5 $kg/m^2$) has been associated with a higher risk of hip fracture in women (Gnudi et al., 2009; Morin et al., 2009). Low birth weight and higher mortality rate has also been associated with a low BMI in pregnant mothers (Hosegood & Campbell, 2003). The prevalence and trends of underweight and overweight over time may provide useful information about changes in the level of public health and reflect the general living environment of a given population. This is particularly important for developing countries where health and medically related reforms are being actively implemented.

Secular trends of increasing BMI have been observed in many Western countries (Flegal et al., 1988; Shah et al., 1991; Gullinford et al., 1992; Lahti-Koski et al., 2001; Lysens & Vansant, 2001; Bielicki et al., 2001; Mascie-Taylor & Goto, 2007; Walls et al., 2010). Negative trends in BMI have been reported in a Glasgow alumni cohort (Okasha et al., 2003). An increasing tendency towards a negative trend has also been found in Vietnam (Khan et al., 2010), China (Chen & Ji, 2009), Kuwait (Al-Isa, 1997) and Japan (Yanai et al., 1997). An examination of these trends in BMI is of special importance for married women in developing countries.

A decreasing tendency in BMI have been observed in female populations using only 2007 BDHS data (Hossain et al., 2012) and also for the university female students

(Hossain et al., 2012) in Bangladesh. Efforts have been made to improve the general conditions of this population section, and BMI can provide a tool for evaluation of the effectiveness of these measures. Special attention should be paid to married women considering their potential influence on the family and their contribution to the nation's workforce and productivity. Due to their unique role in the population, it is important to investigate the pattern of nutritional status (BMI) over time.

The purpose of the present study is to test the presence of trends in BMI of married, non-pregnant Bangladeshi women born over four decades.

## 3.2 Review of literatures

The term 'trend / secular changes' refers to long-term systematic or non-random changes in a wide variety of morphological traits in successive generations living in the same geographical area (Tobias and Netscher, 1977). Many researchers have tried to study secular changes in BMI of different populations. Some of these studies are described in below (Flegal et al., 1988; Shah et al., 1991; Gullinford et al., 1992; Rauschenbach et al., 1995; Al-Isa, 1997; Ortega et al., 1997; Yanai et al., 1997; De Castro et al., 1998; Hulens et al., 2001; Lahti-Koski et al., 2001; Freedman et al., 2002; Torrance et al., 2002; de Vasconcelos and da Silva, 2003; Okasha et al., 2003; Sobal et al., 2003; Al-Lawati and Jousilahti, 2004; Bendixen et al., 2004; Nobre et al., 2004; Pryer et al., 2004; Berg et al., 2005; Dal Grande et al., 2005; Sarkar and Taylor, 2005; Ali and Lindstrom, 2006; Bianka Caliman et al., 2006; Pryer and Rogers, 2006; Bharati et al., 2007; Ji et al., 2007; Mascie-Taylor and Goto, 2007; Shafique et al., 2007; Khanam and Costarelli, 2008; Li et al., 2008; Lissner et al., 2008; Aekplakorn and Mo-Suwan, 2009; Balarajan and Villamor, 2009; Chen and Ji, 2009; Khan and Kraemer, 2009; Lai and Yin, 2009; Subramanian et al., 2009; Cardoso and Caninas, 2010; Esteghamati et al., 2010; Hossain et al., 2010; Khan et al., 2010; Nagai et al., 2010; Pierce et al., 2010; Walls et al., 2010; Ahmed et al., 2012; Bakhshi et al., 2012; Hossain et al., 2012; Hossain et al., 2012; Nasreddine et al., 2012; Xi et al., 2012; Yates et al., 2012; Austin et al., 2013; Avila et al., 2013; Badr et al., 2013; Binkowska-Bury et al., 2013; Gallus et al., 2013; Karageorgi et al., 2013; Okoh, 2013; Orden et al., 2013; Ancheta et al., 2014; Kriaucioniene et al., 2014; Ogden et al., 2014; Robles et al., 2014; Wang et al., 2014 and Zajc Petranovic et al., 2014):

### 3.2.1 Other population studies

**Flegal et al. (1988)** investigated secular trends in BMI and skin-fold thickness with socio-economic factors in young adult women aged 18-34 years; they extracted data from the three successive national surveys: NHES Cycle I, NHANES I, and NHANES II over the period 1960-80. They found that mean BMI and skin-fold thickness were negatively associated with both education and income. The mean BMI over the 20-years period increased for both white and black women at all levels of income and education.

**Shah et al. (1991)** examined the secular trend in BMI in the adult population of three communities from the upper mid-western part of the USA; they received data from the Minnesota Heart Health Program (1980-1987). They found that significant secular increased in BMI adjusted for age and education was found in both men (0.08 $kg/m^2$/year, $p<0.02$) and women (0.19 $kg/m^2$/year, $p<0.0001$). In women, the secular increased occurred throughout the distribution of body weights but the change in the upper end was two to three times greater than that in the other parts of the distribution. In men, most of the increased in BMI occurred in the upper end of the distribution. Prevalence of obesity (defined as BMI $\geq$ 85th percentile at year 1: men, 30.16 $kg/m^2$; women, 29.94 $kg/m^2$) increased by 0.6 percent/year ($p<0.11$) in men and by 1.0 percent/year ($p<0.003$) in women. The results indicated that body weight was increasing in upper mid-western adults, probably largely as a result of already overweight individuals becoming more obese. The secular increased in BMI was not accompanied by systemic change in reported food intake and exercise, and could not be explained by decreased prevalence of smoking. Large increased in body weight, especially among those who were already overweight, might be significant public health impact.

**Gullinford et al. (1992)** examined trends in body mass index in young adults in England and Scotland from 1973 to 1988; they selected 20 study areas (16 in England and four in Scotland) by stratified random sampling. They used a mixed longitudinal data of children's growth in their study and found that mean body mass index showed an annual increase of 0.10 (95% CI: 0.03-0.17%) per year of study for women. BMI also increased with increasing age and family size and was greatest for women with husbands in manual occupations. The secular trend in BMI in women was not explained by changes in the distribution of these variables. The proportion of women with BMI greater than 25 $kg/m^2$ increased over the study period. In men the secular trend in BMI was not quite significant in this age group [annual increase 0.05% (-0.01 to 0.12%)]. Their findings suggested that there had been an increase in the BMI of young women in England and Scotland over the years 1973 to 1988. This increase was not explained by changes in the age, parity, social class of the subjects sampled. Evidence of a trend in men was not found.

**Rauschenbach et al. (1995)** described the change in marital status on weight change over one year; they extracted data from the National Survey of Personal Health Practices and Consequences, a telephone survey of 2,436 adults interviewed twice approximately 1 year apart. Two statistical methods for analyzing weight change were compared, and both produced similar results: regression analysis of weight change and regression analysis of weight at follow-up controlling for baseline weight. Their findings revealed that women who entered marriage had greater weight change than women who remained married. Analysis of weight gain and weight loss separately showed that women who became married lost less weight than those who remained married. For men, there were no statistically significant relationships between marital change and weight change over a 1-year period. The results suggest gender differences might be existed in the rate of body weight change after marriage, with more immediate changes in women than men.

**Al-Isa (1997)** investigated the temporal changes in BMI, overweight and obesity between two periods, among adult Kuwaitis; the author received data from the two independent cross-sectional samples of Kuwaitis studied in 1980-81 and 1993-94. He used 2067 (896 men and 1171 women) and 3435 (1730 men and 1705 women) adults (aged $\geq$ 18 years), drawn from primary health care clinics and studied for nutritional assessment and for prevalence of obesity in 1980-81 and 1993-94, respectively. The author found that the mean BMI ($kg/m^2$) increased significantly ($p<0.001$) by 10.0 and 6.2% (2.5 and 1.7 $kg/m^2$) among men and women, respectively and he reported the prevalence of overweight and obesity (BMI>25 and >30 $kg/m^2$) increased by 20.6 and 15.4% and by 13.7 and 8.4% among men and women, respectively. After controlling for socio-demographic differences between the two study periods, the author also found that the mean BMI was 2.0 and 1.6 $kg/m^2$ higher in 1993-94 than in 1980-81 among men and women, respectively. Prevalence of overweight and obesity (BMI>25 and >30 $kg/m^2$) also increased among both genders between the two periods (OR=2.1, 95% CI: 1.7-2.7 and OR=1.9, 95% CI: 1.5-2.4, for men and OR=2.2, 95% CI: 1.6-3.0 and OR=1.4, 95% CI: -1.0-1.9, for women). This study concluded that

BMI, prevalence of overweight and obesity increased among Kuwaitis between 1980-81 and 1993-94, probably due to the effects of modernization, affluence, increased food consumption and the concomitant changes to sedentary lifestyles. The rate of temporal changes in BMI and obesity were higher, by comparison, in Kuwait than in selected other countries.

**Ortega et al. (1997)** established the relationships between concern regarding body weight and energy balance in a group of female university students from Madrid, Spain. They observed that all students with BMI $\geq 25$ kg/m$^2$ (6.2% of the total) described themselves as fat. 71.4% had, at some time, followed a weight-reduction diet. However, even among students with BMI <20 kg/m$^2$ (28.4% of the total), 2.9% thought themselves fat and 17.1% had at some time followed a slimming diet. This showed excessive concern over losing weight in some women. Estimated energy expenditure was similar to energy intake in students with BMI <20 kg/m$^2$. However, as BMI rose (with a corresponding increase in theoretical energy expenditure), the reported energy intake decreased. It was therefore likely that underestimation of energy intake increased with BMI (r=0.4498). These results indicated that a large percentage of the women studied would like to lose weight until they reach, or indeed exceed, the lower limit of the acceptable normal range. This could be a danger to their health. Underestimation of energy intake was found to increase with BMI, a phenomenon that should be kept in mind when designing diet studies.

**Yanai et al. (1997)** described BMI in Japanese adult's aged 18-69 years in 1993. They found that the geometric mean BMI and the prevalence of overweight in men were highest in the 30-39 years age groups. For women the maximum BMI and prevalence of overweight occurred in the decade 50-59 y. The cut-off points for overweight in that sample were 24.7 kg/m$^2$ for men and 22.6 kg/m$^2$ for women. These were considerably lower than the figures of 27.8 kg/m$^2$ and 27.3 kg/m$^2$ estimated for Americans. Their study suggested that the prevalence of overweight was increased as age increased in both sexes, especially in women.

**De Castro et al. (1998)** examined the secular trend of weight, height and obesity among young Portuguese males; they extracted data from the review of military census files conducted from 1960 to 1990. A progressive and significant increase in weight, height and BMI of the young male population was found between 1960 and 1990. They also found that for certain variables the increase was also statistically significant within a five-year period, as it was the case for height between 1965 and 1980 and for weight between 1985 and 1990. The increase in BMI experienced some minor fluctuation along the reference period; however, it was statistically significant between 1985 and 1990. The increase in weight and in BMI was greater in the highest percentiles and particularly noticeable between 1985 and 1990. The percentage of young males with BMI over 25 kg/m$^2$ was of 8.1% in 1960 and of 18.0% in 1990, while those having a BMI over 27 kg/m$^2$ varied between 3.6% and 6.4% in the same period, respectively. The percentage of young adult males with BMI higher than 25 kg/m$^2$ doubled between 1960 and 1990.

**Hulens et al. (2001)** studied trends in BMI among Belgian children, adolescents and adults from 1969 to 1996; they used cross-sectional and mixed longitudinal data in their study. In Belgian children, they found that the degree of overweight had increased between 1969 and 1993, and tracking of BMI was high in adolescence (r=0.77) and adulthood (r=0.69-0.91) and moderate from adolescence to adulthood (r=0.49). In Belgian males, they found that the probability of overweight at 40 y of age in the presence of overweight at different ages in adolescence was important (odds ratios 5.0-6.9). Their findings suggested that trends and tracking of BMI from

1969 until 1996 in Belgium indicated an increase in the degree of childhood overweight and obesity. Moreover, the risk of an overweight male adolescent becoming an overweight adult was substantial. Measures to restrict the Belgian overweight and obesity epidemic should be taken.

**Lahti-Koski et al. (2001)** described changes in BMI by birth cohort in eastern Finland adults aged 25-64 years; they extracted data from the six cross-sectional population surveys repeated in eastern Finland every fifth year between 1972 and 1997. They found that BMI increased with age was more prominent in women (4.2 $kg/m^2$ in 25 years) than in men (3.3 $kg/m^2$ in 25 years), and was very similar in all birth cohorts. In men, the BMI increased with age varied across cohorts. Among birth cohorts participating in each survey, the BMI increased over the 25 years period was most prominent (3.9 $kg/m^2$ in 25 years) in men born between 1943 and 1947. Among all birth cohorts, the strongest upward trend (0.2 $kg/m^2$ per year) was observed in men born between 1953 and 1957. Their findings suggested that weight gain with age had remained unchanged in women over the 25 years period, whereas in men, the younger the birth cohort, the more prominent was the BMI increased with age.

**Freedman et al. (2002)** examined trends and correlates of class III obesity in the United States adults; they extracted data from the Behavioral Risk Factor Surveillance System telephone survey between 1990 and 2000. They observed that the prevalence of class III obesity increased from 0.78% (1990) to 2.2% (2000). In 2000, class III obesity was highest among black women (6.0%), persons who had not completed high school (3.4%), and persons who are short. During the 11-year period, the median BMI level increased by 1.2 units and the $95^{th}$ percentile increased by 3.2 units. Their findings suggested that the prevalence of class III obesity was increasing rapidly among adults, because these extreme BMI levels were associated with the most severe health complications, the incidence of various diseases will increase substantially in the future.

**Torrance et al. (2002)** reported the secular trends in obesity and overweight among Canadian adults between 1970 and 1992; they extracted data from the three national health surveys Nutrition Canada Survey (1970-1972), Canada Health Survey (1978-1979) and Canadian Heart Health Surveys (1986-1992). Among men, they found that the proportion overweight and obese increased steadily from 1970-1972 to 1986-1992. Among women, there was a substantial increased in the proportion overweight and obese between 1970-1972 and 1978-1979, then an increased in proportion obese, but not overweight, between 1978-1979 and 1986-1992. Although the prevalence of obesity increased in all education levels, the sub-groups with the greatest relative increase were men in the primary education category, and women in the secondary and post-secondary between 1970-1972 and 1986-1992. An increase in the prevalence of obesity was greatest among current smokers and, to a lesser extent, among former smokers.

**de Vasconcelos and da Silva (2003)** determined the prevalence rates for overweight and obesity in Northeast Brazilian male adolescents from 1980 to 2000; they received data from the Brazilian Army database. They reported that an upward curve was identified, showing that the secular tendency in the last twenty years increased for both overweight and obesity. The upward trend in overweight and obesity prevalence rates was observed in all States of Northeast Brazil. Although lower prevalence rates were observed than in developed countries, the speed of increase was cause for concern.

**Okasha et al. (2003)** studied the trends in BMI in Glasgow Alumni cohort from 1948 to 1968; they extracted data from the young adults attending Glasgow University.

They found that the mean BMI increased from 1948 to 1968 in men, and decreased slightly in women. The proportion of men who were overweight increased, whereas that of women changed little. These data might be interpreted in light of the fact that the study participants were relatively affluent, and not representative of the whole population in terms of socioeconomic position in childhood. The increases of BMI in men evident from 1948 to 1968 suggested that recent changes in exercise and dietary patterns did not fully explain changes in body weight over time.

**Sobal et al. (2003)** described the body mass index of American adults; they extracted data from the US National Health and Nutrition Epidemiological Follow-up Survey (NHEFS). They used longitudinal national data in their study and found that men's and women's weights were differently associated with marital changes. Women who were unmarried at baseline and married at follow-up had greater weight change than those who were married at both times. They also analyzed of weight loss and weight gain separately revealed that socio-demographic variables, including marital change, were more predictive of variation in weight loss than weight gain. They also reported that unmarried women who married gained more weight than women married at both times. Men who remained divorced/separated and men who became widowed lost more weight than men married at both baseline and follow-up. Their findings suggested that changes in social roles, such as entering or leaving marriage, influence physical characteristics such as body weight.

**Al-Lawati and Jousilahti (2004)** determined the prevalence of overweight and obesity in Omani citizens aged $\geq 20$ years; they used data that was collected by two national cross-sectional surveys conducted in 1991 and 2000. In the year 2000, they found that the age adjusted prevalence of obesity reached 16.7% in men, compared to 10.5% in 1991 ($p<0.001$) and in women, the prevalence was 23.8% in 2000, compared to 25.1% in 1991 (p<0.232). They also found that the prevalence of overweight increased among men, from 28.8-32.1% (p<0.012) and decreased among women, from 29.5-27.3% (p<0.054). When obesity and overweight were combined, there was a significant increase in men (9.5%; p for the change <0.001) and decrease in women (3.5%; p for the change <0.003). Obesity and overweight combined was markedly more common in the Southern part of Oman (70%) compared to Northern areas (32-57%). People living in urban areas were more obese (21.1%) than those living in the rural communities (13.1%) (p<0.001). The results of this study suggested that the prevalence of obesity was high in Oman and has increased predominantly among men.

**Bendixen et al. (2004)** examined the secular trends in the prevalence of obesity and overweight in Danish adults between 1987 and 2001; they extracted data from a series of seven independent cross-sectional surveys. They reported the prevalence of obesity more than doubled between 1987 and 2001, in men from 5.6% to 11.8% (OR=2.3, 95% CI: 1.9-2.8, p<0.0001) and in women from 5.4% to 12.5% (OR=2.6, 95% CI: 2.1-3.2, p<0.0001), with the largest increase among the 16- to 29-year-old subjects (men, from 0.8% to 7.5%; OR=10.2, 95% CI: 4.1-25.3, p<0.0001; women, from 1.4% to 9.0%; OR=7.0, 95% CI: 3.5-14.1, p<0.0001). Between 1987 and 2001, they also reported the prevalence of overweight increased from 34% to 40% in men and from 17% to 27% in women. Their findings suggested that the prevalence of overweight and obesity in Denmark has increased substantially between 1987 and 2001, particularly among young adults, a development that resembles that of other countries. There was clearly a need for early preventive efforts in childhood to limit the number of obesity-related complications in young adults.

**Nobre et al. (2004)** assessed the trends in height, weight and BMI in young men in Portugal; they got data from military census records of medical inspections 1994-95 and 1998-99. The results of their study showed an increase of weight, height and BMI between 1995 and 1999 ($p<0.001$). In 1995 the percentage of men with a BMI equal or higher than 25 was 15% and in 1999 was 22%. The percentage of men with a BMI higher than 30 was 1.4% and 2.3%, respectively. Their findings suggested that obesity and overweight prevention programs and therapeutic strategies must continue to be a major issue in health politics.

**Berg et al. (2005)** studied the secular trends in overweight and obesity aged 25-64 years from 1985 to 2002 in Göteborg, Sweden; they got data from the cross-sequential population-based surveys that were conducted by WHO-MONICA (1985, 1990, 1995) and the INTERGENE (2002). They found that the mean body weight increased by 3.3 kg for women and 5 kg for men, with a significant upward trend for BMI in men but not women over the 17-y observation period. They found the prevalence of overweight and obesity increased significantly in both sexes over the period. The largest increase was observed in men, and in women aged 25-34 y. In 2002, the prevalence of overweight was 38% in women and 58% in men, and the prevalence of obesity was 11% in women and 15% in men. No significant secular trends were observed for waist-to-hip ratio (WHR), but there was an upward trend in prevalence of WHR >0.85 in women. They also found a decreased prevalence of smoking in both sexes together with an increase in reported leisure time physical activity. No significant secular trends were observed in rates of self-reported diabetes, although the risk of diabetes attributable to obesity was 24%. Their findings indicated that 25-64-y-olds in the recent survey were more overweight and obese than earlier studied MONICA participants. The increase in BMI was more pronounced in men while abdominal obesity increased principally in women. Although obesity and overweight were clearly important risk factors for type 2 diabetes, the number of diabetics remains low and any secular increase was not yet apparent.

**Dal Grande et al. (2005)** studied obesity in South Australian adults; they collected data from the face-to-face interviews of representative population samples of people aged 18 years and over living in South Australia from 1991 to 1998 and again in 2001 and 2003. They found that the proportion of respondents classified as obese according to their self-reported body mass index (BMI $\geq$ 30 to <35) increased significantly from 8.7% in 1991 to 14.1% in 2003 ($\chi^2$=79.4, p<0.001). Severe obesity (BMI $\geq$ 35) increased significantly from 2.6% in 1991 to 5.3% in 2003 ($\chi^2$=50.4, p<0.001). Current prevalence trends indicated that by 2013, the self-reported prevalence of obesity in South Australian adults would be 27.8%, with the prevalence in males being 26.4% and in females, 29.3%. Secular obesity trends indicated that younger birth cohorts had the greatest percentage increases. Their findings suggested that obesity had increased significantly between 1991 and 2003, and was increasing fastest among younger adults. Multi factorial interventions at all levels of the population were required to prevent overweight and obesity and promote weight maintenance, weight loss and address the health burden of obesity.

**Ali and Lindstrom (2006)** studied several determinants of BMI in Scanian young women; they extracted data from the 2000 public health survey. They used the cross-sectional data in their study and the logistic regression model adjusted for age was used to investigate the association between socioeconomic, psychosocial, health behaviour, self reported global and psychological health, locus of control, and the BMI categories. They found that the 17.5% proportion of the women, aged 18-34 years, were underweight (BMI<20.0), 18.4% were overweight, and 7.0% obese. The prevalence of underweight according to the BMI <18.5 definition was 5.8% among women aged 18-34 years. Women who were underweight had significantly higher odds ratios for overtime work, being students, low emotional support, and poor self reported global as well as poor psychological health than normal weight women. Women who were overweight/obese were unemployed, had low education, low social participation, low emotional and instrumental support, were daily smokers, had a sedentary lifestyle, had poor self reported global health, and had lack of internal locus of control compared with normal weight women. Their findings suggested that underweight women were more likely to have poorer psychological health than normal weight women. In contrast, overweight and obese women were more likely to have poor health related behaviours and lack of internal locus of control compared with normal weight women. These differing patterns suggested both different etiology and different preventive strategies to deal with the health risks of people who were underweight as opposed to those who were overweight or obese.

**Bianka Caliman et al. (2006)** studied trends in growth in Brazilian male adolescents; they extracted data from the list for Armed Services in the city of Viçosa-Minas Gerais, Brazil, between 1995 and 2004. They found that there was a positive secular trend for height and weight, with a 4 cm and 3 kg median increment, respectively, along time. There was a reduction from 28.0% to 11.6% on the prevalence of short stature in the period. It was estimated positive correlation ($p<0.05$) between education and stature, weight and BMI. The prevalence of weight excess (risk of overweight and overweight) increased from 7.1% (1995) to 9.1% (2004). Although it was observed positive secular trend for stature and weight, it was not sufficient to reach the median of the National Center for Health Statistics/Center for Disease Control and Prevention. Weight excess and short stature prevalence must be monitored, being necessary the implementation of measures that focus to prevent these disturbance and aim at reaching or maintaining an adequate nutritional state for future generations.

**Bharati et al. (2007)** investigated the prevalence and causes of chronic energy deficiency (CED) and obesity in Indian women; they extracted data from the Indian National Family Health Survey, 1998-1999. A multiple linear regression analysis was applied to see the relation between nutritional status of women and different socioeconomic factors. Their data revealed that the prevalence of CED, overweight, and obesity in India were 31.2%, 9.4%, and 2.6%, respectively. The incidences of CED and obesity were negatively related. The prevalence of CED was the lowest in Arunachal Pradesh and highest in Orissa. Punjab had the highest prevalence of obesity, and Bihar had the lowest. For the zone wise distribution the Northeast zone had the lowest degree of prevalence of CED and the East zone was at the bottom of the list with the highest degree of malnutrition. They also found that the nutritional status of women went together with the enhancement of their educational status, standard of living, and so on. There were also significant differences between rural and urban sectors and among castes, religions, and occupations. Furthermore, regression analysis showed that all the socioeconomic variables considered here significantly affect BMI in Indian women.

**Ji et al. (2007)** analyzed the secular growth trends of the Chinese urban youth from 1979 to 2005. They found that the overall increments were 6.5 and 4.7 cm for stature, and 8.9 and 5.2 kg for weight, for boys and girls, respectively. Swiftest rates were found in the period of 1985-1995, with the increments which were as high as 3.8 and 3.0 cm/decade for height, and 4.7 and 3.1 kg/decade for weight, for boys and girls respectively. They mentioned puberty played the most contributing role in those trends, with the peak height rates being 2.4 cm/decade for girls at the age of 12 and 3.3 cm/decade for boys at the age of 14, respectively. The increments of adult height were 3.2 and 2.1 cm, while the rates were 1.2 and 0.8 cm/decade, for males and females, respectively. The distributing curves of BMI showed an accelerating tendency of going to the right side, which suggested that, the prevalence of childhood obesity was increasing rapidly. Their findings suggested that China was experiencing an overall and positive secular trend, which was reflected not only by the accelerating physical growth in childhood, advanced puberty, and steady increments of adult height, but also by the dramatic changes of body shape. They should not only feel proud of the achievements of those secular growth changes and the active socioeconomic influences, but also pay much attention to their negative effects, especially those that may induce the dangers of hypertension, hyperglycemia, type 2 diabetes mellitus and other adulthood diseases, as well as the disease risks of metabolic syndrome that may even occur early in childhood and adolescence.

**Mascie-Taylor and Goto (2007)** studied human variation and BMI and they found that on average, women were more obese than men, while men were more likely to be pre-obese than women. Urban rates of overweight and obesity were generally higher than rural rates in both sexes. The trend in pre-obesity and obesity over time was generally upward, with very marked increases in the USA and UK in both sexes over the last 10 years.

Secular trends in obesity and related lifestyle factors were reported by **Lissner et al. (2008)** in two generations of 38- and 50-year old Swedish women; they selected samples from population registries. They found that the weight, height, waist circumference, waist-hip ratio, triceps and sub-scapular skinfold measures were all significantly higher in later-born cohorts, although BMI and obesity were not significantly changed. They also found higher sodium excretion was observed among later-born sub-groups, consistent with reports of increasing salt preference. Lower proportions of energy as fat and sucrose, but higher carbohydrate, protein and fiber concentrations were reported by later-born cohorts. There were shifts towards increased frequency of wine and liquor consumption, but decreased beer. Leisure time physical activity and perceived stress levels both increased significantly over 36 years. Their findings suggested that increases in subcutaneous and abdominal fatness were detected without significantly increasing BMI; while some aspects of diet showed improvement, increases in salt preference and sodium excretion were cause for concern.

**Aekplakorn and Mo-Suwan (2009)** described the prevalence of obesity in Thailand; they extracted data from the three consecutive National Health examination surveys (NHES). They got the result that the prevalence of obesity with body mass index $\geq 25$ $kg/m^2$ in adults increased from 13.0% in men and 23.2% in women in 1991 to 18.6% and 29.5% in 1997 and 22.4% and 34.3% in 2004 respectively. They also got the result that the obesity prevalence in children, using weight for height criteria, increased from 5.8% in 1997 to 7.9% in 2001 for the 2-5-year-olds and from 5.8% to 6.7% for the 6-12-year-olds. They concluded that the disproportionate increases of obesity in the rural area, which indicates the problem no longer restricts to the higher socioeconomic group.

**Chen and Ji (2009)** studied secular changes in stature and weight for Chinese Mongolian youth from 1964 to 2005; they extracted data from the 1985, 1991, 1995, 2000 and 2005 cycles of the Chinese National Survey on Students' Constitution and Health aged 7-18 years. During the past 41 years, they found that the average rates of stature increments for 7- to 17- year-olds were 1.9 and 2.0 cm per decade, of weight were 2.2 and 1.5 kg per decade and of BMI were 0.5 and 0.3 kg/m$^2$ per decade, for males and females, respectively. The overall increments of stature in 18-year-old males and females from 1985 to 2005 were 2.3 and 2.1 cm, respectively. The rate of change of stature was stronger in the first three decades, while that of weight and BMI were greater in the last decade. Evidence strongly suggested that changes may have occurred since the late 1970s. They concluded that the positive growth changes of Chinese Mongolian people were closely related to urbanization, socio-economic progress and living improvements.

**Lai and Yin (2009)** analyzed the relations of body mass index (BMI) and obese prevalence in differently aged women and explored the effective strategy for preventing obesity among adult Chinese women. They got data from the 2002 National Nutrition and Health Survey and the method of multi-steps cluster sampling was adopted. In urban areas, they found that the average body weights of unmarried, married and without childbearing experience, and the married with born-child were (53.7±9.0) kg, (57.6±9.4) kg and (54.5±8.5) kg respectively; the body weights of unmarried, married and without childbearing experience were significantly higher than that of the married with born-child women ($t=12.25$, $p<0.001$; $t=8.32$, $p<0.001$); the BMIs of unmarried, married without childbearing experience, and the married with born-child women were (21.1±3.3) kg/m$^2$, (22.8±3.4) kg/m$^2$ and (22.0±2.9) kg/m$^2$ respectively; the BMIs of married without childbearing experience and married with born-child women were significantly higher than that of unmarried women ($t=14.88$, $p<0.001$; $t=5.76$, $p<0.001$). On the other hand in the rural areas, they found that the body weights of unmarried, married without childbearing experience, and the married with born-child women were (52.3±7.8) kg, (55.3±8.6) kg and (52.8±8.1) kg respectively; the body weights of unmarried, the married with born-child women were significantly higher than that of married without childbearing experience (t=11.67, p<0.001; t=14.15, p<0.001); the BMIs of unmarried, married without childbearing experience, and the married with born-child women were (21.2±2.8) $kg/m^2$, (22.5±3.1) $kg/m^2$, and (21.8±3.0) $kg/m^2$ respectively; the BMIs of married and the married with born-child were significantly higher than that of unmarried women (t=13.80, p<0.001; t=5.34, p<0.001). In urban areas, the rate of low body weight of unmarried women (18.1%) was higher than that of married without childbearing experience and married with born-child group (7.3% vs. 9.1%; comparing with married without childbearing experience: $\chi^2$=113.69, p<0.001; comparing with married with born-child: $\chi^2$=29.65, p<0.001); the prevalence of overweight and obesity (32.7%) in married without childbearing was significantly higher than that of unmarried women (14.4%) ($\chi^2$=28.257, p<0.001). In rural areas, the rate of low body weight of unmarried women (12.4%) was higher than that of married without childbearing group (6.7%, $\chi^2$=50.040, p<0.001); however, the prevalence of overweight (22.4%) in the married without childbearing was significantly higher than that of unmarried women (12.3%) ($\chi^2$=69.119, p<0.001) and the married with born-child women (15.4%) ($\chi^2$=69.866, p<0.001). The prevalence of overweight and obesity of the married with born-child women was decreasing with extending time of postpartum in urban and rural areas. They concluded that weight retention of married with born-child women was one of the most important factors leading to the obesity in the adulthood. However, more attentions should be paid to the changing trend of body weight in the married without childbearing experience.

**Subramanian et al. (2009)** assessed whether burdens of underweight and overweight coexist among lower socioeconomic groups in Indian women aged 15-49 years; they received data from the 1998-1999 and 2005-2006 Indian National Family Health

Surveys. They observed that the ratio of underweight to overweight women decreased from 3.3 in 1998-1999 to 2.2 in 2005-2006, there were still considerably more underweight women than overweight women. It was only in the top wealth quintile and in groups with higher education that there was a slight excess of overweight women as compared with underweight women. There was a strong positive relation between socioeconomic status (SES) and BMI at both time points and across urban and rural areas. A positive relation between SES and BMI was also observed for men in 2005-2006. Their findings suggested that the distribution of underweight and overweight in India remained socially segregated. Despite rapid economic growth, India had yet to experience a situation in which underweight and overweight coexist in the low-SES groups.

**Cardoso and Caninas (2010)** examined differences in the secular trend of height, weight and BMI of 10-16-year-old boys in Lisbon, Portugal, in the early and late 20th century; they collect from the Colégio Militar military boarding school and the Casa Pia de Lisboa residential school. While boys from both schools showed an approximate increase of 13.6 cm in height, 13.5 kg in weight and 2.4 $kg/m^2$ in BMI, the Casa Pia students were shorter and lighter than their Colégio Militar counterparts throughout the 90-year period. Social class differences in mean height, weight and BMI tend to be greater in 1910 than in 2000, but results were statistically significant for height alone. When the two periods were taken together, Colégio Militar boys differ from their Casa Pia counterparts by approximately 6.4 cm in height, 4.8 kg in weight and 0.4 $kg/m^2$ in BMI. Both samples showed a considerable increase in height, weight and BMI but class differences in height, weight and BMI decreased slightly if at all, throughout the 90-year period. Their results suggested that socioeconomic disparities were persistent, having diminished only slightly since the early 20th century.

**Esteghamati et al. (2010)** investigated the secular trends of overweight and obesity among Iranian adults (25-64 years old) within an 8-year period (1999-2007); they extracted data from the National Health Survey (1999), National Surveys of Risk Factors for Non-Communicable Diseases (2005), and National Surveys of Risk Factors for Non-Communicable Diseases (2007). They used cross-sectional data in their study and found that the overall prevalence of obesity increased from 13.6% in 1999 to 19.6% in 2005 and 22.3% in 2007 (OR=1.08 per year; $p<0.001$). For overweight subjects, the rates were, respectively, 32.2%, 35.8% and 36.3% (OR=1.02 per year; $p<0.001$). During these years, the mean BMI increased from 25.03 in 1999, to 26.14 in 2005, and 26.47 in 2007 ($p<0.001$). The increase in prevalence of obesity was seen in both males (OR=1.09 per year; $p<0.001$) and females (OR=1.07 per year; $p<0.001$) and both urban (OR=1.07 per year; $p<0.001$) and rural (OR=1.10 per year; $p<0.001$) residents. Their findings highlighted that the growth of obesity was rapidly increased during recent years in Iran.

**Khan et al. (2010)** assessed secular trends in growth and nutritional status of Vietnamese adults in rural Red River delta after 30 years (1976-2006). The initial study in 1976 found that average height and weight of Vietnamese adults was similar to data collected by French experts Huard and Bigot in 1938. Hence, no noticeable secular trends were observed in almost 40 years. However, the 2006 follow-up study revealed a positive secular trend in growth of adults, aged 16-60 years. The average increased rate in height of males was up to 1.1 cm/decade in the age group 26-40 years and up to 2.7 cm/decade in the age group 16-25 years. In 2006, average dietary intake of fat and animal protein was higher than that found in 1976. The percentage of energy from fat in the diet increased from 6% in 1976 to 16% in 2006. Their study showed that Vietnam was entering the nutrition transition period.

**Nagai et al. (2010)** clarified the effect of age on the association between BMI and all-cause mortality among Ohsaki cohort in Japan. They used Cox proportional hazards regression analysis and observed that a significantly increased risk of mortality in underweight elderly men: the multivariate hazard ratio (HR) was 1.26 (0.92-1.73) in middle-aged men and 1.49 (1.26-1.76) in elderly men. They also observed that a significantly increased risk of mortality in obese middle-aged men: the multivariate HR was 1.71 (1.17-2.50) in middle-aged men and 1.25 (0.87-1.80) in elderly men. In women, there was an increased risk of mortality irrespective of age group in the underweight: the multivariate HR was 1.46 (0.96-2.22) in middle-aged women and 1.47 (1.19-1.82) in elderly women. There was no excess risk of mortality with age in obese women: the multivariate HR was 1.47 (0.94-2.27) in middle-aged women and 1.26 (0.95-1.68) in elderly women. They concluded that obesity was associated with a high mortality risk in middle-aged men, whereas underweight, rather than obesity, was associated with a high mortality risk in elderly men and in women, obesity was associated with a high mortality risk during middle age; underweight was associated with a high mortality risk irrespective of age. The mortality risk due to underweight and obesity may be related to sex and age.

**Walls et al. (2010)** analyzed changes in BMI of urban Australian adults from 1980 to 2000; they extracted data from the National Heart Foundation Risk Factor Prevalence Studies (1980, 1983 and 1989), the National Nutrition Survey (1995) and the Australian Diabetes, Obesity and Lifestyle Study (1999/2000). They found that the mean BMI was higher in 2000 than 1980 in all sex and age groups. The age-adjusted increase was 1.4 kg/m$^2$ in men and 2.1 kg/m$^2$ in women. The BMI distribution shifted rightwards for all sex and age groups and became increasingly right-skewed. The change between 1980 and 2000 ranged from a decrease of 0.04 kg/m$^2$ at the lower end of the distribution for men aged 25-34 years to an increase of 7.4 kg/m$^2$ at the higher end for women aged 55-64 years. While the prevalence of obesity doubled, the prevalence of obesity class III increased fourfold. Their findings suggested that in a large increased in the prevalence of obesity, particularly the more severe levels of obesity. It would be important to monitor changes in the different classes of obesity and the extent to which obesity interventions both shift the BMI distribution leftwards and decrease the skew of the distribution.

**Ahmed et al. (2012)** studied the trends in prevalence of overweight and obesity in Kuwaiti adults, and examined their association with selected socio-demographic and lifestyle factors; they extracted data from the National Nutrition Surveillance System from 1998 to 2009. They used cross-sectional data in their study and found that prevalence of BMI $\geq$25 kg/m$^2$ rose from 61·8 % and 59·3 % in females and males respectively, peaked in 2004-2005 (81·4 % and 79·2 %) and fell slightly in 2008-2009 (77·3 % and 77·4 %). Obesity prevalence in females exceeded males for all years and age groups; by 2009, it had increased by 11·3 % in males and 14·6 % in females. Overweight and obesity prevalence in both genders increased until 2004-2005 but fell thereafter, with significant falls for females in 2008-2009. Logistic and linear regression analyses confirmed these temporal changes for both prevalence and BMI in both genders. The odds of obesity increased with age until the fifth decade for both genders and then declined significantly for males. Education level was negatively associated with obesity prevalence in females, while participation in leisure-time exercise was negatively associated with obesity prevalence in males. They concluded that the combined prevalence of overweight and obesity (BMI≥25 kg/m$^2$) seemed to decrease from 2005 to 2009 among Kuwaiti adults.

**Bakhshi et al. (2012)** investigated the associations between some factors with weight gain across age groups in Iranian women aged 20-69 years; they extracted data from the National Health Survey in Iran. Proportional odds model was used to estimate the probability of BMI categorized as a function of education, economic index, workforce, smoking, marital status, and place of residence adjusted for age. For all covariates, they found that age was directly associated with overweight and obesity before 60 years of age. Among women aged 20-40 years, the rates of change in probabilities of overweight and obesity were highest. Among women, being inactive, with high economic index, married, being nonsmoker, in an urban residence, with lower educational attainment, all increased the probabilities of overweight and obesity. They concluded that women aged 20-40 years gained weight faster than other groups; and may need additional information and more support on how to reduce their risk for weight gain through positive health behaviors.

**Nasreddine et al. (2012)** examined and analyzed secular trends in the prevalence of overweight and obesity in Lebanese population; they extracted data from the two national cross-sectional surveys conducted in 1997 and 2009. Compared to 1997, they found that the mean BMI values were significantly higher in 2009 among all age and sex groups, except for 6-9 year old children. Whereas the prevalence of overweight appeared stable over the study period in both 6-19 year old population (20.0% vs. 21.2%) and adults aged 20 years and above (37.0% vs. 36.8%), the prevalence of obesity increased significantly (7.3% vs. 10.9% in 6-19 year olds; 17.4% vs. 28.2% in adults), with the odds of obesity being 2 times higher in 2009 compared to 1997, in both age groups (OR=1.96, 95% CI: 1.29-2.97 and OR=2.01, 95% CI: 1.67-2.43, respectively). Their findings highlighted an alarming increase in obesity prevalence in the Lebanese population.

**Xi et al. (2012)** examined the trends in BMI, waist circumference (WC) and prevalence of overweight (BMI 25-27.49 kg/m$^2$), general obesity (BMI≥27.5 kg/m$^2$) and abdominal obesity (WC≥90 cm for men and WC≥80 cm for women) among Chinese adults; they extracted data from the China Health and Nutrition Survey conducted from 1993 to 2009. They reported that mean BMI values increased by 1.6 kg/m$^2$ among men and 0.8 kg/m$^2$ among women; mean WC values increased by 7.0 cm among men and 4.7 cm among women. The prevalence of overweight increased from 8.0 to 17.1% among men ($p<0.001$) and from 10.7 to 14.4% among women ($p<0.001$); the prevalence of general obesity increased from 2.9 to 11.4% among men ($p<0.001$) and from 5.0 to 10.1% among women ($p<0.001$); the prevalence of abdominal obesity increased from 8.5 to 27.8% among men ($p<0.001$) and from 27.8 to 45.9% among women ($p<0.001$). Similar significant trends were observed in nearly all age groups and regions for both men and women. The prevalence of overweight, general obesity and abdominal obesity among Chinese adults had increased greatly during the past 17 years.

**Yates et al. (2012)** assessed the secular trends in the care of overweight and investigated the secular association between obesity with care of overweight in primary care and self-care of overweight among US non-pregnant adults; they got the data from the National Health and Nutrition Examination Survey (NHANES) III (1988-1994) and the Continuous NHANES (1999-2008). They founded the that the combined secular increased in the prevalence of overweight and obesity (BMI>25.0 kg/m$^2$) between 1994 and 2008 (56.1-69.1%), there was no secular change in the odds of being diagnosed overweight by a physician when adjusted for covariates; however, overweight and obese individuals were 40 and 42% less likely to self-diagnose as overweight, and 34 and 41% less likely to self-direct weight loss in 2008 compared to 1994, respectively. Physicians were also significantly less likely to direct weight loss for overweight and obese adults with weight-related comorbidities across time ($p<0.05$). Thus, the surveillance of secular trends revealed that the likelihood of physician- and self-care of overweight decreased between 1994 and 2008 and further highlights the deficiencies in the management of excess weight.

The maternal obesity trends in Egypt were observed by **Austin et al. (2013)**. They extracted data from the Egyptian Demographic and Health Surveys from 1995 to 2005. This research was aimed at documenting obesity trends and identifying the populations most at risk for obesity. A linear model was employed to seek associations between household wealth, urban/rural residence, governorate of residence, employment status, parity and age and increases in body mass index (BMI) among married Egyptian women between the ages of 15-49 using data from 1995 and 2005. Between 1995 and 2005, they showed that the mean BMI of women of reproductive age in Egypt increased from 26.31 to 28.52. Although there was an overall trend towards greater obesity between 1995 and 2005, older women residing in rural, poor households became obese at a faster rate than younger women residing in richer, urban households. Their studies were shown that household wealth was a key determinant of food consumption patterns. They concluded that rising obesity rates among the poor in developed countries were linked to the relatively cheap price of high-calorie, nutrient-poor foods. They also concluded that one factor that might be contributing to the rapid increases in obesity among the rural poor in Egypt was the subsidization of high-energy, low-nutritive value foods that form a larger part of the diet of poor, rural populations.

**Avila et al. (2013)** verified the secular trends of height, weight and body mass index (BMI) of Brazilian military schools students aged 18-20 years who were born between the 1920s and 1990s; they collect data from the files of two Army schools survey. During the evaluation period, they observed that the height increased 7.3 cm, weight 9.8 kg and BMI 1.8 kg/m$^2$. The most significant gains were observed in subjects born from the 1920s to the 1940s and the 1960s to the 1970s. They concluded that the secular trends of growth in military students born in the 20th century were positive in Brazil, although increases were not constant decade-by-decade.

**Badr et al. (2013)** assessed the prevalence of overweight and obesity among elderly Kuwaitis aged 50 or older, examine their socio-demographic correlates, and analyze the association between obesity and its co-morbidities; they extracted data from a cross-sectional face-to-face interview survey. They found that about 81% respondents were overweight of whom 46% were obese. Mean BMI was 30.0 (31.2 for women and 28.1 for men). Multinomial logistic regression analysis revealed that relatively young elderly Kuwaitis (50-59) were 1.7 and 2.2 times more likely to be overweight and obese, respectively, compared with those aged 70 or older. Married individuals had 2.3 times higher risk to be overweight or obese than non-married individuals. Women were 3.6 times more likely to suffer from obesity than men. Overweight and obesity were found to be independent risk factors for hypertension (OR=1.3 and 1.9, respectively), diabetes (OR=1.4), and osteoarthritis (OR=1.8 and 1.6, respectively). They concluded that prevalence of overweight and obesity were alarmingly high among elderly Kuwaitis. The associated disease burden is substantial. Stakeholders should address the problem and launch national extensive health-promoting campaigns targeting perceptible lifestyle changes.

**Binkowska-Bury et al. (2013)** investigated secular trends in body mass index among the young military population aged 19 years in Poland; they got data from the each medical record for all recruits reporting for examination between 2000 and 2010 to the Military Headquarters in south-east of Poland. They found that the secular trends in body mass index had changed significantly between 2000 and 2010. A statistically significant increase in both the prevalence of overweight (10.5% to 15.6%) and obesity (2.5% to 3.8%) were observed. However, the prevalence of underweight also increased from 8.3% to 10.2%.

**Gallus et al. (2013)** examined the trends and reported the prevalence of underweight, overweight, and obesity in Italian adults. They used data from five surveys conducted annually between 2006 and 2010, representative of the Italian adult population, including self-reported information on height and weight. They found that 3.1% of the Italian adult population was underweight (BMI, <18.5 kg/m$^2$; 0.8% men, 5.3% women), 31.8% overweight (25≤BMI<30 kg/m$^2$; 39.8% men, 24.4% women), and 8.9% obese (BMI≥30 kg/m$^2$; 8.5% men, 9.4% women). They observed no specific pattern of overweight/obesity across calendar years in men (multivariate prevalence ratios, PR, for 2010 vs 2006: 0.95; p for trend: 0.980) and a non-significant decreased trend in women (PR: 0.92; p for trend: 0.051). They also looked prevalence of overweight/obesity significantly increased with age (PRs for ≥65 vs 18-24 years: 2.01 in men, 2.65 in women), decreased with education (PRs for high vs low education: 0.79 in men, 0.54 in women), and was less frequent in single than in married adults (PRs: 0.85 in men, 0.78 in women) and overweight/obesity was significantly more frequent in adults from southern versus northern Italy (PRs: 1.13 in men, 1.32 in women) and in former versus never smokers (PRs: 1.23 in men, 1.19 in women). They did not find unfavorable trends in overweight and obesity prevalence across calendar years. However, there were specific subgroups of the population with elevated prevalence of overweight and obesity, mainly adults from southern Italy and less educated ones.

**Karageorgi et al. (2013)** reviewed the findings and methodology of studies on the prevalence, trends and risk factors of obesity in Kuwait; they got data from the PubMed database (1997-2012). Only 30% of studies used random sampling. The prevalence ($BMI \geq 30$) in studies with a nationally representative sample ranged from 24% to 48% overall and in adults >50 years was greater than 52%. Rates were significantly higher in women than those in men. Studies that examined trends showed an increase in obesity prevalence between 1980 and 2009. Multiple risk factors including socio-cultural factors were investigated in the studies; however, factors were only crudely assessed. Their findings suggested that there was a need for future studies, particularly surveillance surveys and prospective cohort studies utilizing advanced methods, to monitor trends and to comprehensively assess the factors contributing to the obesity epidemic in Kuwait.

**Okoh (2013)** explored the associations of socio-demographic factors with increased BMI among Nigeria women aged 20-49 years; the author got the data from 2008 NDHS. Chi-Square was used to compare categorical variables and multi-nominal logistic regression was used to examine for correlates in his study and he found that the prevalence of overweight (BMI 25 to 29.9 $kg/m^2$) and obesity ($BMI \geq 30$ $kg/m^2$) in this population were 18.1% and 7.1%, respectively. The prevalence of overweight/obesity was highest among Igbo women. Multivariable logistic regression revealed increased frequency of watching television, belonging to a particular ethnic group, having a tertiary education and increased parity as risk factors for increased BMI. His findings confirmed a high prevalence of overweight and obesity among Nigerian women and identified high risk groups for excessive weight gain.

**Orden et al. (2013)** assessed secular changes in physical growth and the current prevalence and trend of overweight/obesity in Argentinean school children; they got data from the two surveys conducted in 1990 and 2005-2007. They used one-way analysis of variance in their study and found that 6 and 12 year-old boys and girls were significantly heavier (1.2-3.2 kg) and had higher BMIs (0.7-1.0 $kg/m^2$) in 2005-2007 than in 1990. Significant differences in height were seen in 6 year old boys (1.5 cm) and 12 year old girls (1.3 cm). Overweight and obesity increased by 4.4% (OR=1.4, 1.1-1.8) and 5.9% (OR=4.3, 2.8-6.5), respectively; obesity being higher in younger children.

**Ancheta et al. (2014)** reported the prevalence of cardiovascular risk factors and diabetes increases with a body mass index of $\geq 23$ $kg/m^2$ in Filipino American women. They used the cross-sectional data in their study and found BMI correlated significantly with waist circumference ($p<0.0001$), systolic blood pressure ($p<0.0001$), diastolic blood pressure ($p<0.001$), fasting blood glucose ($p<0.05$), hemoglobin A1c ($p<0.001$), triglycerides ($p<0.001$), high sensitivity C-reactive protein ($p<0.001$) and high density lipoprotein -C ($p<0.001$). The prevalence of diabetes, decreased levels of high density lipoprotein-cholesterol, hypertension, elevated triglycerides, and high sensitivity C-reactive protein increased significantly ($p<.01-.001$) with BMI categories starting at BMI 23-24.9 $kg/m^2$. Their findings suggested that body mass index was an excellent predictor of elevated cardiovascular disease (CVD) risk factors in this population and the prevalence of most of these factors increased at BMIs as low as 23-24.9 $kg/m^2$ suggesting a need to investigated risk factors and CVD events as a function of BMI in larger studies of Filipino American women.

**Kriaucioniene et al. (2014)** assessed trends in BMI and in the prevalence of overweight and obesity among Lithuanian adults between 1994 and 2012; they extracted data from the ten biennial cross-sectional surveys of Lithuanian Health Behaviour Monitoring. They found that the most prominent increase in mean BMI was observed in the oldest age group (55-64 years) of men. A decrease in mean BMI occurred in the youngest age groups (20-34 and 35-44 years) of women. The proportion of overweight men increased from 47.0% to 62.5%, and the proportion of obese men from 10.6% to 19.0%. In women, the prevalence of obesity was similar in the first and in the last survey (19.0% and 20.5% respectively).

**Ogden et al. (2014)** reported the prevalence of childhood and adult obesity in the United States; they extracted data from the National Health and Nutrition Examination Survey (2011-2012). In 2011-2012, they found that the 8.1% (95% CI: 5.8%-11.1%) of infants and toddlers had high weight for recumbent length, and 16.9% (95% CI: 14.9%-19.2%) of 2- to 19-year-olds and 34.9% (95% CI: 32.0%-37.9%) of adults (age-adjusted) aged 20 years or older were obese. Overall, there was no significant change from 2003-2004 through 2011-2012 in high weight for recumbent length among infants and toddlers, obesity in 2- to 19-year-olds, or obesity in adults. There was a significant decreased in obesity among 2- to 5-year-old children (from 13.9% to 8.4%; $p<0.031$) and a significant increased in obesity among women aged 60 years and older (from 31.5% to 38.1%; $p<0.007$). Their findings suggested that overall; there have been no significant changes in obesity prevalence in youth or adults between 2003-2004 and 2011-2012. Obesity prevalence remains high and thus it was important to continue surveillance.

**Robles et al. (2014)** described the prevalence of overweight and obesity among low-income women in rural West Virginia (WV) and urban Los Angeles County (LA County); they got data from the National Communities Putting Prevention to Work program during 2010-2012. They performed multivariable regression analyses to describe the relationships between overweight and obesity and selected covariates (e.g., dietary behaviors) and they found that overweight and obesity were prevalent among low-income women from WV (73%, combined) and LA County (67%, combined). In both communities, they also found that race and ethnicity appeared to predict the two conditions; however, the associations were not robust. In LA County, for example, African American and Hispanic women were 1.4 times (95% CI: 1.12-1.81) more likely than white women to be overweight and obese. Collectively, these subpopulation health data served as an important guide for further planning of obesity prevention efforts in both communities. These efforts became a part of the subsequent Community Transformation Grants portfolio.

**Wang et al. (2014)** determined trends in health status over a 10-year interval in a high-risk remote Australian Aboriginal community aged five years or older; they got data from the health surveys conducted from 1992 to 1997 and from 2004 to 2006. In the second survey, they observed that birth weights tended to be higher, and there were significant increases in heights of adolescents and young adults, and high density lipoprotein cholesterol (HDL-C) levels generally. Young adult males were lighter, had lower measurements for waist circumference and blood pressure and less frequently had overt-albuminuria, while elevated blood pressure was less common in older males. However, females ≥15 years had higher measurements for waist circumference, waist to hip ratio (WHR), body mass index (BMI) and diastolic blood pressure and a higher proportion of diabetes, notably in those aged older than 45 years. Males aged 15-24 years were less likely to be smokers while women aged less than 45 years were more often current drinkers.

**Zajc Petranović et al. (2014)** evaluated how socioeconomic conditions influence the growth during the adolescence, they tracked the body size of 15-19 year-olds over the last sixty years covering the socialist period (1951-1990), the war (1991-1995) and the transition to capitalistic economy (1996-2010) in Croatia. They observed that from 1951 to 2010 the girls' height approximately increased by 6.2 cm and weight by 6.8 kg, while the boys' height increased by 12.2 cm and weight by 17.3 kg. Prior to 1991 mean BMI in girls was higher than in boys, but from 1991 on, the interrelation between the sexes had been opposite, possibly mirroring the cultural trends that started in mid-1970s and reflecting higher sensitivity of boys to the socio-economic changes. Their findings suggested that the secular trend in body size over the investigated period reflected the positive economic trends interrupted by the war.

### 3.2.2 Bangladeshi studies

**Pryer et al. (2004)** identified socio-economic demographic and environmental factors that predict better height-for-age for children under 5 years of age in a Dhaka slum population in Bangladesh; they extracted data from a panel survey conducted between 1995 and 1997. They observed that 31% of children had height-for-age Z-score > -2. Logistic regression adjusted for cluster sampling showed that better nourished children were more likely to have taller mothers, to be from female-headed households and from families with higher income, electricity in the home, better latrines, more floor space and living in Central Mohammadpur. Better nourished children were less likely to have fathers who have taken days off from work due to illness.

**Sarkar and Taylor (2005)** determined the duration of lactation which was associated with weight loss in rural Bangladeshi mothers aged 18-40 years. They used cross-sectional data in their study and found that the mean difference in body-weight and body mass index (BMI) of lactating mothers who breastfed their children up to 24 months was significantly lower compared to non-lactating mothers of the same age group, but no differences were observed for those who breastfed beyond 24 months. The frequency of consumption of principal food items was comparable between the non-lactating and the lactating mothers who breastfed beyond 24 months. multiple linear regression analysis demonstrated that body-weight of mothers was negatively correlated with 1-12 month(s) and 13-24 months of lactation after controlling for height, education, and food consumption (slope -1.04, $p<0.05$ and slope -1.23, $p<0.05$ respectively). Height and consumption of meat and milk were significantly positively correlated with body-weight (slope 0.53, $p<0.001$; slope 1.44, $p<0.001$; and slope 0.75, $p<0.05$ respectively). The study concluded that Bangladeshi women who breastfed up to 24 months were of lower weight than non-lactating mothers, most likely due to the effect of lactation. These mothers were not taking any additional foods during their lactating period. Based on the findings of the study, it was recommended that mothers consume additional energy-rich foods during the first 24 months of lactation to prevent weight loss.

**Pryer and Rogers (2006)** identified socioeconomic, demographic and environmental factors that predict under nutrition in adults in a Dhaka slum population in Bangladesh; they got data from a panel survey conducted between 1995 and 1997. There was a sex difference with female adults having a significant odds ratio for low BMI compared with male adults ($p<0.03$). There was no difference by age for males, but there was a difference by age for female adults, with women aged 30-39 and 40-

49 years having the worst BMI ($p<0.04$; $p<0.04$). The Beri Bahd area of residence had the worst BMI ($p<0.001$). Deficit situation as the self-reported financial situation had the worst BMI ($p<0.03$). Casual wage workers, unskilled and dependent self-employed individuals had the worst BMI ($p<0.005$; $p<0.003$). Not being involved in credit organizations and NGO credit organizations was associated with worst BMI ($p<0.008$; $p<0.03$). Those households that had an income of 2000-2499 Taka had the worst BMI ($p<0.07$). Households with a floor area of 5 $m^2$ or more per consumption unit had the best BMI ($p<0.01$). Households without electricity had the worst BMI ($p<0.007$). Households with tube well water had the worst BMI compared with those with tap water ($p<0.001$).

**Shafique et al. (2007)** explored trends of under- and overweight in Bangladeshi women; they extracted data from the Nutritional Surveillance Project during 2000-2004. They found that while the prevalence of chronic energy deficiency (CED, BMI<18.5 $kg/m^2$) continued to be major nutritional problem among Bangladeshi women (38.8% rural, 29.7% urban poor; $p<0.001$), between 2000-2004, 9.1% of urban poor and 4.1% of rural women were overweight (BMI $\geq$ 25 $kg/m^2$, $p<0.001$). In addition, 9.8% of urban poor and 5.5% of rural women were found to be 'at risk of overweight' (BMI 23.0-<25 $kg/m^2$). From 2000 to 2004, prevalence of CED decreased (urban poor: 33.8-29.3%; rural: 42.6-36.6%), while prevalence of overweight increased (urban poor: 6.8-9.1%; rural: 2.8-5.5%). The risk of being overweight was higher among women who were older and of higher socio-economic status. Rural women with at least 14 years of education had a 8.1-fold increased risk of being overweight compared with non-educated women [95% CI: 6.6-8.7]. Women living in houses of at least 1000 sq ft (93 $m^2$) were 3.7 times more likely to be overweight compared with women living in <250 sq ft (23 $m^2$) houses (95% CI: 3.2-4.3). Their findings suggested that the recent increase in overweight prevalence among both urban poor and rural women, along with high prevalence of CED, indicated the emergence of a double burden of malnutrition in Bangladesh.

**Khanam and Costarelli (2008)** investigated the attitudes on health and exercise in Bangladeshi women aged 30-60 years; they extracted data from the Borough of Tower Hamlets, East London. They found that 40% of the subjects were obese and the remaining 60% were overweight. The great majority of the subjects (96%) reported that they were only willing to take up exercise if they were referred to the gym by their GP as an alternative or additional treatment for their complaints. They would not exercise voluntarily. Even though all women in their sample were either overweight or obese, 16% of the subjects reported that they did not know if they were overweight and 20% thought that they were actually of normal weight. Most women identified swimming as the type of physical activity of preference, if they had to exercise, followed by slow walking, with running being the least enjoyed activity. The findings of this study suggested that Bangladeshi women took little regular exercise to improve their health, predominant because of certain cultural beliefs and attitudes. More needs to be done to encourage levels and types of exercise that would be more appropriate for this ethnic group.

**Li et al. (2008)** elucidated the effect of nutrition on organic arsenic (As) methylation in pregnant Bangladeshi women; they extracted data from Matlab, where people are chronically exposed to inorganic arsenic (iAs) via drinking water. They found that the median concentration of As in urine was 97 microg/L (range, 5-1,216 microg/L, adjusted by specific gravity). The average proportions of iAs, monomethylarsonic acid, and dimethylarsinic acid in urine in gestational week 8 were 15%, 11%, and 74%, respectively. Thus, the women had efficient As methylation in spite of being poorly nourished (one-third had BMIs<18.5 kg/$m^2$) and having elevated As exposure, both of which were known to decrease As methylation. The metabolism of iAs was only marginally influenced by micronutrient status, probably because women, especially in pregnancy and with low folate intake, have an efficient betaine-mediated remethylation of homocysteine, which was essential for an efficient As methylation. Their findings suggested that in spite of the high As exposure and prevalent malnutrition, overall As methylation in women in early pregnancy was remarkably efficient. The As exposure level had the greatest impact on As methylation among the studied factors.

**Balarajan and Villamor (2009)** examined trends in the prevalence of overweight-obesity and underweight among women of reproductive age in Bangladesh, Nepal, and India between 1996 and 2006 and identified socio-demographic correlates of overweight in the most recent survey; they extracted data from the 8 Demographic and Health Surveys. They found that the prevalence of overweight-obesity increased substantially in all countries. Comparing the first to the latest survey in Bangladesh, the prevalence of overweight-obesity increased from 2.7 to 8.9% [age and parity-adjusted prevalence ratio (PR): 2.42; 95% CI: 1.88-3.13]; in Nepal, from 1.6 to 10.1% [adjusted PR: 4.18; 95% CI: 3.00-5.83]; and in India, from 10.6 to 14.8% [adjusted PR: 1.28; 95% CI: 1.20-1.36]. These increases were observed in both rural and urban areas and were greater in rural areas. During their study period, the prevalence of underweight decreased substantially in Bangladesh and only modestly in Nepal and India. Overweight-obesity was positively related to age, higher socioeconomic status, and urban residence in all countries. They concluded that while the prevalence of underweight had remained high in Bangladesh, Nepal, and India, the prevalence of overweight-obesity in women of reproductive age had risen between 1996 and 2006.

**Khan and Kraemer (2009)** studied the factors influenced underweight, overweight and obese among ever-married non-pregnant urban Bangladeshi women; they extracted data from the Bangladesh Demographic and Health Survey 2004. They observed that a variety of adverse health outcomes such as diabetes mellitus, cardiovascular diseases, low birth weight, poor quality of life and higher mortality were associated with underweight, overweight and obese categories. Bivariable, factor and multinomial logistic regression analyses were performed in their study. They got the result that the prevalence of being underweight, overweight and obese among ever-married non-pregnant urban women in Bangladesh was 25.2 percent, 15.7 percent and 3.9 percent, respectively. Age, education, region of residence, marital status, current use of contraception and type of occupation were significantly associated with BMI categories. Adjusted multinomial logistic regression analysis indicated that women with a high socioeconomic status were significantly negatively associated with being underweight (OR=0.55, 95% CI: 0.48-0.63) but positively associated with being overweight (OR=1.70, 95% CI: 1.48-1.96) and obese (OR=2.48, 95% CI: 1.89-3.26), as compared to the women with normal BMI. In contrast, women who migrated from rural to urban areas showed a significantly positive association with being underweight (OR=1.15, 95% CI: 1.04-1.27) but negative associations with being overweight (OR=0.80, 95% CI: 0.71-0.89) and obese (OR=0.75, 95% CI: 0.62-0.92), when compared with women who did not migrate. They concluded that suitable interventions based on further studies were needed to reduce the prevalence of being underweight and overweight among ever-married non-pregnant urban women in Bangladesh. They also concluded that factors, viz. socioeconomic status, rural-urban migration and education, should be considered while developing interventional strategies to reduce the prevalence of extreme BMIs among women living in urban areas of Bangladesh.

**Hossain et al. (2010)** document secular trends in age at menarche and their association with anthropometric measures and socio-demographic factors in university students in Bangladesh; they extracted data from Rajshahi University using a stratified sampling technique. Multiple regression analysis was used to assess the association of age at menarche with adult anthropometric measures and various socio-demographic factors. They observed the mean and median ages of menarche were 13.12±1.16 and 13.17 years, respectively, with an increasing tendency among birth-year cohorts from 1979 to 1986. Menarcheal age was negatively associated with BMI ($p<0.01$), but positively associated with height ($p<0.05$). Early menarche was especially pronounced among students from urban environments, Muslims and those with better educated mothers. Increasing age at menarche might be explained by improved nutritional status among Bangladeshi populations. Early menarche was associated with residence location at adolescence, religion and mother's education.

**Pierce et al. (2010)** reported the association between BMI and mortality in Bangladeshi populations aged 18-75 years; they extracted data from the Health Effects of Arsenic Longitudinal Study (HEALS) in Araihazar, Bangladesh. They observed that low BMI was strongly associated with increased mortality in that cohort ($p<0.0001$). Severe underweight (BMI<16 kg/m$^2$; hazard ratio (HR) 2.06, CI: 1.53-2.77) and moderate underweight (16.0-16.9 kg/m$^2$; HR 1.39, CI: 1.01-2.90) were associated with increased all-cause mortality compared with normal BMI (18.6-22.9 kg/m$^2$). The highest BMI category (BMI$\geq$23.0 kg/m$^2$) did not show a clear association with mortality (HR 1.10, CI: 0.77-1.53). The BMI-mortality association was stronger among individuals with <5 years of formal education ($p<0.03$). They concluded that underweight was a major determinant of mortality in the rural Bangladeshi population.

**Hossain et al. (2012)** reported on changes in the BMI of married Bangladeshi women; they got data from the 2007 Bangladesh Demographic and Health Survey (BDHS). They also looked the trends in BMI among reproductive women over time. The mean BMI was 20.85 ± 3.66 kg/m$^2$, and a decreasing tendency in BMI was found among birth year cohorts from 1972 to 1992. It was also found that the proportion of underweight females has been increasing in those born during the last 20 years of the study period (1972 to 1992).

**Hossain et al. (2012)** observed trends in BMI of Bangladeshi university female students; they have been taken data from University of Rajshahi, Bangladesh conducted from July 2004 to May 2005. They used ANOVA technique in their study and observed that height, weight and BMI did not display significant difference among the birth year cohorts. By using regression technique they also observed that the weight and BMI showed slightly decreasing tendencies during the invested period. Their findings suggested that the slight decreasing tendency of BMI had been occurring for approximately about eight years in adult Bangladeshi female students.

## 3.3 Materials and Methods

Cross-sectional data were derived from the Bangladesh Demographic and Health Survey (BDHS) 1996-97, 1999-2000, 2004, 2007 and 2011 conducted from November 02, 1996 to March 11, 1997; November 10, 1999 to March 15, 2000; January 01 to May 24, 2004; March 24 to August 11, 2007 and July 08 to December 27, 2011 respectively. These are the national-level surveys represented with the various districts of Bangladesh. The sample unit of these study consisted of 45,572 married, currently non-pregnant Bangladeshi women. Ages at the time of measurements ranged from 15 to 49 years, with an average age of $30.11 \pm 9.041$ years. The survey collected socio-demographic, health and lifestyle information from each subject. In addition, body height and weight were measured. The sampling technique, survey design, survey instruments, measuring system and quality control have been described elsewhere (NIPORT, 2013). Body mass index was defined and calculated as the ratio of weight in kilograms to height in metres squared. Data from a sample of 59,949 married Bangladeshi women were collected by the 1996-97, 1999-2000, 2004, 2007 and 2011 BDHS. The data set was checked for outliers by the present authors using statistical techniques (Dunn & Clark, 1974), because these abnormal points can affect the interpretation of results (Stevens, 1996). Some missing values were also detected, and these cases were excluded. Pregnant women were also excluded in the present study. After removing outliers, cases with incomplete data, and excluding currently pregnant women, the data set was reduced to 45,572 for the analysis in the present study.

To find the trends in averages of height, weight and BMI over time, the sample was subdivided into 5 groups according to measurement years from 1996-97 to 2011. To examine the interclass variation of height, weight and BMI, a one-way analysis of variance (ANOVA) was utilized. The model corresponding to each variable is:

$$Y_{ij} = \mu + \beta_i + \varepsilon_{ij}, \; i = 1,2,...,p, \;\; j = 1,2,...,q,$$

where $Y_{ij}$ is the $j$th observation (response variable) for the $i$th measurement year; $\mu$ is the general mean effect; $\beta_i = \mu_i - \mu$ the additional effect of $i$th measurement year; $\mu_i$ is the average effect of $i$th measurement year; $\varepsilon_{ij}$ is the random error term, which follows normal distribution with mean zero (0) and variance ($\sigma^2$), $p$ is the number of years, and $q$ is the number of observations for each year. The ANOVA procedure is primarily concerned with testing the hypothesis $H_0: \ \beta_1 = \beta_2 = ... = \beta_p = 0$ or equivalently $\mu_1 = \mu_2 = ... = \mu_p = \mu$ by means of a single F-test. If the hypothesis of equality of year means is rejected, it may be concluded that there are differences among the year means. The standard assumptions of the ANOVA, randomness, normality and homogeneity of cohort variances were checked using the Kolmogorov–Smirnov non-parametric test, a normal probability plot, and the Levene test, respectively.

Again to find the trends in averages of height, weight and BMI over time, the sample was subdivided into 41 groups according to birth year cohorts from 1955 to 1995. To examine the interclass variation of height, weight and BMI, a one-way analysis of variance (ANOVA) was utilized. The model corresponding to each variable is:

$$Y_{ij} = \mu + \beta_i + \varepsilon_{ij}, \ i = 1,2,..., p, \ \ j = 1,2,..., q,$$

where $Y_{ij}$ is the $j$ th observation (response variable) for the $i$ th birth year cohort; $\mu$ is the general mean effect; $\beta_i = \mu_i - \mu$ the additional effect of $i$ th birth year cohorts; $\mu_i$ is the average effect of $i$ th birth year cohorts; $\varepsilon_{ij}$ is the random error term, which follows normal distribution with mean zero (0) and variance ($\sigma^2$), $p$ is the number of cohorts, and $q$ is the number of observations for each cohort. The ANOVA procedure is primarily concerned with testing the hypothesis $H_0: \ \beta_1 = \beta_2 = ... = \beta_p = 0$ or equivalently $\mu_1 = \mu_2 = ... = \mu_p = \mu$ by means of a single F-test. If the hypothesis of equality of cohort means is rejected, it may be concluded that there are differences among the cohort means. The standard assumptions of the ANOVA, randomness, normality and homogeneity of cohort variances were checked using the Kolmogorov-

Smirnov non-parametric test, a normal probability plot, and the Levene test, respectively.

To find the proportion of trends of women for each category of BMI, the BMI was subdivided into four classes according to most widely used categories of BMI for adults. These were: underweight (BMI $\leq$ 18.5 kg/m$^2$), normal weight (18.5<BMI<25 kg/m$^2$), overweight (25 $\leq$ BMI<30 kg/m$^2$) and obese (BMI $\geq$ 30 kg/m$^2$) (Hossain et al., 2012).

Finally, linear regression analysis was applied to detect the presence of trends in BMI among the birth year cohorts and polynomial model was fitted to the cohort data. All statistical analyses were performed using SPSS (verson 17.0).

## 3.4 Results

### 3.4.1 Descriptive statistics for married women in Bangladesh

Descriptive statistics used to calculate means and standard deviations of respondent's age, height, weight and BMI of married and currently non-pregnant Bangladeshi women are presented in current section. The descriptive statistics provide a useful description for data from any distribution; especially for quantitative variables.

A total sample of 45,572 married and currently non-pregnant Bangladeshi women were analyzed in this study. The age of subjects varied from 15 to 49 years with mean age 30.11 $\pm$ 9.041 years (95% CI: 30.03-30.20). The average height of the women was 150.60 $\pm$ 5.441 cm (95% CI: 150.55-150.65), ranging from 123.40 to 180.00 cm. Their average weight was 46.93 $\pm$ 9.236 kg (95% CI: 46.85-47.01), ranging from 24.80 to 99.30 kg. The BMI varied from 12.06 to 45.27 kg/m$^2$, with a mean of 20.65 $\pm$ 3.670 kg/m$^2$ (95% CI: 20.616-20.684). The mean age, height, weight and BMI of Bangladeshi married non-pregnant women by measurement year 1996-1997, 1999-2000, 2004, 2007 and 2011 was 25.91, 25.99, 30.64, 31.15 and 31.36 years; 150.14, 150.44, 150.54, 150.51 and 150.87 cm; 42.53, 44.05, 46.15, 47.38 and 49.09 kg; and 18.84, 19.43, 20.32, 20.87 and 21.52 kg/m$^2$, respectively (Table 3.1).

**Table 3.1:** Descriptive Statistics of age, height, weight and BMI of women by measurement years

| Variable | Measurement Year | N | Mean | SD | SE | 95% CI for mean | | Minimum | Maximum |
|---|---|---|---|---|---|---|---|---|---|
| | | | | | | Lower | Upper | | |
| Age (year) | 1996-1997 | 4036 | 25.91 | 6.543 | 0.103 | 25.71 | 26.11 | 15 | 49 |
| | 1999-2000 | 4671 | 25.99 | 6.597 | 0.097 | 25.80 | 26.18 | 15 | 49 |
| | 2004 | 10483 | 30.64 | 9.342 | 0.091 | 30.46 | 30.81 | 15 | 49 |
| | 2007 | 10125 | 31.15 | 9.286 | 0.092 | 30.97 | 31.33 | 15 | 49 |
| | 2011 | 16257 | 31.36 | 9.185 | 0.072 | 31.22 | 31.50 | 15 | 49 |
| | Total | 45572 | 30.11 | 9.041 | 0.042 | 30.03 | 30.20 | 15 | 49 |
| Height (cm) | 1996-1997 | 4036 | 150.14 | 5.614 | 0.088 | 149.96 | 150.31 | 123.40 | 180.00 |
| | 1999-2000 | 4671 | 150.44 | 5.420 | 0.079 | 150.29 | 150.60 | 129.30 | 178.30 |
| | 2004 | 10483 | 150.54 | 5.429 | 0.053 | 150.43 | 150.64 | 127.50 | 178.20 |
| | 2007 | 10125 | 150.51 | 5.442 | 0.054 | 150.40 | 150.62 | 126.50 | 176.40 |
| | 2011 | 16257 | 150.87 | 5.398 | 0.042 | 150.79 | 150.96 | 124.90 | 179.80 |
| | Total | 45572 | 150.60 | 5.441 | 0.026 | 150.55 | 150.65 | 123.40 | 180.00 |
| Weight (kg) | 1996-1997 | 4036 | 42.53 | 6.850 | 0.108 | 42.32 | 42.74 | 26.10 | 90.10 |
| | 1999-2000 | 4671 | 44.05 | 7.570 | 0.111 | 43.84 | 44.27 | 27.00 | 99.20 |
| | 2004 | 10483 | 46.15 | 8.821 | 0.086 | 45.98 | 46.32 | 24.80 | 99.30 |
| | 2007 | 10125 | 47.38 | 9.306 | 0.093 | 47.20 | 47.56 | 25.40 | 98.80 |
| | 2011 | 16257 | 49.09 | 9.725 | 0.076 | 48.94 | 49.24 | 26.50 | 99.00 |
| | Total | 45572 | 46.93 | 9.236 | 0.043 | 46.85 | 47.01 | 24.80 | 99.30 |
| BMI (kg/m$^2$) | 1996-1997 | 4036 | 18.84 | 2.664 | 0.042 | 18.76 | 18.92 | 12.37 | 40.32 |
| | 1999-2000 | 4671 | 19.43 | 2.937 | 0.043 | 19.35 | 19.51 | 13.24 | 42.66 |
| | 2004 | 10483 | 20.32 | 3.479 | 0.034 | 20.25 | 20.39 | 12.06 | 45.27 |
| | 2007 | 10125 | 20.87 | 3.710 | 0.037 | 20.80 | 20.95 | 12.14 | 43.74 |
| | 2011 | 16257 | 21.52 | 3.879 | 0.030 | 21.46 | 21.58 | 12.45 | 43.35 |
| | Total | 45572 | 20.65 | 3.670 | 0.017 | 20.62 | 20.68 | 12.06 | 45.27 |

### 3.4.2 ANOVA for height, weight and BMI

First we attempted to look the trends in height, weight and body mass index among the BDHS measurements years from 1996-1997 to 2011. Since the data of the current section has subdivided into measurement year, this facilitated a study of possible trends over time. The variation in height, weight and BMI among the measurement years from 1996-1997 to 2011 examined with the ANOVA. Before using ANOVA, it is necessary to ensure that the standard assumptions underlying the ANOVA model is satisfied. Consequently, the data were checked for randomness, normality and homogeneity. The Kolmogorov–Smirnov non-parametric test and the normal probability plot exhibited no serious problems concerning the normality of the data. In addition, the Levene test showed that the data were homogeneous. Thus, the data satisfied the standard assumptions of the ANOVA model. The ANOVA results demonstrated that the variations in height, weight and BMI of Bangladeshi women among the measurement years from 1996-1997 to 2011 were statistically significant ($p<0.001$) (Table 3.2).

**Table 3.2:** Analysis of variance results for height, weight and BMI of married Bangladeshi women by measurement years from 1996-1997 to 2011

| Variable | Source of variation | Sum of Squares | df | Mean Square | $F_{cal}$ -value | p-value |
|---|---|---|---|---|---|---|
| Height (cm) | Between Groups | 2311.29 | 4 | 577.82 | 19.55 | <0.001 |
| | Within Groups | 1346806.58 | 45567 | 29.56 | | |
| Weight (kg) | Between Groups | 200777.90 | 4 | 50194.47 | 620.41 | <0.001 |
| | Within Groups | 3686618.41 | 45567 | 80.91 | | |
| BMI ($kg/m^2$) | Between Groups | 34167.11 | 4 | 8541.78 | 671.43 | <0.001 |
| | Within Groups | 579692.98 | 45567 | 12.72 | | |

Fig.3.1 displays mean height of Bangladeshi women according to measurement years conducted from 1996-1997 to 2011. The height showed the increasing tendency with changing time (1996-1997, 1999-2000, 2004, 2007 and 2011).

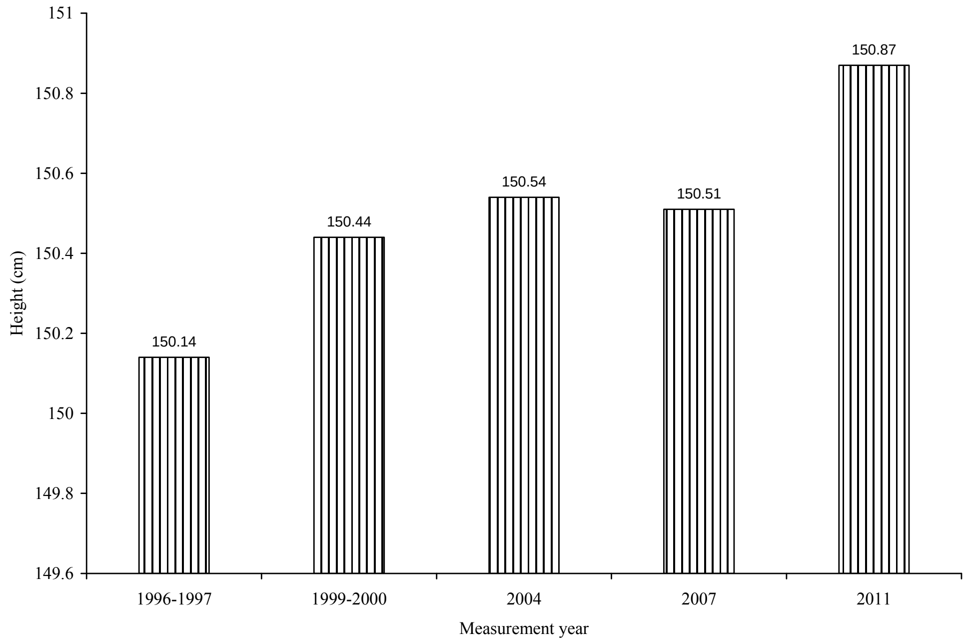


**Fig. 3.1:** Trend in height of Bangladeshi women according to the measurement years

The means of weight are depicted graphically in Fig. 3.2. This figure showed that the increasing tendency in weight of Bangladeshi women among measurement years cohorts from 1996-1997 to 2011.

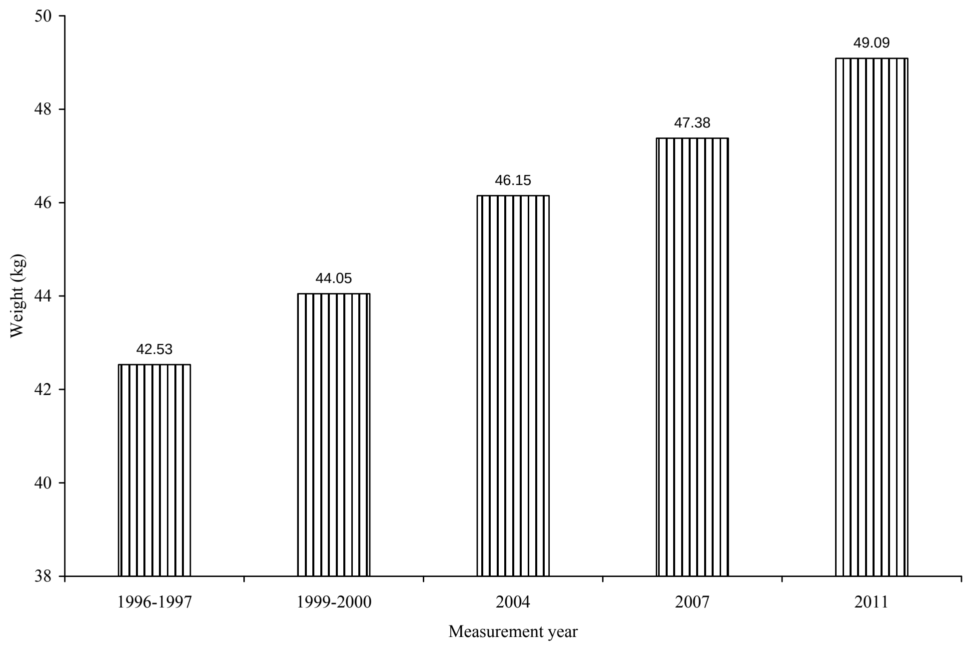


**Fig. 3.2:** Trend in weight of Bangladeshi women according to the measurement years

Fig. 3.3 displays mean BMI of Bangladeshi women according to measurement years conducted from 1996-1997 to 2011. The BMI showed the increasing tendency same as height and weight over time.

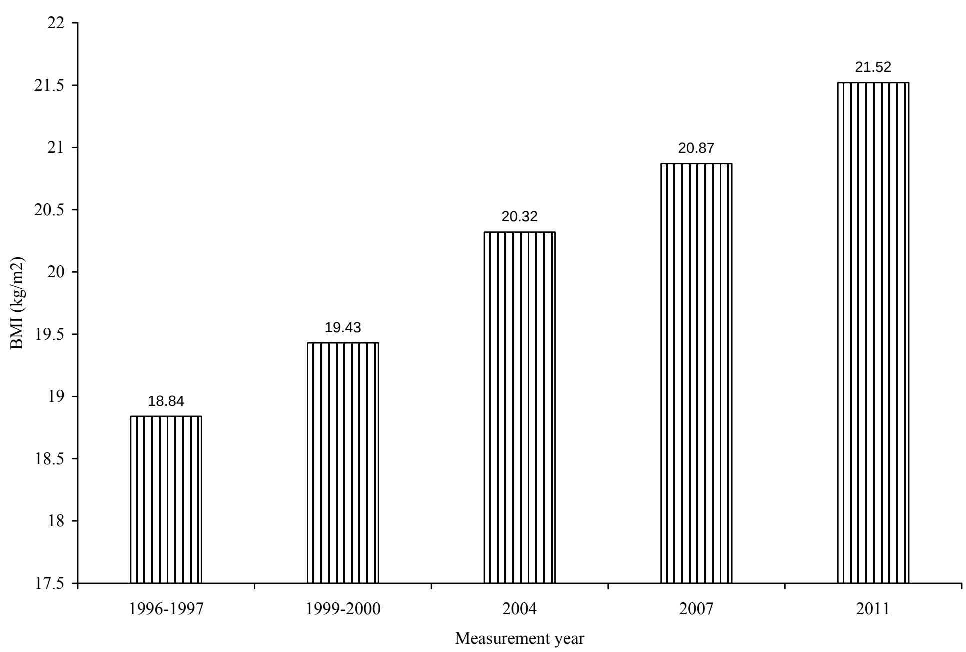


**Fig. 3.3:** Trend in BMI of Bangladeshi women according to the measurement years

### 3.4.3 Frequency distribution of BMI categories of married Bangladeshi women

The frequency distribution of body mass index (BMI) categories of married Bangladeshi women is presented in table 3. More than half of the participants in the current study were normal in weight (56.1%), and 31.4% were underweight. Some participants were overweight (10.4%) and a few were obese (2.1%) (Table 3.3).

**Table 3.3:** Frequency distribution of BMI categories of married Bangladeshi women (N=45,572)

| BMI category | n | % | Cumulative % |
|---|---|---|---|
| Underweight (BMI ≤ 18.5 kg/m$^2$) | 14332 | 31.4 | 31.4 |
| Normal weight (18.5 < BMI < 25 kg/m$^2$) | 25527 | 56.1 | 87.5 |
| Overweight (25 ≤ BMI < 30 kg/m$^2$) | 4740 | 10.4 | 97.9 |
| Obese (BMI ≥30 kg/m$^2$) | 973 | 2.1 | 100.0 |

### 3.4.4 Bivariate distribution of BMI categories of Bangladeshi women by measurement years from 1996-1997 to 2011

Table 3.4 displays the bivariate distribution of BMI categories of Bangladeshi women by measurement years conducted from 1996-1997 to 2011. Maximum proportion (percentage) of participants who were in underweight (51.3%) came from 1996-1997 measurement year where minimum proportion of participants (23.6%) came from 2011 measurement year. Similarly, minimum proportion (percentage) of obese participants (0.5%) came from 1996-1997 measurement year where maximum proportion of participants (3.1%) came from 2011 measurement year. Proportion of normal in weight, overweight and obese showed the increasing tendency with changing time but proportion of underweight showed the decreasing tendency with changing time (1996-1997, 1999-2000, 2004, 2007 and 2011).

**Table 3.4:** Bivariate distribution of BMI categories of ever married Bangladeshi women by Measurement Years (N= 45572)

| Measurement Year | Underweight | | Normal Weight | | Overweight | | Obese | | Total | |
|---|---|---|---|---|---|---|---|---|---|---|
| | N | % | N | % | N | % | N | % | N | % |
| 1996-1997 | 2069 | 51.3 | 1853 | 45.9 | 92 | 2.3 | 22 | 0.5 | 4036 | 100.0 |
| 1999-2000 | 2023 | 43.3 | 2407 | 51.5 | 204 | 4.4 | 37 | 0.8 | 4671 | 100.0 |
| 2004 | 3500 | 33.4 | 5886 | 56.1 | 918 | 8.8 | 179 | 1.7 | 10483 | 100.0 |
| 2007 | 2904 | 28.7 | 5832 | 57.6 | 1161 | 11.5 | 228 | 2.3 | 10125 | 100.0 |
| 2011 | 3836 | 23.6 | 9549 | 58.7 | 2365 | 14.5 | 507 | 3.1 | 16257 | 100.0 |
| Total | 14332 | 31.4 | 25527 | 56.0 | 4740 | 10.4 | 973 | 2.1 | 45572 | 100.0 |

### 3.4.5 Trends in various types of body size

Fig. 3.4 indicates the trend in various types of body size of Bangladeshi women during the measurement years conducted from 1996-1997 to 2011. A decreasing pattern in proportion of underweight women was observed from measurement years 1996-1997 to 2011. But the proportion of normal weight, overweight and obese individuals showed the increasing pattern over the same periods.

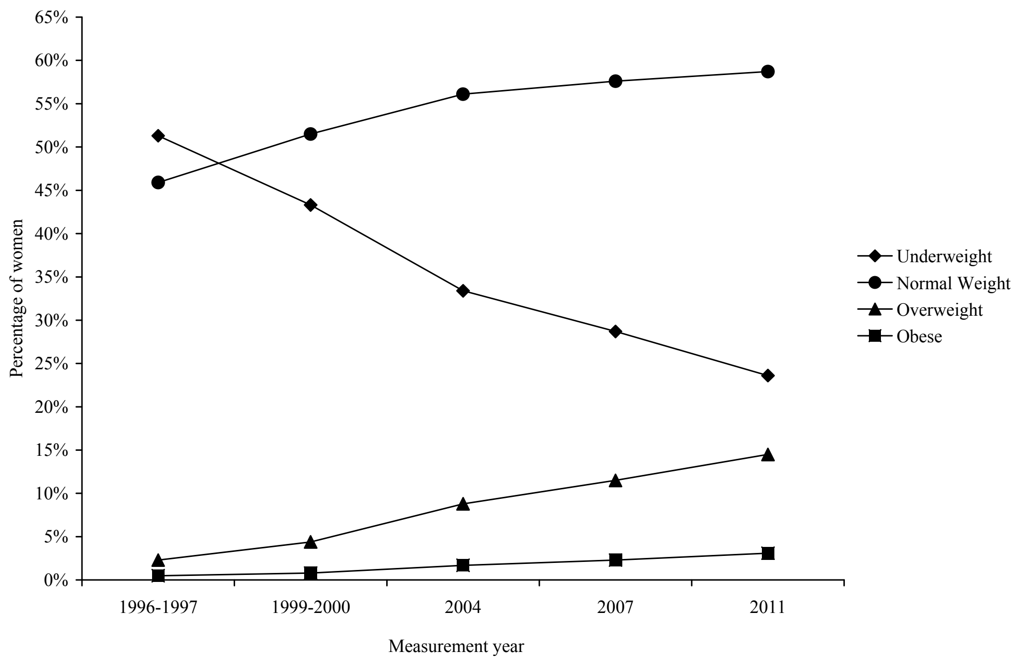


**Fig. 3.4:** Trend in body size of Bangladeshi women during the measurement years

### 3.4.6 Trends in various types of body size with age group

For looking trends the data of the current section has subdivided into four groups according to age of the women on the basis of reproductive pattern. Fig. 3.5 (a, b, c and d) indicated that the proportion of normal weight, overweight and obese women showed the increasing pattern with changing time but the proportion of underweight women showed the decreasing pattern with changing time (1996-1997, 1999-2000, 2004, 2007 and 2011) for various age groups ($\leq 19$, 20-29, 30-39 and $\geq 40$ years).

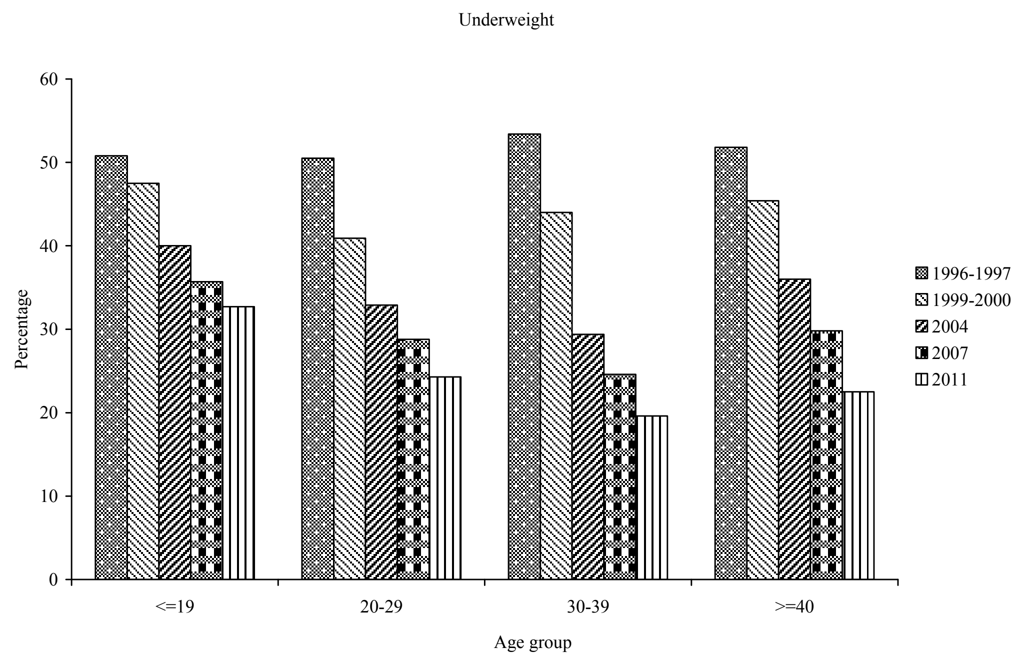


**Fig. 3.5(a):** Trends in underweight women over time with age group

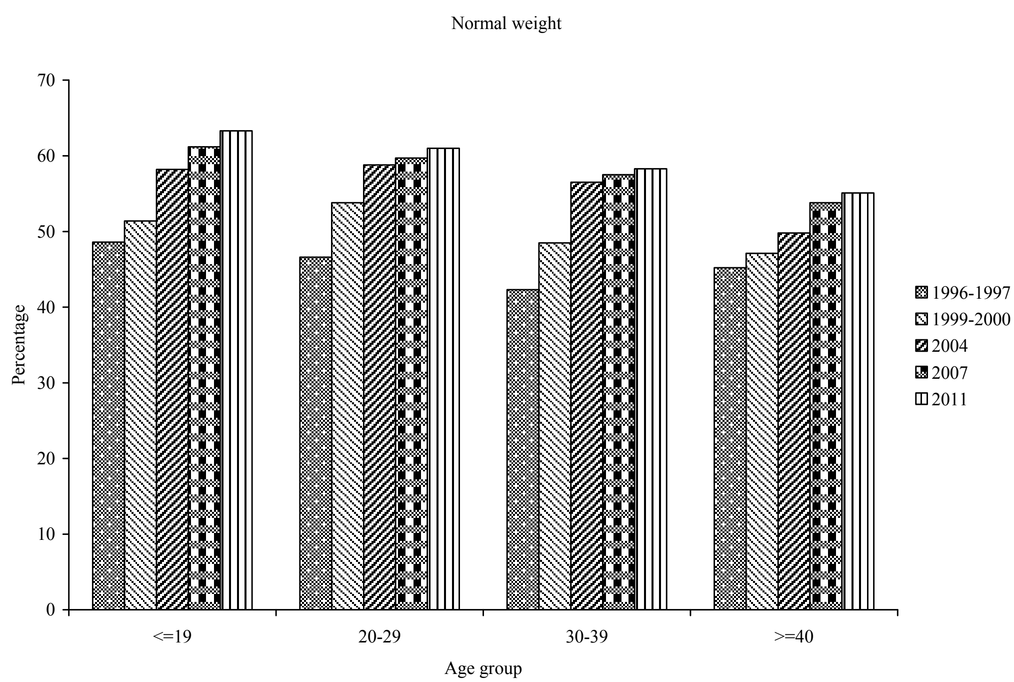


**Fig. 3.5(b):** Trends in normal weight women over time with age group

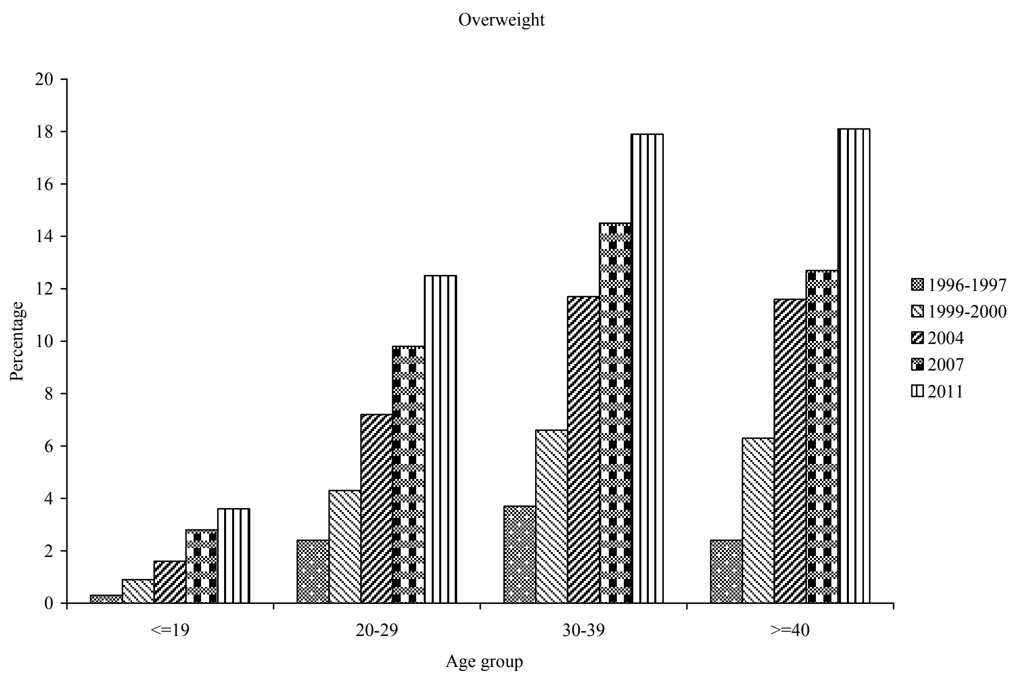


**Fig. 3.5(c):** Trends in overweight women over time with age group

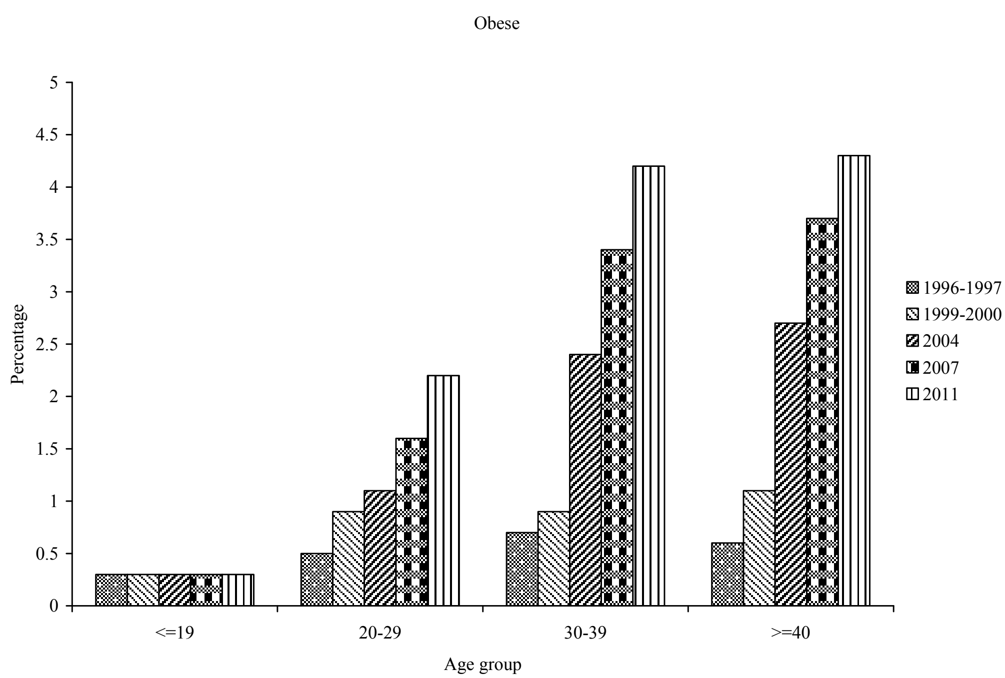


**Fig. 3.5(d):** Trends in obese women over time with age group

### 3.4.7 Break down by birth year cohorts

Again the data of the current section has subdivided into cohorts by birth year; this facilitated a study of possible trends over time. The variation in height, weight and BMI among the birth year cohorts from 1955 to 1995 examined with the ANOVA. Before using ANOVA, it is necessary to ensure that the standard assumption underlying the ANOVA model is satisfied. Consequently, the data were checked for randomness, normality and homogeneity. The Kolmogorov–Smirnov non-parametric test and the normal probability plot exhibited no serious problems concerning the normality of the data. In addition, the Levene test showed that the data were homogeneous. Thus, the data satisfied the standard assumptions of the ANOVA model. The ANOVA results demonstrated that the variations in height, weight and body mass index of Bangladeshi women among the birth year cohorts from 1955 to 1995 were statistically highly significant ($p<0.001$) (Table 3.5).

**Table 3.5:** Analysis of variance results for BMI of married Bangladeshi women by Birth year cohorts from 1955 to 1995

| Variable | Source of variation | Sum of Squares | df | Mean Square | $F_{cal}$ -value | p-value |
|---|---|---|---|---|---|---|
| Height (cm) | Between Groups | 3597.781 | 40 | 89.945 | 3.044 | <0.001 |
| | Within Groups | 1345520.088 | 45531 | 29.552 | | |
| Weight (kg) | Between Groups | 28424.539 | 40 | 710.613 | 8.384 | <0.001 |
| | Within Groups | 3858971.768 | 45531 | 84.755 | | |
| BMI (kg/$m^2$) | Between Groups | 5082.732 | 40 | 127.068 | 9.504 | <0.001 |
| | Within Groups | 608777.351 | 45531 | 13.371 | | |

### 3.4.8 Secular trends in BMI of Bangladeshi women over time (birth year cohort from 1955 to 1995)

To examine the presence of trends in BMI, polynomial regression coefficients were computed. The mean BMI values of the study population are depicted graphically in Fig. 3.6(a) by birth year cohort from 1955 to 1995. This figure showed yearly fluctuations in average BMI. This is a characteristic of such cohort study. There was an increasing trend during the first seventeen years from 1955 to 1971, but a decreasing trend thereafter. Consequently, a second-degree polynomial was found to be a good fit and the model explained 82.77% of the variation of the data (Fig. 3.6(a)). Again the mean BMI values of the study population are depicted graphically in Fig. 3.6(b) and in Fig. 3.6(c) by birth year cohort from 1955 to 1995 for urban and rural residence, separately. For both urban and rural residence, a second-degree polynomial was found to be a good fit and the model explained 87.64% and 65.76% of the variation of the data respectively (Fig. 3.6(b) and Fig. 3.6(c)). From Fig. 3.6(a), Fig. 3.6(b) and Fig. 3.6(c) it was found that all the secular trends in BMI of Bangladeshi women over time were almost same.

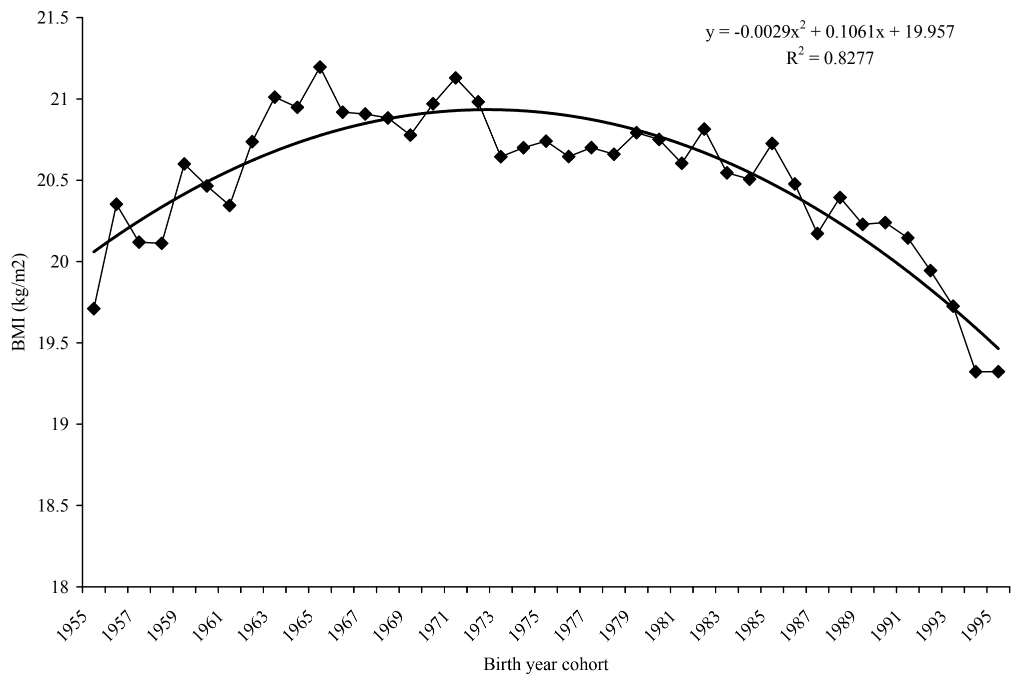


**Fig. 3.6(a):** Secular trends in BMI of Bangladeshi women over time

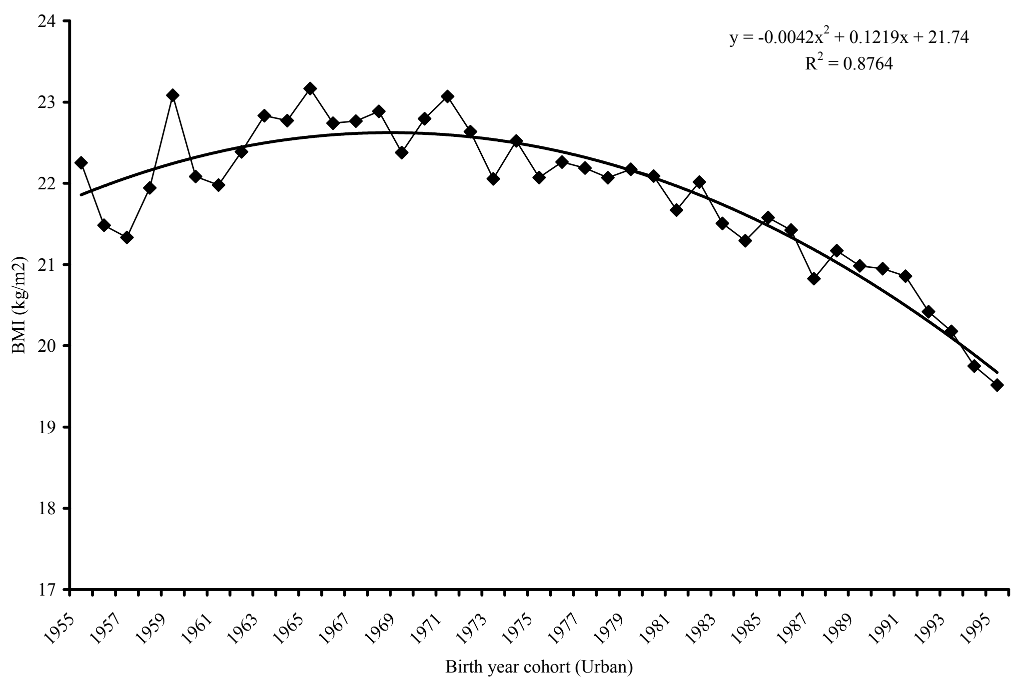


**Fig. 3.6(b):** Secular trends in BMI of urban Bangladeshi women over time

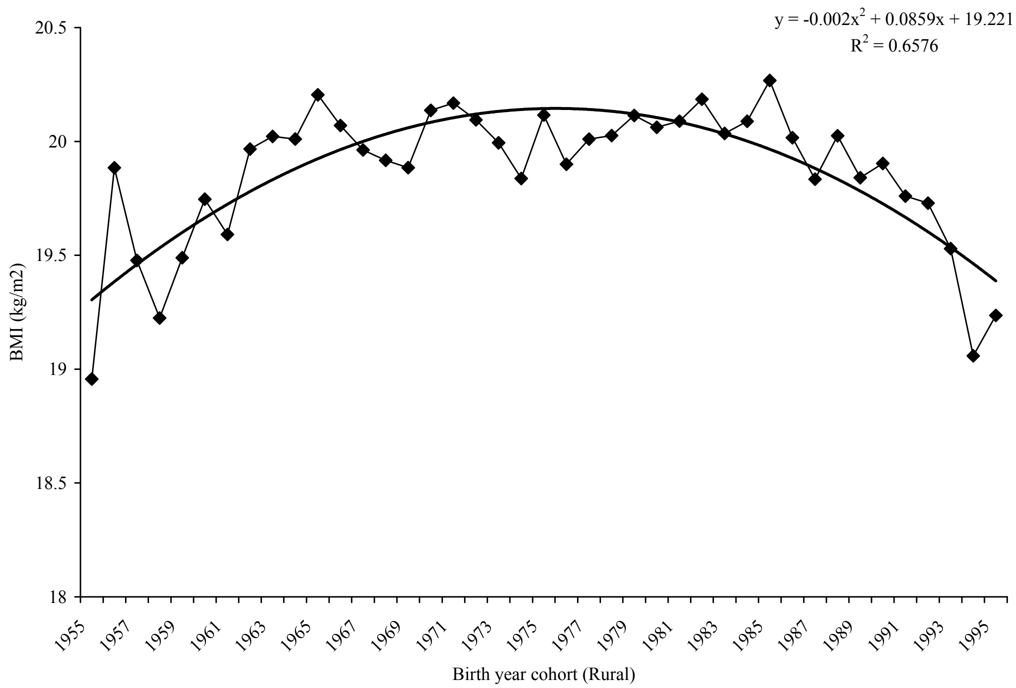


**Fig. 3.6(c):** Secular trends in BMI of rural Bangladeshi women over time

To further examine the presence of trends in BMI, the mean BMI values of the study population are depicted graphically in Fig. 3.6(d) and in Fig. 3.6(e) by birth year cohort from 1955 to 1971 and from 1971 to 1995 separately. These figures showed yearly fluctuations in average BMI. Linear regression analysis was used separately for birth year cohorts from 1955 to 1971 and those of 1971 to 1995 to calculate the average rate of increase and decrease in BMI values with increase in birth year cohorts, respectively. The coefficient of regression analysis showed that the average rate of increase of BMI was 0.069 kg/m$^2$ (95% CI: 0.044 to 0.093, p<0.001) among the birth year cohorts from 1955 to 1971. The coefficient -0.055 (95% CI: -0.068 to -0.041) indicated an average rate of decrease 0.055 kg/m$^2$ (p<0.001) among the birth year cohorts from 1971 to 1995 (Table 3.6).

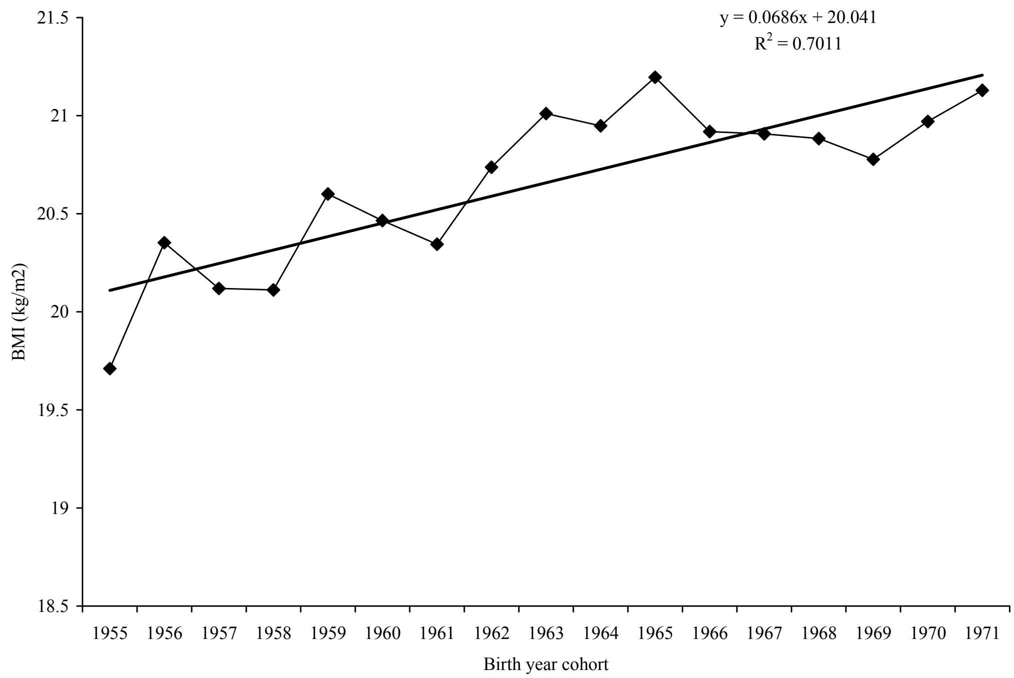


**Fig. 3.6(d):** Increasing linear trend in BMI of Bangladeshi women over time

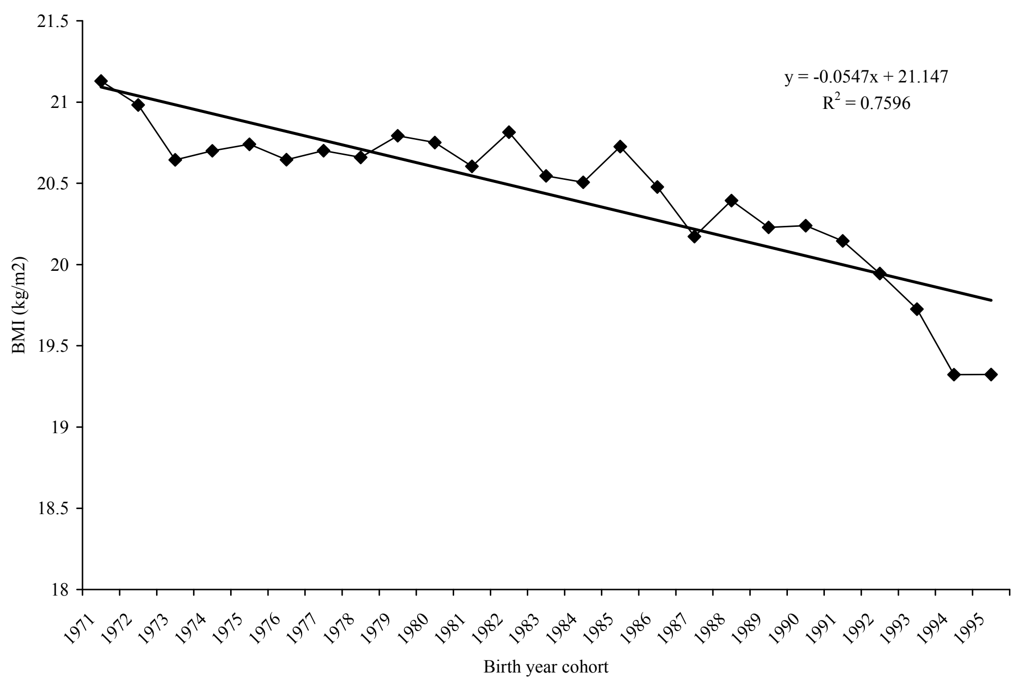


**Fig. 3.6(e):** Decreasing linear trend in BMI of Bangladeshi women over time

**Table 3.6:** Regression coefficient for the effect of birth year on BMI of married Bangladeshi currently non-pregnant women

| Birth year cohort | Regression equation | Regression coefficient | $R^2$ (%) | p-value | 95% CI for coefficient | |
|---|---|---|---|---|---|---|
| | | | | | Lower | Upper |
| 1955-1971 | Y = 20.04 + 0.069X | 0.069 | 70.11 | <0.001 | 0.044 | 0.093 |
| 1971-1995 | Y = 21.15 - 0.055X | -0.055 | 75.96 | <0.001 | -0.068 | -0.041 |

### 3.4.9 Trends in proportion for each category of BMI

To find the trends in various type of BMI, the samples were classified into seven classes according to birth cohort (1955-1960, 1961-1966, 1967-1972, 1973-1978, 1979-1984, 1985-1990 and 1991-1995). The proportions of women (percentage) for each category of BMI are displayed in Fig. 3.7. A decreasing pattern in proportion of underweight women was observed from 1955-1960 to 1967-1972. The proportion then increased with increasing birth year cohort from 1967-1972 to 1991-1995. The proportion of overweight and obese individuals showed a pattern in the opposite direction over the same periods. The proportion of women who were of normal weight increased with increasing birth year cohort from 1955 to 1995 (Fig. 3.7).

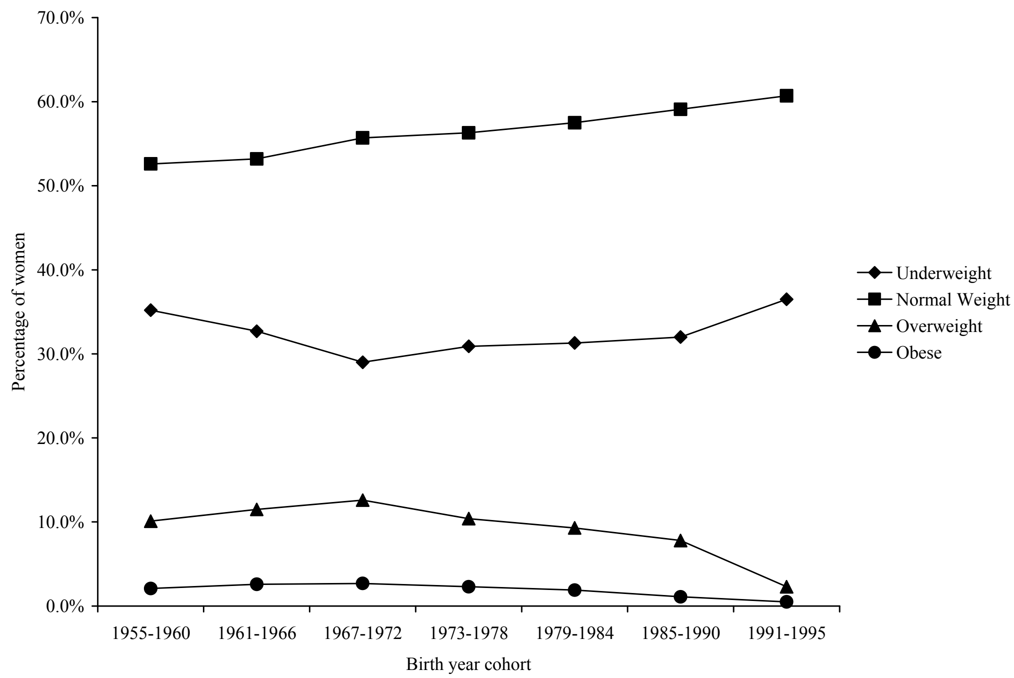


**Fig. 3.7:** Secular trends in various types of body size over time.

## 3.5 Discussions

The data used in this study gathered by the Bangladesh Demographic and Health Surveys conducted in 1996-1997, 1999-2000, 2004, 2007 and 2011. The samples were nationally representative, covering both urban and rural areas of Bangladesh. Previous studies in Bangladesh have examined the relationship between BMI and age, mortality, level of education, wealth index and other social variables (Shafique et al., 2007; Khan & Kraemer, 2009), but they used much smaller data sets that were not representative of the nation. Recently, Hossain and others investigated the trend in BMI of Bangladeshi women but they used only BDHS 2007 data (Hossain et al., 2012). In addition, in the present study the change in BMI of Bangladeshi women over four decades (birth year cohorts from 1955 to 1995) has been identified.

Result demonstrated that the mean BMI of married Bangladeshi women between the ages of 15 and 49 years was 20.65±3.670 kg/$m^2$ for whole sample. When observed the individual measurement period of BDHS, the mean BMI in surveys conducted years 1996-1997, 1999-2000, 2004, 2007 and 2011 was 18.84, 19.43, 20.32, 20.87 and 21.52 $kg/m^2$, respectively. More than half of the women (56.1%) were of normal weight. Underweight women constituted 31.4% of the study population, while overweight women constituted 10.4%. Only 2.1% were considered obese. This information is consistent with other studies on Bangladeshi women. A study on Bangladeshi women reported that 57.73% were normal weight, 28.66% were underweight, 11.45% were overweight and 2.16% were obese (Hossain et al., 2012). Other study on Bangladeshi women living in an urban area reported that 15.7% were overweight and 3.9% were obese (Khan & Kraemer, 2009), while another study on women living in the slum area of Dhaka reported that 54% of women were underweight (Pryer et al., 2003). A relatively similar pattern was also observed in a large population study in neighbouring India, where 56.9% of married women were reported to be of normal weight, 31.2% were underweight, 9.4% were overweight and 2.6% were obese (Bharati et al., 2007).

The BMI of married Bangladeshi women varied over the birth year cohorts from 1955 to 1995 (Fig. 3.6(a)). There was an increasing trend during the first seventeen years (1955 to 1971), and over the last 24 years (1971–1995) a decreasing trend was noted. This variation may represent the trends in BMI of married Bangladeshi women over the four decades, although this may not be the only factor. A slight decrease in mean BMI was reported in female students attending Glasgow University in the United Kingdom between 1948 and 1964, although the value increased in male students over the same period (Okasha et al., 2003). On the other hand, a study on the secular trend of various anthropometric measurements conducted for two generations of 38- and 50- year-old Swedish women was not able to detect a significant change in BMI over the years (Lissner et al., 2008). A similar finding was noted in another study conducted in Finland from 1972 to 1997 (Lahti-Koski et al., 2001).

The socioeconomic conditions of Bangladesh have been adversely affected by many factors, including political instability and natural calamities. Independence from Britain in 1947 was followed by a period of relative stability. However, political turmoil gradually developed in the 1960s cumulating in war between West Pakistan (now Pakistan) and East Pakistan (now Bangladesh) in March 1971. There were critical shortages of essential food grains and other staples because of wartime disruptions. The war ended in December 1971 with the establishment of the new country called Bangladesh (Iqbal, 2008). A rapid increase in population due to a lack of family planning policies and returning of refugees from neighbouring countries exerted a heavy strain on this small country, which was also regularly ravaged by natural disasters such as floods and cyclones. The general condition may have eased over the last two decades, as reported by a more recent study by Shafique et al., 2007; which showed a decrease in percentage of underweight and an increase in percentage of overweight Bangladeshi women from 15 to 45 years of age between the years 2000 and 2004. This recent change was beyond the present section’s study period.

In most other parts of the world, a decrease in the percentage of underweight women and an increase in the percentage of overweight and obese women have been reported over the last 50 years. The most obvious changes have been observed in North American (Freedman et al., 2002; Torrance et al., 2002) and European countries (Gullinford et al., 1992; Bendixen et al., 2004; Berg et al., 2005), and a similar pattern has also been reported for Australia (Dal Grande et al., 2005) and parts of Asia (Aekplakorn & Mo- Suwan, 2009). The uncontrolled increase in population with limited natural resources is probably be the single most important factor that contributed towards the increasing percentage of underweight women over the last 24 years in Banglasdesh. However, the percentage of normal weight women has shown an increasing tendency over the last four decades.

## 3.6 Conclusions

It is important to determine the risk factors which are related to BMI of Bangladeshi married women. BDHS used multistage stratified cluster sampling for selecting household from different enumeration areas. Since the data collected by BDHS from multistage clustered samples and the dependence among observations came from several levels of the hierarchy. There is a cluster effect of the data set. The single level statistical model is not appropriate for analyzing such kind of data set. Further studies should be needed to analyze the BDHS data and active measures have been taken to improve the situation.

# *CHAPTER FOUR*

## Effect of Socio-Economic and Demographic Factors on BMI of Bangladeshi Non-Pregnant Married Women of Reproductive Age: Multilevel Linear Regression Analysis

## 4.1 Introduction

Nutritional status is the state of a person's health in terms of the nutrients in his/her diet. Nutritional status is a global term that encompasses a number of specific components from nutritional assessments. Nutritional assessment is a comprehensive approach to define nutritional status using medical, nutrition and medication histories, physical examination, anthropometric measurement, and laboratory data. Body mass index (BMI) is accepted by the World Health Organization (WHO) as a valid indicator of nutritional status. BMI is essentially based on a person's weight and height and is considered an indirect measure of nutritional status. The change in nutritional status plays an important role in the course of a person's health. Therefore, BMI can be used as an indicator for health status, and association with some diseases can be expected. So, BMI is a good indicator of nutritional status in a population. The BMI formula was developed by Belgium statistician Adolphe Quetelet (1796-1874), and was known as the Quetelet Index. BMI is also referred to as 'body mass indicator'. BMI is an internationally used measure of obesity. A BMI value of over or equal to 30 $kg/m^2$ has been shown to be a risk factor for hypertension, heart disease, diabetes mellitus, cardiovascular disease, gall bladder disease and various types of cancer. On the other hand, a low BMI (underweight $BMI \leq 18.5\ kg/m^2$) has been associated with a higher risk of hip fracture in women (Gnudi et al., 2009; Morin et al., 2009). Low birth weight and higher mortality rate has also been associated with a low BMI in pregnant mothers (Hosegood & Campbell, 2003). Association between BMI and various socio-demographic factors may provide useful information about changes in the level of public health and reflect the general living environment of a given population. This is particularly important for developing countries where health and medically related reforms are being actively implemented.

Relationship between BMI and socio-demographic factors for other population have been described elsewhere (Tavani et al., 1994; Brener et al., 2004; Ali and Lindstrom, 2006; Morin et al., 2009; Okoh, 2013; Hou et al., 2014; Sundararajan et al., 2014). In Bangladesh, researchers have investigated the relationship between BMI and mortality (Hosegood & Campbell, 2003; Pierce et al., 2010) and socioeconomic and demographic factors (Pryer et al., 2003; Shafique et al., 2007; Khan & Kraemer, 2009) and socio-demographic factors (Hossain et al., 2012) in female populations. Efforts have been made to improve the general conditions of this population section, and BMI can provide a tool for evaluation of the effectiveness of these measures. Special attention should be paid to married women considering their potential influence on the family and their contribution to the nation's workforce and productivity. Due to their unique role in the population, it is important to investigate the relationship between the BMI of married women and important factors such as age, number of family members, wealth index, number of ever born children, age at first birth, age at first marriage, residence, education level, husband education, watching television, religion, currently use contraceptive, currently breastfeeding, living with husband and currently working status, in order to ensure corrective measures can be undertaken.

The purpose of the present study is to look at the relationship between BMI and various socio-demographic factors.

## 4.2 Review of literatures

Many researchers have tried to establish the relationship between BMI and socio-demographic factors of different populations. Some of these studies are described in below (Flegal et al., 1988; Naidu and Rao, 1994; Tavani et al., 1994; Ortega et al., 1997; Ahmed et al., 1998; Damron et al., 1999; Hosegood and Campbell, 2003; Pryer et al., 2003; Brener et al., 2004; Pryer et al., 2004; Flegal et al., 2005; Sarkar and Taylor, 2005; Ali and Lindstrom, 2006; Cilliers et al., 2006; Pryer and Rogers, 2006; Bharati et al., 2007; Khanam and Costarelli, 2008; Li et al., 2008; Mejia-Rodriguez et al., 2008; Siza, 2008; Yahia et al., 2008; Khan and Kraemer, 2009; Morin et al., 2009; Subramanian et al., 2009; Wandell et al., 2009; Hossain et al., 2010; Nagai et al., 2010; Pierce et al., 2010; Ahmed et al., 2012; Hossain et al., 2012; Hossain et al., 2012; Okoh, 2013; Oliveira et al., 2013; Prpic et al., 2013; Chasse et al., 2014; Emaus et al., 2014; Hou et al., 2014; Kwon, 2014; Rosato et al., 2014; Smith et al., 2014; Sundararajan et al., 2014 and Zhou et al., 2014):

### 4.2.1 Other population studies

**Flegal et al. (1988)** investigated secular trends in BMI and skin fold thickness with socio-economic factors in young adult women aged 18-34 years; they extracted data from the three successive national surveys: NHES Cycle I, NHANES I, and NHANES II over the period 1960-80. They found that mean BMI and skin fold thickness were negatively associated with both education and income. The mean values of BMI over the 20-years period increased for both white and black women at all levels of income and education.

**Naidu and Rao (1994)** studied in BMI of Indian populations; they derived data from the National Nutrition Monitoring Bureau surveys. They observed that nearly one-half (49%) of adult Indian rural population was suffering from some grade of chronic energy deficiency (CED). Mean BMI values were lower in landless agricultural occupational groups and in low per capita income group households compared with cultivators, artisan and higher income groups. Mean birth weights showed definite differences between BMI classes (2500 g in grade III CED and 2800 g in the normal BMI group). The odds ratio for low birth weight (LBW) was found to be three times more in severe

CED groups compared to normal BMI groups of mothers. The influence of BMI on the incidence of LBW was evident despite the confounding factors of parity and maternal age. The frequency distribution of BMI values of adults who had been malnourished at the age of 5 years was distinctly different from that of the well-nourished group. The mean BMI of the group who were malnourished as children was 16, while those who had been well nourished were now 21 on average. Data from affluent and well-grown Indians suggests that a cut-off point of 18 rather than 18.5 would be more appropriate to distinguish the nutritionally normal groups from the energy deficient group.

**Tavani et al. (1994)** found the determinants of body mass index of northern Italian adults; they extracted data from a comparison group of a case-control study of gastrointestinal cancers from the four largest teaching and general hospitals in Milan, northern Italy. They investigated the influence of some socioeconomic, behavioral, dietary and reproductive factors on BMI. The following were measured: BMI (Quetelet's index, weight, BMI) and the corresponding standard errors in strata of selected variables, linear regression coefficients and correlation coefficients between BMI and each variable. Mean value of BMI had been increasing over time with age until 35-44 years in men and 45-54 years in women. In both sexes BMI was inversely associated with education and social class. Smokers tended to be leaner than non-smokers, but no consistent trend was observed with increasing numbers of cigarettes. Alcohol drinkers had mean BMI similar to non-drinkers, except heavy drinking women who were lighter. BMI was not significantly associated with coffee, decaffeinated coffee, tea, bread, vegetable and fruit consumption. No relation was observed between total estimated caloric intake and BMI. In women BMI was directly associated with marriage and number of children, and inversely with oral contraceptive use.

**Ortega et al. (1997)** established the relationships between concern regarding body weight and energy balance in a group of female university students from Madrid, Spain. They observed that all students with BMI $\geq 25$ kg/m$^2$ (6.2% of the total) described themselves as fat. 71.4% had, at some time, followed a weight-reduction diet. However, even among students with BMI <20 kg/m$^2$ (28.4% of the total), 2.9% thought themselves fat and 17.1% had at some time followed a slimming diet. This showed excessive concern over losing weight in some women. Estimated energy expenditure was similar to energy intake in students with BMI <20 kg/m$^2$. However, as BMI rose (with a corresponding increase in theoretical energy expenditure), the reported energy intake decreased. It was therefore likely that underestimation of energy intake increased with BMI (r = 0.4498). These results indicated that a large percentage of the women studied would like to lose weight until they reach, or indeed exceed, the lower limit of the acceptable normal range. This could be a danger to their health. Underestimation of energy intake was found to increase with BMI, a phenomenon that should be kept in mind when designing diet studies.

**Damron et al. (1999)** examined associated with attendance in a National Cancer Institute-funded randomized trial of nutrition education to increase fruit and vegetable consumption among women served by the Special Supplemental Nutrition Program for Women, Infants, and Children (WIC). Demographic data were collected in a baseline survey. Attendance data and telephone and address changes were also collected. The post intervention survey included a question regarding reasons for nonattendance. Focus groups were also held to ascertain reasons for attendance or nonattendance. $\chi^2$-tests of trend and multiple logistic regression, adjusted for within-site correlation, were used in statistical analyses. They found that 54% of enrollees attended at least one session. Multiple logistic regression analysis showed increased odds of attending with higher age, breast-feeding, and/or knowledge of the recommendation to eat five or more servings of fruits and vegetables daily. There were decreased odds of attending for pregnant women who already had children. There were insignificant trends toward decreased attendance among unmarried women compared with married women and among blacks compared with non-blacks. Reasons given for nonattendance included withdrawal from WIC, moving, conflicting activities, negative feelings about nutrition education, and lack of transportation or child care. They suggested that numerous barriers hinder participation in nutrition programs aimed at low-income women. These barriers should be considered by health care professionals when planning intervention programs. Overcoming these barriers presented a major challenge.

**Brener et al. (2004)** investigated the association between weight perception and BMI among high school students. They found that 1.5% of students were classified as underweight or at risk for underweight, 51.2% of students were normal weight, and 47.4% were overweight or at risk for overweight. Among this same sample of students, however, 34.8% perceived themselves as underweight, 42.9% perceived themselves as about the right weight, and 22.3% perceived themselves as overweight. The findings of this study suggested the perception of overweight was a key determinant of adolescent nutritional habits and weight management, many students who were overweight or at risk for overweight but who did not perceive themselves as such were unlikely to engage in weight control practices. Increasing awareness of medical definitions of overweight might improved accuracy of weight perceptions and lead to healthier eating and increased physical activity.

**Flegal et al. (2005)** estimated deaths associated with underweight, overweight, and obesity in the United States in 2000; they got data from the nationally representative National Health and Nutrition Examination Survey (NHANES) I (1971-1975) and

NHANES II (1976-1980), with follow-up through 1992, and from NHANES III (1988-1994), with follow-up through 2000, these relative risks were applied to the distribution of BMI and other covariates from NHANES 1999-2002 to estimate attributable fractions and number of excess deaths, adjusted for confounding factors and for effect modification by age. Relative to the normal weight category, they found that obesity was associated with 111,909 excess deaths (95% CI: 53,754-170,064) and underweight with 33,746 excess deaths (95% CI: 15,726-51,766). Overweight was not associated with excess mortality (-86,094 deaths; 95% CI: -161,223 to -10,966). The relative risks of mortality associated with obesity were lower in NHANES II and NHANES III than in NHANES I. This study concluded that underweight and obesity, particularly higher levels of obesity were associated with increased mortality relative to the normal weight category. The impact of obesity on mortality might be decreased over time, perhaps because of improvements in public health and medical care. Their findings were consisted with the increases in life expectancy in the United States and the declining mortality rates from ischemic heart disease.

**Ali and Lindstrom (2006)** studied several determinants of BMI in Scanian young women; they extracted data from the 2000 public health survey. They used the cross-sectional data in their study and the logistic regression model adjusted for age was used to establish the association between socioeconomic, psychosocial, health behaviors, self reported global and psychological health, locus of control, and the BMI categories. They found that the 17.5% proportion of the women, aged 18-34 years, were underweight (BMI<20.0), 18.4% were overweight, and 7.0% obese. The prevalence of underweight according to the BMI <18.5 definition was 5.8% among women aged 18-34 years. Women who were underweight had significantly higher odds ratios for overtime work, being students, low emotional support, and poor self reported global as well as poor psychological health than normal weight women. Women who were overweight/obese were unemployed, had low education, low social participation, low emotional and instrumental support, were daily smokers, had a sedentary lifestyle, had poor self reported global health, and had lack of internal locus of control compared with normal weight women. Their findings suggested that underweight women were more likely to have poorer psychological health than normal weight women. In contrast, overweight and obese women were more likely to have poor health related behaviors and lack of internal locus of control compared with normal weight women. These differing patterns suggested both different etiology and different preventive strategies to deal with the health risks of people who were underweight as opposed to those who were overweight or obese.

**Cilliers et al. (2006)** investigated the association between the weight and status of first-year female students (FYFS) in South African university. They did cross- sectional study and they found that the mean BMI of the FYFS was 21.8 $kg/m^2$, with 7.2% being underweight, 81.9% normal-weight, 10.0% overweight and 0.8% obese. Underweight, normal-weight and overweight students differed with regard to their perception of their weight ($p<0.001$), weight goals ($p<0.001$) and previous weight-loss practices ($p<0.001$). Mean±SD score on the 26-item eating attitudes test (EAT-26) was 8.5±9.0 with 8.4% classified as high scorers. Mean±SD score on the 34-item Body Shape Questionnaire (BSQ) was 87.7±32.2, with 76.1% classified as low, 11.9% as medium and 11.9% as high scorers. The self-concept questionnaire indicated that 36.7% had a high, 43.9% a medium and 19.4% a low self-concept. Higher BMI correlated with a higher BSQ score ($p<0.001$), a lower self-concept ($p<0.030$) and a higher EAT-26 score ($p<0.001$). Smoking was prevalent amongst 13.1% of students, and 51.2% used vitamin and/or mineral supplements. Students who quitted smoking had higher ($p<0.007$) BMI

(22.7±2.9 kg/m$^2$) than those who never smoked before (21.6±2.5 kg/m$^2$). Normal-weight students were more physically active than underweight or overweight students ($p<0.039$). Their results suggested that the specific weight management-related needs of FYFS included information about supplement use, smoking, realistic weight goals, safe and sound weight-loss methods, weight cycling, body-shape perceptions, eating attitudes and behaviors, self-concept and physical activity.

**Bharati et al. (2007)** investigated the prevalence and causes of chronic energy deficiency (CED) and obesity in Indian women; they extracted data from the Indian National Family Health Survey, 1998-1999. A multiple linear regression analysis was applied to see the relation between nutritional status of women and different socioeconomic factors. Their data revealed that the prevalence of CED, overweight, and obesity in India were 31.2%, 9.4%, and 2.6%, respectively. The incidences of CED and obesity were negatively related. The prevalence of CED was the lowest in Arunachal Pradesh and highest in Orissa. Punjab had the highest prevalence of obesity, and Bihar had the lowest. For the zone wise distribution the Northeast zone had the lowest degree of prevalence of CED and the East zone was at the bottom of the list with the highest degree of malnutrition. They also found that the nutritional status of women went together with the enhancement of their educational status, standard of living, and so on. There were also significant differences between rural and urban sectors and among castes, religions, and occupations. Furthermore, regression analysis showed that all the socioeconomic variables considered here significantly affect BMI in Indian women.

**Mejia-Rodriguez et al. (2008)** described the BMI and anemia of Mexican women; they got data from the Mexican National Nutrition Survey in 1999. They used the survey data and identified the types of nutritional supplements (NS) commonly used and explore the associations between NS consumption and socio-demographic characteristics, nutritional status, measured as BMI, and anemia in Mexican women aged 12 to 49 years. They calculated the probability (P) of supplement consumption using logistic regression. For the statistical analysis characteristics at the individual and household level were included in the statistical models, and adjusted for the study design. Interaction effects were also explored. They found multiple mixed vitamin and mineral supplements were the most commonly consumed (36.7%) followed by vitamins only (34.3%), married women were significantly ($p<0.05$) more likely ($p<0.001$) to consume NS compared to unmarried women, as were those with more access to public and private health care ($p<0.011$), with higher education level ($p<0.005$) and living in the South region ($p<0.004$). Anemia modified the association between supplement consumption and socio-economic status (SES) ($p<0.017$), non anemic women having greater probabilities of NS consumption. These results suggested that NS use among Mexican women is associated with better living conditions. On the other hand, they also found that women living in the South region, the poorest region of the country, had higher probability of NS consumption compared to the North region. This could be related to participation in food assistance programs; however they were unable to explore this potential explanation.

**Siza (2008)** determined factors associated with low birth weight of neonates among pregnant women of northern Tanzania; he extracted data from the Kilimanjaro Christian Medical Centre in Moshi, Tanzania. He found that out of 648 pregnant women who were tested for HIV infection 59 (9.1%) were positive for the infection. Twelve (20.3%) of HIV positive women gave birth to LBW neonates. HIV positive women were twice more likely to give birth to LBW infants than HIV negative ones ($\chi^2=6.7$; $p<0.01$; OR=2.4, 95% CI: 1.1-5.1). Mothers without formal education were 4 times more likely to give birth to LBW neonates than those who had attained higher education (OR=3.6, 95% CI: 2.2-5.9). There was a linear decrease in low birth weights of newborns as fraternal educational level increased (t=42.7; p<0.01). There was no statistically significant difference among parents' occupations regarding LBW of their newborns. Unmarried mothers were more likely to give birth to LBW neonates as compared to their married counterparts (OR=1.65, 95% CI: 1.2-2.2) and the difference was statistically significant ($\chi^2$=13.0, p<0.01). Hypertension, pre-eclampsia and eclampsia disease complex had the highest prevalence (46.67%) and population attributable fraction of low birth weight (PAF=25.2%, 95% CI: 22.0-27.6). Bleeding and schistosomiasis had the same prevalence (33.33%) of LBW babies. Other complications and diseases which contributed to high prevalence of LBW included anemia (25%), thromboembolic diseases (20%), tuberculosis (17%) and malaria (14.8%). Prevalence of LBW was high in women with premature rupture of membrane (38%), placenta previa (17%) and abruption of placenta (15.5%). LBW was strongly associated with gestational age below 37 weeks (OR=2, 95% CI: 1.5-2.8) contributing to 42% of LBW deliveries in the study population (PAF=42.4%, 95% CI: 25-55). Pregnant women with malnutrition (BMI<18) gave the highest proportions 17% of LBW children followed by underweight (BMI; 18-22) who gave 15.5% of LBW neonates. There was a statistical significant difference between the proportions of LBW infants from mothers who did not receive antenatal care (28.6%) and those who attended for the services (13.8%) ($\chi^2$=8.8; p<0.011). There was need of increasing promotion of reproductive health services in relation to safe motherhood at community level in order to reduce risk factors of LBW.

The prevalence of overweight and obesity among university students in Beirut, Lebanon was studied by **Yahia et al. (2008).** Sample was selected from the Lebanese American University (in Beirut) and to examine their eating habits; they got data from the Lebanese American University (LAU) campus during the fall 2006 semester. They used the cross-sectional data in their study and observed that the majority of the students

(64.7%) were of normal weight (49% male students compared to 76.8% female students). The prevalence of overweight and obesity was more common among male students compared to females (37.5% and 12.5% vs. 13.6% and 3.2%, respectively). In contrast, 6.4% female students were underweight as compared to 1% males. Eating habits of the students showed that the majority (61.4%) reported taking meals regularly. Female students showed healthier eating habits compared to male students in terms of daily breakfast intake and meal frequency. 53.3% of female students reported eating breakfast daily or three to four times per week compared to 52.1% of male students. There was a significant gender difference in the frequency of meal intake ($p<0.001$). Intake of colored vegetables and fruits was common among students. A total of 30.5% reported daily intake of colored vegetables with no gender differences (31.5% females vs. 29.2% males). Alcohol intake and smoking were not common among students.

**Morin et al. (2009)** tried to establish the association between weight, body mass index (BMI), the Osteoporosis Self-Assessment Tool (OST), bone mineral density (BMD) and fracture risk in women aged 40 to 59 years; they extracted data from the administrative health management databases. Linear regression and Cox proportional multivariate models were created to examine the associations with weight, BMI, OST, BMD, and subsequent fractures throughout a 3.3-year follow-up. They observed that body weight, BMI, and OST had a similar overall performance in their ability to classify women with femoral neck T-score $\leq$-2.5. After adjustment for age, prevalent fractures, and used of corticosteroids, each standard deviation decrease in weight was associated with a 19% increase in the risk of incident fracture (95% CI: 1.01-1.35). Femoral neck BMD and the presence of prevalent fractures were also associated with the risk of incident fractures. They concluded that low weight and BMI predict osteoporosis and were associated with increased fracture risk in younger women. The negative impact of low body weight on bone health should be more widely recognized.

**Subramanian et al. (2009)** assessed whether burdens of underweight and overweight coexist among lower socioeconomic groups in Indian women aged 15-49 years; they received data from the 1998-1999 and 2005-2006 Indian National Family Health Surveys. They observed that the ratio of underweight to overweight women decreased from 3.3 in 1998-1999 to 2.2 in 2005-2006, there were still considerably more underweight women than overweight women. It was only in the top wealth quintile and in groups with higher education that there was a slight excess of overweight women as compared with underweight women. There was a strong positive relation between socioeconomic status (SES) and BMI at both time points and across urban and rural areas. A positive relation between SES and BMI was also observed for men in 2005-2006. Their findings suggested that the distribution of underweight and overweight in India remained socially segregated. Despite rapid economic growth, India had yet to experience a situation in which underweight and overweight coexist in the low-SES groups.

**Wändell et al. (2009)** established the association between BMI value and long-term mortality population in Stockholm country. They used a stratified sample in 1969 of population aged 18-64 years and participants were followed up in the National Cause of Death Register until the end of 1996. Multivariate analysis was performed by Cox regression for men and women separately, with different models, with step-wise adjustment for several variables and they observed among men, the age-adjusted hazard ratios was 1.68 (95% CI: 1.10-2.57) for underweight and 1.62 (95% CI: 1.08-2.43) for obesity, and among women it was 0.93 (95% CI: 0.58-1.51) for underweight and 1.88 (95% CI: 1.26-2.82) for obesity. In men, the significantly increased mortality remained when also adjusting for care need category, but not when adjusting for other factors, whereas the opposite was found regarding obesity. For women, underweight was significantly associated with decreased mortality when adjusting for smoking and for all factors together, whereas obesity was associated with increased mortality when adjusting for the different factors except for all factors together. Their findings suggested that underweight was associated with higher mortality among men, but not when adjusting for covariates, whereas underweight was associated with lower mortality among women when adjusting for smoking.

**Nagai et al. (2010)** clarified the effect of age on the association between BMI and all-cause mortality among Ohsaki cohort in Japan. They used Cox proportional hazards regression analysis and observed that a significantly increased risk of mortality in underweight elderly men: the multivariate hazard ratio (HR) was 1.26 (0.92-1.73) in middle-aged men and 1.49 (1.26-1.76) in elderly men. They also observed that a significantly increased risk of mortality in obese middle-aged men: the multivariate HR was 1.71 (1.17-2.50) in middle-aged men and 1.25 (0.87-1.80) in elderly men. In women, there was an increased risk of mortality irrespective of age group in the underweight: the multivariate HR was 1.46 (0.96-2.22) in middle-aged women and 1.47 (1.19-1.82) in elderly women. There was no excess risk of mortality with age in obese women: the multivariate HR was 1.47 (0.94-2.27) in middle-aged women and 1.26 (0.95-1.68) in elderly women. They concluded that obesity was associated with a high mortality risk in middle-aged men, whereas underweight, rather than obesity, was associated with a high mortality risk in elderly men and in women, obesity was associated with a high mortality risk during middle age; underweight was associated with a high mortality risk irrespective of age. The mortality risk due to underweight and obesity may be related to sex and age.

The trends in prevalence of overweight and obesity in Kuwaiti adults, and examined their association with selected socio-demographic and lifestyle factors were done by **Ahmed et al. (2012).** They extracted data from the National Nutrition Surveillance System from 1998 to 2009. They used cross-sectional data in their study and found that prevalence of BMI ≥25 kg/m$^2$ rose from 61·8 % and 59·3 % in females and males respectively, peaked in 2004-2005 (81·4 % and 79·2 %) and fell slightly in 2008-2009 (77·3 % and 77·4 %). Obesity prevalence in females exceeded males for all years and age groups; by 2009, it had increased by 11·3 % in males and 14·6 % in females. Overweight and obesity prevalence in both genders increased until 2004-2005 but fell thereafter, with significant falls for females in 2008-2009. Logistic and linear regression analyses confirmed these temporal changes for both prevalence and BMI in both genders. The odds of obesity increased with age until the fifth decade for both genders and then declined significantly for males. Education level was negatively associated with obesity prevalence in females, while participation in leisure-time exercise was negatively associated with obesity prevalence in males. They concluded that the combined prevalence of overweight and obesity (BMI≥25 kg/m$^2$) seemed to decrease from 2005 to 2009 among Kuwaiti adults.

**Okoh (2013)** explored the associations of socio-demographic factors with increased BMI among Nigeria women aged 20-49 years; the author got the data from 2008 NDHS. $\chi^2$-test was used to compare categorical variables and multi-nominal logistic regression was used to examine for correlates in his study and he found that the prevalence of overweight (BMI 25 to 29.9 kg/m$^2$) and obesity (BMI ≥ 30 kg/m$^2$) in this population were 18.1% and 7.1%, respectively. The prevalence of overweight/obesity was highest among Igbo women. Multivariable logistic regression revealed increased frequency of watching television, belonging to a particular ethnic group, having a tertiary education and increased parity as risk factors for increased BMI. His findings confirmed a high prevalence of overweight and obesity among Nigerian women and identified high risk groups for excessive weight gain.

**Oliveira et al. (2013)** investigated the effect of five dimensions of social relationships on obesity and potential sex differences in these associations of Swedish adults; they extracted data from the Swedish Level of Living Surveys (LNU) in 1991 and 2000. Longitudinal data was used in their study. The dimensions of social relationships examined in this study include emotional support, frequency of visiting friends, marital status, marital status changes, and a Social Relationships Index (SRI). Obesity status was based on BMI ($kg/m^2$) and calculated with self-reported measurements. The association between social relationships and the incidence of obesity after 9 years of follow-up was evaluated through Poisson regressions. After controlling for confounders, they found that the lack of emotional support (RR=1.98; 95% CI: 1.1-4.6) influenced the incidence of obesity among men. In addition, men with the lowest levels of SRI (RR=2.22; 95% CI: 1.1-4.4) had an increased risk of being obese. Among women, SRI was not significantly associated with obesity. Women who changed their marital status from married to unmarried had lower risk of obesity (RR=0.39; 95% CI: 0.2-0.9).

**Prpić et al. (2013)** investigated associations between obesity and periodontitis, oral hygiene, and tooth loss in Croatian non-smoking adults aged 31-75 years; they got data from the Dental Clinic, Clinical Hospital Centre in Rijeka, Croatia. Multiple regression and logistic regression analysis were used in their study and they found that use of interdentally brushes/flossing and number of missing teeth correlated significantly with BMI, but the same could not be proven for periodontitis and frequency of tooth brushing. Also they observed that the subset of obese, poorly educated women aged 36-55 years were 5-6 times more likely to develop severe forms of periodontal disease.

They concluded that obesity was associated with tooth loss, oral hygiene, and education level in the investigated group. BMI could not be correlated with severity of periodontal disease, except in poorly educated women aged 36-55 years.

The association between body mass index (BMI) and the risk of nonfatal body injury in Canadian adults was observed by **Chassé et al. (2014).** They got data from the Canadian Community Health Survey conducted in 2009-2010. Log-binomial models were used to estimate crude and adjusted relative risks of the association between BMI and the risk of body injury for men and women. They found that 13.4% had self-reported body injuries during the past 12 months, with a 12-month cumulative incidence of 13.7%. There was a significant interaction between gender and BMI in relation to the risk of body injury, and therefore, analyses were stratified by gender. For women, they found a significant association between BMI and an increased risk of body injury. Women with an increased BMI had a significant increased risk of body injuries as compared with those with normal weight (adjusted relative risk: 1.13, 95% CI: 1.02-1.25 for BMI 30.0-34.9 $kg/m^2$; 1.17, 95% CI: 1.00-1.37 for BMI 35.0-39.9 $kg/m^2$; 1.41, 95% CI: 1.16-1.69 for BMI $\geq$ 40 $kg/m^2$). A reduced risk of injury was observed in underweight women. There was no significant association between BMI and the risk of body injury for men. Obese persons of both genders were more likely to suffer injuries to the knee and lower leg, and in less demanding activities such as household chores or using the stairs. Their findings suggested that increased BMI might be a risk factor for body injury in women, but not in men.

**Emaus et al. (2014)** examined the effect of combined profiles of smoking, physical activity and body mass index (BMI) on lifetime bone loss; they collected data from the population-based Tromsø Study conducted in 2001-02 and 2007-08 surveys. Linear mixed models with second-degree fractional polynomials was used in their study and they found that from peak at the age around 40 years to 80 years of age, loss rates varied between 4% at the total hip and 14% at femoral neck in non-smoking, physically active men with a BMI of 30 kg/$m^2$ to approximately 30% at both femoral sites in heavy smoking, physically inactive men with a BMI value of 18 kg/$m^2$. In women also, loss rates of more than 30%, were estimated in the lifestyle groups with a BMI value of 18 kg/$m^2$. BMI had the strongest effect on Bone mineral density (BMD), especially in the oldest age groups, but a BMI above 30 kg/$m^2$ did not exert any additional effect compared to the population average BMI of 27 kg/$m^2$. At the age of 80 years, a lifestyle of moderate BMI to light overweight, smoking avoidance and physical activity of 4 hours vigorous activity per week through adult life may result in 1-2 standard deviations higher BMD levels compared to a lifestyle marked by heavy smoking, inactivity and low weight. In the prevention of osteoporosis and fracture risk, the effect of combined lifestyles through adult life should be highlighted.

**Hou et al. (2014)** explored the relationship between BMI and clinical outcomes of in vitro fertilization and embryo transfer (IVF/ICSI-ET) cycles in patients with endometriosis; they extracted data from the data of infertile women with endometriosis undergoing 244 IVF/ICSI-ET cycles between January, 2011 and August, 2012. They found that there was significant difference between moderate to severe endometriosis group and the control group in the number of ampoules, oocytes retrieved and embryos transferred. The patients with moderate or severe endometriosis had significantly lower BMI and clinical pregnancy rate than those with mild or no endometriosis. The findings suggested that endometriosis was inversely correlated with BMI, and BMI of the patients with endometriosis may affect the pregnancy rate of IVF cycles.

**Kwon (2014)** elucidated whether disparities of adiposity, age and insulin resistance (IR) at the time of diabetes diagnosis exist between women and men in the adult Korean population; the author got data from the Korea National Health and Nutrition Examination Survey from 2007 to 2010. The author found that the mean age of diabetes diagnosis was 58.5 years in women and was 55.1 years in men ($p<0.016$). The mean body mass index (BMI) of newly diagnosed diabetes subjects was 26.1 kg/$m^2$ in women and 25.0 kg/$m^2$ in men ($p<0.002$). The BMI was inversely related to age in both genders, and the higher BMI in women than men was consistent throughout all age groups divided by decade. The homeostasis model assessment IR in women with diabetes was higher than in men with diabetes (7.25±0.77 vs. 5.20±0.32; $p<0.013$). Korean adult women were diagnosed with type 2 diabetes at higher BMI and older age than men and were more insulin-resistant at the time of diabetes diagnosis. The results may help explained why women with diabetes have an increased risk of developing cardiovascular disease after the diagnosis of diabetes, compared to men.

**Rosato et al. (2014)** evaluated whether left ventricular mass (LVM) was related to adult patients' nutritional status and to determine clinically relevant features of systemic sclerosis (SSc). They found that the prevalence of protein-energy malnutrition (PEM) as assessed by BMI <20 kg/$m^2$ was 19%, whereas 15% of patients reported involuntary weight loss of any degree. Patients who lost weight reported gastrointestinal symptoms more frequently ($p<0.05$). PEM was not associated with disease activity. LVM (g/$m^2$) correlated with patients' BMI ($r=0.32$; $p<0.01$), and the vascular domain of disease severity (DDS) ($r=0.21$; $p<0.05$), but it showed a negative correlation with skin thickening ($r=-0.21$; $p<0.011$). Patients with ulcers had a significantly greater LVM than patients without skin lesions. Their findings showed that LVM correlated with patients' BMI, skin thickening, and the vascular DDS. Therefore, LVM could serve as a marker of nutritional status and fibrosis in patients with SSc.

**Smith et al. (2014)** observed the relationships among self-rated health, stress, sleep quality, loneliness, and self-esteem, in obese young adult women; they collect data from a health center. Descriptive statistics and bivariate procedures used to assess relationships and group differences in their study and they observed that scores reflected stress, loneliness, poor sleep quality, and poor self-esteem. There were positive correlations among stress, loneliness, and sleep quality and, a high inverse correlation between loneliness and self-esteem. Those who ranked their health as poor differed on stress, loneliness, and self-esteem when compared to those with rankings of good/very good. They concluded that assessing and addressing stress, loneliness, sleep quality and self-esteem could lead to improved health outcomes in obese young women.

**Sundararajan et al. (2014)** assessed the relationship between diet quality and body mass index (BMI) in Canadian adults; they got data from the 2004 Canadian Community Health Survey. They found that there were 2 latent classes (low-BMI and high-BMI components), and that Diet Quality Index (DQI) and Healthy Eating Index (HEI) indices were negatively associated with BMI in the high-BMI component. In the high-BMI component, a one-unit increased in DQI score was associated with a 0.053 $kg/m^2$ decreased in BMI, whereas a one-unit increased in HEI score was associated with a 0.095 $kg/m^2$ decreased in BMI. Subgroup analyses revealed that the association between diet quality and obesity was stronger in women. Their findings suggested that diet quality was associated with lower BMI in high-BMI individuals in Canada.

**Zhou et al. (2014)** investigated the association of measured body mass index (BMI), and self-reported physical activity with ovarian cancer-specific and all-cause mortality in postmenopausal women enrolled in the Women's Health Initiative (WHI). Cox proportional hazard regression was used to examine the associations between BMI, physical activity and mortality endpoints in their study. They found that the vigorous-intensity physical activity was associated with a 26% lower risk of ovarian cancer specific-mortality (HR=0.74; 95% CI: 0.56-0.98) and a 24% lower risk of all-cause mortality (HR=0.76; 95% CI: 0.58-0.98) compared to no vigorous-intensity physical activity. They also found that BMI was not associated with mortality. Their findings suggested that participating in vigorous-intensity physical activity, assessed prior to ovarian cancer diagnosis, appears to be associated with a lower risk of ovarian cancer mortality.

### 4.2.2 Bangladeshi studies

**Ahmed et al. (1998)** explored a number of socioeconomic factors thought to explain the wide prevalence of under nutrition among rural Bangladeshi women. They used the 1992 baseline survey data of the BRAC-ICDDR,B Joint Research Project at Matlab in their study. Compared with women from better-off households, they found that the mean weight (41.2 vs 43.0 kg; $p<0.001$), mid-upper arm circumference (MUAC) (22.1 vs 22.7; $p<0.001$), and BMI (18.5 vs 19.1; $p<0.001$) of poor women were consistently lower. However, no significant difference in mean height was found between the two groups. Their results showed that women aged more than 35 years were twice as likely to have a BMI <18.5 compared with younger women. Both years of schooling received and socioeconomic status were found to be important predictors of women's BMI. Women who have received one or more years of formal education were nearly half as likely to suffer chronic energy deficiency (BMI<18.5) than women with no schooling. Again, better-off women were found to be 0.77 times less likely to have chronic energy deficiency than women from poor households. The implications of these findings in improving the nutritional status of rural Bangladeshi women were discussed.

**Hosegood and Campbell (2003)** examined the association between BMI and mortality in Bangladeshi women; they extracted data from the demographic surveillance system of the International Centre for Health and Population Research, Bangladesh (1975-1979). Proportional hazards regression was used to examine the relation between BMI and all-cause mortality. They found that the association between BMI and mortality was reverse J-shaped. After adjustment for socio-economic indicators, the risk of dying was highest in women with BMIs in the lowest 10% of the decile distribution (<16.39) and lowest in women with intermediate (11-89% range of the decile distribution) BMIs (16.39-20.71). Women with BMIs in the highest 10% of the distribution (>20.71) had slightly elevated mortality (NS) compared with those with intermediate BMIs. Age and education were strongly associated with mortality. Women without schooling had a risk of mortality 4 times that of women with ≥1 year of schooling. They concluded that a woman's BMI relative to the BMI distribution in the local population may be a better predictor of mortality than was absolute BMI. The contribution of education in reducing mortality supports development programs aimed at increasing women's education.

**Pryer et al. (2003)** detected factors affecting nutritional status in female adults in Dhaka slums, Bangladesh; they extracted data from the slums in Mohammadpur, Dhaka, Bangladesh. Logistic regression showed that women with income above 1,500 taka per capita were 1.78 times more likely to have a higher BMI (OR=1.7863, 95% CI: 0.671-3.639). Women with their own savings were 1.89 times more likely to have higher BMI (OR=1.879, 95% CI: 0.01163-1.6431). Women were 4.5 times more likely to have a higher BMI when food expenditure per capita above 559 taka per month (OR=4.55, 95% CI: 1.0302-8.0799). Women were 1.82 times more likely to have higher BMI when there was a break even situation in financial status (OR=1.8212, 95% CI: -0.15709-3.6285). Female headed households were 3.3 times more likely to have a higher BMI compared to women living in male headed households (OR=3.2966, 95% CI: 0.33711-6.25620). Women who work 15-23 days per month were 2.3 times more likely to have a higher

BMI (OR=2.33, 95% CI: 0.1133-4.5600). Women who were the budget manager were 1.12 times more likely to have a higher BMI (OR=1.125, 95% CI: 0.29296-2.0966). Where as a husband who beats his wife was 1.83 more likely to have a poorer BMI (OR=1.8312, 95% CI: -3.72596-0.17508). Women who had no marriage documents and women who take days off due to illness less than 11 days per month were more likely to have a poorer BMI (OR=0.5567, 95% CI: -0.049339-2.8379; OR=0.7569, 95% CI: 0.183167-2.0002). Women's nutritional status and well being could influence their ability to provide for themselves and their families and the demonstration of a relationship between measures of women's autonomy and control in the household and women's nutritional status was an important indication of the importance of these sociological constructs. Women's participation in work outside the home might be a factor increasing their autonomy.

**Pryer et al. (2004)** identified socio-economic demographic and environmental factors that predict better height-for-age for children under 5 years of age in a Dhaka slum population in Bangladesh; they extracted data from a panel survey conducted between 1995 and 1997. They observed that 31% of children had height-for-age Z-score >-2. Logistic regression adjusted for cluster sampling showed that better nourished children were more likely to have taller mothers, to be from female-headed households and from families with higher income, electricity in the home, better latrines, more floor space and living in Central Mohammadpur. Better nourished children were less likely to have fathers who have taken days off from work due to illness.

**Sarkar and Taylor (2005)** determined the duration of lactation which was associated with weight loss in rural Bangladeshi mothers aged 18-40 years. They used cross-sectional data in their study and found that the mean difference in body-weight and body mass index (BMI) of lactating mothers who breastfed their children up to 24 months was significantly lower compared to non-lactating mothers of the same age group, but no differences were observed for those who breastfed beyond 24 months. The frequency of consumption of principal food items was comparable between the non-lactating and the lactating mothers who breastfed beyond 24 months. multiple linear regression analysis demonstrated that body-weight of mothers was negatively correlated with 1-12 month(s) and 13-24 months of lactation after controlling for height, education, and food consumption (slope -1.04, $p<0.05$ and slope -1.23, $p<0.05$ respectively). Height and consumption of meat and milk were significantly positively correlated with body-weight (slope 0.53, $p<0.001$; slope 1.44, $p<0.001$; and slope 0.75, $p<0.05$ respectively). The study concluded that Bangladeshi women who breastfed up to 24 months were of lower weight than non-lactating mothers, most likely due to the effect of lactation. These mothers were not taking any additional foods during their lactating period. Based on the findings of the study, it was recommended that mothers consume additional energy-rich foods during the first 24 months of lactation to prevent weight loss.

**Pryer and Rogers (2006)** identified socioeconomic, demographic and environmental factors that predict under nutrition in adults in a Dhaka slum population in Bangladesh; they got data from a panel survey conducted between 1995 and 1997. There was a sex difference with female adults having a significant odds ratio for low BMI compared with male adults ($p<0.03$). There was no difference by age for males, but there was a difference by age for female adults, with women aged 30-39 and 40-49 years having the worst BMI ($p<0.04$; $p<0.04$). The Beri Bahd area of residence had the worst BMI ($p<0.001$). Deficit situation as the self-reported financial situation had the worst BMI ($p<0.03$). Casual wage workers, unskilled and dependent self-employed individuals had the worst BMI ($p<0.005$; $p<0.003$). Not being involved in credit organizations and NGO credit organizations was associated with worst BMI ($p<0.008$; $p<0.03$). Those households that had an income of 2000-2499 Taka had the worst BMI ($p<0.07$). Households with a floor area of 5 $m^2$ or more per consumption unit had the best BMI ($p<0.01$). Households without electricity had the worst BMI ($p<0.007$). Households with tube well water had the worst BMI compared with those with tap water ($p<0.001$).

**Khanam and Costarelli (2008)** investigated the attitudes on health and exercise in Bangladeshi women aged 30-60 years; they extracted data from the Borough of Tower Hamlets, East London. They found that 40% of the subjects were obese and the remaining 60% were overweight. The great majority of the subjects (96%) reported that they were only willing to take up exercise if they were referred to the gym by their GP as an alternative or additional treatment for their complaints. They would not exercise voluntarily. Even though all women in their sample were either overweight or obese, 16% of the subjects reported that they did not know if they were overweight and 20% thought that they were actually of normal weight. Most women identified swimming as the type of physical activity of preference, if they had to exercise, followed by slow walking, with running being the least enjoyed activity. The findings of this study suggested that Bangladeshi women took little regular exercise to improve their health, predominant because of certain cultural beliefs and attitudes. More needs to be done to encourage levels and types of exercise that would be more appropriate for this ethnic group.

**Li et al. (2008)** elucidated the effect of nutrition on organic arsenic (As) methylation in pregnant Bangladeshi women; they extracted data from Matlab, where people were chronically exposed to inorganic arsenic (iAs) via drinking water. They found that the median concentration of As in urine was 97 microg/L (range, 5-1,216 microg/L, adjusted by specific gravity). The average proportions of iAs, monomethylarsonic acid, and dimethylarsinic acid in urine in gestational week 8 were 15%, 11%, and 74%, respectively. Thus, the women had efficient as methylation in spite of being poorly nourished (one-third had BMI<18.5 kg/m$^2$) and having elevated as exposure, both of which were known to decrease As methylation. The metabolism of iAs was only marginally influenced by micronutrient status, probably because women, especially in pregnancy and with low folate intake, have an efficient betaine-mediated remethylation of homocysteine, which was essential for an efficient As methylation. Their findings suggested that in spite of the high As exposure and prevalent malnutrition, overall As methylation in women in early pregnancy was remarkably efficient. The As exposure level had the greatest impact on As methylation among the studied factors.

**Khan and Kraemer (2009)** studied the factors influenced underweight, overweight and obese among ever-married non-pregnant urban Bangladeshi women; they extracted data from the Bangladesh Demographic and Health Survey 2004. They observed that a variety of adverse health outcomes such as diabetes mellitus, cardiovascular diseases, low birth weight, poor quality of life and higher mortality were associated with underweight, overweight and obese categories. Bivariable, factor and multinomial logistic regression analyses were performed in their study. They got the result that the prevalence of being underweight, overweight and obese among ever-married non-pregnant urban women in Bangladesh was 25.2 percent, 15.7 percent and 3.9 percent, respectively. Age, education, region of residence, marital status, current use of contraception and type of occupation were significantly associated with BMI categories. Adjusted multinomial logistic regression analysis indicated that women with a high socioeconomic status were significantly negatively associated with being underweight (OR=0.55, 95% CI: 0.48-0.63) but positively associated with being overweight (OR=1.70, 95% CI: 1.48-1.96) and obese (OR=2.48, 95% CI: 1.89-3.26), as compared to the women with normal BMI. In contrast, women who migrated from rural to urban areas showed a significantly positive association with being underweight (OR=1.15, 95% CI: 1.04-1.27) but negative associations with being overweight (OR=0.80, 95% CI: 0.71-0.89) and obese (OR=0.75, 95% CI: 0.62-0.92), when compared with women who did not migrate. They concluded that suitable interventions based on further studies were needed to reduce the prevalence of being underweight and overweight among ever-married non-pregnant urban women in Bangladesh. They also concluded that factors, viz. socioeconomic status, rural-urban migration and education, should be considered while developing interventional strategies to reduce the prevalence of extreme BMIs among women living in urban areas of Bangladesh.

**Hossain et al. (2010)** documented secular trends in age at menarche and their association with anthropometric measures and socio-demographic factors in university students in Bangladesh; they collected data from university students in Rajshahi University using a stratified sampling technique. Multiple regression analysis was used to assess the association of age at menarche with adult anthropometric measures and various socio-demographic factors. They observed the mean and median ages of menarche were 13.12±1.16 and 13.17 years, respectively, with an increasing tendency among birth-year cohorts from 1979 to 1986. Menarcheal age was negatively associated with BMI ($p<0.01$), but positively associated with height ($p<0.05$). Early menarche was especially pronounced among students from urban environments, Muslims and those with better educated mothers. Increasing age at menarche might be explained by improved nutritional status among Bangladeshi populations. Early menarche was associated with residence location at adolescence, religion and mother's education.

**Pierce et al. (2010)** reported the association between BMI and mortality in Bangladeshi populations aged 18-75 years; they extracted data from the Health Effects of Arsenic Longitudinal Study (HEALS) in Araihazar, Bangladesh. They observed that low BMI was strongly associated with increased mortality in this cohort ($p<0.0001$). Severe underweight (BMI<16 kg/$m^2$; HR=2.06, 95% CI: 1.53-2.77) and moderate underweight (16.0-16.9 kg/$m^2$; HR=1.39, 95% CI: 1.01-2.90) were associated with increased all-cause mortality compared with normal BMI (18.6-22.9 kg/$m^2$). The highest BMI category (≥23.0 kg/$m^2$) did not show a clear association with mortality (HR=1.10, 95% CI: 0.77-1.53). The BMI-mortality association was stronger among individuals with <5 years of formal education (interaction $p<0.021$). They concluded that underweight was a major determinant of mortality in the rural Bangladeshi population.

**Hossain et al. (2012)** established the relationship between BMI and socio-demographic factors in Bangladeshi women; they extracted data from the 2007 Bangladesh Demographic and Health Survey (BDHS). They found that body mass index increased with increasing age, education level of the woman and her husband, wealth index, age at first marriage and age at first delivery, and decreased with increasing number of ever-born children. Lower BMI was especially pronounced among women who were living in rural areas, non-Muslims, employed women, women not living with their husbands (separated) or those who had delivered at home or non-Caesarean delivery.

**Hossain et al. (2012)** studied association between BMI and socio-demographic factors of Bangladeshi university female students; they got data from University of Rajshahi, Bangladesh conducted from July 2004 to May 2005. They observed that mote than half of the females (63.42%) were normal weight, followed by underweight (33.17%), overweight (3.11%) and obese (0.30%). They also observed that BMI were significantly ($p<0.05$) related to number of sibling, order of birth, parents' residence and parents' educational level. Their findings suggested that BMI was related to some demographic variables, parents' residence and education levels in adult Bangladeshi female students.

## 4.3 Materials and Methods

The sample used in the present study consisted of 14022 married non-pregnant Bangladeshi women of reproductive age (15-49 years). The cross-sectional data were extracted from Bangladesh Demographic and Health Survey (BDHS)-2011. BDHS collected socio-economic, demographic, anthropometric, health and lifestyle information from 17,842 ever-married Bangladeshi women from July 8, 2011 to December 27, 2011. Age at the time of measurements ranged from 12 to 49 years, with an average age of 30.78±9.27 years. This is a national-level survey with the various districts of Bangladesh represented. BDHS used as a sampling frame the list of enumeration areas (EAs) prepared for the 2011 Population and Housing Census, provided by the Bangladesh Bureau of Statistics (BBS) (Khan and Shaw, 2011). BDHS used multistage stratified cluster sampling for selecting household from different enumeration areas. The sampling technique, survey design, survey instruments, measuring system, quality control, ethical approval and subject consent have been described elsewhere (NIPORT, 2013). Body mass index was defined and calculated as the ratio of weight in kilograms to height in metres squared.

Data from a sample of 17,842 married Bangladeshi women were collected by the BDHS-2011. The data set was checked for outliers by the present authors using statistical techniques (Dunn and Clark, 1974). Pregnant women were excluded in this study. After removing outliers, cases with incomplete data, women who was currently pregnant, the data set was reduced to 14022 non-pregnant married women to analyze for the present study.

Since the data used in the present study collected from multistage clustered samples and the dependence among observations came from several levels of the hierarchy. There is a cluster effect of the data set. The single level statistical model is not appropriate for analyzing such kind of data set (Khan and Shaw, 2011). Intra-class correlation coefficient, ICC $=\frac{\sigma_u^2}{\sigma_u^2+\sigma_e^2}$ was used in this study to determine whether or not multilevel is even necessary for our data. The value of ICC ranges from 0 to 1. If ICC is 0, that means the observations within clusters are no more similar than observations from different clusters, if ICC is greater than 0, multilevel regression model is appropriate for the analysis (Park and Lake, 2005). To remove the cluster effect, two levels multiple regression analysis was utilized to examine the relationship between BMI and socioeconomic, demographic and behavioral factors among married women. BMI was used as dependent variable. Multilevel regression model is a powerful statistical tool to remove the cluster effect for finding relationship between dependent (continuous) and independent variables at different levels of the hierarchy data. The two levels multiple regression models are:

**Level I:** $Y_{ij}=\beta_{0j}+\beta_1 X_{1ij}+\beta_2 X_{2ij}+\ldots+\beta_k X_{kij}+e_{ij}$; (i=1,2,…,n)

**Level II:** $\beta_{0j}=\beta_0+u_{0j}$, $u_{0j}\sim N(0,\sigma_u^2)$, $e_{ij}\sim N(0,\sigma_e^2)$

where, $\beta_0$ and $\beta_1,\beta_2,\ldots,\beta_k$ are fixed regression coefficients; $u_{0j}$ and $e_{ij}$ are multilevel residuals; $\sigma_u^2$ and $\sigma_e^2$ are random parameters to be estimated along with the (fixed) regression coefficients. In multiple regression analysis, an important assumption is that the explanatory variables are independent of each other; that is, there is no significant correlation between the explanatory variables used to estimate the ordinary least squares (OLS) relationship. However, in some applications of regression, the explanatory variables are related to each other. In this study, the relationship between the predictor variables was examined using a variance inflation factor (VIF). The VIF for independent variables $X_j$ is: $VIF_j=1/\left(1-R_j^2\right)$; $j=1,2,\ldots,k$; where k is the number of predictor variables and $R_j^2$ is the square of the multiple correlation coefficient of the $j$ th variable with the remaining (k-1) variables where:

1) if 0 < VIF < 5, there is no evidence of multicollinearity problem;

2) if $5 \leq \text{VIF} \leq 10$, there is a moderate multicollinearity problem; and

3) if VIF > 10, there is a seriously multicollinearity problem of variables (Chatterjee & Hadi, 2006).

Finally, the t-test and ANOVA for comparison of mean values were utilized to find the differences in BMI between categories: education level; husband education; rural versus urban; Muslim versus Others; watching television versus no; currently breastfeeding versus no; currently use contraceptive versus no; living with husband versus without (separated); and currently working versus no. Statistical significance was accepted at $p<0.05$. Statistical analyses were carried out using STATA (version 11) and SPSS software (version IBM 19).

## 4.4 Results

### 4.4.1 Descriptive statistics for age, height, weight and BMI of Bangladeshi married women

Descriptive statistics used to calculate means and standard deviations of respondent's age, height, weight and BMI of married and currently non-pregnant Bangladeshi women are presented in current section. A total sample of 14,022 married and currently non-pregnant Bangladeshi women were analyzed in this study. The age of subjects varied from 15 to 49 years with mean age $31.70 \pm 8.77$ years (95% CI: 31.55-31.84). The average height of the women was $150.92 \pm 5.36$ cm (95% CI: 150.83-151.01), ranging from 130.10 to 179.80 cm. Their average weight was $49.28 \pm 9.69$ kg (95% CI: 49.12-49.44), ranging from 26.50 to 94.60 kg. The BMI varied from 12.45 to 39.63 kg/m$^2$, with a mean of $21.60 \pm 3.86$ kg/m$^2$ (95% CI: 21.53-21.66) (Table 4.1).

**Table 4.1:** Descriptive statistics for age, height, weight and BMI of married Bangladeshi women aged 15-49 years (N=14022)

| Variable | Mean | SD | SE | 95% CI | | Mini-mum | Maxi-mum |
|---|---|---|---|---|---|---|---|
| | | | | Lower | Upper | | |
| Age | 31.70 | 8.77 | 0.074 | 31.55 | 31.84 | 15 | 49 |
| Height (cm) | 150.92 | 5.36 | 0.045 | 150.83 | 151.01 | 130.1 | 179.8 |
| Weight (kg) | 49.28 | 9.69 | 0.082 | 49.12 | 49.44 | 26.5 | 94.6 |
| BMI (kg/m$^2$) | 21.60 | 3.86 | 0.033 | 21.53 | 21.66 | 12.45 | 39.63 |

### 4.4.2 Frequency distribution of BMI categories of Bangladeshi married women

The frequency distribution of BMI categories of married Bangladeshi women is presented in table 4.2. More than half of the participants in the current study were normal in weight (59.1%), and 22.8% were underweight. Some participants were overweight (14.9%) and a few were obese (3.2%) (Table 4.2).

**Table 4.2:** Frequency distribution of BMI categories of married Bangladeshi women (N=14,022)

| BMI category | n | % | Cumulative % |
|---|---|---|---|
| Underweight (BMI ≤ 18.5 kg/m$^2$) | 3200 | 22.8 | 22.8 |
| Normal weight (18.5 < BMI < 25 kg/m$^2$) | 8281 | 59.1 | 81.9 |
| Overweight (25 ≤ BMI < 30 kg/m$^2$) | 2094 | 14.9 | 96.8 |
| Obese (BMI ≥30 kg/m$^2$) | 447 | 3.2 | 100.0 |

### 4.4.3 Descriptive statistics for BMI by socio-demographic factors of Bangladeshi married women and least significance difference test of education levels and wealth index among respondents and her husbands

Again the descriptive statistics was utilized to calculate the mean, SD and SE in BMI by socio-demographic factors of Bangladeshi non-pregnant married women (Table 4.3). Independent sample t-test and ANOVA were applied in this study for comparing the means of two samples and more than two samples respectively. Before utilizing ANOVA, it was necessary to check that the standard assumptions underlying the model of ANOVA were satisfied. Kolmogorov–Smirnov non-parametric test has been used to test the normality of the data, and Levene test was performed for checking the group homogeneous in BMI. These tests showed that our data was normally distributed and groups were homogeneous. Thus, the data satisfied the standard assumptions of the ANOVA model. The descriptive statistics demonstrated that education of women is an important factor for getting body weight; ANOVA results showed that the variation in BMI of Bangladeshi women among education level was significant ($p<0.001$) (Table 4.3). Least significance difference (LSD) test was used for pair wise group comparing in BMI of Bangladeshi women. LSD test established that higher educated women had significantly larger BMI than secondary ($p<0.001$), primary ($p<0.001$) and uneducated ($p<0.001$) women, the BMI of secondary educated women was significantly higher than primary ($p<0.001$) and uneducated ($p<0.001$) women, and primary educated women had significantly higher BMI than uneducated ($p<0.001$) women (Table 4.4). Husbands' education also was an important factor for getting body weight of women. The variation of women BMI among their husband's education level was significant ($p<0.001$) (Table 4.3). LSD test demonstrated that BMI of higher educated husband's wife was significantly higher than secondary ($p<0.001$), primary ($p<0.001$) and uneducated ($p<0.001$) husbands' wife. Secondary educated husband's wife had larger BMI than primary ($p<0.001$) and uneducated husband's wife ($p<0.001$) (Table 4.4). T-test established that women who was living in urban environment had significantly ($p<0.001$) larger BMI than rural women (Table 4.3). ANOVA results showed that the variation in BMI of married among family economic conditions was significant ($p<0.001$) (Table 4.3). LSD test demonstrated that women came from rich family had higher BMI than middle ($p<0.001$) and poor ($p<0.001$) family women, and middle family women had larger BMI than poor women ($p<0.001$) (Table 4.4). T-test provided that women who was watching television had higher BMI than their counterparts ($p<0.001$). Non breastfeeding mother had significantly ($p<0.001$) higher BMI than currently breastfeeding mother (Table 4.3). Women who was currently using contraceptive had significantly ($p<0.05$) more BMI than their counterparts (Table 4.3). Women who were currently living with her husband had somewhat less BMI ($p<0.01$) than their counterparts (table 4.3). A woman who was working outside of her house had significantly ($p<0.05$) higher BMI value than their counterpart (Table 4.3).

**Table 4.3:** Descriptive statistics for BMI by socio-demographic factors of married Bangladeshi women aged 15-49 years (N=14022)

| Group (N) | Mean | SD | SE | 95% CI | | Mini-mum | Maxi-mum | p-value |
|---|---|---|---|---|---|---|---|---|
| | | | | Lower | Upper | | | |
| Education level, | | | | | | | | |
| No (3744) | 20.76 | 3.53 | 0.058 | 20.65 | 20.88 | 12.45 | 37.41 | <0.001 |
| Primary (4325) | 21.09 | 3.58 | 0.055 | 20.98 | 21.20 | 13.07 | 37.39 | |
| Secondary (4910) | 22.14 | 4.00 | 0.057 | 22.03 | 22.25 | 13.54 | 39.63 | |
| Higher (1043) | 24.11 | 3.94 | 0.122 | 23.87 | 24.35 | 14.42 | 38.65 | |
| Husband education, | | | | | | | | |
| No (4185) | 20.50 | 3.33 | 0.051 | 20.40 | 20.60 | 12.45 | 36.94 | <0.001 |
| Primary (3858) | 21.05 | 3.49 | 0.056 | 20.94 | 21.16 | 13.39 | 37.41 | |
| Secondary (3973) | 22.05 | 3.96 | 0.063 | 21.93 | 22.17 | 13.49 | 39.63 | |
| Higher (2006) | 24.03 | 4.15 | 0.093 | 23.85 | 24.21 | 14.04 | 39.16 | |
| Residence, | | | | | | | | |
| Rural (9179) | 20.88 | 3.47 | 0.036 | 20.81 | 20.95 | 12.45 | 39.63 | <0.001 |
| Urban (4843) | 22.96 | 4.17 | 0.060 | 22.84 | 23.07 | 12.89 | 37.72 | |
| Wealth index, | | | | | | | | |
| Poor (5027) | 19.95 | 2.92 | 0.041 | 19.87 | 20.03 | 12.45 | 34.11 | <0.001 |
| Middle (2735) | 21.02 | 3.35 | 0.064 | 20.90 | 21.15 | 13.49 | 36.11 | |
| Rich (6260) | 23.17 | 4.10 | 0.052 | 23.07 | 23.27 | 13.71 | 39.63 | |
| Religion, | | | | | | | | |
| Muslim (12405) | 21.60 | 3.86 | 0.035 | 21.53 | 21.66 | 12.45 | 39.63 | 0.954 |
| Others (1617) | 21.59 | 3.85 | 0.096 | 21.40 | 21.78 | 14.15 | 37.68 | |
| Watching television, | | | | | | | | |
| No (5420) | 20.34 | 3.18 | 0.043 | 20.25 | 20.42 | 12.45 | 38.49 | <0.001 |
| Yes (8602) | 22.39 | 4.03 | 0.044 | 22.30 | 22.47 | 13.07 | 39.63 | |
| Currently breastfeeding, | | | | | | | | |
| No (9805) | 22.06 | 3.97 | 0.040 | 21.98 | 22.14 | 12.45 | 39.63 | <0.001 |
| Yes (4217) | 20.52 | 3.36 | 0.052 | 20.42 | 20.62 | 13.54 | 36.73 | |
| Currently use contraceptive, | | | | | | | | |
| No (4404) | 21.48 | 3.96 | 0.060 | 21.37 | 21.60 | 12.89 | 38.65 | 0.019 |
| Yes (9618) | 21.65 | 3.81 | 0.039 | 21.57 | 21.72 | 12.45 | 39.63 | |
| Living with husband, | | | | | | | | |
| No (1535) | 21.88 | 3.81 | 0.097 | 21.69 | 22.07 | 13.65 | 37.47 | 0.002 |
| Yes (12487) | 21.56 | 3.86 | 0.035 | 21.49 | 21.63 | 12.45 | 39.63 | |
| Currently working status, | | | | | | | | |
| No (12345) | 21.57 | 3.87 | 0.035 | 21.50 | 21.63 | 12.45 | 39.63 | 0.016 |
| Yes (1677) | 21.81 | 3.80 | 0.093 | 21.63 | 21.99 | 13.83 | 37.72 | |

**Table 4.4:** Least significance difference test of education levels and wealth index among respondents and her husbands

| Variables | Groups | Mean Difference | p-value | 95% CI Lower | 95% CI Upper |
|---|---|---|---|---|---|
| Education level, | | | | | |
| No education | Primary | -0.3285 | <0.001 | -0.4926 | -0.1644 |
| | Secondary | -1.3768 | <0.001 | -1.5362 | -1.2173 |
| | Higher | -3.3505 | <0.001 | -3.6079 | -3.0932 |
| Primary | Secondary | -1.0483 | <0.001 | -1.2016 | -0.8950 |
| | Higher | -3.0221 | <0.001 | -3.2756 | -2.7685 |
| Secondary | Higher | -1.9738 | <0.001 | -2.2244 | -1.7232 |
| Husband education, | | | | | |
| No education | Primary | -0.5449 | <0.001 | -0.7058 | -0.3837 |
| | Secondary | -1.5487 | <0.001 | -1.7085 | -1.3888 |
| | Higher | -3.5283 | <0.001 | -3.7243 | -3.3323 |
| Primary | Secondary | -1.0039 | <0.001 | -1.1670 | -0.8408 |
| | Higher | -2.9835 | <0.001 | -3.1822 | -2.7849 |
| Secondary | Higher | -1.9796 | <0.001 | -2.1773 | -1.7820 |
| Wealth index, | | | | | |
| Poor | Middle | -1.0723 | <0.001 | -1.2387 | -0.9060 |
| | Rich | -3.2189 | <0.001 | -3.3515 | -3.0863 |
| Middle | Rich | -2.1466 | <0.001 | -2.3071 | -1.9861 |

### 4.4.4 Relationship between BMI and some demographic factors of Bangladeshi married women

Pearson correlation coefficients demonstrated that the linear relationship between BMI and age of the respondent was positive (r=0.156) and was significant (p<0.001) (Table 4.5). The relationship between BMI and the total children ever born of women was negative (r=-0.055) and it was significant (p<0.001). Positive relationship (r=0.124) was found between BMI and age at first marriage of women which was statistically significant (p<0.001). Number of family members did not show significant (p=0.891) relationship with BMI. Finally, a positive (r=0.123) relationship was found between BMI and age at first birth and it was significant ($p<0.001$) (Table 4.5).

**Table 4.5:** Pearson correlation coefficient between BMI and some continuous variables

| Variables | r-value | p-value |
|---|---|---|
| Age | 0.156 | <0.001 |
| Number of ever born children | -0.055 | <0.001 |
| Age at first marriage | 0.124 | <0.001 |
| Number of family members | 0.001 | 0.891 |
| Age at first birth | 0.123 | <0.001 |

### 4.4.5 Effects of socio-economic and demographic factors on BMI of Bangladeshi married women

Multilevel (two level) linear regression model was selected in this study for the hierarchical continuous outcome data which were collected by BDHS using multistage stratified cluster sampling. The two level linear regression models showed that the value of intra-class correlation coefficient (ICC) is 0.062, the selected multilevel model were appropriate for this study. Based on these analysis, the coefficients of the multilevel linear regression analysis exhibited a significant positive relationship (ß=0.07; $p<0.001$) between BMI and respondents' age, this result suggested that older women had higher BMI than younger. The coefficient of age at first marriage was positive (ß=0.05; $p<0.001$), women who got marriage later had higher BMI than their counterparts. A negative association was observed between BMI and number of ever born children (ß=-0.197; $p<0.001$), this result indicated that a woman having one more child had less BMI than her counterpart (Table 4.6). The multiple linear regression also provided that urban women had higher BMI than women who were living in rural environment (ß=1.708; $p<0.001$) (Table 4.6). Women with higher education had more BMI (ß=0.314; $p<0.05$) than uneducated women. Married men who were uneducated were less likely their wife's BMI compared to men with primary (ß=0.2842; p<0.01)), secondary (ß=0.955; p<0.001) and higher (ß=2.306; p<0.001) education. Women from poor economy quintile had less BMI to compare those from middle (ß=0.732; p<0.001) and rich (ß=2.202; p<0.001) economic quintile. Women who were watching television were more likely BMI (ß=0.668; p<0.001) than their counterparts. Woman who was using contraceptive method had more BMI (ß=0.279; p<0.001) than her counterpart. Mother who were currently breastfeeding had less BMI value (ß=- 0.711; p<0.001) than who were not breastfeeding (Table 4.6).

**Table 4.6:** Effects of socio-economic and demographic factors on BMI using multilevel linear regression

| Variable | Coefficients | SE | z-value | p-value |
|---|---|---|---|---|
| Age | 0.0711 | 0.0057 | 12.40 | <0.001 |
| Number of family members | -0.000041 | 0.0124 | -0.0001 | 0.997 |
| Number of ever born children | -0.1971 | 0.0262 | -7.53 | <0.001 |
| Age at first birth | -0.0226 | 0.0143 | -1.58 | 0.114 |
| Age at first marriage | 0.0500 | 0.0158 | 3.16 | 0.002 |
| Residence,<br>Urban Vs Rural | 1.7083 | 0.1061 | 16.10 | <0.001 |
| Education level, | | | | |
| Primary Vs No | -0.0886 | 0.0828 | -1.07 | 0.284 |
| Secondary Vs No | 0.0587 | 0.0920 | 0.64 | 0.523 |
| Higher Vs No | 0.3138 | 0.1599 | 1.96 | 0.049 |
| Husband education, | | | | |
| Primary Vs No | 0.2842 | 0.0832 | 3.41 | 0.001 |
| Secondary Vs No | 0.9554 | 0.0910 | 10.50 | <0.001 |
| Higher Vs No | 2.3063 | 0.1283 | 17.98 | <0.001 |
| Wealth index, | | | | |
| Middle vs Poor | 0.7324 | 0.0859 | 8.33 | <0.001 |
| Rich vs Poor | 2.2019 | 0.0845 | 26.05 | <0.001 |
| Watching television,<br>Yes Vs No | 0.6675 | 0.0732 | 9.12 | <0.001 |
| Religion,<br>Others Vs Muslim | -0.0921 | 0.1114 | -0.83 | 0.408 |
| Currently use contraceptive,<br>Yes Vs No | 0.2796 | 0.0678 | 4.13 | <0.001 |
| Currently breastfeeding,<br>Yes Vs No | -0.7105 | 0.0779 | -9.12 | <0.001 |
| Living with husband,<br>Yes Vs No | -0.1434 | 0.1020 | -1.41 | 0.160 |
| Currently working status,<br>Yes Vs No | -0.1437 | 0.0953 | -1.51 | 0.132 |
| Constant | 19.2334 | 0.1656 | 156.85 | <0.001 |

## 4.5 Discussions

In the present chapter, we assessed the effect of socio-economic and demographic factors on BMI among Bangladeshi non-pregnant married women in reproductive age. The study allowed us to provide a more comprehensive analysis of the target population because the sample population was derived from various geographical regions of the Bangladesh. Previous studies in Bangladesh have examined the relationship between BMI and age, mortality, level of education, wealth index and other social variables (Shafique et al., 2007; Khan & Kraemer, 2009), but they used much smaller data sets that were not representative of the nation. Recently, Hossain et al., 2012 examined the relationship between BMI and some socio-demographic factors but they did not remove cluster effect. We used multilevel linear regression in this study to remove the cluster effect of this condition and data set was collected by BDHS from different geographical areas applying cluster sampling. In addition, the present study may be the first to examine other pertinent information such the association of BMI with watching television, currently contraceptive and currently breastfeeding.

This study showed that the mean BMI of married Bangladeshi women between the ages of 15 and 49 years was 21.60 kg/m$^2$. More than half of the women (59.0%) were of normal weight. Underweight women constituted 22.8% of the study population, while overweight women constituted 14.9%. Only 3.3% were considered obese. This information is consistent with other studies on Bangladeshi women. A study on female Bangladesh women living in an urban area reported that 15.7% were overweight and 3.9% were obese (Khan & Kraemer, 2009), while another study on women living in the slum area of Dhaka reported that 54% of women were underweight (Pryer et al., 2003). Recently, another study on women reported that 57.73% were of normal weight, 28.66% were of underweight, 11.45% were of overweight and only 2.16% were of obese using

2007 BDHS data (Hossain et al., 2012). A relatively similar pattern was also observed in a large population study in neighbouring India, where 56.9% of married women were reported to be of normal weight, 31.2% were underweight, 9.4% were overweight and 2.6% were obese (Bharati et al., 2007).

It was noted that BMI is higher with increasing age, education level of women and their husbands, wealth index, age at first marriage. On the other hand, BMI decreases with increasing age at first delivery and number of ever born children. The present study also demonstrated that higher BMI was especially pronounced among women those who were watching television, currently use contraceptive, currently breastfeeding, Muslims, poor economical background and those living in urban areas. These results are partially supported by the findings of a Bangladeshi study using the 2004 BDHS samples (Khan & Kraemer, 2009). They found that age, education level, region of residence, marital status and type of occupation affected the BMI of married non-pregnant urban women in Bangladesh. However, the study was based on only urban women. The results of the current study are also in partial agreement with the findings of another Bangladeshi study (Shafique et al., 2007). They used data from the Nutritional Surveillance Project (NSP) from 2000 to 2004 and observed that age, level of education, wealth index, residence and area were important factors affecting the BMI of 15- to 45-year-old, non-pregnant women with children under 5 years of age. Moreover, another study reported that the BMI of Bangladeshi females was associated with age, smoking status and level of education (Pierce et al., 2010).

More than 35% of the women in this study were living under poor economic conditions, and 32% were illiterate and did not have enough knowledge about good health practices (NIPORT, 2009). They may not have sufficient resources to meet their caloric requirements. Education can play an important role in improving women's knowledge of general health and balanced nutrition, and this is supported by the observed positive association between BMI and level of education. The majority of the study women were living in rural areas. More than 61% of rural women who participated in the current study did not receive adequate health care, and more than 80% delivered their babies at home without any specialist help. Both the mother and the newborn child are thus exposed to a higher risk of birth-related complications. Thus, people living in rural environments still face major health problems. The percentage of underweight women was higher in rural compared with urban regions, while the reverse was observed for the percentage of obese women.

The present study suggests that poor economic conditions, illiteracy, early age at marriage, early age at first delivery and insufficient medical facilities in rural areas are the main causes of the observed decrease in BMI of married non-pregnant women in Bangladesh. Decreased protein in the diet, increased psychological and physiological stress and decreased socioeconomic conditions of married Bangladeshi women are some of the other possible reasons for the decrease in BMI. Nowadays some wealthy adult women in Bangladesh are very conscious of their body weight and try to keep themselves slim without performing any exercise and only controlling their diet. Consequently, they are not aware of the long-term medical problems related to being underweight. It may be necessary for the authorities to make the general population aware of the importance of a balanced diet and the need to make good conscious decisions on health.

## 4.6 Conclusions

Two level linear regression model was utilized in the present chapter to investigate the effect of socio-economic, demographic and behavioral factors among Bangladeshi married non-pregnant women in reproductive age. The cross-sectional hierarchy nested data was used in this study that was collected by Bangladesh Demographic and Health Survey (BDHS-2011) applying multistage cluster sampling. The multilevel linear regression analysis provided that the influence factors on BMI of Bangladeshi married women were age, total children ever born, age at first marriage, residence, respondents' education level, husbands' education level, wealth index, watching television, contraceptive use and breastfeeding. Other possible influences on BMI include smoking habits, weight goals, weight-loss methods, body-shape perceptions, eating attitudes and behaviors, self-concept and physical activity (Cilliers et al., 2006), level of energy intake (Ortega et al., 1997; Herrera et al., 2003; Najat et al., 2008) and age at menarche (Hossain et al., 2010). Presumably, the answer is multi-factorial and consists of a combination of various factors to explain the variation of BMI among Bangladeshi married women in reproductive age. Therefore, more research is required.

# *CHAPTER FIVE*

## Prevalence and Associated Factors of Anemia among Non-Pregnant Women of Reproductive Age in Bangladesh: Multilevel Logistic Regression Analysis

## 5.1 Introduction

Anemia is defined as a low level of hemoglobin in the blood, as evidenced by fewer numbers of functioning red blood cells. Hemoglobin in red blood cells is an oxygen-carrying protein that binds oxygen through its iron component. Hemoglobin transports oxygen to most cells in the body for the generation of energy. When hemoglobin levels are low less oxygen reaches the cells to support the body's activities. The heart and lungs also must work harder to compensate for the blood's low capacity to carry oxygen. Because of oxygen's role in generating energy in the body and hemoglobin's role in transporting oxygen, one of the first symptoms of anemia is feeling tired. Because the heart has to work harder to get blood and oxygen to the tissues, anemia, particularly severe anemia, can result in cardiac arrest.

There are multiple causes of anemia, of which iron deficiency is the most common. Other important causes include folate deficiency, malaria, AIDS, hemoglobinopathies including thalassaemia, and parasitic infections. Anemia affects the lives of people throughout the life cycle, however, it is usually most prevalent and severe in preschool children and pregnant women, whose iron requirements for growth and reproduction are relatively highest. Iron deficiency and anemia in pregnancy is linked with poor outcomes, including premature delivery, greater risk of obstetrical complications including prolonged delivery, low birth weight infants and prenatal mortality (DeMaeyer and Adiels-Tegman, 1985). Infants born of mothers with iron deficiency anemia are more likely to have low iron stores and to become anemic in infancy and childhood. Iron deficient infants have lowered immune resistance to infectious diseases, delayed psychomotor development and impair cognitive development, lowering IQ by about 9 points (Lozoff et al., 1998). Impaired cognition may persist after correction of iron deficiency and anemia and may even be irreversible. Adolescents are vulnerable to the harmful effects of anemia during a period of life when they are both growing and learning. Anemia adversely affects cognitive function, motor performance, education achievement, growth, physical capacity and work performance. The onset of menstruation combined with rapid physical growth increases dietary requirements in adolescent girls, which may lead to dietary deficiencies and anemia. In later life, iron deficiency and anemia impair work productivity in adults (Edgerton et al., 1979).

Anemia is an important global public health problem among women (Benoist et al., 2008). Anemia in reproductive aged women has been associated with numerous morbidities including miscarriage (Szerafin and Jako, 2010), preterm delivery (Scholl et al., 1992), abruption placenta (Arnold et al., 2009) and low birth weight (Rasmussen, 2001). It is also related to higher risk of prenatal and maternal mortality (Lee et al, 2006; Mulayim et al., 2008; Brabin et al., 2001). In addition, anemic individuals have generally more infectious diseases (Ndyomugyenyi et al., 2008) and will have lower physical and work capacity (Scholz et al., 1997). Center for Disease Control and Prevention (CDCP) of United States has identified anemia as an important indicator for general health among non-pregnant women, and recommended that all non-pregnant women should check their hemoglobin level every 5-10 years throughout their childbearing age (CDC, 1998). Information on the prevalence of anemia can be useful for the development of health intervention programs designed to prevent and control anemia. The study on prevalence of anemia among married women is particularly important for developing countries where health and medically related reforms are being actively implemented.

The prevalence of anemia has been reported in Bangladesh since the early 1960s as part of national nutrition surveys on small samples of women and children

(USDHEW, 1996). Helen Keller International (HKI) in collaboration with the Institute of Public Health Nutrition (IPHN) of Bangladesh conducted anemia surveys first in 1997-98 and again in 2001, but these were limited to the rural areas (HKI/IPHN, 1999; HKI/IPHN, 2002). In developing countries, married women are often responsible for maintaining the family, and many are also contributing towards the workforce and productivity of the nation. Due to their unique role in the population, study on prevalence of anemia among married women is very useful for the authorities to evaluate the status of general health and plan remedial measures that can be effectively target groups or population at risk. The government of Bangladesh is working towards achieving Millennium Development Goals (MDGs), and three among the eight goals are related to health (NIPORT, 2013).

The purpose of the present study is to investigate the prevalence of anemia among non-pregnant married women of reproductive age of Bangladesh and explore important socio-demographic factors that may be associated with this condition.

## 5.2 Review of literatures

Many researchers have tried to study between anemia and socio-demographic factors of different populations. Some of these studies are described in below (Hossain et al., 1995; Wang et al., 1999; Ahmed, 2000; Bhargava et al., 2001; Dangour et al., 2001; Massawe et al., 2002; Bentley and Griffitths, 2003; Chandyo et al., 2007; Trish and Dibley, 2007; Heck et al., 2008; Ngnie-Teta et al., 2008; Pala and Dundar, 2008; Pasricha et al., 2008; Schulze et al., 2008; Ansari et al., 2009; Ashtiani et al., 2009; Fu et al., 2009; Gulati et al., 2009; Khambalia et al., 2009; Pasricha et al., 2009; Shamah-Levy et al., 2009; Ahmed et al., 2010; Akhter et al., 2010; Rao et al., 2010; Zhu et al., 2010; Leal et al., 2011; Merrill et al., 2011; Ahmed et al., 2012; Bobdey and Sinha, 2012; Merrill et al., 2012; Yasmeen et al., 2012; Balarajan et al., 2013; Bari et al., 2013; Kedir et al., 2013; Pei et al., 2013; Shamah-Levy et al., 2013; Smagulova et al., 2013; Sultana et al., 2013; Tofail et al., 2013; Collins et al., 2014; Ota et al., 2014; Rawat et al., 2014; Shill et al., 2014 and Vaezghasemi et al., 2014):

### 5.2.1 Other population studies

**Hossain et al. (1995)** were studied to (i) define blood hemoglobin (Hb) levels; (ii) estimate the prevalence of anemia; (iii) examine the role of iron deficiency in causing anemia; (iv) identify the correlates of anemia prevalence; and (v) assess the acceptability to parents of an anemia screening test for children aged 1-22 months (mo) and their mothers in Al Ain city, Abu Dhabi Emirate, United Arab Emirates, during 1992 and 1993. They got the results that the levels of Hb in all subjects and the levels of serum ferritin in anemic (Hb<11 g/dl) children aged ≥6 mo and innon-pregnant women with Hb < 11 g/dl were determined by a HemoCue Photometer and an enzyme immunoassay, respectively. Each woman was interviewed to obtain pertinent data. In children, anemia was detected in 3% of those aged 1-2 mo (Hb<9 g/dl), in 8% of those aged 3-5 mo (Hb<10 g/dl), and in 25-39% of those aged ≥6 mo (Hb<11 g/dl). Of 19 children tested, ten (53%) were iron-depleted (serum ferritin<12 micrograms/l). After multivariate adjustment, the only significant positive correlate of anemia in children was older age (1-5 mo vs 6-22 mo; OR, 9.51; 95% CI: 3.92-23.08). Anemia was detected in 14% of pregnant women (Hb<11 g/dl) and 16% of non-pregnant women (Hb<12 g/dl).

**Wang et al. (1999)** investigated the prevalence of anemia in women of reproductive age including workers, farmers, cadres and students and to analyze the influencing factors in anemia. Mean value of Hb was 116.35 ± 14.67 g/L in 1,529 cases and the prevalence rate of anemia was 31.2%. Majority of the anemia identified belonged to the 'iron deficiency type'. Influencing factors on anemia included occupation, education, marriage status, menstruation, status of family expenses and physical exercise. Their findings suggested that the prevalence rate of anemia in reproductive aged women was high, thus more attention should be paid. In order to lower the incidence of anemia, preventive and intervenient measurements should be conducted accordingly.

**Dangour et al. (2001)** estimated the prevalence of anemia among adult non-pregnant women in the Kzyl-Orda region of Kazakhstan, and to determine the association between hemoglobin concentration and anthropometric, socioeconomic, reproductive and dietary factors. They used sequential linear regression analysis in their cross-sectional study and they got the results that iron deficiency anemia, as reflected by low hemoglobin levels (Hb<12 g/dl), was detected in 40.2% of the total sample. There was a significant curvilinear relationship between hemoglobin concentration and age, with the nadir of the curve in the 30-40 years age-group. Hemoglobin concentration was found to be positively associated with BMI and socioeconomic factors. Significant negative associations were found between hemoglobin concentration and duration of menses, use of the intra-uterine contraceptive device and the consumption of tea. Their study demonstrated that iron deficiency anemia was present at considerable levels among adult women living in Kzyl-Orda region, Kazakhstan, and provided important baseline information for future research and public health interventions.

**Massawe et al. (2002)** estimated the prevalence of anemia among non-pregnant parous women, and to investigate the main underlying cause for the anemia of reproductive women in Dar-es-Salaam, Tanzania. They used the cross-sectional data in their study and they received the results that 49% were anemic (Hb<12 g/dl) and

1.6% severely anemic (Hb<7 g/dl) out of 504 parous non-pregnant women. Anemia was not related to socio-demographic and obstetric history characteristics, but decreased significantly with increasing BMI (p<0.043). The prevalence of anemia was significantly lower in women using hormonal contraceptives, compared to non-users (36% vs 54%; p<0.05). 87% of the anemic women were iron deficient and 8.7% had elevated serum C-reactive protein indicating undiagnosed infections.

**Bentley and Griffiths (2003)** investigated the prevalence and determinants of anemia among women in Andhra Pradesh. They examined differences in anemia related to social class, urban/rural location and nutrition status (BMI). They observed that rural women would have higher prevalence of anemia compared to urban women, particularly among the lower income groups, and that women with low BMI (<18.5 kg/m2) would have a higher risk compared to normal or overweight women. They collected data from the National Family Health Survey 1998-99 (NFHS-2) provided nationally representative cross-sectional survey data on women's hemoglobin status, body weight, diet, social, demographic and other household and individual level factors. Ordered logit regression analyses were applied to identify socio-economic, regional and demographic determinants of anemia in their study and they got the results that the prevalence of anemia was high among all women. In all 32.4% of women had mild (100-109.99 g/l for pregnant women, 100-119.99 for non-pregnant women), 14.19% had moderate (70-99.99 g/l), and 2.2% had severe anemia (<70 g/l). Protective factors included Muslim religion, reported consumption of alcohol or pulses, and high socioeconomic status, particularly in urban areas. Poor urban women had the highest rates and odds of being anemic. 52% of thin, 50% of normal BMI, and 41% of overweight women were anemic.

**Chandyo et al. (2007)** determined the prevalence of anemia and iron status as assessed by biochemical markers and to explore the associations between markers of iron status and iron intake of reproductive healthy women in Bhaktapur district, Nepal. They used cross-sectional data in their study and they received the results that the prevalence of anemia (Hb concentration<12 g/dl) was 12% (n=58). The prevalence of depleted iron stores (plasma ferritin<15 microg/l) was 20% (n=98) whereas the prevalence of iron deficiency anemia (anemia, depleted iron stores with elevated transferrin receptor i.e. >1.54 mg/l) was 6% (n=30). 7% (n=35) of women were having iron-deficient erythropoiesis (depleted iron stores and elevated transferrin receptor but normal Hb). Out of the 58 anemic women, 41 (71%) and 31 (53%) were also having elevated plasma transferrin receptor and depleted iron stores, respectively. 54% of the women ate less than the recommended average intake of iron. The main foods contributing to dietary iron were rice, wheat flour and green and dry vegetables.

**Trinh and Dibley (2007)** determined anemia prevalence and related factors in pregnant women (PW), post partum women (PPW) and non pregnant women (NPW) in a remote mountainous district, Vietnam. They collected data from cross-sectional survey conducted in 2001 and they got the results that more than half (58%) were anemic: 54% mild and 4% severe. Mean Hb was 11.1g/dL. More PPW had anemia (62%; OR, 1.4; 95% CI: 1.1-2.1 compared to NPW) than NPW (54%) and PW (53%). Other related factors were being BoY, Ede and Koho ethnics (OR, 2.7; 95% CI: 1.4-5.0 compared to Kinh ethnic), having primary education or lower (OR, 1.5; 95% CI: 1.1-2.1 compared to secondary education or higher). Among PW, being pregnant during the third trimester increased anemia (OR, 2.2; 95% CI: 1.3-3.8 compared to being pregnant during the second trimester). Among PPW, women aged 30 or older were more anemic (OR, 1.7, 95% CI: 1.1-2.9 compared to women aged 20-29). They concluded that the anemia prevalence was very high. Interventions should be focused on PPW, PW during the last trimester, minority ethnic women, low-educated and older women.

**Ngnie-Teta et al. (2008)** identified and compared individual and contextual factors associated with various levels of anemia among women aged 15 to 49 years in Mali, West Africa. They collected data from the 2001 Mali Demographic and Health Survey and Multilevel regression analyses were performed in their study. They received the results that among the eleven potential risk factors included in the models; two factors were associated with mild anemia (BMI and education), three with any anemia (pregnancy, BMI and education) and six with moderate-to-severe anemia (pregnancy, BMI, education, wealth, childhood residency and region of residence). Clustering of anemia within communities was 20% for moderate to severe anemia and 13% for mild anemia. Despite significant differences in the prevalence of anemia across regions in Mali, no difference between regions in the risk of mild anemia was found and only the region of Gao showed a significantly higher risk of moderate-to-severe anemia. Their findings indicated that socio-demographic risk factors as well as clustering of anemia varied with the severity of anemia. Specific studies were needed to identify risk factors of mild anemia as well as its consequences, as mild anemia accounts for 20-40% of total prevalence of anemia in Africa.

**Pala and Dundar (2008)** determined the anemia prevalence and risk factors in women of reproductive age group in Nilufer Public Health Training and Research Area, Bursa, Turkey. They used cross-sectional data in their study and multivariate logistic regression analysis was used to determine the risk factors related to anemia. They got the results that the prevalence of anemia was 32.8% (hemoglobin level<12 g/dl). Usage of more than 2 sanitary pads in a day during menstruation (OR, 3.67; 95% CI: 2.30-5.88; p<0.001) and duration of menstrual bleeding more than 5 days (OR, 3.01; 95% CI: 1.94-4.66; p<0.001) were found to be risk factors for anemia.

**Pasricha et al. (2008)** assessed the prevalence of iron deficiency and anemia and associated risk factors in a community-based sample of women living in a rural province of northwest Vietnam. They used cross-sectional data in their study and they got the results that 37.53% were anemic (Hb<12 g/dL), and 23.10% were iron deficient (ferritin<15 ng/L). Hookworm infection was present in 78.15% of women, although heavy infection was uncommon (6.29%). Iron deficiency was more prevalent in anemic than non-anemic women (38.21% vs 14.08%, p<0.001). Consumption of meat at least three times a week was more common in non-anemic women (51.15% vs 66.67%, p<0.043). Mean ferritin was lower in anemic women (18.99 vs 35.66 ng/mL, p<0.001). There was no evidence of a difference in prevalence (15.20% vs 17.23%, p<0.630) or intensity (171.07 vs 129.93 eggs/g, p<0.413) of hookworm infection between anemic and non-anemic women. Although intensity of hookworm infection and meat consumption were associated with indices of iron deficiency in a multiple regression model, their relationship with hemoglobin was not significant. Anemia, iron deficiency, and hookworm infection were prevalent in that population. Intake of meat was more clearly associated with hemoglobin and iron indices than hookworm. An approach to addressing iron deficiency in that population should emphasize both iron supplementation and de-worming.

**Ansari et al. (2009)** determined the frequency and nutritional risk factor of iron deficiency anemia (IDA) in Pakistani women of child bearing age. They conducted data from the October 2005 to March 2006 at the Department of Medicine, Ward-5, and out-patients department of Jinnah Postgraduate Medical Centre, Karachi. 200

non-pregnant females of child bearing age were included in their study; 100 with no previous pregnancy and remaining 100 with at least one prior history of pregnancy. Out of them 89 patients were found to be having iron deficiency anemia in various age groups. Results also showed that dietary habit of patients was one of the causative factors leading to iron deficiency anemia. Their findings demonstrated to overcome iron deficiency anemia a thorough and comprehensive strategy was required, i.e., educating the subjects to consume food rich in iron, community based program, monitoring severely anemic cases and their treatment.

**Ashtiani et al. (2009)** established the prevalence of hemoglobinopathies in a mainly healthy Iranian population. All files of the hematology unit of the Boghrat laboratory over a period of 10 years (1998-2007) were analyzed in relation to the age, sex, full blood count, hemoglobin electrophoresis results, high performance liquid chromatography (HPLC) findings, and iron profile of healthy subjects referred for consultation before marriage. There were 34,030 files; 13,432 (39.5%) were for men, and 20,567 (60.4%) for women. 0.74% of subjects (255) showed a hemoglobinopathy. The distribution of variant hemoglobins in these 255 subjects was: Hb D 75.67% (193 cases), Hb S 4.7%, Hb E 3.13%, Hb O-Arab 1.96% and Hb Lepore 0.39%. A fast hemoglobin was found in 4.71% of subjects. Of the subjects tested, 13.2% (4478) had beta-thalassaemia minor, 0.2% (52) beta-thalassaemia intermedia and 0.1% (30) beta-thalassaemia major. In comparison with other parts of world, there was a different pattern of hemoglobinopathy with a high prevalence of Hb D, which appears to be Hb D Iran.

**Fu et al. (2009)** determined the prevalence of anemia and the relationship between tea-drinking and anemia in reproductive married women in rural China. They used cross-sectional data in their study. Chi-square test, and binary and multinomial

Logistic regression models were used for data analysis in their study and they received the results that the average concentration of hemoglobin were 114.7 ± 17.0 g/L, the prevalence of anemia were 63.3%, and most were mild and moderate anemia (Such prevalence were 63.5%, 63.2% and 63.4% respectively at the ages of 20-30 years, 31-40 years, and 41-49 years.). Subjects with tea-drinking were higher in average concentration of hemoglobin than those of no tea-drinking ($t=3.33$, $p<0.002$). There were significant associations between tea-drinking and anemia OR was 0.56 (95% CI: 0.45-0.73). Further, such protective effects of tea-drinking were observed among subjects with different anemia [ORs were 0.57 (95% CI: 0.43-0.75), 0.57 (95% CI: 0.43-0.75), and 0.28 (95% CI: 0.11-0.70)] in mild, moderate and severe anemia, respectively. Their findings suggested the prevalence of anemia in reproductive married women in rural of China could be higher and tea-drinking could be a possible protective factor.

**Gulati et al. (2009)** evaluated hematological outcomes in non-pregnant, rural Gambian women of reproductive age, receiving daily multimicronutrient (MMN) supplements for 1 year. They used 293 women aged from 17 to 45 years old in their study and they got the results that anemic women (hemoglobin concentration<12 g per 100 ml) were more likely to be older and in economic deficit at baseline. Mean change in hemoglobin concentration was 0.6 ± 1.4 g per 100 ml in the intervention arm and -0.2 ± 1.2 g per 100 ml in the placebo arm ($p<0.001$). After supplementation with MMN, the relative risk of anemia (<12 g per 100 ml) was 0.59 (95% CI: 0.46-0.76) compared with placebo. Anemic subjects at baseline showed an increase in mean hemoglobin from 10.6 g per 100 ml to 11.8 g/l ($p<0.001$) after MMN supplementation. They concluded that MMN supplementation should be considered as a strategy for improving the micronutrient and hematological status of non-pregnant women of reproductive age.

**Pasricha et al. (2009)** assessed the ability of iron indices to predict the hemoglobin response (HBR) to weekly iron-folic acid supplementation (WIFS) in anemic rural Vietnamese women. They compared hemoglobin, serum ferritin, and soluble transferrin receptor in a cohort of 221 non-pregnant women of reproductive age before and after 3 months of WIFS and deworming. At baseline, they got anemia (Hb<120 g/L) was present in 81/221 (36.7%) of subjects. After 3 months, anemia prevalence fell to 58/221 (26.2%), and the mean hemoglobin change was 3.5 g/L (95% CI: 0.9-6.6). A hemoglobin response was observed in 50/75 (66.6%) of anemic women. A ferritin cut-off <30 ng/mL was a more sensitive predictor of response than ferritin <15 ng/mL.

**Shamah-Levy et al. (2009)** described the prevalence of anemia in Mexican women and analyze its trends with information from the last two national nutrition surveys. They received the results that the overall prevalence of anemia for pregnant women was 20.2% (95% CI: 15.9-26.2) and 15.5% for non-pregnant women (95% CI: 14.7-16.4). The prevalence of anemia in women decreased from 1999 to 2006 in all socio-economic profiles. Adolescent women living in the northern and in the southern regions had a greater risk of anemia than those in Mexico City ($p<0.06$). Significant risk was found among low socioeconomic level ($p<0.06$). Greater parity was a significant risk factor ($p<0.05$) for being anemic.

**Rao et al. (2010)** examined various socio-demographic aspects related to consumption of micronutrient-rich foods like green leafy vegetables (GLV), which would be helpful in modifying dietary habits, a strategy that merits consideration for prevention of anemia for rural women of childbearing age (15-35 years) in three villages near Pune city, Maharashtra, India. They used cross-sectional data in their study and got the results that the mean Hb was 11.07 g/dl. 77% of the women were anemic (Hb<12 g/dl) and 28% had iron-deficiency anemia (IDA), indicating that a large proportion of the women had nutritional anemia. Higher prevalence of IDA was associated with several socio-demographic and maternal parameters, but multiple logistic regression analysis showed significant ($p<0.05$) risk of IDA with lower body weight (<40 kg), short maternal height (<145 cm), younger age at marriage (<19 years) and higher parity ($\geq 2$). Various socio-cultural reasons associated with low consumption of GLV included non-cultivation of GLV, priority for selling them rather than home consumption, dislike of GLV by husband and children, and lack of awareness about different recipes for GLV. Their findings highlighted that low consumption of GLV, whose were treasures of micronutrients including Fe, was associated with genuine social reasons.

**Zhu et al. (2010)** assessed the prevalence of folate, vitamin B(12), and iron deficiencies and their associations with anemia among women of childbearing age in northern China, an area with a reported high incidence of neural tube defects. They collected data from the Xianghe County, Hebei Province, China in June 2004 among 1,671 non-pregnant women of childbearing age and they got the results that the geometric means (95% CI) of plasma concentrations were 9.3 (4.0-21.6) nmol/L for folate, 213.1 (82.4-550.9) pmol/L for vitamin B(12), 17.4 (1.1-278.6) microg/L for ferritin, and 129.9 (104.6-161.4) g/L for hemoglobin (Hb). Approximately 24% of women had biochemical evidence of folate deficiency (<6.8 nmol/L), 21.4 % were deficient (<148 pmol/L) in vitamin B(12), 30.2 % had iron depletion (<15 microg/L), and anemia (Hb<120 g/L) was detected among 15.4% of women. Of the three nutrients, only iron depletion (ferritin<15 microg/L) was independently associated with anemia (AOR=6.4; 95% CI: 4.8-8.6). Their results demonstrated that iron deficiency was the most important contributor to anemia among women of childbearing age in northern China.

**Leal et al. (2011)** estimated the prevalence of anemia and to identify its associated factors in children aged 6-59 months. They extracted data from the Third Health and Nutrition Survey of the State of Pernambuco, Northeastern Brazil. They used cross-sectional data in their study and multivariate analysis was performed though a hierarchical model, using robust-variance Poisson regression to estimate the prevalence ratio as a function of the following variables: biological factors, morbidity, child nutritional state, socioeconomic factors, housing, sanitation and maternal factors. They received the results that the weighted prevalence of anemia was 32.8% overall: 31.5% in urban areas and 36.6% in rural areas. In urban areas, anemia was significantly associated with maternal education, consumer goods, number of children less than five years old in the home, drinking water treatment, maternal age, maternal anemia and the child’s age but in rural areas, only maternal age and the child’s age were significantly associated with anemia. They concluded that the prevalence of anemia in children in Pernambuco was similar in urban and rural areas. The factors associated with anemia that were presented here should be taken into consideration in planning effective measures for its control.

**Bobdey and Sinha (2012)** highlighted the problem of anemia in non-pregnant wives of serving enrolled personnel of the Indian Navy in the reproductive age group. Physical examination and hemoglobin estimation was done for 257 (100% sample) non-pregnant/non-lactating wives of serving enrolled personnel of the Indian Navy of age between 18 and 45 years. They used the cross sectional study in their study and got the results that the prevalence of anemia was found to be 31.90%. Also literacy status and mean BMI of women with anemia was found to be significantly less than subjects without anemia. They concluded that a larger multicentric study was being planned to evaluate the prevalence and factors associated with anemia in families of Armed Forces personnel because the prevalence of anemia in wives of naval personnel, which though found much lower than national average was still high at 31.90% for their small study.

**Balarajan et al. (2013)** examined the patterns of social inequalities in anemia over time among women of reproductive age in India. They used repeated cross-sectional data collected from the 1998-1999 and 2005-2006 National Family Health Surveys of India in their study. Multivariate modified Poisson regression models were used to assess trends and social inequalities in anemia and they received the results that the anemia prevalence increased significantly from 51.3% (95% CI: 50.6%-52%) to 56.1% (95% CI: 55.4%-56.8%) among Indian women over the 7-year period. That corresponded to a 1.11-fold increased in anemia prevalence (95% CI: 1.09-1.13) after adjustment for age and parity, and 1.08-fold increased (95% CI: 1.06-1.10) after further adjustment for wealth, education and caste. There was marked state variation in anemia prevalence; in only 4 of the 25 states did anemia prevalence significantly decline. In both periods, anemia was socially patterned, being positively associated with lower wealth status, lower education and belonging to scheduled tribes and scheduled castes. In that context of overall increasing anemia prevalence, adjusted relative and absolute socioeconomic inequalities in anemia by wealth, education and caste had narrowed significantly over time. Their findings suggested that the significant increased in anemia among India's women during that period was a matter of concern, and in contrast to secular improvements in other markers of women's health and nutritional status. While socioeconomic inequalities in anemia persist, the relative and absolute inequalities in anemia had decreased over time.

**Kedir et al. (2013)** determined the prevalence and predictors of anemia among pregnant women in the rural eastern Ethiopia. Data were collected in a community-based setting by them and Multilevel mixed effect logistic regression was used to determine the adjusted odds ratios (AOR) with 95% confidence intervals (CI) for the predictors of anemia. They used a community-based cross-sectional data in their study and they got the results that anemia was observed among 737(43.9%) of the 1678 pregnant women studied (95% CI: 41.5%-46.3%). They also received the results that the risk of anemia was 29% higher in the women who chewed khat daily than those who sometimes or never did so (AOR, 1.29; 95% CI: 1.02-1.62) after controlling for the confounders. The study subjects with restrictive dietary behavior (reduced either meal size or frequency) had a 39% higher risk of anemia compared to those without restrictive dietary behavior (AOR, 1.39; 95% CI: 1.02-1.88). The risk of anemia was increased by 68% (AOR, 1.68; 95% CI: 1.15-2.47), and 60% (AOR, 1.60; 95% CI: 1.08-2.37) in parity levels of 2 births and 3 births, respectively. Compared to the first trimester, the risk of anemia was higher by two-fold (AOR, 2.09; 95% CI: 1.46-3.00) in the second trimester and by four-fold (AOR, 4.23; 95% CI: 2.97-6.02) in the third trimester. They concluded that two out of five women were anemic in their study; and chewing khat and restrictive dietary habits that were associated with anemia in the setting should be addressed through public education programs. Interventions should also focus on the women at higher parity levels and those who were in advanced stages of pregnancy.

**Pei et al. (2013)** investigated the levels and associated factors of maternal anemia on human function, particularly on women between 2001 and 2005 in rural Western

China. 6172 and 5372 mothers with children under three years old were selected from 8 provinces in 2001 and from 9 provinces in 2005 respectively in Western China by means of a multi-stage probability proportion to size sampling method (PPS). A two-level logistic regression model was employed to identify the determinants and provincial variations of women anemia in 2001 and 2005. They got the results that the crude prevalence of women anemia in 2005 was higher than the rate in 2001 (45.7% vs 33.6%). Based on the nationwide census data in 2000, the age-standardized prevalence of women anemia in their study were obtained as 38.0% in 2001 and 50.0% in 2005 respectively. Two-level logistic model analysis showed that compared to the average, women were more likely to be anemic in Guangxi and Qinghai in 2001 as well as in Chongqing and Qinghai in 2005; that women from Minority groups had higher odds of anemia in contrast with Han; that women with higher parity, longer breastfeeding duration and higher socioeconomic level had a lower rate of anemia, while age of women was positively associated with anemia. The positive correlation between women anemia and altitude was also observed. Their study demonstrated that the burden of maternal anemia in rural Western China increased considerably between 2001 and 2005. The Chinese government should conduct integrated interventions on anemia of mothers in this region.

**Shamah-Levy et al. (2013)** studied the prevalence of anemia and its trend in Mexican women of childbearing age over the past 13 years. They constructed data from the three national probabilistic surveys whose were National Health and Nutrition Survey 2012 and 2006 and from the National Nutrition Survey 1999, representative at regional and rural/urban level. They got the results that the national prevalence of anemia in 2012 in non-pregnant women was 11.6% and in pregnant women was 17.9%. Between 1999 and 2012, a 10 percentage point (pp) decreasing in anemia prevalence was observed in the first ones and a 13.5 pp in the second ones. Their finding demonstrated that anemia in women of childbearing age remains as a serious public health problem in the past 13 years and it was considered necessary to design strategies to prevent iron deficiency and for the early detection of anemia in women.

**Smagulova et al. (2013)** studied on the prevalence of anemia among women of reproductive age and children, residing in the various regions of Kazakhstan. Their study involved participation of 1303 women at the age of 15-49 years, and of 1318 children, 353 (26.8%) of whom were in the age of 6 up to 23 months, and 985 (73.2%) were in the age range of 24-59 months. 89 women were pregnant, which constituted 6.8%. They observed that the average hemoglobin level in the blood of pregnant women was $11.1 \pm 1.6$ g/dL, which was significantly lower compared to that of non-pregnant women, for whom the figure was $12.1 \pm 1.6$ g/dL. The average level of hemoglobin in the blood of children in the age range of 6-23 months was $10.7 \pm 1.4$ g/dL, and was significantly lower than that of children in the age range of 24-59 months, for whom the figure was, in average, $11.5 \pm 1.4$ g/dL ($p<0.05$). The rate of prevalence of iron deficiency anemia among pregnant women was 43.8%, among non-pregnant women 39.0%, among children aged 6-59 months 35.2%. It was found that the prevalence of anemia was significantly higher in children aged 6-23 months (53.3%) compared with children aged 24-59 months (28.8%). As for degree of severity of anemia, mild form prevailed in all of the examined groups: children 53.6%, pregnant women 51.2% and non-pregnant 77.2%. Moderate anemia was mostly diagnosed in children in the age range of 6 to 23 months and in pregnant women (50.5 and 43.6% relatively). They concluded that the comprehensive program of prevention and control of iron-deficiency anemia among children and women included food fortification, supplementation of target groups with iron preparation and folic acid, food diversification, monitoring and evaluation of program execution, as well as training of medical students and medical staff with policies and strategies of struggle against iron-deficiency anemia.

**Collins et al. (2014)** examined individual- and neighborhood-level determinants of current wheezing among Hispanic children living in El Paso, Texas using multilevel logistic regression modeling. They collected data from the US Census Bureau and a population-based survey of El Paso school children during of May 2012. Results revealed that economic deprivation (measured based on poverty status) at both neighborhood- and individual-levels was associated with reduced odds of wheezing for Hispanic children. A sensitivity analysis revealed similar significant effects of individual- and neighborhood-level poverty on the odds of doctor-diagnosed asthma. Neighborhood-level poverty did not significantly modify the observed association between individual-level poverty and Hispanic children's wheezing; however, greater neighborhood poverty tends to be more protective for poor (as opposed to non-poor) Hispanic children. Their findings supported a novel, multilevel understanding of seemingly paradoxical effects of economic deprivation on Hispanic health.

**Ota et al. (2014)** estimated the association between the birth of small for gestational age (SGA) infants and the risk factors and adverse perinatal outcomes among twenty-nine countries in Africa, Latin America, the Middle East and Asia in 359 health facilities in 2010-11. They analyzed facility-based, cross-sectional data from the WHO Multi-country Survey on Maternal and Newborn Health and they constructed multilevel logistic regression models with random effects for facilities and countries to estimate the risk factors for SGA infants using country-specific birth-weight reference standards in preterm and term delivery, and SGA's association with adverse perinatal outcomes. They also compared the risks and adverse prenatal outcomes with appropriate for gestational age (AGA) infants categorized by preterm and term delivery. They got the results that the overall prevalence of SGA was highest in Cambodia (18.8%), Nepal (17.9%), the Occupied Palestinian Territory (16.1%), and Japan (16.0%), while the lowest was observed in Afghanistan (4.8%), Uganda (6.6%) and Thailand (9.7%). They also got the results that the risk of preterm SGA infants was significantly higher among nulliparous mothers and mothers with chronic hypertension and preeclampsia/eclampsia (aOR: 2.89; 95% CI: 2.55-3.28) compared with AGA infants. Higher risks of term SGA were observed among socio-demographic factors and women with preeclampsia/eclampsia, anemia and other medical conditions. Multiparity ($\geq 3$) (AOR: 0.88; 95% CI: 0.83-0.92) was a protective factor for term SGA. The risk of perinatal mortality was significantly higher in preterm SGA deliveries in low to high HDI countries. They concluded that the preterm SGA was associated with medical conditions related to preeclampsia, but not with socio-demographic status, where the term SGA was associated with socio-demographic status and various medical conditions.

**Vaezghasemi et al. (2014)** examined the extent of the dual burden of malnutrition across different provinces in Indonesia and determined how gender, community social capital, place of residency and other socioeconomic factors affect the prevalence of the dual burden of malnutrition. They utilized data from the fourth wave of the Indonesian Family Life Survey (IFLS) conducted between November 2007 and April 2008. The dataset contained information from 12,048 households and 45,306 individuals of all ages. Their study focused on households with individuals over two years old. To account for the multilevel nature of the data, a multilevel multiple logistic regression was conducted. They got the results approximately one-fifth of all households in Indonesia exhibited the dual burden of malnutrition, which was more prevalent among male-headed households, households with a high Socio-economic status (SES), and households in urban areas. Minimal variation in the dual burden of malnutrition was explained by the community level differences (<4%). Living in households with a higher SES resulted in higher odds of the dual burden of malnutrition but not among female-headed households and communities with the highest social capital. They concluded that improved household health and reduced the inequality across different SES groups, their study emphasized the inclusion of women's empowerment and community social capital into intervention programs addressing the dual burden of malnutrition.

### 5.2.2 Bangladeshi studies

**Ahmed (2000)** provided a comprehensive review of the changes in the prevalence and the extent of anemia among different population groups in Bangladesh up to the present time. The report also focused on various factors in the aetiology of anemia in the country. He collected data from the national nutrition surveys 1962-64, 1975-76, 1981-82 and 1995-96, as well as small studies in different population groups. Since the 1975-76 survey the average national prevalence of anemia had not fallen; in 1995-96, 74% were anemic (64% in urban areas and 77% in rural areas). However, age-specific comparisons suggested that the rates have fallen in most groups except adult men: in preschool children in rural areas it had decreased by about 30%, but the current level (53%) still falls within internationally agreed high risk levels. Among the rural population, the prevalence of anemia was 43% in adolescent girls, 45% in non-pregnant women and 49% in pregnant women. The rates in the urban population were slightly lower compared with rural areas, but were high enough to pose a considerable problem. It appeared that severe anemia in the Bangladeshi population was less frequent, possibly present among only 2-3% of the population. The data on the aetiology of anemia revealed that iron deficiency might be a substantial cause of anemia in the Bangladeshi population. Other dietary factors in addition to parasitic infestations might also precipitate the high prevalence of anemia.

**Bhargava et al. (2001)** extended algorithms for calculating bioavailable iron from mixed diets, taking into account the enhancers and inhibitors of iron absorption under alternative assumptions on body iron stores and developed a comprehensive longitudinal model for the proximate determinants of hemoglobin concentration that included the subjects' dietary intakes, nutritional status, morbidity and socioeconomic factors and the unobserved between-subject differences. The model for hemoglobin concentration was estimated using three repeated observations on 514 free living women in Bangladesh. Socioeconomic factors affecting the iron intake from meat, fish and poultry and from all animal sources were also modeled. The main results were that bioavailable iron, women's height and mid upper arm circumference and intake of iron tablets were significant predictors of hemoglobin concentration. Increases in household incomes were associated with higher intake of iron from meat, fish and poultry and from all animal sources. The algorithms for estimating bioavailable iron showed the importance of assumptions regarding body iron stores and underscored the need to develop suitable algorithms for subjects in developing countries.

**Heck et al. (2008)** examined the association between arsenic exposure and anemia, based on blood hemoglobin concentration in Bangladesh. They used longitudinal data in their study. They used general linear modeling to assess the association between arsenic exposure and hemoglobin concentration, examining men and women separately and they got arsenic exposure (urinary arsenic>200 microg/L) was negatively associated with hemoglobin among all men and among women with hemoglobin <10 d/L. Other predictors of anemia in men and women included older age, lower body mass index, and low intake of iron. Among women, the use of contraceptives predicted higher hemoglobin. Their findings suggested that an association between high arsenic exposure and anemia in Bangladesh.

**Schulze et al. (2008)** characterized the role of hepcidin in the anemia of pregnancy. They examined the relationships between urinary hepcidin, iron status indicators, hemoglobin, erythropoietin, alpha-1 acid glycoprotein, and C-reactive protein in a cross-sectional study conducted among 149 pregnant rural Bangladeshi women in biospecimens obtained during home visits. Urinary hepcidin was measured using surface-enhanced laser desorption/ionization time-of-flight mass spectrometry. Urinary hepcidin, as log(intensity per mmol/L creatinine), was correlated with log ferritin ($r=0.33$, $p<0.001$), the transferrin receptor index ($r=-0.22$, $p<0.008$), and log alpha-1 acid glycoprotein ($r=0.20$, $p<0.02$), but not hemoglobin ($r=0.07$, $p<0.41$), log transferrin receptor ($r=-0.07$, $p<0.42$), log erythropoietin ($r=-0.01$, $p<0.89$) or log C-reactive protein ($r=0.06$, $p<0.49$). The strength of the relationship between hepcidin and ferritin was maintained in a multiple linear regression analyses after enhancing the sample with women selected for low iron stores ($n = 41$). Among pregnant women in a community-based study in rural Bangladesh, urinary hepcidin levels were related to iron status and AGP but not hemoglobin, erythropoietin, or C-reactive protein.

**Khambalia et al. (2009)** described the iron and folate status of married, nulliparous women in rural Bangladesh from March to May 2007. Of 272 women, 37% were anemic (hemoglobin<120 g/L), 13% were folate deficient (plasma folate$\leq$10 nmol/L), 15% were iron deficient (plasma ferritin<12 $\mu g/L$ or tranferrin receptor>4.4 mg/L), 11% were iron deficient and anemic, and 81% were estimated to have < 500 mg of iron stores. Risk of anemia was 4 times greater among nonstudents than students (95% CI: 1.23-14.69), twice as likely among women with a previous miscarriage compared with those who had never been pregnant (95% CI: 1.04-5.47), and 6 times greater among iron-deficient compared to iron-replete women (95% CI: 2.76-11.81). Adolescents ($\leq 19$ y) had lower mean plasma ferritin concentration ($38.3 \pm$ SD vs. $49.1 \pm$ SD $\mu g / L$; p<0.005) and body iron stores [$3.4 \pm 5.2$ mg/kg vs. $4.3 \pm 5.6$ mg/kg ($0.06 \pm 0.09$ mmol/kg vs. $0.08 \pm 0.10$ mmol/kg); p<0.007] compared with adults. An unacceptably high percentage of nulliparous women in rural Bangladesh have inadequate iron and folate status. As they enter pregnancy, more than one-third will be anemic, >80% will have inadequate iron stores, and more than one-tenth will be folate deficient. Further research was needed on risk factors of poor nutritional status before the start of a woman's childbearing years.

**Ahmed et al. (2010)** examined long-term once- or twice-weekly supplementation of multiple micronutrients (MMN) can improve hemoglobin (Hb) and micronutrient status more than twice-weekly iron + folic acid (IFA) supplementation in anemic adolescent girls in Bangladesh. Anemic girls (n = 324) aged 11–17 years attending rural schools were given once- or twice-weekly MMN or twice-weekly IFA, containing 60 mg iron/dose in both supplements, for 52 wk in a randomized double-blind trial. Blood samples were collected at baseline and 26 and 52 wk. Intent to treat analysis showed no significant difference in the Hb concentration between treatments at either 26 or 52 wk. However, after excluding girls with hemoglobinopathy and adjustment for baseline Hb, a greater increase in Hb was observed with twice-weekly MMN at 26 wk (p<0.046). Although all 3 treatments effectively reduced iron deficiency, once-weekly MMN produced significantly lower serum ferritin concentrations than the other treatments at both 26 and 52 wk. Both once- and twice-weekly MMN significantly improved riboflavin, vitamin A, and vitamin C status compared with IFA. Overall, once weekly MMN was less efficacious than twice-weekly MMN in improving iron, riboflavin, RBC folic acid, and vitamin A levels. Micronutrient supplementation beyond 26 wk was likely important in sustaining improved micronutrient status. Their findings highlighted the potential usefulness of MMN intervention in that population and had implications for programming.

**Akhter et al. (2010)** assessed the effect of maternal iron deficiency anemia (MIDA) on cord blood iron status, placental weight and fetal outcome [birth weight, APGAR (appearance, pulse, Grimace, activity, and respiration) scores and birth asphyxia]. They conducted a cross sectional analytic study on fifty hospitalized pregnant women and their neonates over a year in a teaching hospital in the capital city of Bangladesh. Serum and cord hemoglobin concentration [Hb] with ferritin values were determined immediately after delivery, placental weight, gestational age, birth weight, APGAR scores and birth asphyxia were recorded. It was observed that 36% of the pregnant women were anemic. Maternal [Hb] and serum ferritin showed a highly significant positive correlation ($r=0.92$, $p<0.001$) indicating that iron deficiency was the most dominant factor in the causation of anemia amongst them. The maternal [Hb] showed a significant correlation with placental weight ($r=0.40$, $p<0.001$), birth weight ($r=0.35$, $p<0.001$), APGAR score ($r=0.52$, $p<0.001$), gestational age ($r=0.61$, $p<0.001$) and birth asphyxia. Maternal serum ferritin also correlated positively with cord ferritin ($r=0.94$, $p<0.001$), placental weight ($r=0.26$, $p<0.001$) and birth weight ($r=0.27$, $p<0.001$). Iron deficiency anemia (IDA) during pregnancy had significant adverse affect on the foetal outcome.

**Merrill et al. (2011)** evaluated the association between groundwater iron intake and iron status in a rural Bangladeshi population of women deficient in dietary iron. In 2008, participants (n = 209 with complete data) were visited to collect data on 7-d food frequency, 7-d morbidity history, 24-h drinking water intake, and rice preparation, and to measure the groundwater iron concentration. Blood was collected to assess iron and infection status. Plasma ferritin (μg/L) and body iron (mg/kg) concentrations were [median (IQR)] 67 (46, 99) and 10.4 ± 2.6, respectively, and the prevalence of iron deficiency (ferritin$<$12 μg/L) was 0%. Daily iron intake from water [42 mg (18, 71)] was positively correlated with plasma ferritin ($r=0.36$) and total body iron ($r=0.35$) ($p<0.001$ for both). In adjusted linear regression analyses, plasma ferritin increased by 6.1% (95% CI: 3.8-8.4) and body iron by 0.3 mg/kg (0.2-0.4) for every 10-mg increase in iron intake from water ($p<0.001$). In that rural area of northern Bangladesh, women of reproductive age had no iron deficiency likely attributable to iron consumed from drinking groundwater, which contributed substantially to dietary intake. Those findings suggested that iron intake from water should be included in dietary assessments in such settings.

**Ahmed et al. (2012)** examined whether long-term supplementation with once- and twice-weekly multiple micronutrients (MMN-1 and MMN-2) can improve Hb and micronutrient status more than twice-weekly Fe-folic acid (IFA-2) supplementation in non-anemic adolescent girls in Bangladesh. An equal number of 324 rural schoolgirls aged 11-17 years were given MMN-1 or MMN-2 or IFA-2 supplements for 52 weeks in a randomized, double-blind trial. Blood samples were collected at baseline, and at 26 and 52 weeks of supplementation. The girls receiving IFA-2 supplements were more likely to be anemic than the girls receiving MMN-2 supplements for 26 weeks (OR, 5·1, 95% CI: 1·3-19·5; $p<0{\cdot}019$). All three supplements reduced Fe deficiency effectively. Both the MMN-1 and MMN-2 groups showed significantly greater improvements in vitamins A, B(2) and C status than the girls in the IFA-2 group, as might be expected. Receiving a MMN-1 supplement was found to be less effective than MMN-2 supplement in improving Fe, vitamins A, B(2) and folic acid status.

Receiving micronutrient supplements beyond 26 weeks showed little additional benefit in improving micronutrient status. In conclusion, given twice-weekly for 26 weeks, MMN supplements could improve micronutrient status effectively with no significant increased in Hb concentration compared with IFA supplements in non-anemic Bangladeshi adolescent girls. However, it significantly reduced the risk of anemia. Before any recommendations could be made, further research, including into cost-effectiveness, was needed to see whether MMN supplementation had any additional longer-term health benefits over that of IFA supplementation in that population.

**Merrill et al. (2012)** assessed the relative influence on anemia of thalassemia, groundwater arsenic and iron, and diet among women of reproductive age living in rural Bangladesh. Women (n=207) sampled from a previous antenatal nutrient intervention trial in rural Bangladesh were visited during two seasons in 2008. Collected data included 7-day dietary and 24-hour drinking water intake recalls, 7-day morbidity recall, anthropometry, and drinking water arsenic and iron concentrations. Capillary blood was analyzed for iron (plasma ferritin, soluble transferrin receptor), inflammation (C-reactive protein) and thalassemia (β thalassemia and Hb E) status. In stratified, adjusted analyses, only parity was associated with anemia (OR, 11.34; 95% CI: 1.94-66.15) for those with thalassemia (28% prevalent). In contrast, groundwater iron intake (>30 mg/d) (OR, 0.48; 95% CI: 0.24-0.96) and wasting (OR, 2.32; 95% CI: 1.17-4.62) were associated with anemia among those without thalassemia. Elevated groundwater arsenic (>50 µg/L, 12% of tubewells) and a diverse diet were unrelated to anemia regardless of thalassemia diagnosis (p>0.70 and p>0.47, respectively). Among women in this typical rural Bangladeshi area, the prevalence of thalassemia was high and, unlike iron deficiency which was absent most likely due to high iron intake from groundwater, contributed to the risk of anemia. In such settings, the influence of environmental sources of iron and the role of thalassemias in contributing to anemia at the population level might be underappreciated.

**Yasmeen et al. (2012)** evaluated the effect of short-term administration of recombinant human erythropoietin (rHuEPO) with iron and folic acid in very low birth weight (VLBW) neonates in the prevention of anemia of prematurity (AOP). Sixty preterm very low birth weight (PTVLBW) babies were enrolled from Dhaka Shishu Hospital in their study. Thirty were assigned to rHuEPO group and 30 as control. Baseline haematologic values were estimated before administration of rHuEPO. From day 7 of life rHuEPO-200 IU/kg/dose subcutaneously every alternate day for 2 weeks was administered to rHuEPO group. All infants in both groups have received oral iron, folic acid from day 14. Clinical and haematological assessment was done at 6 and 10 weeks of life. Baseline clinical characteristics and haematologic values were almost similar in both groups. Their study had shown increase in haematological values (hemoglobin and haematocrit) and reduction in the number of blood transfusions during both the 1st and 2nd follow up in rHuEPO group in comparison to control group ($p<0.01$). Short-term rHuEPO appeared to be very effective in prevention of Anaemia of prematurity.

**Bari et al. (2013)** found the association of iron deficiency, in anemia with rheumatoid arthritis (RA) and to find a sensitive and less invasive marker to differentiate iron deficiency anemia from the anemia of chronic disease. They used cross-sectional data in their study conducted from the Department of Medicine, Mymensingh Medical College Hospital, Mymensingh during December 2009 to November 2010. The mean age of the patients was 42.6 years (22-66 years) with female to male ratio being roughly 3:1. Majority (97%) of the patients presented weakness followed by 78.8%

dizziness, 54.5% palpitation, 24.2% pallor, 12.1% breathlessness, another 12.1% smooth tongue and 6.1% nail change. About 79% of the patients were positive for RA test and nearly 70% of patient had moderate anemia. The mean serum ferritin was significantly reduced in patients with hypochromic with or without microcytic anemia than that with normocytic normochromic anemia ($p<0.001$). While total iron binding capacity was found to be significantly increased in patients with iron deficiency anemia than that in patients with anemia of chronic disease ($p<0.021$). The serum iron level was considerably reduced in the former group than that in the later group ($p<0.066$). Bone marrow iron grading revealed 48.5% of the patients with iron depleted and 51.5% with iron repleted. Serum ferritin level of patients with iron depleted bone marrow was significantly decreased than that in patients with iron repleted bone marrow ($p<0.001$). Serum iron level of the former group was also reduced than that of the later group ($p<0.133$). Total iron binding capacity was significantly raised in patients with iron depleted group than that in patients with iron repleted group ($p<0.001$). Their study suggested that anemia of chronic disease and iron deficiency anemia frequently coexist in patients with RA and serum ferritin and total iron binding capacity were considered good indicator for differentiating iron deficiency anemia from the anemia of chronic disease.

**Sultana et al. (2013)** evaluated the role of red cell distribution width (RDW) and RBC indices in determining iron deficiency early and provide reliable and useful technique. RDW compared with MCV, MCH and MCHC in various stages of iron deficiency in their study. In latent stage of iron deficiency higher RDW was found significant than MCV, MCH, MCHC ($p<0.05$). In this study RDW had sensitivity 82.3% and specificity 97.4%. Whereas MCV, MCH and MCHC had 29.2%, 68.1% and 15% sensitivity but specificity was 98.7%, 83.1% and 96.1% in the detection of iron deficiency. Iron deficiency anemia without other complicating disease could be screened out early by increased RDW when RBC indices were normal.

**Tofail et al. (2013)** compared the effects of psychosocial stimulation on the development of children with iron deficiency anemia (IDA) and children who were neither anemic nor iron deficient (NANI). NANI (n=209) and IDA (n=225) children, aged 6-24 months, from 30 Bangladeshi villages were enrolled in their study. The villages were then randomized to stimulation or control, and all children with IDA received 30 mg iron daily for 6 months. Stimulation comprised 9 months weekly play sessions at home. They assessed children's development at baseline and after 9 months by using the Psychomotor Development Index (PDI) and the Mental Development Index (MDI) of the Bayley Scales of Infant Development-II, and rated their behavior during the test. When they controlled for socioeconomic background, the IDA and NANI groups did not differ in their Bayley scores and behavior at baseline. After 9 months, the IDA group had improved in iron status compared with baseline but had lower PDI scores and were less responsive to the examiner than the NANI group. Random-effects multilevel regressions of the final Bayley scores of the IDA and NANI groups showed that stimulation improved children's MDI [B±SE= 5.7±1.9 (95% CI: 2.0-9.4), $p<0.004$], and the interaction between iron status and stimulation showed a suggestive trend ($p<0.11$), indicating that children with IDA and NANI responded differently to stimulation, with the NANI group improving more than the IDA group. In addition to iron treatment, children with IDA might require more intense or longer interventions than NANI children.

**Rawat et al. (2014)** determined the contribution of iron deficiency (ID), infections and feeding practices to anemia in Bangladeshi infants aged 6-11 months. Multivariate logistic regression was used to identify risk factors for anemia and ID, and population attributable fractions (PAF) were computed to estimate the proportion of anemia that might be prevented by the elimination of individual risk factors in their study and they got the results that 68% of the infants were anemic, 56% were Fe deficient, and one-third had evidence of subclinical infections. The prevalence of anemia and ID increased rapidly, until 8-9 months of age, while that of subclinical infections was constant. ID (adjusted OR (AOR), 2·6-5·0; p< 0·001) and subclinical infections (AOR, 1·4-1·5; p< 0·01) were major risk factors for anemia, in addition to age and male sex. Similarly, subclinical infections, age and male sex were significant risk factors for ID. Previous-day consumption of Fe-rich foods was very low and not associated with anemia or ID. The PAF of anemia attributable to ID was 67% (95% CI: 62-71) and that of subclinical infections was 16% (95% CI: 11-20). These results suggested that a multipronged strategy that combines improvements in dietary Fe intake alongside infection control strategies was needed to prevent anemia during infancy in Bangladesh.

**Shill et al. (2014)** estimated the prevalence of iron-deficiency anemia among the university students of Noakhali region, Bangladesh. They used cross-sectional data in their study and collected during October to December 2011. They found 55.3% students were anemic, of whom 36.7% were male, and 63.3% were female in their study. Students aged 20-22 years were more anemic (43.4%) than other age-groups. Majority (51.3%) of male students showed their hemoglobin level in the range of 13-15 g/dL, followed by 26.0% and 21.3% with 10-12 g/dL and 16-18 g/dL respectively. Although 50.5% anemic and 51.1% non-anemic female students showed normal BMI--lower percentage than anemic (60.7%) and non-anemic (71.9%) male students, the underweight students were found more anemic than the overweight and obese subjects. Regular breakfast-taking habit showed significant (p<0.036, 95% CI: 0.5-

1.0) influence on Iron-deficiency anemia (IDA) compared to non-regular breakfast takers. Consumption of meat, fish, poultry, eggs, or peanut butter regularly; junk food; multivitamins; and iron/iron-rich food showed insignificant (95% CI: 0.5-1.1, $p < 0.098$; 95% CI: 1.1-2.3, $p<0.054$; 95% CI: 0.6-1.2, $p<0.149$; and 95% CI: 0.7-1.4, $p<0.488$ respectively) role in provoking IDA. In the case of non-anemic subjects, all of the above parameters were significant, except the junk food consumption (95% CI: 0.5-1.2, $p<0.343$). Their study revealed that majority of university students, especially female, were anemic that might be aggravated by food habit and lack of awareness. The results suggested that anemia could be prevented by providing proper knowledge on the healthful diet, improved lifestyle, and harmful effect of anemia to the students.

## 5.3 Materials and Methods

The sample used in the present study consisted of 5293 married non-pregnant Bangladeshi women of reproductive age (15-49 years). The cross-sectional data were extracted from Bangladesh Demographic and Health Survey (BDHS)-2011. BDHS collected socio-economic, demographic, anthropometric, health and lifestyle information from 17,842 ever-married Bangladeshi women from July 8, 2011 to December 27, 2011. Age at the time of measurements ranged from 12 to 49 years, with an average age of 30.78±9.27 years. This is a national-level survey with the various districts of Bangladesh represented. BDHS used as a sampling frame the list of enumeration areas (EAs) prepared for the 2011 Population and Housing Census, provided by the Bangladesh Bureau of Statistics (BBS) (Khan and Shaw, 2011). BDHS used multistage stratified cluster sampling for selecting household from different enumeration areas. The sampling technique, survey design, survey instruments, measuring system, quality control, ethical approval and subject consent have been described elsewhere (NIPORT, 2013).

BDHS-2011 has taken blood from only 5902 Bangladeshi married women in reproductive age (15-49 years) for testing their anemia covering urban and rural areas, of which 95 percent of the measurements were complete and credible. Anemia testing process has been described elsewhere (NIPORT, 2013). The data set was checked for outliers by the present authors using statistical techniques (Dunn and Clark, 1974). Pregnant women were excluded in this study. After removing outliers, cases with incomplete data, women who was currently pregnant, the data set was reduced to 5293 non-pregnant married women to analyze for the present study. Our sample was classified into two groups according hemoglobin level (i) Anemic (hemoglobin level<12.0 g/dl) and (ii) Non anemic (hemoglobin level≥12.0 g/dl). In addition the anemic women again subdivided into three groups, (i) Mild anemic (hemoglobin level lies between 10.0-1.9 g/dl), (ii) Moderate Anemic (hemoglobin level lies between 7.0-9.9 g/dl) and (iii) Severe Anemic (hemoglobin level<7.0 g/dl) (CDC, 1998).

Since the data used in the present study collected from multistage clustered samples and the dependence among observations came from several levels of the hierarchy. There is a cluster effect of the data set. The single level statistical model is not appropriate for analyzing such kind of data set (Khan and Shaw, 2011). Intra-class correlation coefficient,

$$\text{(ICC)} = \frac{Variation of\ constant}{Variation of\ constant + variation of\ residual}$$

was used in this study to determine whether or not multilevel is even necessary for our data. The value of ICC ranges from 0 to 1. If ICC is 0, that means the observations within clusters are no more similar than observations from different clusters, if ICC is greater than 0, multilevel regression model is appropriate for the analysis (Park and Lake, 2005). To remove the cluster effect, two levels multiple logistic regression analysis was utilized to examine the association between anemia and socioeconomic, demographic and nutritional factors among married women. The category of anemia level was used as dependent variable. Multilevel logistic regression model is a powerful statistical tool to remove the cluster effect for finding association between dependent (category) and independent variables at different levels of the hierarchy data. The two levels multiple logistic regression models are:

**Level I:** $\eta_{ij} = \beta_{0j} + \beta_{1j} x_{ij}$, $p_{ij} = \dfrac{\exp(\eta_{ij})}{1+\exp(\eta_{ij})}$, where $y_{ij} = 1$ with probability $p_{ij}$,

$y_{ij} = 0$ with probability $1 - p_{ij}$,

$$\ln\left(\frac{p_{ij}}{1-p_{ij}}\right) = \beta_{0j} + \beta_{1j} x_{ij}$$

**Level II:** $\beta_{0j} = \gamma_{00} + u_{0j}$, $\beta_{1j} = \gamma_{10}$, $u_{0j} \sim N(0, \tau_{00})$,

$\pi = P(Y = 1 \mid X_1 = x_1, X_2 = x_2, ..., X_p = x_p) = \dfrac{e^{g(x_i)}}{1+e^{g(x_i)}}$, where

$g(x_i) = \beta_0 + \beta_1 x_{i1} + \beta_2 x_{i2} + ... + \beta_k x_{ik}; (i = 1,2,...,n)$.

$\beta_i$ = unknown logistic regression coefficients (i = 1, 2, …, n). The parameter $\beta_i$ refers to the effect of $X_i$ on the log odds such that Y = 1, controlling the other $X_i$. In multiple logistic regression, there is an important assumption in multiple logistic regression model is that the explanatory variables are independent of each other (multicollinearity problem). In the present study, the magnitude of the standard error (SE) was used to detect the multicollinearity problem, if the magnitude of the SE lies between 0.001 and 0.5, it is judged that there is no evidence of multicollinearity (Chan, 2004). Chi-square test was utilized in this study for selecting independent factors for multilevel logistics regression models. Statistical significance was accepted at $p<0.05$. Statistical analyses were carried out using STATA (version 11) and SPSS software (version IBM 19).

## 5.4 Results

In the current chapter, the total of 5293 non-pregnant married Bangladeshi women aged 15-49 were considered for observing the prevalence of anemia and factors associated with anemia.

### 5.4.1 Prevalence of anemia among Bangladeshi married women

The prevalence of anemia among non-pregnant Bangladeshi married women was 41.3% (urban 37.2% and rural 43.5%). Among the anemic women, 35.5% (urban 31.9% and rural 37.5%) were mild, 5.6% (urban 5.2% and rural 5.9%) were moderate and only 0.2% (urban 0.1% and rural 0.2%) were severe (Table 5.1).

**Table 5.1:** Prevalence of anemia among Bangladeshi non-pregnant married women of reproductive age

| | | Total | Urban | Rural |
|---|---|---|---|---|
| | | Frequency (%) | | |
| Anemia | No | 3107 (58.7) | 1166 (62.8) | 1941 (56.5) |
| | Yes | 2186 (41.3) | 690 (37.2) | 1496 (43.5) |
| Categories of anemia | Severe | 8 (0.2) | 2 (0.1) | 6 (0.2) |
| | Moderate | 298 (5.6) | 96 (5.2) | 202 (5.9) |
| | Mild | 1880 (35.5) | 592 (31.9) | 1288 (37.5) |

### 5.4.2 Association between anemia and socio-economic, and demographic factors

We used Chi-square ($\chi^2$) test in the present study to know the association between anemia status and some selected factors. More than 43% and 37% rural and urban women were anemic. $\chi^2$-test demonstrated that the association between the residence and anemia was statistically significant ($p<0.01$). Our study also showed that 45.9% of the uneducated, 43.0% of the primary educated, 38.1% of the secondary educated and 33.2% of the higher educated women were anemic. The association between women education level and anemia was again significant (p<0.01). When we study the husband's education level, we got significant association between their level of education with anemia of their spouses (p<0.01). Percentage of anemia in currently breastfeeding and non-breastfeeding women were 45.9% and 39.7%, and the association between the two factors was significant (p<0.01). Percentages of anemia among married women who were currently amenorrheic, currently not use contraceptive, and staying in houses with unhygienic toilets are higher than those of their counterparts, and these factors were significantly (p<0.01) associated with anemia. Percentages of married women with anemia was also noted to be higher among non-Muslim women compared to Muslim women (40.2% vs 49.2%), and those from poor and middle income families as compared to rich family (47.5%, 42.1% and 36.0%), and these factors were also significantly (p<0.01) associated with anemia.

Underweight has a strong association with anemia where more than 50% of underweight married women were anemic. Percentages among those who were normal weight, overweight and obese were 40.8%, 31.0% and 27.4% respectively. The association between BMI and anemia was significant (p<0.01). We also noted association older age group, where 43.6% of married women between 30–49 years old were anemic compared only 38.6% among those between 15–29 years. All these variables were significantly (p<0.01) associated with anemia. The highest percentage (51.0%) of anemia was found among married women who had 7 or more children, followed 3-6 children (44.1%), 1-2 children (38.4%) and then no children (37.7%). We observed that the association between parity and anemia was statistically significant (p<0.01).

Other selected variables, currently working status, drinking source of water, living with husband and age at first marriage did not show significantly (p>0.05) association with anemia.

**Table 5.2:** Association between anemia and socio-economic, and demographic factors

| Variables | Group (N) | Anemic (%) | $\chi^2$-value | p-value |
|---|---|---|---|---|
| Residence | Urban (1856) | 37.2 | 20.043 | 0.0001 |
| | Rural (3437) | 43.5 | | |
| Education level | No (1402) | 45.9 | 32.940 | 0.0001 |
| | Primary (1620) | 43.0 | | |
| | Secondary (1873) | 38.1 | | |
| | Higher (398) | 33.2 | | |
| Husband education | No (1546) | 44.7 | 20.965 | 0.0001 |
| | Primary (1498) | 43.0 | | |
| | Secondary (1492) | 38.5 | | |
| | Higher (757) | 36.6 | | |
| Currently breastfeeding | No (3935) | 39.7 | 16.293 | 0.0001 |
| | Yes (1358) | 45.9 | | |
| Currently amenorrhea | No (5003) | 40.4 | 28.123 | 0.0001 |
| | Yes (290) | 56.2 | | |
| Currently use contraceptive | No (2025) | 44.1 | 10.598 | 0.0010 |
| | Yes (3268) | 39.6 | | |
| Currently working status | No (4550) | 40.9 | 1.898 | 0.1680 |
| | Yes (743) | 43.6 | | |
| Drinking water source | Non-improved (458) | 41.0 | 0.013 | 0.9090 |
| | Improved (4835) | 41.3 | | |
| Toilet facility | Unhygienic (2467) | 43.3 | 7.871 | 0.0050 |
| | Hygienic (2826) | 39.5 | | |
| Living with husband | No (350) | 43.4 | 0.701 | 0.4030 |
| | Yes (4943) | 41.1 | | |
| Religion | Muslim (4668) | 40.2 | 19.370 | 0.0001 |
| | Non-Muslim (625) | 49.4 | | |
| Wealth index | Poor (1891) | 47.5 | 57.348 | 0.0001 |
| | Middle (1016) | 42.1 | | |
| | Rich (2386) | 36.0 | | |
| Body mass index | Underweight (1302) | 50.5 | 94.302 | 0.0001 |
| | Normal weight (3035) | 40.8 | | |
| | Overweight (788) | 31.0 | | |
| | Obese (168) | 27.4 | | |
| Age group | 15-29 years (2411) | 38.6 | 13.579 | 0.0001 |
| | 30-49 years (2882) | 43.6 | | |
| Age at first marriage | Less than 18 years (4137) | 41.9 | 2.505 | 0.1130 |
| | 18 years and above (1156) | 39.3 | | |
| Number of ever born children | No (422) | 37.7 | 27.545 | 0.0001 |
| | 1-2 (2411) | 38.4 | | |
| | 3-6 (2219) | 44.1 | | |
| | 7 and more (241) | 51.0 | | |

### 5.4.3 Effects of socio-economic and demographic factors on anemia

The associated factors were considered as independent variables for anemia in multilevel logistic regression model. The multilevel (two level) logistic regression model showed that the value of intra-class correlation coefficient (ICC) is 0.063, the selected multilevel model were appropriate for this study. Based on these analysis, we were able identify the several independently factors that were predictors to anemia, and they were: staying in rural environment (OR=0.854, 95% CI: 1.004-0.726; p=0.057), poor economic background (OR=0.781, 95% CI: 0.918-0.664; p<0.01), being uneducated (OR=0.638, 95% CI: 0.870-0.468; p<0.01), non-Muslims (OR=1.506, 95% CI: 1.238-1.833; p<0.01), currently not use contraceptive (OR=0.875, 95% CI: 0.999-0.766; p<0.05), currently breastfeeding (OR=1.349, 95% CI: 1.593-1.143; p<0.01), currently amenorrheic (OR=1.635, 95% CI: 2.197-1.217; p<0.01), underweight (OR=0.717, 95% CI: 0.827-0.622; p<0.01), and those from 30-49 year age group (OR=1.469, 95% CI: 1.723-1.253; p<0.01) (Table 5.3).

**Table 5.3:** Effects of socio-economic and demographic factors on anemia using multilevel logistic regression

| Variable | Coefficients | SE | p-value | Odds Ratio (OR) | 95% CI of OR | |
|---|---|---|---|---|---|---|
| | | | | | Upper | Lower |
| Residence,<br>Urban Vs Rural | -0.0349 | 0.0184 | 0.057 | 0.854 | 1.004 | 0.726 |
| Education Level, | | | | | | |
| Primary Vs No | -0.0248 | 0.0184 | 0.179 | 0.897 | 1.053 | 0.765 |
| Secondary Vs No | -0.0591 | 0.0204 | 0.004 | 0.769 | 0.919 | 0.644 |
| Higher Vs No | -0.0988 | 0.0347 | 0.005 | 0.638 | 0.870 | 0.468 |
| Husband Education, | | | | | | |
| Primary Vs No | 0.0108 | 0.0185 | 0.559 | 1.049 | 1.233 | 0.894 |
| Secondary Vs No | -0.0112 | 0.0206 | 0.585 | 0.950 | 1.137 | 0.795 |
| Higher Vs No | 0.0120 | 0.0283 | 0.671 | 1.055 | 1.353 | 0.823 |
| Toilet facility,<br>Unhygienic Vs Hygienic | -0.0229 | 0.0138 | 0.099 | 0.903 | 1.019 | 0.799 |
| Watching television,<br>Yes Vs No | -0.0003 | 0.0164 | 0.987 | 0.999 | 1.156 | 0.865 |
| Religion,<br>Non-Muslim Vs Muslim | 0.9338 | 0.0227 | 0.001 | 1.506 | 1.833 | 1.238 |
| Currently use contraceptive,<br>Yes Vs No | -0.2925 | 0.0148 | 0.049 | 0.875 | 0.999 | 0.766 |
| Currently breastfeeding,<br>Yes Vs No | 0.0649 | 0.0185 | 0.001 | 1.349 | 1.593 | 1.143 |
| Currently amenorrhea,<br>Yes Vs No | 0.1118 | 0.0334 | 0.001 | 1.635 | 2.197 | 1.217 |
| Wealth index, | | | | | | |
| Middle Vs Poor | -0.03334 | 0.0194 | 0.086 | 0.865 | 1.027 | 0.729 |
| Rich Vs Poor | -0.0551 | 0.0183 | 0.003 | 0.781 | 0.918 | 0.664 |
| Age group,<br>(30-49) years Vs (15-29) years | 0.0832 | 0.0176 | 0.001 | 1.469 | 1.723 | 1.253 |
| BMI category, | | | | | | |
| Normal Vs under weight | -0.0759 | 0.0162 | 0.001 | 0.717 | 0.827 | 0.622 |
| Over Vs under weight | -0.1559 | 0.0232 | 0.001 | 0.491 | 0.605 | 0.368 |
| Obese Vs under weight | -0.1991 | 0.0407 | 0.001 | 0.396 | 0.584 | 0.268 |
| Number of ever born children, | | | | | | |
| 1-2 Vs No | -0.0215 | 0.0271 | 0.426 | 0.901 | 1.149 | 0.706 |
| 3-6 Vs No | 0.0007 | 0.0293 | 0.980 | 0.995 | 1.294 | 0.764 |
| 7 and more Vs No | 0.0282 | 0.0426 | 0.508 | 1.117 | 1.629 | 0.766 |
| Constant | 0.4849 | 0.0198 | 0.001 | | | |

## 5.5 Discussions

In the present chapter, we evaluated the prevalence of anemia and assessed the effect of socio-economic and demographic factors on anemia among Bangladeshi non-pregnant married women in reproductive age. The study allowed us to provide a more comprehensive analysis of the target population because the sample population was derived from various geographical regions of the Bangladesh. Previous studies reported prevalence and factors associated of anemia for women from rural population (Merrill et al., 2011), university students in a particular region (Shill et al., 2014), infants (Rawat et al., 2014), students of a particular medical college (Bari et al., 2013), etc. We used multilevel regression in this study to remove the cluster effect of this condition and data set was collected by BDHS from different geographical areas applying cluster sampling.

The present study demonstrated that the prevalence of anemia among Bangladeshi non-pregnant women in reproductive age was high (41.3%), and it was higher among women from rural population (43.5% in rural area compared to 37.2% in urban area). A previous study reported that 73% of non-pregnant Bangladeshi women living in rural area were anemic, and this result was higher than what we found (41.3%) even if we only considered women from the rural area (43.5%). Bangladesh Bureau of Statistics (BBS) reported the prevalence of anemia among non-pregnant Bangladeshi women from urban region in Bangladesh and as 34% (BBS, 2003), and that was relatively similar to our findings for urban population (37.2%). The prevalence (41.3%) of anemia among Bangladeshi non-pregnant women in reproductive age was higher than that of many countries like Iran, 14.5% (Sadeghian et al., 2013), Europe (Serbia, 27.7% (Rakic et al., 2013), Belgium, 7.7% (Massot and Vanderpas, 2003)), Japan, 15.7% (Takimoto et al., 2003), South America (Brazil, 32.7% (Coimbra et al., 2013), Mexico, 15.5% (Shamah-Levy et al., 2009)), Kazakhstan, 39% (Smagulova et al., 2013), Turkey, 32.8% (Pala and Dundar, 2008), China, 15.1% (Liao, 2004), also in Global, 29% (Stevens et al., 2013), and rather similar to countries in west and central Africa, 40% (Ayoya, 2012). However, the prevalence was less than that of India, 56% (Balarajan et al., 2013) and Tanzania, 49% (Massawe et al., 2002). Our study showed that poverty and lack of education were two important factors related to having anemia. Eradication of poverty and improving level of education among women are two essential components that should be able to reduce the prevalence of anemia. Education is one of the major socioeconomic factors that influence public health; education is broadly recognized as benefiting both the person and society. Particularly among women, education is associated with positive outcomes, including intergenerational health and nutrition benefits, but still 27.7% Bangladeshi women in reproductive age is uneducated (NIPORT, 2013). To increase the literacy rate, Bangladesh Government has taken the national education policy (NIPORT, 2013) explicitly stipulated that education would be free of cost up to the secondary level in the public sector and provided subsidies to create demand for education of the poor and of girls to meet MDG targets. The current study will serve a reference for changes in level of anemia among women from various populations in this nation in the near future.

The economic condition (wealth index) is one of the predictor of anemia for reproductive age of non-pregnant women. Poor women had more chance to get anemia than middle and rich women. Nutritional status (BMI) is also an important influencing factor of anemia. Present study showed that those who were currently use oral contraceptive had lower risk of having anemia than those who were using intra-uterine device among non-pregnant Bangladeshi women in reproductive age. The other studies had also shown similar result (Massawe et al., 2002; Heck et al., 2008).

The current study demonstrated that lactating women were more likely to be anemic than non-lactating women most probably due to increased nutritional demand during lactating period. This result is also supporting the finding of other research (Pei et al., 2013). We found that amenorrheic women were more likely to get anemia than their counterparts. Amenorrhea is a multi-factorial condition, and can be due to undiagnosed pregnancy, lactation and poor general health, and all these are associated with anemia. We found that undernourished women got anemia more than healthy (normal weight), overweight and obese women. The other study has also shown that the hemoglobin concentration is positively associated with BMI (Dangour et al. 2001).

## 5.6 Conclusions

The prevalence of anemia among Bangladeshi married non-pregnant women was 41.3%, especially those from the rural region. The multilevel multiple logistic regression model provided that women who are living in rural environment, uneducated, using unhygienic toilet, non-Muslim, currently not use contraceptive, currently breastfeeding, amenorrheic, living under poor economical condition, older (30-49 years old) and suffering from chronic energy deficiency (underweight) were factors associated with higher risk of anemia as compared to their counterparts. In addition to identification of risk factors for anemia, results from this study provide a useful baseline for future reference of ongoing corrective measures.

# *CHAPTER SIX*

## Conclusions and Future Perspectives

## 6.1 Concluding Remarks

In this thesis we applied statistical models to nutritional status (BMI) among Bangladeshi non-pregnant married women in reproductive age. In addition anemia also considered in the current study as the nutritional (health) problem among the non-pregnant married women in reproductive age.

First we looked the secular changes in BMI among married women; ANOVA and linear regression analysis were used in this purpose. A total number of 45,572 married non-pregnant women in reproductive age were used in this study and data were collected from measurement years 1996-97 to 2011 by BDHS. The mean value of BMI of Bangladeshi non-pregnant married women was 20.65±3.67 kg/m$^2$ with height and weight were 150.60±5.44 cm and 46.93±9.24 kg, respectively. ANOVA model provided that the BMI was significantly different among measurement years and birth year cohorts. The trends of these variations was checked by linear regression and the slope of this model showed that the nutritional status among married women have been increasing since measurement years 1996-97, but when we considered birth year cohorts, we found nutritional status have been increasing during birth years 1955 to 1971, however, decreasing tendency was showed from birth years 1971 to 1995.

Secondly, we observed the effects of socio-economic and demographic factors on nutritional status among non-pregnant Bangladeshi married women in reproductive age. The total number of sample 14,022 was used in the present study and data were collected by BDHS-2011. Descriptive statistics, t-test, ANOVA were used in this study and multilevel linear regression was utilized to determine the risk factors of nutritional status after removing the cluster effect of our BDHS-2011 dataset. Descriptive statistics showed that the mean±SD of women was 21.60±3.86 kg/m$^2$ with height and weight was 150.92 ±5.36 cm and 49.28 ± 9.69 kg, respectively. The prevalence of underweight, normal weight, overweight and obese were 22.8%, 59.1%, 14.9% and 3.2%, respectively of the respondents. ANOVA demonstrated that the BMI of respondents was significantly different among respondents' and her husbands' education level and wealth index. The t-test showed that the differences of BMI was significant between (i) residence, urban and rural, (ii) watching television, yes and no, (iii) currently breastfeeding, yes and no, (iv) currently use contraceptive, yes and no, (v) living with husband, yes and no and (v) currently working status, yes and no. Pearson's correlation coefficients exhibited that respondent's age, age at first marriage and age at first birth were significantly positive related with BMI of married women in reproductive age, and there was a negative association between number of ever born children and BMI. Multilevel (two level) regression model exhibited that older women got more BMI than younger and women had a chance to get more BMI who got marriage earlier than their counterparts. Married women had more BMI who had more children ever born than their counterparts. BMI was especially less pronounced among non-pregnant married women who came from rural, uneducated, uneducated husband, came from poor family, house wife, currently not use contraceptive and not breastfeeding.

Finally, we established the relationship between anemia and socio-economic and demographic factors among non-pregnant Bangladeshi married women in reproductive age. Again we extracted data from BDHS-2011, and the number of total sample 5,293 was used in this study. $\chi^2$-test was utilized in this study to select the independent factors for further analysis. Multilevel logistic regression model was used to find the impact of socio-economic and demographic factors on anemia after removing cluster effect of nested data set. In this study demonstrated that the prevalence of anemia among Bangladeshi married women was more than 41% and among anemic women, 35.5% was mild, 5.6% and only 0.2% were moderate and severe anemic respectively. $\chi^2$-test provided that residence, education level, husband education, currently breastfeeding, currently amenorrhea, currently use contraceptive, toilet facility, religion, wealth index, BMI, age group, number of ever born children were significantly associated with anemia. The multilevel (two level) logistic regression model demonstrated that women who were currently breastfeeding and amenorrhea had more likely to get anemia than their counterparts. Underweight women had a higher chance to get anemia than normal weight, overweight and obese. Uneducated women were more likely to get anemia than secondary and higher educated. Anemia was especially less pronounced among non-pregnant women who are currently use contraceptive, Muslim and came from rich family. Moreover, women who were 30-49 years old had more likely to get anemia than younger.

In this study we found that underweight is the major health problems of Bangladeshi married non-pregnant women in reproductive age, undernourished women are living under poor condition and most of them are uneducated. Government and non-government organization of Bangladesh should take step to increase people education level and improve economic condition for removing under-nutrition and anemia among married women in reproductive. We hope this study can help health authorities of Bangladesh to develop and improve the policies for making awareness among married women for their reproductive health and insure the better health service for women especially for rural area.

## 6.2 Future Perspectives

This study only investigated trends in BMI and its association with selected socio-economic and demographic factors. It may be extended the present study for considering other possible influences on BMI such as smoking habits, weight goals, weight-loss methods, body-shape perceptions, eating attitudes and behaviors, self-concept and physical activity, level of energy intake and age at menarche. We also established the relationship between anemia and some selected anthropometric, socio-economic and demographic factors among Bangladeshi non-pregnant married women in reproductive age. This study may be extended for considering some other factors such as age at menarche, birth weight, childhood living conditions, food habits in childhood, physical activity, life-style factors and nutrition.

The BDHS-2011 data set used in the present study was based on multistage stratified cluster sampling. For multistage clustered samples, the dependence among observations often comes from several levels of the hierarchy, thus single model is not appropriate such kind of data set. Two level regression models were utilized in this study. This model may be used for any nested data set, such as data come from education, biology and medicine. As we mentioned in the present study, only two level regressions was used in BDHS data set, number of level may be extended for BDHS data set to determine the risk factors for nutritional status and anemia among women. As for example, BDHS data set came from several (three) levels such as, the units at lower level (level-1) were individuals, who were nested within units at higher level (clusters: level-2) and the clusters were again nested within units at the next higher level (divisions: level-3).

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# List of Abbreviations

| | |
|---|---|
| AGA | Appropriate for Gestational Age |
| AIDS | Acquired Immune Deficiency Syndrome |
| ANOVA | Analysis of Variance |
| AOP | Anemia of Prematurity |
| AOR | Adjusted Odds Ratio |
| APGAR | Appearance, Pulse, Grimace, Activity and Respiration |
| BBS | Bangladesh Bureau of Statistics |
| BDHS | Bangladesh Demographic and Health Survey |
| BMD | Bone Mineral Density |
| BMI | Body Mass Index |
| BRAC | Bangladesh Rural Advancement Committee |
| BSQ | Body Shape Questionnaire |
| CAPI | Computer Assisted Personal Interviewing |
| CATI | Computer Assisted Telephone Interviewing |
| CDCP | Center for Disease Control and Prevention |
| CED | Chronic Energy Deficiency |
| CI | Confidence Interval |
| CSPro | Census and Survey Processing System |
| CVD | Cardiovascular Disease |
| DCM | Data Collection Methodology |
| DDS | Domain of Disease Severity |
| DHS | Demographic and Health Survey |
| DQI | Diet Quality Index |
| EAs | Enumeration Areas |
| FYFS | First Year Female Students |
| GLV | Green Leafy Vegetables |
| Hb | Hemoglobin |
| HBR | Hemoglobin Response |
| HDI | Human Development Indicators |
| HDL-C | High Density Lipoprotein Cholesterol |
| HEALS | Health Effects of Arsenic Longitudinal Study |
| HEI | Healthy Eating Index |

| | |
|---|---|
| HIV | Human Immunodeficiency Virus |
| HKI | Helen Keller International |
| HPLC | High Performance Liquid Chromatography |
| HR | Hazard Ratio |
| ICC | Intraclass Correlation Coefficient |
| ICDDR'B | International Center for Diarrheal Disease Research, Bangladesh |
| ICF | International Classification of Functioning, Disability and Health |
| ID | Iron Deficiency |
| IDA | Iron Deficiency Index |
| IFA | Iron Folic Acid |
| IFLS | Indonesian Family Life Survey |
| IPHN | Institute of Public Health Nutrition |
| IR | Insulin Resistance |
| LA | Los Angeles |
| LAU | Lebanese American University |
| LBW | Low Birth Weight |
| LSD | Least Significant Difference |
| LVM | Left Ventricular Mass |
| MDG | Millennium Development Goal |
| MDI | Mental Development Index |
| MIDA | Maternal Iron Deficiency Anemia |
| MMN | Multimicronutrient |
| MUAC | Mid Upper Arm Circumference |
| NANI | Neither Anemic Nor Iron Deficiency |
| NDHS | Nigeria Demographic and Health Survey |
| NFHS | National Family Health Survey |
| NGO | Non Government Organization |
| NHANES | National Health and Nutrition Examination Survey |
| NHEFS | National Health and Nutrition Epidemiological Follow-up Survey |
| NHES | National Health Examination Survey |
| NIPORT | National Institute for Population Research and Training |
| NPW | Non Pregnant Women |
| NS | Nutritional Supplements |

| | |
|---|---|
| NSP | Nutritional Surveillance Project |
| OLS | Ordinary Least Square |
| ONS | Office for National Statistics |
| OR | Odds Ratio |
| OST | Osteoporosis Self-Assessment Tool |
| PAF | Population Attributable Function |
| PDI | Psychomotor Development Index |
| PEM | Protein Energy Malnutrition |
| PPS | Probability Proportion to Size |
| PPW | Post Partum Women |
| PR | Prevalence Ratio |
| PSU | Primary Sampling Unit |
| PTVLBW | Preterm Very Low Birth Weight |
| PW | Pregnant Women |
| QMAS | Qualitative Methods Applied to Surveys |
| RA | Rheumatoid Arthritis |
| RDW | Red Cell Distribution Width |
| rHuEPO | Recombinant Human Erythropoietin |
| SD | Standard Deviation |
| SE | Square Error |
| SES | Socioeconomic Status |
| SGA | Small for Gestational Age |
| SMAs | Statistical Metropolitan Areas |
| SPSS | Statistical Package for Social Science |
| SRI | Social Relationships Index |
| SSc | Systemic Sclerosis |
| UK | The United Kingdoms |
| UP | Union Parishad |
| USA | United States of America |
| USAID | United States Agency for International Development |
| VIF | Variance Inflation Factor |
| VLBW | Very Low Birth Weight |
| WC | Waist Circumference |

| | |
|---|---|
| WHI | Women's Health Initiative |
| WHO | World Health Organization |
| WHR | Waist to Hip Ratio |
| WIC | Women, Infants and Children |
| WIFS | Weekly Iron Folic Acid Supplementation |
| WV | West Virginia |

# Glossary

**ANOVA:** Analysis of variance. The purpose of ANOVA is to test for significant differences between means. The name analysis of variance (ANOVA) is derived from the fact that in order to test for statistical significance between means, we are actually comparing (i.e., analyzing) **variances**.

**Chi-squared ($\chi^2$) test:** Pearson's chi-squared test ($\chi^2$) is a statistical test applied to sets of categorical data to evaluate how likely it is that any observed difference between the sets arose by chance. It is suitable for unpaired data from large samples. It is the most widely used of many $\chi^2$ tests (Yates, likelihood ratio, portmanteau test in time series, etc.) - statistical procedures whose results are evaluated by reference to the $\chi^2$ distribution. Its properties were first investigated by Karl Pearson in 1900. In contexts where it is important to improve a distinction between the test statistic and its distribution, names similar to Pearson $\chi^2$-test or statistic are used.

**Correlation: Correlation** is a statistical measure that indicates the extent to which two or more variables fluctuate together. A positive correlation indicates the extent to which those variables increase or decrease in parallel and a negative correlation indicates the extent to which one variable increases as the other decreases.

**Dependent variable:** A **variable** which assumes its value as a result of a second **variable** or a system of variables taking up any set of arbitrary values assigned to them is called a dependent variable.

**Independent variable:** A **variable**, which may take any arbitrary value assigned to it, is called an independent variable.

**Intercept:** The constant term in linear regression analysis is called intercept. It is simply the value at which the fitted line crosses the y-axis.

**Intraclass correlation coefficient (ICC):** The ratio of the between-cluster variance to the total variance is called the **intraclass correlation coefficient** and it is defined by $ICC = \frac{\sigma_u^2}{\sigma_u^2 + \sigma_\varepsilon^2}$.

**Lines of regressions:** If the variables in a bivariate distribution are related we will find the points in the **scatter diagram** will cluster round some curve called the curve of regression. If the curve is a straight line, it is called the line of regression and there is said to be linear regression between the variables.

**Negative secular change:** The direction of secular changes is negative.

**Outliers:** Outliers are atypical (by definition), infrequent observations (abnormal data point). Outliers have a profound influence on the slope of the regression line and consequently on the value of the correlation coefficient. A single outlier is capable of considerably changing the slope of the regression line and, consequently, the value of the correlation.

**Parameter:** Parameter is an unknown **constant** which uniquely specifies a distribution.

**Positive secular change:** The direction of secular changes is positive.

**Regression:** A model for predicting one variable from another. Due to Francis Galton (1822-1911), the word comes from the fact that when measurements of offspring, whether peas or people, were plotted against the same measurements of their parents, the offspring measurements “went back” or regressed towards the mean. Regression analysis is a mathematical measure of the average relationship between two or more variables in terms of the original units of the data. In regression analysis there are two types of variables, **dependent** and **independent**.

**Scatter diagram:** It is the simplest way of the diagrammatic representation of bivariate data. Thus for the bivariate distribution ($x_i$, $y_i$); i=1,2,…,n if the values of the **variables** X and Y be plotted along the x-axis and y-axis respectively in the xy-plane, the diagram of dots so obtained is known as scatter diagram. From the scatter diagram, we can form a fairly good, though vague, idea whether the **variables** are **correlated** or not. If the points are very dense, i.e., very close to each other, we should expect a fairly good amount of correlation between the variables and if the points are widely scattered, a poor correlation is expected. This method, however, is not suitable if the number of observations is fairly large.

**Secular change:** The meaning of the term 'trend / secular changes' refers to long-term systematic or non-random changes in a wide variety of morphological traits in successive generations living in the same geographical area.

**Slope of regression line:** The slope of the **line of regression** of **dependent variable** on **independent variable** is also called the coefficient of regression of dependent variable on independent variable. It represents the increment in the value of dependent variable corresponding to a unit change in the value of independent variable.

**Standard deviation:** Standard deviation usually denoted by the Greek letter small sigma ($\sigma$) is the positive square root of the arithmetic mean of the squares of the deviations of the given values from their **arithmetic mean**. For the frequency distribution, $\sigma = \sqrt{\frac{1}{N}\sum_{i=1}^{k} f_i(x_i - \bar{x})^2}$ where $\bar{x}$ is the arithmetic mean of the distribution and $\sum_{i-1}^{k} f_i = N$.

**t-test:** A two-sample **t-test** examines whether two samples are different and is commonly used when the variances of two normal distributions are unknown and when an experiment uses a small sample size.

**Variable:** A variable is a quantity (or symbol) which can take various values.

**Variance:** The square of **standard deviation** is called the variance.