UNIVERSITY OF SOUTHAMPTON

FACULTY OF LAW, ARTS & SOCIAL SCIENCES

School of Social Sciences

Modelling Growth Trajectories of Children: A Longitudinal Analysis of Individual and Household Effects on Children's Nutritional Status in Rural Pakistan

by

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ABSTRACT

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MODELLING GROWTH TRAJECTORIES OF CHILDREN: A LONGITUDINAL ANALYSIS OF INDIVIDUAL AND HOUSEHOLD EFFECTS ON CHILDREN'S NUTRITIONAL STATUS IN RURAL PAKISTAN

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This thesis explores the pathways through which individual and household factors are associated with temporal changes in child nutritional status. In this study the concept of nutrition deprivation is used in two ways: firstly as indicated by the child's anthropometric measures, and secondly in terms of food consumption. The thesis also explores how nutritional deprivation is linked with economic deprivation. The main objectives of the study are: to examine the physical growth trajectories of children, to investigate the household's economic and nutritional (food) deprivations, to explore the determinants of child malnutrition, and finally to investigate the relationship between temporal changes in the poverty status of households and temporal changes in child nutritional status.

The study uses the Pakistan Panel Data collected by the International Food Policy Research Institute (IFPRI) from 1986-89, covering four rural districts of Pakistan. The study employs a comprehensive child health framework to establish the mechanism of child nutritional status by linking the various factors at child, household and community levels. This framework specifies poverty as the root cause of malnutrition. The basic-need absolute poverty approach is used to work out the incidence and the dynamic nature of poverty. Various statistical modelling techniques for analysing the longitudinal data are used in this study. For example, to study the height and weight growth trajectories of children a growth curve modelling technique is employed, and to study the determinants of child malnutrition a three-level hierarchical linear model for longitudinal data is used.

The predicted average growth velocities indicate a slower growth during first year of child's life in comparison with the usual growth velocities amongst the normal children. However, in a particular cohort of children some evidence of growth acceleration is found during the third year of a child's life after a growth deceleration during the second year. Child level factors, such as breastfeeding and the incidence of diarrhoea and morbidity, are found to explain most of the variability in child nutritional status. The results reveal dissimilarities in nutritional status between children in a household. The results also indicate associations between poverty and stunting while chronic poverty is found to be associated with wasting. The results indicate that caloric and protein consumption amongst the study households was notably high. However, food consumption patterns mostly revolve around the staple food, and even in the top expenditure quintile this pattern remains persistent.

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I dedicate this thesis to
My father Prof. (Late) M. Abrar Hussain and
my mother Iqbal Jahan

List of acronyms

ACC/SCN	Administrative Committee on Co-ordination/Subcommittee on Nutrition
ADB	Agricultural Development Bank
AEU	Adult Equivalent Unit
BHU	Basic Health Unit
FAO	Food and Agriculture Organisation
GEE	Generalised Estimating Equation
GNP	Gross National Product
HAZ	Height-for-age
HDI	Human Development Index
HLM	Hierarchical Linear Model
IFPRI	International Food Policy Research Institute
IMF	International Monetary Fund
IMR	Infant Mortality Rate
IUGR	Intrauterine Growth Retardation
KCal	Kilo Calories
MDG	Millennium Development Goal
MNS	Micro Nutrient Survey
MUAC	Mid Upper Arm Circumference
NCHS	National Centre of Health Statistics
NHS	National Health Survey
NNS	National Nutrition Survey
NWFP	North West Frontier Province
OLR	Ordered Logistic Regression
ORS	Oral Rehydration Salt
PDHS	Pakistan Demographic Health Survey
PEM	Protein Energy Malnutrition
PIHS	Pakistan Integrated Household Survey
PNHDR	Pakistan National Human Development Report
PRSP	Poverty Reduction Strategy Paper
PSES	Pakistan Socio Economic Survey
RDA	Recommended Daily Allowance
RHC	Rural Health Centre
Rs	Rupees
UN	United Nations
UNDP	United Nations Development Programme
WAZ	Weight-for-age
WHZ	Weight-for-height
WHO	World Health Organisation

Chapter 1

Introduction

"...everyone has a right to a standard of living adequate for the health and well-being of himself and of his family, including food, clothing, housing, and medical care and necessary social service......motherhood and childhood are entitled to special care and assistance..."[1]

1.1 Background and introduction to the problem

Nutrition is a basic human need that remains unmet for vast numbers of children in most developing countries. Malnutrition is one of the most important health problems in developing countries and contributes substantially to morbidity and mortality in children (Pelletier, 1994). It has been said that there is a range of factors that determine child nutritional status, and this broader concept has been referred to as the nutrition problem (UNICEF, 1990). Such a concept of nutrition underlines the close link between status of malnutrition and general standards of living. Malnutrition is widely considered to be one of the most significant problems in low income countries, and its amelioration sits near the top (at the fourth position) of the list of Millennium Development Goals[2] (MDGs) (Inter-agency Expert Group on MDG Indicators, 2002). Because malnutrition underpins both child mortality and poverty, policies and programmes that improve nutritional status are key to achieving these MDGs. The present study contributes to the understanding of the causes of child poor nutritional status in rural Pakistan.

During the last three decades a significant shift has been observed in understanding, analysing and addressing the issue of malnutrition among children. Until the start of the 1970s malnutrition was considered only in a clinical perspective not in a bio-social

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[1] Article 25 of the 1948 Universal Declaration of Human Rights (http://www.un.org/Overview/rights.html)

[2] These MDGs include combating infant mortality rate and poverty.

context. Since then the role of various socioeconomic factors in determining child nutritional status has received much attention from researchers. In subsequent research, malnutrition is taken not only as a pathophysiological concept but also as a broader concept involving an array of different socioeconomic factors that lead to malnutrition (UNICEF, 1990).

Malnutrition is largely a silent and invisible emergency. It plays a role in more than half of nearly 12 million deaths each year of children under 5 in developing countries, a proportion unmatched since the Black Death ravaged Europe in the 14^{th} century (UNICEF, 1998). Malnutrition affects one out of every three pre-school children living in developing countries (Smith et al., 2003). This disturbing state of affairs presents a major obstacle to the development process. Among the developing country regions, South Asia's particularly high child malnutrition rate has remained a puzzle and some authors have called it the Asian Enigma (Smith et al., 2003). There are serious consequences of being malnourished during childhood such as stunting, which is related to concurrent and possibly subsequent delayed mental and motor development (Grantham, 1995). One major effect in adulthood is limited working capacity due to reduced body mass (Hass et al., 1996).

This chapter provides the definitions of some of the basic concepts of nutrition while these concepts are discussed in detail in Chapter 2. The main purpose of this chapter is to illustrate the aim and objectives of the thesis and to outline the conceptual framework of the study. The chapter also discusses the data set being used in this study. A brief introduction to Pakistan is also provided.

There are several ways of measuring the nutritional status of a child, such as skin fold, mid upper arm circumference (MUAC), anthropometric measures (height and weight), head circumference and the bio-chemical analysis of blood samples. However, most commonly, the nutritional status of a child is assessed through the use of one or more anthropometric measurements such as height and/or weight to determine whether the individual is likely to be well nourished, undernourished or over-nourished. The method generates objective measurements of body dimensions and composition as a proxy indicator of nutritional status. The most commonly used measurements for assessing nutritional status are based on growth and development in children and on body composition in adults. The assessment of child and adult nutritional status is presented in terms of ratios of weight and height, and these indicators are presented in relation to age and gender-specific points of reference (cut-off points). These ratios are weight-for-height, weight-for-age and height-for-age[3]. The ratios are compared with international reference data collected by the National Centre of Health Statistics (NCHS, 1976)[4]. Deficits in any of the anthropometric indices is regarded as an evidence of malnutrition and referred to as stunting, wasting, and underweight to represent low height-for-age, low weight-for-height and low weight-for-age Z-scores respectively. Usually the prevalence of malnourished children (including all three indices) is defined as the proportion of children who are more than 2 standard deviation units (Z-score) below the median of international reference population.

Low height-for-age referred to as stunting indicates a chronic state of malnutrition. Indeed many view poor height growth as a global measure of socio-economic deprivation in these countries, just as it was in Europe and North America in the past. Stunting starts in early childhood or before and usually persists, giving rise to small adult stature. Low weight-for-height indicates wasting. In most cases it indicates a recent and severe process of weight loss, possibly associated with poor food intake or illness. Low weight-for-age is underweight, or in other words an indication that in relation to age the child is at risk of low weight. Underweight nutritional status is influenced by both the height and the age of the child. In general terms, the world-wide variation of low weight-for-age and its age distribution are similar to that of low height-for-age.

1.2 Introducing Pakistan

Pakistan is located in southern Asia, bordering the Arabian Sea between India to the east, Iran and Afghanistan to the west, and China to the north. The total area of Pakistan is about 803,940 sq km (about three times the size of the United Kingdom)[5] of which water covers just over 3 percent. The climate of Pakistan is mostly dry and hot, although the north-west has a temperate climate with some of the highest peaks in the world. Pakistan comprises four provinces, namely Punjab, Sindh, Baluchistan and the North West Frontier Province (NWFP). Punjab is in the east and Sindh in the south. In

[3] Usually denoted as WHZ, WHA and HAZ for weight-for-height, weight-for-age and height-for-age respectively.
[4] For a detailed discussion see Chapter 2.
[5] http://www.unicef.org/pakistan/about-pakistan.htm

addition there are the Federally Administered Tribal Areas (FATA) in the north-west, the Federally Administered Northern Areas (FANA), Azad Jammu and Kashmir (AJK) in the north-east, and the Islamabad Capital Territory (ICT). Punjab is the biggest province in terms of population, comprising almost 60 percent of the total population of Pakistan, while in terms of area Baluchistan is the biggest province, almost the same size as England, but with the lowest population in the country. Pakistan is predominantly an agricultural country with just over 50 percent of the work force employed in occupations related to agriculture. The 1998 census reports that 68 percent of the total population lived in rural areas (Government of Pakistan, 1998).

In the 57 years since its independence, Pakistan has achieved a fair measure of economic growth, but has so far been unable to secure sustained progress in human development. Hence, in Pakistan, it is very important to focus on the human development index (HDI) because of its low position in international rankings: 144 out of 175 countries (UNDP, 2003). The economy of Pakistan has grown over 6 percent per annum between 1960 and 1980s. However, the economic growth rate has been declined to around 4 percent during the 1990s (Economic Survey of Pakistan, 2004). Thus, Pakistan has had per capita growth on average 2.2 percent per year from 1950-1999. Easterly (2001) observes that at the end of the 90s, the permanent component of GDP per capita growth is estimated to be near zero.[6] Yet, after all that, a rapid increase in poverty is recorded during the 1990s and onwards, and now it is estimated that in Pakistan about 34 percent of people live below the poverty line (World Bank, 2001). Despite this, Pakistan has the highest gross national product per capita in South Asia, other than Sri Lanka, it falls behind the averages for health indicators[7] for low income indicators, such as infant mortality in children under 5, population growth and literacy. This comparison is presented in Table (1.1).

[6] Several political economy models could shed light on Pakistan's growth without development (e.g., see Easterly, 2001) but this subject is beyond the scope of this study.

Table 1.1: Comparative health and economic indicators: selected Asian countries for the year 2002

Country	Infant mortality rate[1]	Child mortality Rate[2]	Population growth	Life expectancy (years)[3]	GNP per capita (US$)	Literacy rate (%)	
						Male	Female
Pakistan	82	105	2.2	64	460	58	28
Bangladesh	52	77	1.7	62	240	52	29
India	67	93	1.7	63	340	69	42
Iran	35	36	1.8	70	n/a	86	73
Sri Lanka	16	19	1.4	74	700	94	89

Source: Economic Survey of Pakistan (2004).
[1](IMR) per 1000 live births
[2]Under 5 mortality rate per 1000.
[3]At birth.

Pakistan is the world's seventh most populous country with a population of 130.5 million in 1998 (Government of Pakistan, 1998). This coupled with a high population growth rate; means that Pakistan is expected to overtake other nations in population in near future and may become the third-most populous nation by 2050 if the population control measures fail (Sathar et al., 1998). Not surprisingly, the contraceptive prevalence rate in Pakistan is one of the lowest in the world (24 percent as compared to 60 percent in Bangladesh). Despite the increase in the contraceptive use, fertility remains high at 5.3 births per woman. Pakistan got independence in 1947 and at that time 32.5 million people lived in Pakistan. According to the first census in Pakistan in 1951, the population was 33.7 million. By 2001-02, the population is estimated to have reached 145.96 million (Economic Survey of Pakistan, 2004). Thus, in roughly two generations, Pakistan's population has increased by 113.46 million or has grown at an average rate of 2.2 percent per annum. Having grown at an average rate of slightly above 3.0 percent since 1951 and until 1983, population growth in Pakistan is declining steadily thereafter and has declined to 2.2 percent by 2001-02. However, the current population growth rate is still high and the government is making every effort to reduce it to 1.8 percent (Economic Survey of Pakistan, 2004).

Infant mortality is another indicator that reflects the health status of children and mothers. The infant mortality rate (IMR) (82 per 1000) and the mortality rate for the children under age five (105 per 1000 births) exceed the averages of low income countries by 60 and 36 percent respectively (Economic Survey of Pakistan, 2004). This

[7] Pakistan only spends $ 2 per capita on health (Easterly, 2001).

poor record of Pakistan in health and socio-economic indicators is very much reflective of the nutritional status of children. All the earlier studies so far available on the nutritional situation in Pakistan have revealed a very poor condition of nutritional status among young children. The figures related with child nutritional status from various surveys are reported in Table (1.2). The table reports the prevalence rates of stunting, wasting and underweight amongst children aged 0-72 months in Pakistan. These figures are obtained from various nationally representative surveys. The table reveals a dismal picture of children's nutritional status in Pakistan. The prevalence rates of stunting seem to be increased over time up to year 1998-99 while for underweight the rates seem to be decreased. The prevalence rate of wasting found to be very high according to the nutrition survey in country.

Table 1.2: Prevalence of malnutrition (in percentages) in Pakistan from 1976-2002 amongst children aged 0-72 months

Year	Survey	Stunted	Wasted	Underweight
1976-77	MNS[1]	42.9	8.6	----
1985-87	NNS[2]	41.8	10.8	51.5
1990-91	PDHS[3]	50.2	9.2	40.4
1998-99	PSES[4]	60.1	9.5	38.8
2001-02	NNS[5]	36.8	13.1	38.0

Source: Adapted from Qureshi et al. (2001)
Note: All these surveys are nationally representative.
[1]Micro Nutrient Survey (MNS)
[2]National Nutrition Survey (NNS)
[3]Pakistan Demographic Health Survey (PDHS)
[4]Pakistan Socio Economic Survey (PSES)
[5]National Nutrition Survey (NNS, 2004)

In order to combat high childhood morbidity and mortality, an immunisation programme was initiated in 1978 to protect the young children against six common diseases and pregnant mothers against tetanus. This programme was greatly accelerated in 1982 with the collaboration of WHO and UNICEF. Among children 12 to 23 months of age, 70 percent had received a BCG vaccine, 50 percent a measles, and 43 percent had received all three doses of DPT and polio vaccine, however only 35 percent had received all of the recommended vaccinations, while 28 percent had received none at all (PDHS, 1992). Besides this programme a number of other projects were run focusing on

providing antenatal and postnatal services. Despite having a poor record in health and nutrition related indicators still there is no comprehensive health and nutrition programme at a national level to combat malnutrition. According to National Human Development Report (NHDR, 2003, page 19) three factors account for 60 percent of the burden of disease in Pakistan, when measured in terms of life years lost:
(1) communicable infectious diseases, (2) reproductive health problems and (3) nutritional deficiencies. Despite of the fact that all three factors are preventable as well as treatable, the incidence of mortality and disease remains high. This situation is indicative of high levels of poverty which in turn cause poor nutrition. Hence, it makes Pakistan a perfect choice to investigate the causes of malnutrition amongst the children.

1.2.1 An overview of rural Pakistan

There are three major reasons of focusing on rural Pakistan to study the causes of malnutrition amongst the children: firstly, in Pakistan almost 70 percent of the total population live in rural parts, secondly, the prevalence of malnutrition is generally higher in rural areas than in urban areas (PDHS, 1992) and thirdly, the data under study is the only longitudinal data available in Pakistan and it is based on the rural areas only.

The under-five mortality rate, an important index of health and nutritional status of a community, is high by international standards: 105 for 1,000 births (Economic Survey of Pakistan, 2004). Previous studies indicate urban-rural differentials in health status in Pakistan; according to PDHS (1992), under five mortality is 29 percent lower in urban than in rural areas. Further, the urban-rural differential exists at all ages, which suggests that both social factors and access to health services are important in the greater risk of death among rural children. According to PDHS (1992) almost 36 percent of all deaths occur during infancy in Pakistan. Furthermore, 22 percent of deaths occur in the second to fourth week, so more than half of infant deaths are neonatal deaths that occur within four weeks of birth. Child nutritional status is one of the factors identified by Mosley and Chen (1984) as the proximate determinants through which social, economic and demographic factors affect child mortality. Thus, the higher rates of child mortality in Pakistan indicate a poor nutritional status among children in Pakistan.

Child's health is closely associated with the health of mother and according to the Demographic Health Survey (PDHS, 1992) in rural areas only 17 percent of the births are benefited by antenatal care compared to 71 percent in urban areas. There were 25 percent infants with low birth weights in Pakistan during 1990-97 according to Human Development Report (UNDP, 1999). According to the National Nutrition Survey (NNS, 1988), almost 65 percent of the children and 45 percent of the pregnant and lactating women were suffering from anaemia due to iron deficiency. Causes of anaemia other than nutrient deficiency include malaria, intestinal parasites, and thalassemia. The immune system is adversely affected by the iron deficiency that raises morbidity from infectious diseases.

Child nutritional status is highly associated with the education attainment of mothers. As per the 1998 Census, female literacy rate remains low at 20 percent in rural areas which is one of the lowest in the world. According to Economic Survey of Pakistan (2004) situation of rural women in Pakistan is far worse than their urban counterparts. These women suffer due to malnutrition, inadequate health facilities, violation and poverty. Maternal mortality rate remains very high almost 400 deaths by 100,000. The situation of poor nutrition is even worse in rural areas where according to PDHS (1992), as much as 55 percent of the children were found stunted and 10 percent were found wasted. Pakistan Socio Economic Survey (PSES, 1998) reports very high rates of malnutrition among young children in rural Pakistan (60 and 9 percent stunted and wasted respectively).

The Ministry of Health provides health care services through government hospitals and health outlets (Govt. of Pakistan, 2001). During the 1980s, due to high levels of child morbidity, the government has introduced a basic health care system that was intended to provide a systematic link between village communities and higher-level health facilities (Alderman et al., 1993). Alderman et al. (1993) further states that the highest level in this system is the rural health centre (RHC), which is designed to serve a population of about 100, 000, with a complement of three doctors and eight auxiliary staff responsible for two small hospital wards of up to 10 beds each. Within the sphere of influence of each RHC are 4-10 basic health units (BHU). BHUs are designed to cover 10,000 people with a complement of at least one doctor and four-to-six auxiliary staff. They are equipped to handle only outpatients.

This picture indicates that health facilities provided by the government are not sufficient to cater for the rural population. It is to be noted that although, at BHUs the medical treatment is free of cost, but mostly either the doctor is unavailable to see the patients or the medicines are out of stock. Hence, as a result the poor people do not leave with any other option besides of going to a private clinic or to traditional providers such as dai[8] and hakeem[9]. Approaching private clinic means spending more money. According to PDHS (1992) only 17 percent women received antenatal care during pregnancy in rural areas. Further, 85 percent of the births took place at home and this proportion has declined very little from 1984-85, when 92 percent of the births occurred at home (PDHS, 1992).

Alderman and Garcia (1993) observed the major cause of child poor nutritional status in rural Pakistan is child's exposure to diarrhoea. In Pakistan 40 percent of the disease burden is communicable diseases: diarrhoeal diseases, acute respiratory infections and preventable childhood diseases (Abbasi, 1999). According to Haq and Haq (1998), 45 percent of total population in Pakistan do not have access to health services, 40 percent are deprived of safe drinking water, and 53 percent are living without sanitation facilities. This lack of drinking water and sanitation facilities give rise to diseases like diarrhoea, dysentery, malaria. According to PDHS (1992) almost 27 percent of the under-five deaths were associated with fever and about 17 percent were associated with diarrhoea.

Generally speaking, Pakistan's health system is crippled by chronic underinvestment, both in facilities and in staff, although, Pakistan produces doctors at an alarmingly high rate. It is very rare to find health professionals, particularly women working in rural areas. The inadequacies of the public sector service mean that the private sector is heavily used, although it is barely affordable to pay the expenses involved, particularly for that of poor. The World Bank's assistance to Pakistan in health sector is of recent origin, it began in 1983 with a population project but it was in 1990s when Pakistan decided to invest in the social sector and in this regard asked the World Bank to set up its support in these areas. Malnutrition is a serious problem in Pakistan and at present there is no simple solution to this problem, however, strategies have been evolved to deal effectively with the specific nutrient deficiency diseases like goitre, and anaemia. In spite of substantial economic development and improvement in the total food supply situation, malnutrition continues to be one of the serious problems in Pakistan. The

[8] An unqualified woman who carries out deliveries and provides neonatal and postnatal services to a pregnant woman.

improvement of the nutritional status of the population as a whole is therefore a social economic challenge as well as a nutrition awareness problem. Nevertheless, nutrition is a fundamental pillar of human life, health and development across the entire life span. It is an important foundation of human and national development. Although, over the years Pakistan has made considerable efforts and progress in reducing child and maternal mortality rates, however, in Pakistan, IMR constitutes a large proportion of the under-5 mortality rate. Consequently, without seriously addressing factors affecting the infant mortality rate, it would be impossible to achieve the required targets of MDGs. Thus, it seems prudent to investigate the causes of poor nutritional status among children in Pakistan so that proper policies can be planned and implemented to combat malnutrition.

To investigate the causes of malnutrition and to plan such strategies, one need to consider the performance of Pakistan in the social and health sectors. This performance of Pakistan highlights a need for designing and adopting a model that considers all the relevant factors, and relates them to proposals for changes in the system, particularly in terms of ultimate effects on the nutritional status of low-income groups. By considering all these factors, a conceptual framework is adapted in this study to investigate the determinants of child malnutrition in a way to relate various factors of socio-economic and bio-medical nature together. This framework will be discussed in this chapter following the objectives.

1.3 Objectives of the study

The principal research question of this dissertation is 'how do time, individual and household factors and levels influence child nutritional status?' The specific objectives of the study are listed below:

- To estimate the age specific trends and patterns in height and weight growth trajectories of children;
- To explore nutritional deprivation as measured by food consumption at household level;
- To investigate the determinants of child malnutrition as spelled out by the child health framework;

[9] Herbalist not necessarily a qualified person.

- To examine the link between the temporal changes in child nutritional status and the temporal changes in the status of the economic well-being of households.

The research questions that emerge from these objectives are listed below:

1. How height and weight growth velocities of children can be predicted by using growth curve models?
2. How to calculate the poverty line amongst the study households, further how to trace the movements of households in between two time points from one welfare state to another?
3. What are the food consumption patterns amongst the study households?
4. What are the important determinants of child malnutrition and whether they are different for stunting and wasting?
5. Whether children living in a same household share the correlated health?
6. How does poverty status of a household have an impact on child nutritional status over time?

The present study is designed to contribute to the understanding of child nutritional status dynamics in Pakistan which has practical implications towards designing policies and development projects. In Pakistan, previously some research has been done towards developing an understanding of the causes and consequences of child malnutrition.[10] However, substantial gaps remain about the size and distribution of health and nutrition status, the impact of health and nutrition on socio-economic development and as a result an appropriate nutritional policy. The links between poverty and child health are extensive, strong, and pervasive. However, the distinction between chronic poverty and transient poverty is rarely made in the substantial literature on poverty in Pakistan as well their effects on child nutritional status. Such an insight may in some ways change the calculations of rates of return to different projects and may in fact refine the way certain programmes or policies are designed and selected. The study of the impact of poverty, food consumption, and various individual and household factors on the growth

[10] Alderman & Garcia (1993) conducted the cross-sectional analysis of child's nutritional status (based on round 3 only) by using the same IFPRI data. Besides this report, there is a PhD thesis by Khan (2001) in which he has also examined the nutritional status of children. However, he did not consider household as a separate level in his analyses. Nevertheless, there are no such studies in Pakistan in which (i) children's growth trajectories have ever been examined, (ii) children's nutritional status is linked with poverty status and (iii) household has been taken as a separate level in the nutritional analysis, i.e. a multilevel analysis.

and nutritional status of children will provide planners with information vital to the design and modification of policy.

1.4 The conceptual framework of the study

In 1990 UNICEF published a document entitled 'Strategy for improved nutrition of children and women in developing countries' (UNICEF, 1990). The two key features of this strategy are a method for assessment, analysis and action related to nutrition, and a conceptual framework to guide the analysis of the causes of malnutrition in a given context. One of the primary motivations for developing this strategy and disseminating it vigorously within the international nutrition and development communities was the realisation that our understanding of the nature of the nutrition problem in developing countries has changed dramatically. For example, now experts have started taking child nutritional status as an outcome of socioeconomic and bio-medical factors.

To understand better what causes such problems, it is necessary systematically to consider the causes of undernutrition at different levels of the conceptual framework. The framework under study, which we shall call the 'child health framework', has been adapted from the well known food-care-health conceptual framework. This framework was developed by UNICEF to study the underlying causes of malnutrition (UNICEF, 1998, 1990), and the subsequent extended model is as presented in Engle, Menon and Haddad (1996). According to this framework, the prevalence of malnutrition is determined by immediate, underlying and basic causes. The causes of undernutrition are multisectoral and interrelated. They often operate at many levels, from the individual child to the household and community. Figure 1.1 shows how various nutrition problems, causes and consequences change and interact over time.

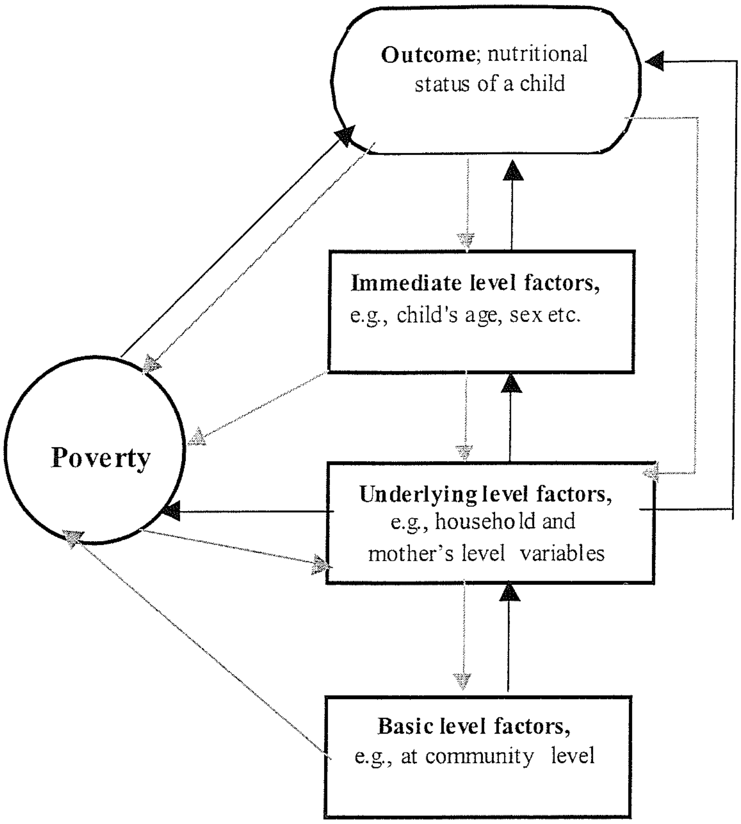


Fig. 1.1: The conceptual framework of the study
Source: Adapted from UNICEF (1990, 1998).

In this framework, the outcome refers to child nutritional status, such as height-for-age and weight-for-height Z-scores. Many of the factors associated with child nutrition are also associated with each other. Consequently, any apparent effect of one factor on child nutrition may be due to the confounding effects of one or more of these factors. However, this conceptual framework should not be seen as rigid, but rather as a guide to identifying the probable causes of the nutrition problem in a given context. For this reason it was adapted in this study to develop models for the prediction of the outcome of interest. This framework reflects the multisectoral nature of the problem and offers a guide to the study of risk factors for malnutrition. It is important to acknowledge the various levels at which the determinants of undernutrition may operate (all such associations are indicated by grey lines). Moreover, by examining the predictive ability of the framework, the degree to which the variables included adequately represent each level of the conceptual framework can be tested. This framework is used as an organising principle for discussions of aetiology and approaches to remedial action. In this conceptual framework, the solid thick black lines indicate those associations that are explored in this thesis, while such associations which are not investigated in this study have been indicated by grey lines.

A brief description of various factors at the three levels of the child health framework follows.

Immediate level

At the immediate level we specify the sex and age of a child along with inadequate dietary intake and exposure to infection. The immediate causes of malnutrition are inadequate dietary intake and a high prevalence of disease, or more frequently an interaction between the two. The relationship between morbidity and undernutrition can work both ways, since undernutrition can weaken a child's immune system, making it more susceptible to infection (UNICEF, 1998). The synergistic interaction between the two immediate causes fuels a vicious cycle that accounts for much of the high morbidity and mortality in developing countries.

The longitudinal nature of the data allows the investigation of temporal changes at various levels of the conceptual framework and their impact on child nutritional status. Hence, this new framework recognises the child's age as an important factor in determining the outcome. Generally, physical growth is a continuous process that follows a certain pattern. Growth begins when a baby is conceived and continues throughout life. The pattern of human linear growth is very well documented (Tanner, 1989); from birth a high velocity is observed with rapid deceleration at about 3 years of age; this is followed by a period with a lower and slowly decelerating velocity up to puberty. Puberty starts with increased velocity; after the age of peak velocity (PV) a deceleration is noted until growth ceases. Growth hormone is responsible for growth during childhood, but the exact age when it begins to control growth in humans is still uncertain (Karlberg, 1987). Thus, the uniqueness of this new child health framework is in the exploration of the physical growth trajectories of children over a period of time, which is a useful exercise for tracing growth retardation among children.

These factors at the immediate level in turn are closely linked to the general standard of living and to whether a population is able to meet its basic needs such as food, housing, and health care. Thus, the assessment of child nutritional status serves as a means of evaluating the health and nutritional status of children, just as it also provides an indirect measurement of the quality of life of an entire population. Once the immediate level causes have been identified it is necessary to extend the analysis to the underlying causes, which are those that lead to inadequate dietary intake and disease. Factors associated with the household are specified at the underlying level.

Underlying level

The underlying causes are usually interrelated and can mostly be considered as the insufficient fulfilment of specific basic needs at the household level. The underlying causes can be organized into various general clusters related to food insecurity, the poor status of mothers and household resources. Under these general categories are a wide range of causes, including inadequate household food supply, poor housing conditions, socio-demographic composition of households, and various maternal characteristics. These groups of underlying factors contribute to inadequate dietary intake and infectious disease. These underlying causes are, in turn, underpinned by basic causes that relate to the amount, control, and use of various resources in the community.

Basic level

Underlying causes are the product of still more basic causes, such as the ways in which potential and existing resources are controlled and managed. What resources are or will be available in a given situation, and the factors that restrict access to those resources for certain groups of people, are rooted in these basic structures. At a community level, prices of food, expenditure on health services can also affect the nutritional status of children.

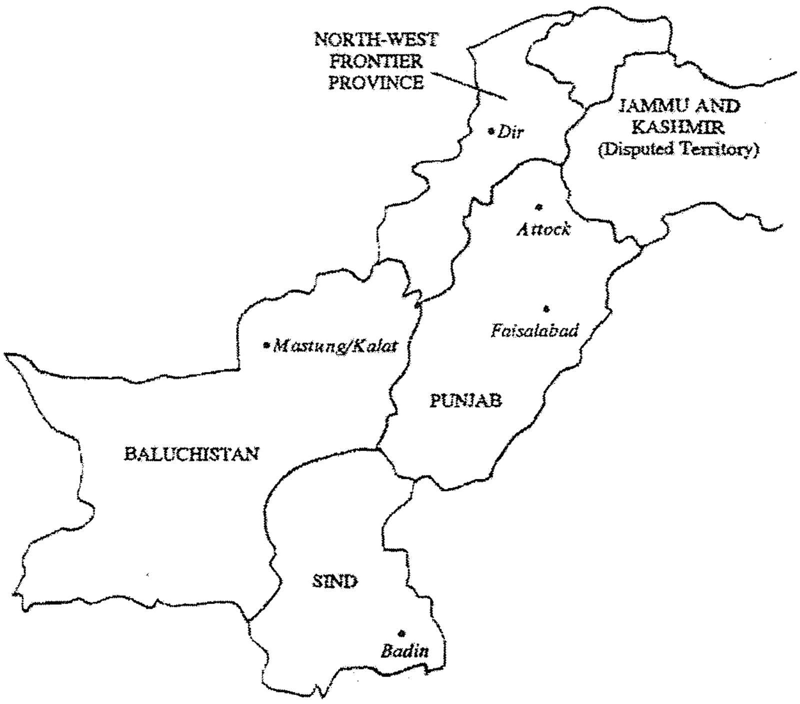
The role of poverty

Although, poverty is a fundamental cause of undernutrition, however, it is important to know how it affects child nutritional status. First, we need to consider the way poverty should be defined in this study; a basic-need poverty approach will be used which takes into account household caloric consumption and household expenditure. According to this approach a household is said to be living below the poverty line if it is unable to spend sufficient money in buying the minimum calories to live. The longitudinal nature of data allows us in exploring the change in economic status of households from one time point to next. Furthermore, in view of policy implications it is vital to know how this change in economic status can be related with the change in child nutritional status over time. Thus, economic deprivation, either short-term or long-term, is expected to affect the nutritional status of children. Hence, it can be hypothesised that children who are persistently poor are more likely to be at higher risk of many adverse health outcomes. On the other hand, children who experience short-term poverty are only slightly worse off than children who are never poor. The next question that needs to be answered is whether the effects of short- or long-term economic deprivation on stunting and wasting are different and if so then why?

1.5 Data and the survey design

The data for this study come from 12 rounds of a household level survey in Pakistan conducted by the International Food Policy Research Institute (IFPRI) Washington (see a report based on this survey by Alderman & Garcia, 1993). The survey was conducted in a series of 12 interviews over a three-year period between July 1986 and September 1989 in four rural districts of Pakistan. This survey is part of the consumption and nutrition studies of the IFPRI on the commercialisation of crops and food subsidies. This unique data set enables researchers to examine the temporal dimensions of food security, income and labour dynamics, consumption and saving dynamics, nutrition and health processes, and many other socioeconomic and health issues that cannot be addressed using cross-sectional data. By its very nature, however, this intensive approach rules out extensive coverage, rather than national coverage, the project focuses on selected districts. Thus, this data set cannot be claimed as a nationally representative but it can be considered as a representative of rural areas of Pakistan.

In the first stage of the survey the districts in the sample were selected purposefully as representing the most deprived in the province, with the exception of Faisalabad (Fig. 1.2). After one year, the Mastang and Kalat districts from Balochistan province had to be dropped from the survey due to logistical problems. Two districts were selected from Punjab, the biggest province of Pakistan in terms of population, constituting about 60 percent of the total population. Of these two districts, Attock is considered as the most deprived in the province, while Faisalabad is an industrial city with rural areas that are more developed compared with the other rural districts of the sample. However, it should be noted that only the rural areas have been selected from Faisalabad district. The reason for selecting Faisalabad is to examine the evidence for greater incidence of poor households in more wealthy localities, i.e., for the income inequality that in turn can affect nutritional status (Alderman et al., 1993).



Note: The survey districts are given in italics
Source: Alderman & Garcia (1993)

Fig. 1.2: Map of the provinces and districts included in the IFPRI panel survey of Pakistan

The sample design was such that, after selecting the districts, villages and households from each selected district were chosen by following stratified random sampling. Within each district two markets (*mandis*) were chosen at random. For each *mandi* three lists of villages were drawn up: those within 5 kilometres of the *mandi*, those within 5 to 10 kilometres and those within 10 to 20 kilometres. Villages were selected randomly from those three lists and then households were selected randomly from the complete list of families from each village. Minor variations in the process reflect special conditions in each area. For example, in villages in Punjab hundreds of families are typically located around a central core, whereas in the lower Sind, villages are administrative units made up of a number of physically separate settlements, or in local language *dehs*. This necessitated an additional random sampling to select a subset of *dehs* from the village list.

Data collection began with the 1986 monsoon *(kharif)* planting season, i.e., after the wheat harvest, and ended with the 1989 winter (*rabi*) harvest. Six rounds of interviews were taken during the first year and three in each of the subsequent two years. Thus, the starting year of the survey, which we shall call Year I begins from July-September 1986 to June-August 1987, the second year, i.e., Year II is from December 1987-February 1988 to August-September 1988 and the third year i.e., Year III is from December 1988-February 1989 to July-August 1989. Each survey team included a male and a female interviewer who filled out separate questionnaires for males and females respectively in each household. In addition, a village questionnaire was also filled out in every round to provide a complete picture of the village infra-structure and physical resources available.

Generally, in total 930 households were selected from 52 villages. There were 927 households which were selected in the round 1 while for the remaining rounds the number of households were: 910, 884, 856, 846, 832, 814, 811, 806, 804, 768 and 761. Hence, the response rate in terms of households were: 99.6%, 98%, 95%, 92%, 91%, 89%, 87%, 87%, 87%, 87%, 82% and 82% for rounds 1, 2, 3, 4, 5, 6, 7, 8, 9, 10, 11 and 12 respectively. Topics in the survey include household characteristics and composition; anthropometry, child health and nutrition; land ownership and tenure; agricultural production and disposition by season; household expenditures on labour, factors of production, food and other nonfood elements; male and female labour use; time allocation of household members(male and female); household asset ownership; long and short term credits; livestock and poultry ownership and income; male and female nonfarm activities and income; women's fertility history; pensions, other transfer incomes, income from trade and crafts. Community/village level information were collected on crop yields, crop prices and irrigation water rate, the daily wage rate on farm and nonfarm activities, the price of essential food and nonfood items, the availability of public services in a village, rural education, migration and employment. Data were also collected on technology adoption and technical skills of wheat farmers, labour on different farm activities and returns to labour.

The male questionnaire consisted of questions that were mainly about production, marketing, financing, male labour, and non-food expenditures. The female questionnaire had questions mainly about demographics, food consumption, health status of children and female labour supply. Food consumption data included purchases of 38 food items and consumption from gifts and own production. In each round of the survey, the status of each member was recorded: present, travelling, moved to a new household or dead.[11]

Besides the variables given in the data, the present study also uses some derived variables[12] such as, nutritive values of food items, imputed values of prices, household consumption expenditure, and HAZ & WHZ Z-scores. This section only outlines the procedure of calculating prices of food items. However, for all other derived variable procedures, readers are directed to read the relevant chapters where these variables are used. The study households found to consume food through various sources, such as purchases from market, own production, received in kind or gift. Alderman & Garcia (1993) reports a high proportion of households consumes food from own production. This results in missing values for the food prices in the IFPRI data. The question is how to fill up such missing values of prices? We filled up the missing prices of food items with district level averages of the prices of various food items which were given in the data. The given prices in the data were those of food purchased by households from the market. Hence, in the present study, the prices are calculated (imputed), where required, by taking the average prices which are available in the survey for every district separately. For example, in imputing the price of wheat for own production or received in kind or as gift, we averaged the price of wheat (per kilogram) which was given in the data for such households who have purchased wheat from the market. This procedure is done at every round for each district separately.

In panel surveys attrition is always a concern, not only because the sample size is reduced, but also because selectivity of sample dropouts could bias the results. Alderman & Garcia (1993, p. 5) in their report based on this survey have mentioned that "the major reasons for households leaving the survey prior to the final round, however, appear to reflect administrative and community politics rather than household self selection. For example, Mastung/Kalat was dropped at the end of the first year in order to simplify the logistics of continued data collection. In both the Sind and NWFP, an entire village dropped out following disputes between survey staff and the village head. While this was unfortunate, it is not likely to have introduced a selection bias."

[11] The household characteristics are presented in Chapter 4 (Table 4.1), the pattern of children's anthropometric measurements is given in Chapter 3, the construction of consumption expenditure is described in Chapter 4 and finally, the food consumption data have been described in Chapter 5.
[12] These derived variables were constructed by the author.

1.6 Organisation of the thesis

The study starts by providing an overview of the underlying mechanisms for determining child nutritional status at various levels of the child health framework. This aspect is covered in Chapter 2. The first objective of the study is addressed in Chapter 3. Physical growth as indicated by height and weight measurements of children can be considered as a yardstick for measuring child health and nutrition. This chapter also provides a detailed description of the hierarchical modelling framework with special reference to growth curve models. Besides that a detailed description of IFPRI data at child-level is provided in this chapter.

Chapter 4 aims to provide a basis for addressing the last objective of the study by analysing the economic well-being of the study households. This chapter takes full advantage of the longitudinal data by investigating the poverty dynamics of households in between the survey years. This chapter also examines the correlates of poverty and chronic poverty.

The second objective of the study is investigated in Chapter 5. The purpose of this objective is to examine the view that nutrition deprivation is related to nutrient deficiency and improper food consumption patterns. A detailed description is provided in this chapter of the food consumption patterns among the study households. An examination of the determinants of caloric and protein acquisition is also presented with the help of the generalised estimating equation (GEE).

The last two objectives of the study are examined in the final analyses presented in Chapter 6. This chapter mainly deals with the investigation of child nutritional status, which is the third objective of the study. The chapter starts by providing an overview of the nutritional status of study children. The focus then moves towards exploring the determinants of malnutrition in the light of the child health framework. A three-level longitudinal hierarchical linear model is used to look at the determinants. The remaining section of this chapter addresses the final objective of the study, which is concerned with linking poverty trajectories with the trajectories of child nutritional status.

The last chapter of the thesis is about the conclusions, discussion, and limitations of the study and recommendations for the future research. These are presented in Chapter 7.

Chapter 2

The mechanism of the child health framework: how does it operate?

In order to study the mechanism underlying child nutritional status, one needs to understand the processes of the child health framework that lead to the determination of nutritional status. The child health framework which has been employed in this study has already been outlined in Chapter 1. The present chapter articulates the mechanism involved in linking various levels of the child health framework to determine and explain child nutritional status. The aim of this chapter is to consider the various factors associated with levels of the child health framework and to probe how they can be used in determining child nutritional status.

The chapter divides into four broad sections. The first section presents an overview of the issues of the nutritional status as developed and considered by researchers over a period of time. This section also presents the view of how child nutritional status can be assessed by using anthropometric measures in comparison with an international reference. The second section discusses the role of various factors specifying at the immediate level in the child health framework in the determination of child nutritional status. The factors at the underlying level are discussed in the third section of the chapter. The last section aims to explore the link between poverty and malnutrition.

2.1 The development of concepts of malnutrition

Data from around the world show that the causes underlying malnutrition have not changed very much over the past 50 years. However, what has changed is the way of analysing and understanding malnutrition. Malnutrition used to be thought of as a clinical problem, but the perspective has changed and it is now very much considered as a social disorder. The following section discusses the way malnutrition used to be seen by experts and the way it is seen now.

Change in the understanding of malnutrition from 1950 to 1970

During the 1950s and 1960s, kwashiorkor and protein deficiencies were seen as the major nutritional problems (Latham, 1997). At that time the distribution of protein-rich food supplements of animal origin was the strategy planned for the control of malnutrition. During the late 1960s and 1970s, the term "protein-energy malnutrition" (PEM) entered the literature (Latham, 1997). PEM is also referred to as protein-calorie malnutrition. It develops in children and adults whose consumption of protein and energy (measured by calories) is insufficient to satisfy the body's nutritional needs. Protein-energy malnutrition (PEM) is a potentially fatal body-depletion disorder. It is the contributing factor of deaths in children in developing countries. Growth failure in children is the first sign of PEM, the basic causes being low intake of energy and proteins and exposure to infection. Increased protein and energy intake by children was seen as the solution, and applied nutrition programmes (ANPs) were offered as strategies. Subsequently, the 1974 World Food Conference began a decade of macroanalysis, which placed nutrition planning first, followed by nutrition surveillance as the dominant strategies for the countries most affected.

Change in the understanding of malnutrition from 1970 and onward

From 1970, economists began to take over from nutritionists and paediatricians as the architects of new policies, with much emphasis on national food security, together with agencies such as the World Bank stressing income generation (Latham, 1997). In 1985 the International Monetary Fund (IMF) began to introduce structural adjustments and WHO and UNICEF reinvented ANPs, which were renamed as Joint Nutrition Support Programmes (JNSPs). In the early 1990s the subject of micronutrients pushed PEM to the background. At that time a number of programmes were run to introduce micronutrient supplements to feed especially children and pregnant women.

The concept of malnutrition in the present day context

The realisation that malnutrition is not just a food problem has existed for many years, but the concept of the importance of giving consideration to food, health, education and care is of more recent origin (See for example Behrman, 1991; Beaton et al., 1990). Through subsequent research studies, both economists and nutritionists became convinced that malnutrition is not only determined by food consumption but also that infection plays a significant role (William et al., 2003; Madise et al., 1999 & 1997; Pelletier, 1994; Alderman et al., 1993; Brown et al., 1985; Black et al., 1982). Hence, food consumption or dietary intake and exposure to infections are now considered as the two proximal causes of malnutrition that can be seen in the child health framework (Fig. 1.1). Further, these two factors are affected at the underlying level by a range of other factors of a socio-demographic nature. Thus, a child's nutritional status is determined by an array of factors ranging from diarrhoea to poverty.

Nutrition transition

Developing countries, at one hand are experiencing higher rates of under or malnourished people and at the same time, experiencing the burden of overweight people. This phenomenon is referred to as 'nutrition transition' which has caught a lot of attention after a pioneering work of Popkin (1993, 1996, 2001 and 2002). A strong link has been found between childhood stunting and obesity later in life (Popkin et al., 1996). Popkin and colleagues (1996), in a study of children aged 3-6 and 7-9 years from four countries found a higher prevalence rates of obesity (9.2%-30.6%) and also higher rates of stunting (9.2%-30.6%). Obesity in the developing world can be seen as a result of a series of changes in diet, physical activity, health and nutrition. There is clear evidence of a demographic, epidemiological and nutrition transition in India that is fuelling the epidemic of chronic diseases and obesity particularly in the urban areas (Shetty, 2002; Griffiths, 2001). This area is of public health interest and needs serious consideration from the policy makers. However, nutrition transition is not a point to be addressed in this study.

2.1.1 Anthropometric measures as an outcome of child nutritional status

As discussed earlier in Chapter 1, anthropometric measures can be used to assess children's nutritional status. Anthropometry, despite its inherent limitations, still remains the most practical tool for assessing the nutritional status of children in the community. In 1956 Gomez and colleagues were the first to use an anthropometric measure (weight) to assess child malnutrition and the associated risk of mortality (Gomez et al., 1956). They developed the indicator weight-for-age and from it the classification of varying degrees of malnutrition. In their study they used the 'average theoretical weights' of Mexican children. The children under study were classified under three categories of malnutrition: first degree (76-90% of the theoretical weight), second degree (61-75%) and third degree (60% and less). With time, the 'Gomez classification', using the Harvard reference values and different cut-off points (i.e., 80%, 70% and 60% of the median) was widely used to classify children under various categories of malnutrition.

As the Gomez criteria relied exclusively on weight-for-age and hence could not discriminate between short-term and long-term forms of malnutrition, the patients classified in terms of weight-for-age criteria by Gomez are actually a mixed group in terms of their clinical nutritional status.

In post-Gomez classifications, weight-for-height has emerged as an important indicator and several authors have identified this indicator for screening severely malnourished children (Van den Broeck et al., 1994; Trownbridge, 1979; Waterlow et al., 1977).

In the use of this indicator, anthropometric measures or values are compared with reference values. Observed growth performance is evaluated in comparison with a standard that is considered best to represent normal growth. The standard that is now widely used for this purpose in many countries is that developed by the National Centre for Health Statistics (NCHS) of the USA, which is based on growth measurements of large numbers of American children (NCHS, 1976). An expert working Group of the WHO was constituted in late 1975 to advise on the use of anthropometric indicators of nutritional status. After careful examination they recommended that the NCHS data were best suited as an international reference, since they meet most of the criteria necessary for this purpose (WHO, 1986).

The WHO Expert Group, however, cautioned that while the NCHS standard might be internationally applicable for children up to 10 years of age, its use beyond this age might not be justified, in view of wide differences in the time of onset of puberty among different population groups. Anthropometric measurements have been widely used as indicators or proxies for various conditions related to health and nutrition, but on an individual basis abnormal anthropometric measurements do not themselves provide specific aetiological information. For example, a child may be abnormally short as a result of infection, inadequate food intake or psychological deprivation due to endocrine, metabolic or other diseases.

Although the NCHS/WHO international growth curves have served many useful purposes throughout these years, they have a number of serious drawbacks and their suitability for international purposes has recently been challenged (de Onis et al., 1996; WHO, 1995). There are some flaws in using the current reference data, arising from both technical and biological considerations. The current NCHS/WHO reference for infants is based on the Fels Longitudinal Study, conducted in Yellow Springs, Ohio from 1929 to 1975 (WHO, 1995). A number of flaws and limitations were mentioned by the WHO Working Group on Infant Health (WHO, 1995). For instance, the sample was drawn from predominantly middle-class families. Secondly, the measurements were taken every three months rather than every month. Lastly, most of the infants were bottle-fed and very few were exclusively breast-fed. Therefore, the growth of breast-fed infants living under favourable conditions in various geographical areas has been reported to be less than expected on the basis of the current NCHS/WHO growth reference (WHO, 1983 & 1986). As a result, an international effort is currently under way to develop a new international growth reference (de Onis et al., 1997; WHO, 1995). Until the new reference is developed, the NCHS/WHO growth reference curves will remain the reference values recommended for international use.

Many researchers argue that there should be local reference values for comparison with anthropometric measures. The basic reason for not developing a local reference or standard is that many populations in developing areas experience growth deficits as a result of poor health and nutrition. Any reference developed from such a population therefore has less screening value for the detection of health and nutritional disorders.

An international reference is clearly needed to allow comparison of the nutritional status of populations in different parts of the world. There is evidence that the growth in height and weight of well fed, healthy children from different ethnic backgrounds and different continents who experience unconstrained growth is reasonably similar at least up to 5 years of age (Martorell, 1985; Graitcher et al., 1981). While it is accepted that there are some variations in the growth patterns of children from different racial or ethnic groups in developed countries, these are relatively minor compared with the large worldwide variation that relates to health nutrition and socioeconomic status (Habicht et al., 1974). For these reasons a common reference has the advantage of uniform application, allowing international comparisons without loss of usefulness for local application. The use of statistically defined cut-off points is not unique to anthropometry. Nevertheless, it is important to consider that using a cut-off based criterion to define what is 'abnormal' is somewhat arbitrary.

Once an anthropometric indicator and a reference population have been selected, it is necessary to determine the limits of normality. There are three ways of comparing a child with a population: firstly the use of Z-scores (standard deviation scores), secondly percentiles and thirdly percent of median. The Gomez classification uses the percent of median method, which is a convenient measure if the reference population distribution has not been normalised. Common cut-offs for percent of median are different for the three anthropometric indicators. Of the three reporting systems, i.e., percentiles, percent of median and Z-scores, only Z-scores are recommended for analysis and presentation because of the various advantages reported by WHO in the late 1970s (WHO, 1995).

Anthropometric data are usually standardised into Z-scores according to the WHO standard. The number of standard deviations of the nutritional indices above or below the median is referred to as the Z-score. To calculate Z-scores it is necessary to take the observed height or weight of the child and subtract the median value for a child of identical age and sex according to widely used international standards based on healthy and well nourished children and divide this by the standard deviation from the same international standard (US National Centre for Health Statistics NCHS, 1976). There are two ways of expressing anthropometry-based results using Z-scores. One is the commonly used cut-off based prevalence and confidence interval for the indicators, the other includes the summary statistics of the Z-scores, mean, median, SD, SE and frequency distribution.

2.2 Immediate-level factors determining child nutritional status

This section discusses the effects of various factors at child level termed as the immediate level at the child health framework. As stated in Chapter 1, these factors are: child's exposure to infection or morbidity, child feeding practices, child's age and child's sex.

2.2.1 Effects of infection on nutritional status

The effects of nutritional status on infections and of infections on malnutrition signify a very important relationship (Scrimshaw et al., 1968; WHO, 1986; Keller, 1991). In most developing countries, the majority of children suffer from malnutrition during their first five years of life. Infection affects nutritional status in several ways. Perhaps the most important of these is that bacterial and some other infections lead to an increased loss of nitrogen from the body (WHO, 1986). Once the infection is overcome, full recovery depends upon the restoration of the amino acids. This requires increased intake of protein, above maintenance levels. In children whose diet is marginal in protein content, or in those who are already protein depleted, growth will be retarded during and after infections.

In developing countries, children from poor families suffer from many infections in quick succession during the post-weaning period and they often have multiple infections (Brown et al., 1985). Anorexia or loss of appetite is another factor in the relationship between infection and nutrition. Infections, especially if accompanied by fever, often lead to loss of appetite and therefore to reduced food intake (Rivera et al., 1988). Some infections cause vomiting and in some societies mothers stop giving food to children and instead give liquids. Mostly such liquids consist of rice water, which has a very poor nutritional composition. This practice may have very serious consequences for child nutritional status. Parasitic infections, particularly intestinal helminthic infections, are extremely prevalent and are increasingly being shown to have an adverse effect on nutritional status (WHO, 1986).

Many studies have shown that diarrhoea is an important cause of PEM (golden et al., 2000). It is very common in poor communities and often lethal. It has been observed that intestinal parasites may contribute to diarrhoea and poor vitamin A status (WHO, 1986). It has also been observed that breastfed infants have some protection against diarrhoea. It is reasonable to conclude that diarrhoea is in some way linked with the weaning process.

2.2.2 Breastfeeding and child nutritional status

Breastfeeding and complementary feeding behaviours are important predictors of infant and child nutrition, health and survival. Breastfeeding provides a complete source of nutrition for the first six months of life, half of all the requirements in the second six months of life and one-third of requirements in the second year of life (WHO, 1998). The health benefits of breastfeeding arise from both biochemical and immunological factors. The biochemical aspects principally concern the digestion and metabolism of foods. Although carbohydrate metabolism develops fairly early in gestation, the ability of the new-born child to digest and metabolise proteins and fats is still limited at birth. As a consequence, the crucial biochemical difference between human milk and cow's milk may lie in the content and composition of proteins and lipids (Umeta et al., 2003). It has been shown that malnutrition may be caused by single or multiple micronutrient deficiencies, such as zinc, iron, vitamin A, or iodine deficiency (Allen, 1994). Breast milk is an important source of both zinc and vitamin A for infants during infancy (Umeta et al., 2003). Furthermore zinc from breast milk is well absorbed. In children, the first 6 to 24 months are very crucial for development, and to meet micronutrient deficiency, particularly of zinc, breast milk is the best source.

The protective effect of breastfeeding on child nutritional status was found to be strongest during the first year of a child's life, as was the negative effect of energy intake from supplemental foods during the first year (Adair et al., 1997). Breastfeeding provides important nutrients needed for growth and also protects against diarrhoea and morbidity through immune factors present in milk (Dewey et al., 1992; WHO, 2000). Human milk provides important immunological protection during the neonatal period when the infant's own defences are weak and continues to do so throughout lactation. After about the age of six months, breast milk alone is probably not sufficient to sustain growth (WHO, 2000). Even so, the evidence suggests that continued breastfeeding with supplementation may be valuable. Complementary food along with breast milk can result in improved child growth (WHO, 2000). However, the process of linear growth retardation (stunting) starts before or during the second three months of life, a period when breast milk intake declines, supplementary foods are given, and susceptibility to infection starts. In developing countries, growth retardation begins within a few months of birth. The causes of this early growth retardation are not fully understood, but factors such as inadequate dietary intake and infection are the proximate causes (Golden et al., 2000; Waterlow, 1994). In the absence of contraceptive use breastfeeding also lengthens the birth interval which is strongly related to infant and child survival.

2.2.3 Age-specific effects on nutrition: human growth patterns

Can undernourished children catch up their growth during adolescence? A number of studies have addressed this issue (Waterlow, 1994; Golden, 1994; Martorell et al., 1990; Satayanarayana et al., 1986). Although some studies have shown that some catch-up growth is possible (see e.g., Martorell et al., 1994), very little work has been done to determine whether nutritional and health interventions targeted at adolescents will bring about significant improvements. Human growth usually follows a pattern which is well documented (Tanner, 1989). According to Tanner, "from birth a high velocity is observed with rapid deceleration up to about 3 years of age; this is followed by a period with a lower and slowly decelerating velocity up to puberty. Puberty starts with increased velocity; after the age at peak velocity (PV) a deceleration is noted until growth ceases". The infancy-childhood-puberty (ICP) model breaks down linear growth mathematically into three components: infancy, childhood and puberty (Karlberg, 1987). The final adult height of an individual is the additive result of the three phases of growth. This section briefly discusses these phases of human growth.

Growth from infancy to childhood

Growth and development constitute the most distinctive features of a child's life. The infancy component begins in mid-gestation and lasts for 2-3 postnatal years. Surprisingly, it is well documented that infants living in developing countries have mean birth heights close to those reported from Western Europe and North America (WHO, 1986; Martorell & Habicht, 1986). However, between 4-6 months and 18 months of age the mean lengths' curves diverge, so that by 24 months the difference is considerable (Dewey et al., 1992; Jalil et al., 1989; WHO, 1986; Martorell & Habicht, 1986; Waterlow et al., 1980). Again, during the second and third year the mean growth curve of infants almost becomes parallel to the western standard curve. Why this is so? The exact reasons are not known but plausible causative mechanisms involve such factors as feeding patterns, general under-nutrition, micro-nutrient deficiencies and social-economic conditions of the household. However, it has been argued that growth during the first year of life may simply represent a postnatal continuation of 'foetal growth' (Karlberg, 1987 and Smith, 1977). In the second year the growth is a result of both the infancy and childhood components. About 75% of normal infants display a fairly constant growth rate with a total gain close to average during this period (Karlberg, 1987).

In growth literature, one term which is frequently encountered is 'growth retardation'. In normal infants the onset of growth faltering occurs between 6 and 12 months of age and is typically abrupt (Karlberg, 1987 & 1990). The age at onset represents the age at which growth hormones (GH) begin to influence normal human linear growth significantly (Karlberg et al., 1994). It is known that the growth of the long bones, as represented in the legs, is more sensitive to GH than other bone structures, such as the short bones in the vertebra (Frasier, 1983). Hence, children with an early deficiency of GH who receive no hormonal therapy run a higher risk of growth retardation. Thus, growth retardation is associated with a sudden decrease in growth velocity. Growth velocity can be estimated by applying suitable statistical models, such as growth curve models[1] (Snijders et al., 1999; Yang et al., 1994; Rao, 1965).

Growth from childhood to adulthood

It is well documented that a period of malnutrition in the first 2-3 years of childhood promotes irrevocable changes in a child so that child is 'locked into' a lower growth trajectory with a lower potential for future growth (Kralberg, 1987; Smith, 1977). Children aged 6 years or younger are considered to be one of the groups at greatest nutritional risk. Catch-up growth or catch-down growth[2] usually takes place in the first two years of life. During this time, children may cross the centile lines either upwards or downwards rather than tracking along with them (Ulijaszek, 1994). The potential for catch-up growth among stunted children is thought to be limited after age two, especially when children remain in a poor environment (Martorell et al., 1994). The alternative hypothesis is that full catch-up growth is possible but is not observed in practice because the correct conditions for catch-up are not satisfied; in most populations the environment and diet associated with poor initial growth performance do not change. Tanner (1986) has written about the possibilities for reversing stunting. He states, "deflect the child from its natural growth trajectory by acute malnutrition and a restoring force develops, so that as soon as the missing food is supplied again the child hastens to catch up towards its original growth curve."

Data from the longitudinal study conducted in Guatemala indicate that there is no catch-up growth during later childhood and adolescence (Martorell et al., 1990). At five years

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[1] For a comprehensive description of growth curve models, readers are referred to Chapter 3.

of age the subjects were grouped according to degree of stunting. The grouping was I (above-2 SD), II (-2 to –3 SD) and III (below –3 SD) using US reference values. Growth from five years to adulthood was similar in all three groups. It is to be noted that the differences in all the groups with respect to the reference data increased by about the same amount. Martorell et al. (1992) found a very high correlation between the heights of children at three years and their final adult height and performance. Such a high correlation between height in childhood and final adult height is well known in other populations in both the developing and developed worlds (Binkin et al., 1988; Mills et al., 1986; Satayanarayana et al., 1986).

The physical growth of children aged six to nine years of age is the result of both environmental and genetic factors and the interaction between them. Environmental factors such as poor food consumption, illness, poor health and hygiene conditions greatly affect the physical growth of children, although in adolescence a second period of rapid growth may provide an opportunity for compensating for early childhood growth failure. However, the potential for significant catch-up at this time is limited. Also, even if the adolescent catches up on some lost growth, the effects of early childhood undernutrition on cognitive development and behaviour may not be fully redressed (Gillespie, 1997). Adolescence is a transitional phase when children become adults. There is very limited literature available on assessing nutritional status in adults and on diagnosis and treating malnourished adults (ACC/SCN, 2000).

Martorell et al. (1994) noted that three outcomes for stunted children living in three different conditions would be possible: (1) continued residence in the environment that gives rise to stunting; (2) continued residence in the same environment but with improvements in nutrition; and (3) relocation to an improved environment linked to improved nutrition. For example, Mexican-Americans have increased in height dramatically in the last 20 years, probably as a result of better growth in early childhood. The smaller size of Mexican –American adolescents with respect to the reference population may reflect, not reduced growth during adolescence per se, but poorer growth in early childhood than that experienced by younger cohorts (Martorell et al., 1994). It has been seen that stunted children are more likely to become stunted adults as compared to non-stunted children if they continue to live in the same

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[2] When the growth starts deteriorating, this reverse phenomenon is sometimes referred to as catch-down growth

environment. For example in a study in India, early childhood stunting among young girls was found, a generation later, to be significantly related to the birth weights and infant mortality risk of their children (Ramachandran, 1989).

2.2.4 Sex-specific effects on nutritional status: growth retardation in girls versus boys

A number of studies based on countries and regions such as Pakistan, and sub-Saharan Africa have demonstrated that a higher proportion of boys than girls is stunted particularly during childhood (Shah et al., 2003; Qureshi et al., 2001; Madise et al. 1999 & 1997). Research has shown that better nourished girls have higher premenarcheal growth velocities and reach menarche earlier than undernourished girls, who grow more slowly. In Uganda, children were found markedly stunted in a follow-up study six to ten years later (Krueger, 1969). Severely stunted children were followed by Graham's group in Peru (Graham & Adrianzen, 1971). Their findings were very interesting as they discovered that in the long term the girls did decidedly better than the boys (they were 2 cm shorter at 1 year and 7 cm taller at 13 years). The girls were taller than their mothers from age 14 years, while the boys lagged behind their fathers at age 16 (150 vs 158 cm) (Graham et al., 1982). It is clear that the girls had a very marked catch-up probably due to their height potential. However, the authors further state that this sex difference has not been frequently reported in other studies. The same sort of longitudinal study was conducted in India to examine growth patterns among boys (Satayanarayana et al., 1980). The boys who were very short at age 5 continued to be so at age 17 years and also their maturation was delayed. But with respect to the Harvard reference data, the differences increased slightly from 5 to 18 years. The growth retardation of early childhood was slightly increased by adulthood in males but decreased in females.

Using longitudinal data from the Philippines, Senauer, et al. (1991) reported that although boys receive a larger percentage of their recommended daily allowance (RDA) for calories, they are more stunted in relationship to the height standard for their age than girls. The greater stunting among boys in this sample could be a reflection of the impact of other inputs into their long-run health production function, which differs from that of girls. A longitudinal study (Satyanarana et al., 1981) in children from 26 villages in India analysed the heights of 197 girls at 5 years and 18 years of age. At 18 years of age the differences in heights with respect to the Harvard mean reference were less than at 5 years. The authors suggest that the most plausible explanation for the apparent catch-up growth is delayed menarche. The authors state that the pubertal growth spurt was delayed and that the growth period was prolonged by about 1.5 years.

2.3 Factors at the underlying level of the conceptual framework

This section discusses various factors specific to the underlying level of the conceptual framework. These factors are associated with household and maternal characteristics. At the household level, we specify factors such as food security, and the household's socioeconomic and demographic characteristics. At the maternal level, factors such as age, education and height are specified. It seems prudent to have an insight into a typical rural Pakistani household and status of women before explaining various factors at the underlying level of the conceptual framework.

2.3.1 A typical rural Pakistani household and women's status

Pakistan's typical family structure is patriarchal and women typically live with their husband's family after they are married (Durrant et al., 2000). A major aspect of gender construction is that of men as economic providers and women as dependants and homemakers. Purdah is a concept deeply rooted in Muslim theology and tradition, dictates that the sexes are physically segregated outside the household and that women wear a veil in public. As a result most Pakistani women lack the freedom or autonomy to move about in public and more often than not, need a chaperone to go anywhere in public including to a health facility (Fikree et al., 2001). This keeps them away from acquiring education, and medical treatment. In Pakistan, women are usually subordinate to men and their role is confined only to the household chores and childcare. They rarely have access to productive resources and have very limited participation in household decisions. Even, most of the decisions of their personal life such as, matters related with reproductive health are either taken by their husband or mother in law in case of extended family set-up.

Two types of households can be seen in a rural Pakistani setting: nuclear household, which is comprised of the father, mother and unmarried children and the extended household that is comprised of the members of nuclear household and other relatives as well. Two types of extended households are common in rural Pakistan. One is the vertically-extended household which typically comprises of parents, their children and grandchildren. The other is a horizontally-extended household usually comprised of collaterally related individuals such as siblings of the husband or wife or cousins belonging to the same generation. In Pakistan generally and in rural areas particularly, the extended family headed by grandfather is a norm. A mother's position can depend on the amount of influence by her mother-in law and other older female household members. This is thought to be the most salient in north India and Pakistan, where a young woman arrives in a new household to find herself not only beholder to her husband his father, but to all of his family members (Das Gupta, 1996). In such settings, the role of other female household members or mother-in law in shaping the mother's autonomy and decision making regarding children is important.

In literature, women autonomy has been represented by various measures such as, their life expectancy, literacy, mobility and involvement in decision-making and economic generating processes, their access to and control over resources and power relations within the household (Sathar et al., 1997). Women's autonomy is strongly influenced by kinship and marriage relationship, by age, by religion and by division of labour within traditional patriarchal societies. The extent of gender biased in Pakistan is evident by considering the ranking of Pakistan in the Gender Development Index (GDI) and the Gender Empowerment Measure (GEM). Pakistan's ranking is 120 and 58 in GDI and GEM respectively (UNDP, 2003). The low ranking of Pakistan in GDI and GEM indicates the lack of opportunities for women to participate in economic and political activities compared with men. Sathar et al. (1997) observes that women's involvement in economic decisions is extremely limited. The majority of women participate only in decisions related to the purchase of food. In all other decisions, either domestic or economic they are not allowed to act as a major decision maker. They found positive relationship between women's paid employment and power of decision making.

Many researchers have demonstrated the role of women's empowerment in South Asian region on demographic outcomes. Most of such studies in South Asian context support the hypothesis that women's status significantly determines their reproductive behaviour (e.g., see Dyson and Moore, 1983; Sathar, 1993; Fikree et al., 2001). In these studies low status of women is characterised by limited mobility, illiteracy, weak ability to participate in household decision-making process. Research indicates that husband's and mothers-in law's authority play a significant role in fertility decision making and the woman is bound to obey his decision regarding practising or non-practising of contraception (Fikree et al., 2001). Another reason regarding the lower use of contraceptive amongst the rural population in Pakistan has been found as the low levels of communication between spouses about reproductive matters (Fikree et al., 2001). It was found that Pakistani women living in nuclear households showed greater autonomy on a range of indicators and were more likely to use contraception than those living in extended households (Sathar et al., 1997).

Durrant and Sathar (2000) observe that women's status has received considerable attention as a significant factor in demographic behaviour and outcomes in South Asia. However, little research has addressed the links between women's status and their investments in children. They used six variables to represent women's status to which three variables were found significant with infant mortality; these variables were mother practices purdah outside home, mother is regularly beaten by husband, and mother's access to financial resources. However, mother's mobility and her decision-making autonomy on child-related issues were not found significant. They concluded that women's status at the individual level (household) has a stronger relationship to infant mortality than women's status at the community level. In Egypt, Roushdy (2004) observed an increased and significant effect of violence on women on children's low height-for-age Z-scores especially on female children. However, she found no significant impact of women's access to cash and her involvement in decision-making process on child's nutrition. In Philippines (Garcia, 1990) found a positive and significant impact of women's wages on the caloric acquisition of herself and her children. However, he found a negative association of mother's income on child's weight-for-age measure while its effect on height-for-age measure found to be positive. He further argues that the effects of mother's income on a short-run measure (weight-for-age) is not very surprising as it is quite possible that the child care provided by those who substitute for the mother may not be of same quality. Agha (2000) observes a relationship between the low status of women and health of Pakistani children. He measures the low status of women in terms of her education attainment.

Despite the norms of having extended family set-up in Pakistan, still there is no such study to investigate the influences of an extended family set-up and particularly the presence of grandmother on child health in Pakistan. In South Africa, beneficial effects of pensions that grandmothers received were found on child outcomes (Duflo, 2000). There is also evidence in literature that grandmothers also help daughters-in law in household chores and looking after children (see Hawkes, 2003). Griffiths (1998) also found a positive impact of the presence of mother-in law in a household on child's nutritional status in Uttar Pardesh, India.

In a detailed study based on five countries in Asia, (Ghuman, 2002, 2003) observes women's autonomy is not a consistent and or strong correlate of infant and child survival and any observed association between autonomy and mortality is often heavily contingent on country and communities within country. For example, in Malaysia and Philippines, the mother's discretion over family income is related to lower post neonatal and child death. But in Pakistan, north India and Thailand several dimensions of women's autonomy such as freedom of movement, discretion over material resources and decision making over children's illness have weak associations with child survival once the socio-economic status of the mother and her family or region of residence were considered.

In conclusion, the literature presents mixed views on women's status and its effects on children's health.

2.3.2 Household standards of living

The child health framework locates the household at the underlying level affecting the immediate level in determining child nutritional status. Many studies have demonstrated the importance of household characteristics as the determinants of child anthropometry (Strauss, 1990; Alderman, 1990; Garcia, 1990). Child survival is an important outcome of household welfare and is often used as an index of living standards. Conditions within the household are thought to be important determinants of child health (Barrera, 1990). Anthropometric outcomes such as height or weight provide a different dimension for the health and nutritional status of children and so might also enter household welfare calculations (Thomas et al., 1991). In defining a household's living of standard, food security and the health and nutrition of the household members are important. Data on household level food consumption are used to estimate own food price effects on nutrient intake by income class, based on the conversion of foods into their nutrient components.

What is the role of the household in determining the living of standard of its members? Garcia (1990) discussed this issue as follows: "in fact defining the household itself is one of the intractable problems in both anthropological and economic investigation. It is now common for social scientists to note that while the household is seen as the integration of economic functions as a unit of production, reproduction and consumption its precise definitions and boundaries are not straightforward. Thus, in the conduct of the analysis, the model used needs to be specified within the context of the socio-cultural and economic setting of the households being studied. Thus it is necessary to examine not only the demographic characteristics but also the patterns of flow of income".

Larger household size is found to be related to poor child nutritional status. A large family size is associated with close spacing of children and most probably a concentration of greater number of siblings at ages under five or even under age ten. Physical resources such as housing space, food, clothing, income and health care are thus spread over a large number of children. A high fertility usually translates into a short birth interval which can result either in child mortality or malnutrition (Rustein, 1984). This section highlights various factors specified at the underlying level of child health framework.

2.3.3 Household food security

The term food security is of recent origin. Most experts define food security as access by all people at all times to enough food for a healthy life. The FAO Committee on World Food Security formalised the definition in 1983 and incorporated the following three specific goals for food security (FAO, 1989):

i) ensuring adequacy of food supplies
ii) maximising stability of supplies
iii) securing access to available supplies to all who need them

Household food security is the ability of the household to secure enough food to provide for all the nutrient requirements of all the members of the household (FAO, 1996). Nutritionists stress also the need for the food to provide for all the nutritional needs of the household members, which means a balanced diet providing all necessary energy, protein and micronutrients. Every household member should have physical and economic access to adequate food to fulfil his/her nutritional requirements. Food insecurity exists when people do not have adequate physical, social or economic access to food as defined above.

Even if a household is food secure it does not mean that each and every member of the household is necessarily well nourished (Gillespie et al., 1990). One possible reason for inadequate nourishment is the pattern of food consumption, i.e., consuming more staple food and less proteins and essential vitamins; another possible reason is exposure to infection. Furthermore, in a food-insecure household it is likely that some of the members are receiving more food and calories than others, and as a result are well nourished compared to others in the same household.

The human body requires a range of nutrients to perform various functions. These nutrients include protein, fats, carbohydrates, vitamins and minerals. It is well known that energy is vital for activity, growth and rest while protein supplies body building material and helps in recouping losses due to wear and tear (Latham, 1997). Many vitamins and minerals are needed by the human body not only for carrying out many vital functions but also for helping in the utilisation of other nutrients like proteins, fats and carbohydrates. These may be required only in small quantities, but their importance is now being seriously recognised. Usually the major source of energy is cereals and vitamins, with proteins and other minerals coming from animals, vegetables and fruits. Insufficient or unbalanced food consumption leads to other problems that are of public health significance. Among these are deficiency in iron, which causes anaemia, deficiency in vitamin A, which leads to blindness, and deficiency in iodine, which contributes to iodine deficiency disorders and goitre.

In a study of the relationship of diet to growth, it was found that linear growth is associated with the protein (especially animal protein) content of the diet but not with energy intake (Dagnelie et al., 1994). Birth weights showed strong positive relationships with the frequency of consumption of both dairy products and fish by the family.

2.3.4 Maternal characteristics and child nutritional status

In the conceptual framework adapted for this study, a range of maternal characteristics thought of having a direct impact on child growth are included at the underlying level of the model. There is a very intricate relationship between mother and child. Child care is a complex set of behaviours that ranges from child feeding practices, to responses that promote a safe and healthy environment for the child and provide adequate health care, to psychosocial interactions and emotional support (Range et al., 1997; Engle et al., 1996). The principal decision-maker as to infant and toddler feeding and care is usually the mother. A mother generally acts in the infant's best interests as she sees them. In Egypt where enough food is available and government intervention attenuates economic effects, one answer to early growth failure is likely to lie in the education of women (Calloway et al., 1988). This section discusses the importance of those maternal characteristics which are thought to be important determinants of child nutritional status. These characteristics include factors such as the mother's age, height and education.

Effects of maternal education and age on child nutritional status

It is well documented that parental education has a profound effect on child survival and child health (Barrera, 1990 & Behrman et al. 1988). It has been seen that both maternal and paternal education has a significant impact on child nutritional status. Educated women are generally better informed about the nutritional demands of their family and especially those of the children. It has been seen that the effects of maternal education on child health are significantly larger than the effects of income on nutritional status (Thomas et al., 1991). Schultz (1984) argues that mother's education can influence child health in a number of ways: (i) education may lead to a more efficient mix of health goods used to produce child health; (ii) better educated mothers may be more effective at producing child health for a given amount and mix of health goods; (iii) educated mothers tend to opt for fewer but healthier children, and (iv) more schooling should raise family incomes which in turn should improve child health status.

The importance of maternal education has been well documented in the child survival literature (Glewwe, 1999; Da Vanzo et al., 1986 & Caldwell, 1979). Using Nigerian data, Caldwell (1979) strongly argues that the education of mothers plays an important role in determining child survival even after controlling for other factors like socio-economic status and education of the father. The same findings were also reported by Behrman & Wolfe (1984b). In Malaysia a sharp decline in child mortality was observed during the 1970s, and the major reason for this decline was the increase in maternal education (Da Vanzo et al., 1986). In a cross-sectional study in rural southern part of Pakistan, it was found that stunted children were 1.27 times more likely to have mothers with no formal education, compared with non-stunted children whose mothers had some level of education (Shah et al., 2003). By using the Pakistan Demographic and Health Survey, Ibrahim (1999) observed a positive and significant impact of mother's education on children's height-for-age and weight-for-age Z-scores. In Philippines, Barrera (1990) found that better educated mothers tended to wean their children sooner, but they compensated for this shortened breastfeeding time with better care; overall their children were healthier as measured by better height-for-age Z-scores. Glewwe (1999) by using the data from Morocco found that health knowledge appears to be the most important skill that mothers (indirectly)[3] obtain from their schooling that prepares them to provide for their children's health.

The impact of maternal education varies with the age of the child, as younger children are more dependent on their mother compared to elder siblings. Also, younger children have different biological physical structure and are more prone to infection, so their nutritional status depends more highly on their mothers. Women's education has also been claimed in a number of studies to influence a range of non-market outcomes, and unobserved attitudes and abilities related to family background (Behrman et al., 1976). Behrman and Wolfe (1984b) argue strongly that education is positively correlated with income as well as nutrient consumption.

Garcia (1990), in his detailed study of resource allocation within the household, observes that women's schooling is the major component affecting food consumption at the household level. He further mentions that the education of wives is strongly correlated with food expenditures, after controlling for income, i.e. more educated women are well informed about the importance of nutrient composition of the food. The results suggest that an increase in the educational level of wives is associated with a significant increase in total food expenditure. An increase in total food expenditure is an indication of consuming more food and sometimes food that is enriched with proteins

[3] Glewwe (1999) argued that schooling contributes to mother's health knowledge in Morocco indirectly by using literacy and numeracy skills acquired in school.

and vitamins. An increase in wives' education tends to decrease the consumption of staples, which are a poor source of nutrition, and to increase the share devoted to poultry, fruits and vegetables. On the other hand, Garcia argues that higher education of the husband does not appear to be associated with an increase in total food expenditures. High rates of infant mortality are associated with young maternal ages, with higher birth orders, and with short birth intervals. It has been found that the higher the mother's age the lower the likelihood of infant mortality (Howlader et al., 1999). It has also been shown that maternal age has an effect on child survival and nutritional status, for example children born to very young or very old women face a higher risk of mortality (Habicht et al., 1986). In summary, there is considerable evidence that mother's education improves child health, and some evidence on how this occurs.

Genetic endowment

The most consistent predictor of children's sizes across all ages is the size of the parents, particularly the mother. It has been seen in a study conducted in Thailand (Golden, 1988) that mothers of short children were significantly shorter than those of taller children. It can be concluded that we might be dealing with stunted families. Current research is trying to find a link between intrauterine growth retardation (IUGR) and postnatal growth. IUGR refers to foetal growth that has been constrained by an inadequate nutritional environment in utero and thus characterises a newborn that has not attained its growth potential. Such infants are disadvantaged before they enter the world. IUGR is sometimes also referred to as foetal malnutrition. It is a major clinical and public health problem in developing countries where an estimated 30 million new-born babies are affected every year, i.e. 23.8% of 126 million births per year (ACC/SCN, 2000). World-wide statistics show that 75% of all affected new-borns are from South Asia.

Maternal malnutrition is the major determinant of IUGR in developing countries. Falkner et al. (1994) mentions three categories of health status for the newborn baby dependent on growth in utero: a healthy full-term (FT) infant within the normal birth weight range; a macrocosmic infant above the normal birth weight range; or an infant of low birth weight (ILB). According to the WHO (WHO, 1998), approximately two-thirds of all the infants of low birth weight born in the developed world are true pre-term infants, and one-third are small for gestational age (SGA). These proportions are reversed in developing countries where about 75% ILB are SGA. This very high rate of SGA in developing countries is mainly due to preventable malnutrition and infection.

The nutritional status of an expectant mother and her food intake during pregnancy play an important role for the growth outcomes of the child to be born. It has been shown in previous studies that high rates of infant and child mortality are the result of limited use of health care services by mothers (Kabir et al., 1993). By reducing ill health and premature deaths, reproductive health care is considered a worthy investment in its own right. Proper medical attention during delivery can reduce the risk of infections and facilitate management of complications that can cause death or various illnesses for the mother or the newborn child (Mitra et al., 1997).

Epidemiological evidence from both developing and developed countries now suggests a link between foetal undernutrition and increased risk of various adult chronic diseases. This link is called the 'foetal origins disease hypothesis', usually known as the Barker hypothesis. This hypothesis originated in the 1980s when Professor David Barker of the University of Southampton noted a link between low birth weight and the incidence of cardiovascular disease among middle-aged men and women born in the UK (Barker, 1998). The Barker hypothesis posits that maternal dietary imbalances at critical periods of development in utero can trigger an adaptive redistribution of foetal resources including growth retardation. The area has caught the attention of researchers and has given a new direction to the investigation of the probability that a malnourished child will become a malnourished adult. Therefore, genetic endowment has an important influence on attained height. However, Habicht et al. (1974) concluded that although genetic potential does influence the observed difference in attained height, the accumulated deficit indicates that genetics plays a lesser role than the environment. This finding has been confirmed in other studies (for example, Martorell et al., 1988; Habicht et al., 1974; Smith et al., 1976; Davies, 1988).

About gene-environment interaction, as mentioned by Micklewright et al. (2001) this relationship is complex and still far from fully understood. Schmitt et al. (1988) found that most if not all the geographic variability in stature reported in the biological literature is explained by environmental rather than genetic factors. Ulijaszek (1994) argues that between-population differences in rates of physical growth and development and attained body size are well-documented, but it is difficult to determine the extent to which these differences can be attributed to genetic and environmental factors. By comparing elite peoples from around the world, Martorell (1985) has produced convincing evidence that the genetic component of differences in children's height is, on average, trivial in comparison to the environmental influences. Eveleth & Tanner (1990) argue that differences in anthropometric outcomes between populations are attributed to both genes and environment. Nevertheless, the height potential of an individual is related to the parental height. In impoverished societies this can lead to a circular argument. The parents were themselves short because of malnutrition; this then, in part, determines the target that the child is aiming towards (his individual potential). If he reaches this target, has he had complete catch-up? If so, is the child then normal? These questions show two different concepts of catch-up; one is a catch-up to what is expected of the child and the other is catch-up to a standard height derived from a healthy population where there is no secular trend: the two may be different.

Link between birth order and child nutritional status

There is a close association between birth order and infant and child mortality (Horton, 1988; Behrman, 1988). It has also been observed that higher birth order children are more likely to be born to older mothers, and that these children may face sibling competition for household resources and medical care (Rutstein, 1984). Higher birth order children can suffer due to the increased strain on family resources, particularly in terms of the time available for childcare (Senauer, et al., 1991). The long run health status (height-for-age) of higher birth order children suffers, presumably due to the increased burden on family resources. In particular, children of higher birth order probably receive less parental care and attention than their older siblings did at a similar age. It was also found in a study in the Philippines that the adverse effects of birth order were substantially greater for long run health status than for current health status (weight-for-height) (Horton, 1988). It has been argued that later born children (high birth order) are vulnerable in the season of greatest food scarcity, particularly where the household head has no education (Behrman, 1988). In contrast, Habicht et al. (1986) found in a study in Malaysia that changes in fertility levels and in the timings and spacing of births have had negligible effects in explaining child mortality or child nutritional status.

2.4 Link between poverty and malnutrition

This section gives an overview of various concepts of poverty. Poverty is associated with a range of household socio-demographic factors, such as household size and the education and occupation of the head of the household. Finally, this section discusses the link between nutrition and poverty.

2.4.1 Poverty: some basic concepts

There are a number of approaches to defining and measuring poverty. The traditional model is based on assessing household income or total consumption in relation to a poverty line, which is in turn related to the ability to purchase a basket of foods that meets a given energy consumption level. More recent approaches assess poverty in a social deprivation context, a formulation closely related to the concept of human rights. There exist levels of consumption of various goods (e.g. food and shelter) below which survival is threatened; these levels change from society to society (Lipton & Ravallion 1993).

There is a large body of literature on the concept of poverty and its measures (Lipton & Ravallion, 1993; Lanjouw et al., 1991; Sen, 1981). Poverty is a widespread global problem that afflicts developing countries in particular. According to the World Development Report (World Bank, 2001), 2.8 billion people, almost half the world's population, live on less than $2 a day. Of these, 1.2 billion people live on the very margin of life on less than $1 a day. Thus the extremely poor are 22 percent of the total population of the world, while the poor are 50 percent. According to the World Bank (2001), the number of poor people in sub-Saharan Africa, Latin America and in South Asia has been rising steadily.

There is no unique definition of poverty; rather its concept is multidimensional. The perception of poverty has evolved historically and varies considerably from one culture to another. The criteria for defining poverty tend to reflect specific national priorities and normative concepts of welfare and rights. Traditionally, poverty has been considered as a condition in which people do not have access to basic needs. According to Sen (1981) "poverty is a matter of deprivation". The World Bank has defined poverty as "the inability to attain a minimal standard of living" (World Bank, 1990).

In most countries, poverty has been conceptualised as a state of deprivation with reference to socially accepted norms of basic human needs. Altimir (1982) emphasises a view of poverty as associated for example with poor health, malnutrition, and low levels of education. To Hagenaars (1986), poverty is a situation in which needs are not sufficiently satisfied. Hence, the identification of poor people requires a determination of what constitutes basic needs and what are the minimal standards of living. Basic needs can be defined narrowly as 'those necessary for survival', or more broadly as 'those reflecting the prevailing standards of living in the community'. The former criterion covers only those who are near the borderline of starvation, while the second definition extends to people whose nutrition, housing and clothing, although adequate to preserve life, do not measure up to those of the population as a whole.

Poverty can be viewed in *relative* and *absolute* terms. A relative poverty line can be simply determined from a percentage cut-off point in the welfare distribution, such as the income or consumption level below which, say, 30 percent of the population is located. In other words, relative poverty lines are based on income; however, there are certain disadvantages to this approach. First, the relative poverty line is not useful if one wished to observe changes over time, and furthermore this approach does not allow comparison across regions. Second, the line is arbitrary. Under this concept, which is mostly used in developed countries, poverty is measured in terms of relative shares of national income or consumption of various sections of the population as, for example, being below some percentage of median or average income, such as 50% of the median. In this concept some relative poverty must always remain by definition, as some people will always be judged as poor in comparison with others. It does not say anything about the level of deprivation in society; rather, it gives a measure of income inequality.

Absolute poverty is defined as the inability to meet specific minimum needs. This type of poverty is widespread in developing countries. Anchoring the poverty line in this way allows one to make comparisons over time or across groups. Frequently, the poverty line is expressed in terms of an income level that a household or individual would require to purchase a minimum basket of the goods and services that are deemed necessary to sustain physical and social existence. According to this approach, the narrowest definitions use the income levels needed to fulfil the nutritional requirements for maintaining life. Broader definitions of basic needs may include essential items such as clothing, housing, health, education and the goods and services that are considered necessary to basic standards of living. Concepts of poverty in absolute terms attempt to pinpoint the absolute deprivation levels that may result from prevailing inequalities, on the basis of norms regarding the minimum requirements considered adequate for the satisfaction of basic needs.

2.4.2 Poverty and demographic composition of households

The socioeconomic characteristics of the poor and non-poor reveal that poor households are characterised by large family size, more children, relatively young family heads, and lower per capita income and expenditure. As a consequence, there is a lower intake of calories and lower expenditure on basic needs. A strong association exists between poverty and large household size (Lipton & Ravalion, 1993). Household size has a significant impact on calorie adequacy and height for age. Large household size is associated with a greater incidence of poverty as measured by household consumption or income per person (World Bank 1991a,b; Lipton, 1983).

The incidence of poverty is positively correlated with the number of children in a household: the higher the number of children, the greater the likelihood of higher child mortality rate. As also stated by Lipton (1983), higher infant and child mortality is caused by under-nutrition, and high child/adult ratios cause income poverty. It is well documented that poverty is linked to high child death rates particularly in Asia and in Africa (Roth & Kurup 1989; Caldwel, 1979; Hull & Hull, 1977). In Pakistan it has been shown that there is a strong link between poverty and mortality rates (Irfan, 1989).

There is great debate on whether higher fertility slows down income growth. Although it has been shown in some studies that poverty is positively associated with high levels of fertility (Mueller & Short, 1983), there are others who deny this (National Academy of Sciences, 1985). There is evidence that if poor people go on increasing their family size to increase the labour force per household, the reality is that as the labour force increases the wage rate decreases. This in turn increases the likelihood of poverty (Malthus, 1798 cited in Lipton & Ravalion, 1993). Past studies have shown that there is evidence that education, particularly of women, tends to improve infant survival and nutrition (Schultz, 1993; Thomas et al., 1991). In such houses where women have autonomy of decision making, expenditure patterns appear to be geared relatively more towards human development inputs such as food and education.

Is there widespread 'feminisation of poverty'? In some parts of Asia and elsewhere young females are often exposed to excess poverty-induced nutritional and health risks within households, and this appears to be one factor explaining the 'missing millions' of women (Drez and Sen, 1989). However, lack of data on intra-household distribution often clouds inferences from such studies, and even it were true that poverty is on average no greater amongst women, they remain severe victims of poverty in other respects (Lipton & Ravallion, 1993). In a study in rural India in 1981 it was found that the gender gap in adult literacy was higher among the far poorer scheduled castes (22%-6%) than among the population as a whole (49%-18%) (Bennett, 1991).

2.4.3 Poverty and nutrition

Health correlates strongly with poverty. Poverty is not a direct cause of disease; rather, it relates to other living standard factors such as lack of adequate nutrition, poor access to water and sanitation. Poverty can also be defined as the risk of nutritional shortfall due to inadequate income. The tradition of basing nutritional impoverishment on calorie requirements is well documented (Lipton, 1983). In terms of dietary energy deficiency the link between nutrition and poverty can be seen. Energy deficiency can be measured either by analysing food intake or by considering anthropometric measures. In some cases poverty is associated with smaller stature, harder work and therefore worse health (Lipton & Ravallion, 1993). The poor are therefore best identified as those facing the risk of undernourishment due to inadequate dietary intake as a result of low income.

Poverty has an adverse impact on nutritional status. Widespread poverty resulting in chronic and persistent hunger is the single biggest scourge of the developing world today. The physical expression of this continuous tragedy is the condition of under-nutrition, which manifests itself among large sections of the poor, particularly among women and children. This condition of under-nutrition reduces work capacity and productivity amongst adults and enhances mortality and morbidity amongst children. Such reduced productivity translates into reduced earning capacity, leading to further poverty, and so the vicious circle continues. This lack of access or lack of purchasing power has been forcefully brought out by Sen when he describes it as deprivation "due to non-entitlement or the inability of certain people to command food through the legal means available in the society, including the use of production possibilities, trade opportunities, entitlement vis-à-vis the State and other methods of acquiring food" (Sen, 1981).

Child malnutrition and ill health is of utmost concern since deprivation in early childhood often causes irreversible damage to physical and mental health, reduces learning at school, and leads to lower incomes as adult (ACC/SCN, 2002). In a study in Indonesia it was found that length at birth is strongly associated with indicators of social status, where mothers with higher incomes and levels of education tended to have longer children (Harrison et al., 1992). A study was conducted in Egypt, Kenya and Mexico on 'Food intake and human function', and it was observed that growth in children began to falter early in infancy, at about three to four months of age. Although birth weights were only slightly lower than those of US children, children on average were below the 25th percentile of US norms for height and weight by six months and even lower by 18 months. After this early faltering, children appeared to grow at a normal rate for their reduced height and had reasonably normal weights for height. However, children never caught up to reference heights, and adults were below norms for height (Calloway et al., 1988).

The longitudinal nature of IFPRI data allows in exploring the temporal changes in poverty status over time. Thus, it can be hypothesised that poverty status does not necessarily be a static condition rather households may change their economic status in between two points. How does this change affect the nutritional status of children? By using the new child health framework it can be investigated and this case is presented in detail in Chapter 6.

2.5 Factors at the basic level of the conceptual framework

This section presents an overview of the factors specified at the basic level of the conceptual framework of child health. The effects of various community level variables on child nutritional status have been examined in a number of studies (Thomas et al., 1992; Rustein, 2000; Alderman et al., 2003). A range of variables have been used to measure the services at community level, such as, prices of food commodities, sanitation and water facilities, road infrastructure, hospitals, schools, and proportion of households with access to safe drinking water and sanitation facilities (see Thomas et al., 1992). They find that water and sewerage facilities significantly affect children's height particularly older children in urban areas. However, these results do not hold for urban areas. Nevertheless, there are mixed views in literature about the effects of community level variables on child health, e.g., Grangnolati (1999) finds that the proportion of households with access to piped water has a positive impact on children's height-for-age z-scores in Guatemala while the effect of access to sanitation was negative. Alderman and colleagues (2003) find the investments in the community sanitation and piped water systems dominate the sanitation at household level.

In developed countries investments in water purification, sanitary sewerage, trash and garbage collection and reduction in food contamination had been observed a leading factor in reducing morbidity and mortality (Rustein, 2000). Silva (2005) while working on data from Ethiopia concluded stronger and significant effects of the community sanitation and water services on weight-for-age z-scores as compared to these services at household level. However, no significant associations were found in case of height-for-age z-scores (Silva, 2005). It is also possible that the effects of some of the community level factors on child health pick up some unmeasured aspects of household resources. For example, in a study in Nigeria, it has been found that the village level health facilities are positively related to the level of education the parents (Olaniyan, 2002).

In a detailed study on the effects of community factors on child health in Indonesia (Paknawin-Mock et al., 2000), it has been found that communities with better quality community infrastructure and services have fewer children that are mildly thin (weight-for-height scores) indicating a better child growth. They used a number of variables representing community level factors, such as, garbage management, day care centres, community child health programmes, community primary care clinics and latrines, community water quality, water quality at homes, community class composition and wage earnings, and community educational level. They found that most of these variables had an expected association with weight-for-height scores including the water quality at home. However, the quality of community water sources was negative and significant, indicating children who lived in communities with poor water quality had better weight-for-height scores. The possible reason of this unusual result was that most of the water samples (17 out of 72) had acceptable water quality and the coliform count of many samples was extremely high. (Paknawin-Mock et al., 2000) also concluded that the differences in children's weight-for-height scores between communities can be explained by the differences in the infrastructure between communities. Given the findings of their study, these results require a careful interpretation, as they did not include the household level variables in the regression model.

2.6 Conclusions and discussion

This chapter has served two purposes; first, various issues have been discussed related to the array of concepts to do with child nutrition as specified by the child health framework. Second, this chapter has also provided an overview of various studies that have taken place in the area of child nutrition. Many studies have investigated child nutritional status. However, most of the studies have failed to address effectively (1) changes in children's physical growth as a function of time by employing a suitable statistical model; (2) changes in child nutritional status in association with the changes in other socioeconomic factors; and finally (3) changes in the poverty status of families over a period of time and the impact of such changes on child nutritional status. The lack of studies related to these three points provides a sufficient basis for conducting the present research particularly in the backdrop of Pakistan.

In summary, it has been seen in this chapter that child nutritional status is a result of an array of factors ranging from the broader aspects of poverty to child-specific factors, such as age and disease. The following chapters are organised in a way that addresses effectively various levels of the child health framework. The next chapter presents a view of modelling the physical growth of children by considering time as the important determinant with the help of growth curve models.

Chapter 3

Modelling repeated measures to evaluate growth patterns of children

3.1 Introduction

Physical growth is an important indicator of a child's health. Growth assessment is the single measurement that best defines the health and nutritional status of children, because disturbances in health and nutrition invariably affect child growth. Growth assessment thus serves as a means for evaluating the health and nutritional status of children. Linear growth retardation during early childhood is highly prevalent in developing countries (Martorell et al., 1986) and contributes to short stature and impaired capacities in adults (Martorell et al., 1992). It is of great importance to estimate age specific trends and patterns in height and weight growth velocities as these estimations provide a solid ground in exploring the child's nutritional status. It has been seen previously that normal growth of children could result in greater adult height, which is associated with greater work capacity in men and women and with improved reproductive outcomes in women (WHO Expert Committee, 1995).

Anthropometric measures are widely used indicators for assessing children's nutritional status. The selected rural Pakistan population of children aged up to six years that were followed for three years in the Pakistan Panel Survey collected by IFPRI is ideal to study the physical growth patterns among children for a number of reasons. Firstly, valid estimates can be made describing growth patterns among children in rural Pakistan, which comprises of 70 percent of the total population. Secondly, no such previous study in Pakistan has been carried out so far to address the physical growth patterns in children. Also, previous studies did not address the mechanism of growth faltering in children in a longitudinal setting, particularly the age of a child at onset of the growth deficit. The present chapter uses the height and weight values of the study children to estimate their physical growth. Previously, a number of researchers have used height and weight measures to estimate the growth trajectories of children (Rao

1965[1]; Yang et al., 1994; Goldstein, 1995; Adair, 1999; Black et al., 1999). Nevertheless, the purpose of this chapter is to look at growth patterns amongst the study children rather to examine the nutritional status of children. Hence, height and weight measures are used instead of widely used nutritional status measures, such as height-for-age, weight-for-height and weight-for-age.[2]

When data are available on multiple individuals measured at multiple time points that may vary in number or inter-measurement interval, hierarchical linear models (HLM) may be an ideal option. In the present chapter, the techniques of hierarchical linear models would be used in developing the growth curves.

The main objective of the study is to look at the physical growth patterns of the study children over time. The research questions that are posed here: ***1)*** how the height and weight growth velocities of children can be calculated by using the growth curve models? ***2)*** do regions of residence and the gender of the child have any impact on the growth rates? ***3)*** is there any impact of seasonality on growth? and finally ***4)*** do growth rates vary between years during early years of childhood?

The chapter starts by providing a description of the anthropometric data of the study children including the missingness pattern. Then an overview of the growth of children over time in rural Pakistan is given by presenting some graphs and descriptive statistics as it is thought useful to get some visual information about the nature of data and response variable. Next, the introduction and the formulation of the hierarchical linear models with special emphasis on growth curve modelling are presented. Finally, the focus in the remaining part of the chapter is to answer the research questions, which mainly deals with modelling the child growth trajectories.

[1] His work is one of the pioneering works in studying the growth retardation among children by using the height data.
[2] Chapter 6 deals with the nutritional status of children.

3.2 Structure of the data

The survey also collected anthropometric and health data for children in all twelve rounds. Children's heights and weights were measured during home visits by trained interviewers using calibrated equipment and standard protocols.[3] The interviewers were given special anthropometric training. The height of a child under 24 months of age was a recumbent length, measured with the child lying down on an adjustable wooden measuring board. The same board was used to measure the standing height of older children.

The sample comprised 1242 children in the first round and 1300 children in the twelfth round. Alderman and Garcia (1993) observe that the changes in the number of children were accounted for by births in the intervening period, and dropouts. Also, the focus of survey was household not the individuals, hence, any addition in a household, e. g., birth of a child during the course of survey has also been recorded in the survey. This situation becomes more evident by looking at the number of children at every round by age (Table 3.1). To get an idea about the response rate of children with respect to their height and weight measures, we calculated that how many children were at round 1 and out of such children how many were followed at every round. In this way there were 1242, 1146, 1042, 1070, 1037, 1042, 941, 936, 885, 872, 823 and 752 children at round 1, round 2, round 3, round 4, round 5, round 6, round 7, round 8, round 9, round 10, round 11 and round 12 respectively with respect to children at round 1. Hence, the response rate with respect to the number of children at round 1 at the subsequent rounds were; 92%, 84%, 86%, 83%, 84%, 76%, 75%, 71%, 70%, 66% and 60%. Thus, the number of children at subsequent rounds with respect to round 1 indicates that some of the children who were present at round 1 were not present thereafter, e.g., at round 2 (1242 & 1146 at rounds 1 & 2 respectively). However, Table 3.1, reports the number of children at every round inclusive of the intermittent cases, new cases, dropped outs and complete cases.[4] It can be seen that there is a great variation in the number of children at every round (Table 3.1), e.g., at round 1 there were 1242 children and at round 2 there were 1291 children. This situation indicates that there might be some other children who were not included in round 1 but were present in round 2 and similar is the case for every round. This situation may indicate young children joining the survey, i.e., they are born while survey is in progress. Nevertheless, we have excluded such children: (i) with

[3] As outlined by Lohman et al. (1988).
[4] Hence, the number of children at rounds 2 to 12 are not conditional on the number of children at rd 1.

one measurement only, (ii) children who dead during the course of survey, and (iii) children with very high or very low values of height and weight.[5] Table (3.1) reports those children with at least two measurements that gives 15836 measurements.

Table 3.1: The frequency procedure: age by round

Age (months)	Rounds 1	2	3	4	5	6
<=4	86	72	60	80	86	49
4-8	81	79	72	75	68	84
8-12	96	73	79	73	71	77
12-18	116	134	111	106	105	103
18-24	89	81	112	103	119	115
24-30	119	111	83	82	79	104
30-36	127	93	103	110	97	74
36-42	118	180	135	99	85	110
42-48	145	59	103	163	175	137
48-54	89	193	142	81	51	99
54-60	115	42	65	142	161	131
60+	61	174	156	191	199	249
Total	1242	1291	1221	1305	1296	1332

Age (months)	Rounds 7	8	9	10	11	12	Total
<=4	83	67	61	69	39	61	813
4-8	60	81	45	57	64	47	813
8-12	73	60	86	50	48	52	838
12-18	97	98	86	114	98	67	1235
18-24	97	106	103	86	85	95	1191
24-30	105	101	100	97	88	75	1144
30-36	103	104	94	92	97	76	1170
36-42	64	68	99	100	88	82	1228
42-48	100	83	70	96	84	79	1294
48-54	117	87	85	68	67	81	1160
54-60	97	148	102	100	66	61	1230
60+	339	370	340	489	528	524	3720
Total	1335	1373	1371	1418	1352	1300	15836

From Table (3.1) it can be seen that the sample of children is very heterogeneous, the age of children ranges from 1 month to 104 months. When looking at anthropometric outcomes of children and their health in addition to infants and young children, it is useful to include higher ages as well (see e. g., Barrera, 1990; Senauer et al., 1991). The minimum age of a child for which data are available is one month. At round 1, the minimum value was one month and the maximum was 66 months. The time difference

[5] Such values are identified by using the software ANTHRO.

between the first and the last round was about 38 months; hence the child who was 66 months old in the first round was 104 months old in the last round. There was only one such child who was 104 months old at the last round, which we excluded from our analysis. The further analyses presented in this chapter will be restricted to children up to age 96 months (8 years) beyond there were only 68 children with 74 measurements, so the data are insufficient to pick up any age-specific effects after 96 months which gives rise to 15762 measurements (15836-74). The average age of the children was 40 months with a SD 24 months.

3.2.1 Missing values pattern

Table 3.1 reports the number of children at every round by their height and weight measures who were measured at least twice. However, Table 3.1, does not provide any information that how many children were followed in all the rounds and how many were missed at any round but re-appeared in the coming round (s) and how many were dropped completely, i.e., never appeared again. This section sheds light on missing values pattern in the IFPRI data. This exploration is important due to number of reasons such as, to make a decision whether to use all the available data (including the missing values) or to use only the complete data (excluding the missing values). Secondly, This kind of unbalanced data may give rise to technical problems, as some of the statistical methods do not cope with such incomplete nature of data. Hence, at this stage it is important to explore the missingness pattern of anthropometric measures (height and weight) of children in IFPRI panel data set.

Missing values arise in the analysis of longitudinal data whenever one or more of the sequences of measurements from units within the study are incomplete. As mentioned by Diggle et al. (1994), the units are incomplete in the sense that intended measurements are not taken, are lost or are otherwise unavailable. It is important to make distinction whether the missing values occur intermittently or as dropouts. In the terminology of Diggle et al. (1994) suppose that we intend to take a sequence of measurements $Y_1,\ldots,Y_n$ on a particular unit. Missing values occur as dropouts if whenever Y_j is missing, so are Y_k for all $k \geq j$, otherwise we say that the missing values are intermittent.

The missingness pattern amongst the children in the survey is presented in Fig. 3.1. This graph reports the number of complete cases, dropped outs (children who were included in the survey at some round but never were measured again), new cases and cases that were missing for at least one round and then reappeared at some stage, represented as intermittent in the graph. For example, in round one, there were 1242 children, while 442 (out of 1242) children were followed in all the twelve rounds (35% of 1242), which is evident by looking at the grey columns in the graph. These 442 children are those same children who were present at every round[6]. Dropped out means those children who were included in (t-1) round but were missing in t round, i.e., they never came back in the survey, this pattern has been indicated by the black columns for every round. On the other hand, there might be the case when some children were interviewed the first time in the t round given that they were not present in the (t-1) rounds, this situation is represented as 'new cases' in the graph. The summary analysis demonstrates that missing data is a significant problem. The choice of suitable model should be such that this missingness pattern can be accommodated.

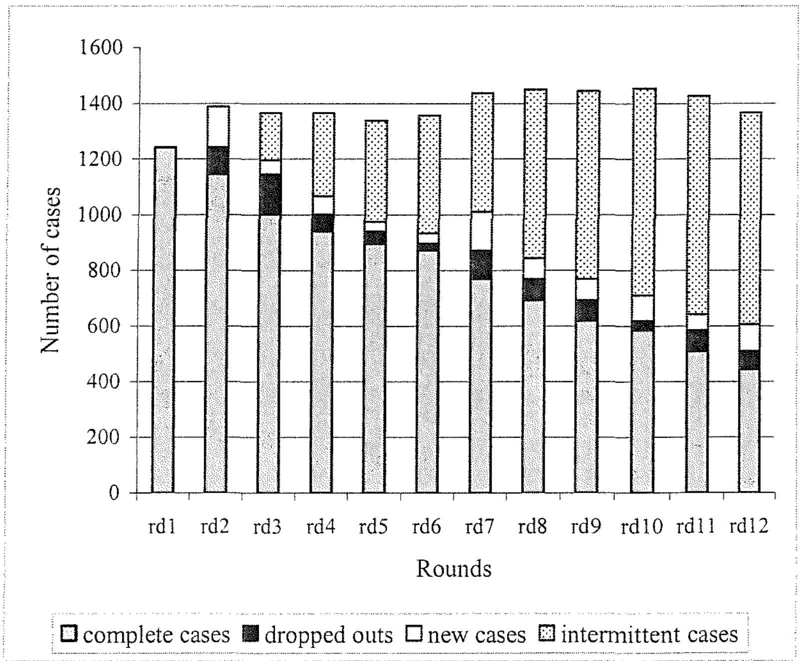


Fig 3.1: Missingness pattern amongst the children in the dataset

[6] Thus, by following the same children were in round 1, round 2, round 3, round 4, round 5, round 6, round 7, round 8, round 9, round 10, round 11 and round 12.

Fig. (3.1) reveals that missing values is a serious problem in the data under study as only 35% of the children were followed in all the 12 rounds. The decision whether to include only the complete cases or to include all the available data for analysis depends upon the nature of the problem to be addressed. We preferred to use all the available data as given in Table 3.1 for the analysis presented in this study.

3.2.2 An overview of the children's growth over time

As a preliminary analysis we compute the height and weight measures of the study children by various age groups and then to have an idea about their growth we compare them with the reference NCHS/WHO children (NCHS, 1976). The study children are found shorter and lighter than the NCHS/WHO growth reference (Table 3.2). This difference is highly noticeable in older age groups of children. The deficit is obvious right from the first months of their lives and with the increase in age this deficit even becomes more widen. By the age of six months the deficit in height is almost 4 cm and in weight it is 0.5 kg relative to the NCHS reference. By 24 months of age the mean deficit in height is 8 cm and in weight it is 1.9 kg. This deficit becomes even wider after 60 months, e.g., the mean height deficit is 9 cm and mean weight deficit is 4.1 kg. This pattern does suggest poor height and weight growth among study children.

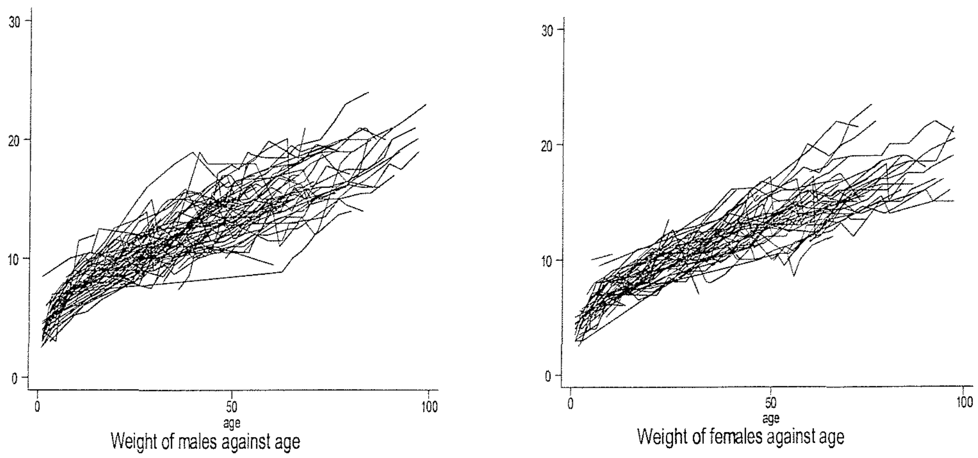
Table 3.2: Average height and weight by age and sex (figures in parenthesis are the height and weight values of the NCHS[*] median)

Agegroup	Both sexes		Males		Females	
(months)	Height[a]	Weight[b]	Height	Weight	Height	Weight
0-6	55 (59)	5.0 (5.5)	55 (59)	5.1 (5.9)	54 (58)	4.8 (5.0)
6-12	63 (70)	7.1 (8.5)	64 (71)	7.3 (9.0)	63 (69)	6.8 (7.9)
12-24	72 (80)	8.9 (10.8)	73 (80)	9.1 (11.3)	71 (79)	8.6 (10.2)
24-36	82 (90)	10.8 (13.2)	82 (90)	11.1 (13.4)	81 (89)	10.6 (13.0)
36-48	89 (98)	12.4 (15.3)	89 (99)	12.7 (15.6)	88 (98)	12.2 (15.0)
48-60	96 (106)	13.9 (17.2)	97 (106)	14.2 (17.6)	96 (105)	13.6 (17.0)
60+	106 (115)	16.2 (20.3)	107 (116)	16.4 (20.8)	106 (115)	16.0 (20.0)

[*] Lohman et al. (1988).
[a]Height measurements are in cm, [b]Weight measurements are in kg
Number of cases: 15762 (excluded children aged >96 months; 15836-74).

As an exploratory analysis, we plotted the height and weight measures by age of children. The graphs with all the children cannot be shown here as there are almost 1300 children over twelve time points which has made the graph too congested and impossible to read. Hence, we randomly selected a sample of both males and females (number of cases = 1200 each for males and females) and then plotted them as shown in Fig 3.2 a & b and 3.3 a & b for weight and height measurements.

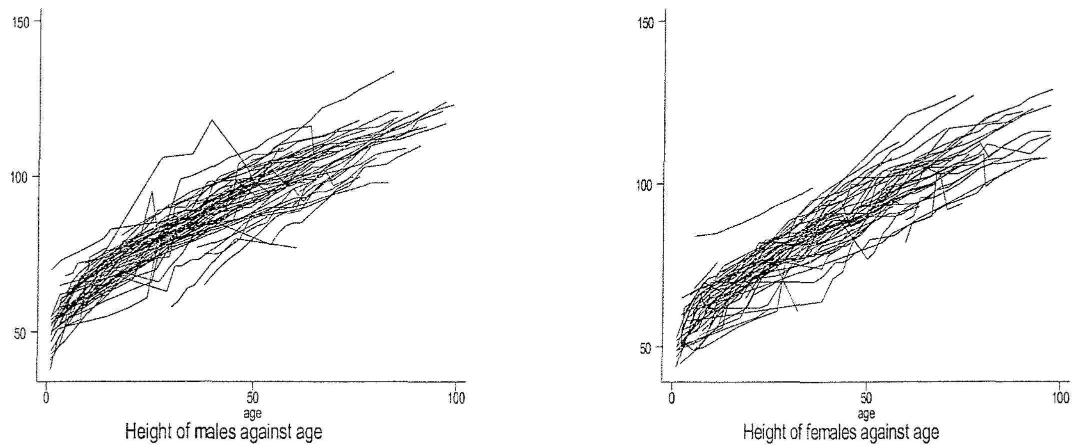
Two kinds of variations can be seen by looking at the individual trajectories, i.e., between subjects and within subjects. A slight variation by sex can be observed both in weight and height measurements. It seems that boys are taller and heavier than girls. To check if this pattern is persistent we need to go beyond exploratory data analysis. It is apparent that there is a positive association between age and height and weight, it means with age these measures are also increasing. However, this increase does not seem to have a linear trend and also the variance is not constant over time. In fact the variance in the initial time is smaller than the later, i.e., the variance increases with time.



(a) Males **(b) Females**

Fig. 3.2: Time series graph of weight of randomly selected children

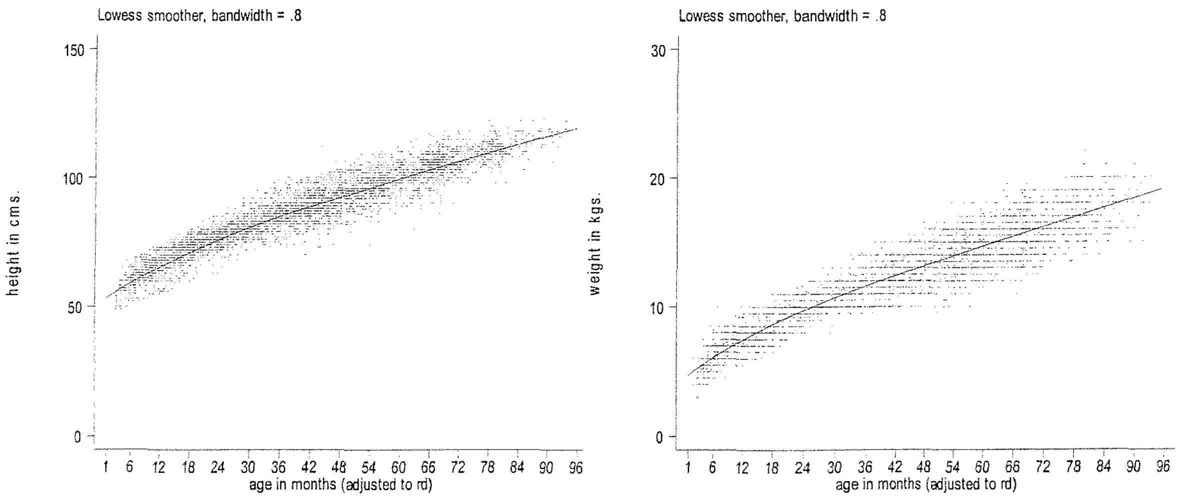
Note: No. of cases = 1200 for males and females.



(a) Males **(b) Females**

Fig. 3.3: Time series graph of height of randomly selected children
Note: No. of cases = 1200 for males and females.

To reveal the general pattern in growth curves with respect to the age of children, we smooth the outcome variable. Figures 3.4 a & b show the lowess graph of height and weight measures by age of children. These graphs are plotted by using the KSM procedure in STATA (Stata, 2001). These plots show all of the data points (no. of cases 15762) and also highlight important central features of the data, i.e., the mean height and weight measures as a function of time. This type of plot is especially important when the time is unequally spaced. The curve is calculated by using lowess (Cleveland, 1979), a non-parametric regression method. Although it seems that the average trend of both height and weight over time is linear, a careful examination of the graphs reveals that there is a decrease in gradient over a small range around the age 24 months.



a) Lowess curve of height **b)** Lowess curve of weight

Fig. 3.4: Lowess curve of height and weight
(*Note: No. of cases = 15762*)

3.2.3 Summary

- The term repeated measures as used in this chapter refers to multiple responses taken in sequence on the same experimental unit such as children. Longitudinal studies play a vital role in biomedical and sociological research.

- The presence of missing values in longitudinal studies is a common feature that needs to be addressed very carefully during analysis (Fig. 3.1).

- Responses measured on the same child are correlated because they contain a common contribution from the child. Moreover measures on the same child close in time tend to be more highly correlated than measures far apart in time.

- Also variances of repeated measures often change with time also evident by looking at Fig 3.2 & 3.3. These potential patterns of correlation and variation may combine to produce a complicated covariance structure of repeated measures.

- Special statistical methods are needed to incorporate the covariance structure. The limitation of OLS in such situations is that it ignores the fact that the observations on the same subject are dependent or correlated. Hence, standard regression methods may produce invalid results because they require mathematical assumptions that do not hold with repeated measures data.

3.3 Modelling the children's growth

Development is a continuous phenomenon. Much of the growth and development focuses on the continuous acquisition and loss of functional characteristics, e.g., the acquisition of growth throughout childhood. To measure the acquisition of growth a researcher might observe and record the height or weight of a child and then repeat the assessments at interval of month (months). Although the measures are taken cross-sectionally during discrete intervals, the underlying process is both instantaneous and continuous, it can be conceptualised as a smoothly evolving function of time. Despite the fact that there is no single definition of growth, virtually everyone defines it in quantitative terms, i.e., growth is not elaboration of function, differentiation of tissues, not the laying down of metabolic pathways. Rather it is the increase or decrease of some measurable quantity. To the cellular biologist, growth may be thought of as either increase in the size of cells or increase in their number and is seen as ongoing process throughout the life of an organism (Goss, 1964, cited in Falkner et al., 1978), however growth may be negative.

Growth curve analysis provides a flexible and powerful approach to modelling development as a continuous process. The analytical objective focuses on developing a statistical equation to summarise the starting point and the trajectory followed by the response variable which is measured repeatedly on each individual. Individual growth models are designed to explore longitudinal data on individuals over time. They allow the growth parameters for each individual to be examined as random effects in the model. Individual level covariates can be entered into the model as fixed effects to determine their impact on the dependent variable and also in interaction with the growth parameters. Until the mid 1980s no coherent analytic strategy fully respondent to these concerns, but now hierarchical linear models enable an integrated approach for studying the structure of individual growth (Bryk et al., 1987). The growth curve models come under the broad class of models known as hierarchical linear models (HLM), linear mixed effects models and the multilevel models.

3.3.1 Hierarchical linear models (HLMs)

Here the purpose is to study the relationship between children's anthropometric measures, i.e., height and weight with their age. In this way, we have a two-level model, where the measurement occasions are at level-1 and children at level-2, this gives rise to a two-level hierarchical structure in the model. Hence, in modelling such kind of hierarchical structure, the within-child and between-children variations need to be taken into account. Hierarchical linear models have been used to summarise each person's response by a function that includes an overall group effect plus a person-specific component. The idea introduced by Harville (1977), which is used by Laird and Ware (1982) to explicitly define a family of models for serial measurements that includes both growth models and repeated measures models as special cases. In statistical literature, the use of two-stage methods was suggested a long time ago. A fundamental paper advocating two-stage methods is Rowell and Walters (1976). Some other references include Gumpertz and Pantula (1989) and Davidian and Giltiman (1995).

There are basically two ways which are commonly used to model these two types of variability (within and between). The approach that seems more natural is to develop the model in two stages. At the first stage, we specify a separate linear regression for the observations on each subject, as a function of covariates made on the observations, for example, time of the observation. There will be as many of these regressions as we have subjects; each regression must use the same set of predictor variables, so that each regression has the same vector of coefficients, but the regression coefficients themselves are allowed to vary over subjects. At the second stage, the regression coefficients modelled at stage one are the random outcome variables, hence the terms *random coefficient regressions* and *random effects* models. The term mixed effects comes from combining the two regressions into a single equation with two types of regression coefficients. The two-stage approach is an attractive approach to use, since the subjects are explicitly treated as the unit of analysis at stage two, and one models directly the two types of regressions: the within at stage one and the between at stage two.

Analysis of this type of two-stage data belongs to the class of statistical problems called mixed-models. This kind of models are mentioned as "mixed-models" (Elston & Grizzle, 1962; Longford, 1987), "variance component models" (Harville, 1977; Dempster, Rubin, & Tsutakawa, 1981), "random coefficient models" (DeLeeuw & Kreft, 1986), "hierarchical linear models" (Bryk & Raudenbush, 1987), "multilevel models" (Goldstein, 1986), and "random-effect regression models" (Laird and Ware, 1982).

3.3.2 Formulation of unconditional growth model

These models are known as the growth curve models where every subject (child) is supposed to have its own intercept and slope[7], i.e., a random intercept and a random slope. Hence, the population intercept and slope parameters represent the overall (population) trend, while the individual parameters express how subjects deviate from the population trend. As the slope varies for individuals (random slope), this model allows the possibility that some individuals do not change across time, while others can exhibit dramatic change. The variance term indicates how much heterogeneity there is in the population. The covariance term represents the degree to which the individual intercept and slope parameters covary.

These models consist of two models, a model for individual growth, which is often termed a within-person model or a level-1 model and a model that enables us to study differences in growth of individuals which is often referred to as a between-person model or level-2 model.

i) The level-1 model

This is to model the within-child effects, or in other words it is an individual growth model. The basic strategy for modelling within-subject growth uses time as the independent variable for predicting response. Thus, the idea underlying growth modelling for an individual is to estimate the person's baseline or starting point and trajectory or shape of curve formed by consecutive assessments taken on the same individual. To capture the growth dynamics, we introduce a quadratic growth curve. The use of a quadratic growth model is also in accordance with the literature, e.g., see Rao (1965), Goldstein (1995), Snijders (1999), and Singer et al. (2003). Therefore a second-order polynomial for the individual growth model is used to provide an adequate fit to the data. The model can be expressed as:

$$Y_{ti}=\lambda_{0i}+\lambda_{1i}(X_{ti}-D)+\lambda_{2i}(X_{ti}-D)^2+e_{ti}$$

Where Y_{ti} is the height or weight of i child at t time. X_{ti} is the age of a child at time t and D is a certain value of age from which deviations are taken to avoid the multicollinearity in this case it is 24 months. Hence, the first step in the analysis is to identify the degree of polynomial to be fitted to the data. In principle a polynomial of any degree can be fitted and tested as long as the time series is sufficiently long. As suggested by Byrk et al. (1992) the visual examination of the individual time series and mean trajectories are used to identify the possible model that fit the data best. For the present analyses, a polynomial of second degree, i.e., a quadratic model has been used. Although, a turning point in the trajectory cannot be observed (Fig. 3.4). However, it is because the turning point seems to be at around age 10 years, which is beyond the data range. In general in fitting a quadratic model, we might find that some individual trajectories with positive curvatures cancel out others with negative curvatures. In this case a line would be a fine description for the group development, but an inadequate

[7] Growth curve models are also known as 'random coefficients models' for a detailed description of growth curve models see Singer et al. (2003).

representation for individual growth. As also mentioned by Willett et al. (1998) most of the researchers assume that the underlying growth model is linear in time and fail to investigate the possibility that an alternative temporal structure might be more realistic and more substantively appealing.

Therefore, the time variable is centred on the time at which measurements were taken at 24 months of age. With this scaling of time, the intercept in the model will give the status of growth at 24 months of age. Unconditional growth for height and weight is modelled as a function of age as a deviation from its mean. Expressing age as a deviation from its mean reduces the multicollinearity between linear and quadratic regression coefficients if a quadratic model is shown to best fit the data. The intercepts and slopes are fitted as random effects that vary across subjects.

In addition to a linear change and a quadratic term to present a bend in curve over time, various nonlinear trajectories are straightforward to model. Functions such as log, exponential and cosine (to model the seasonal variations) can be easily modelled. Nevertheless, by considering the available literature and the nature of problem to be addressed in this chapter, we decided to use the quadratic growth curve model. The use of a quadratic growth model is also in accordance with the literature, e.g., see Rao (1965), Goldstein (1995), Snijders (1999), and Singer et al. (2003).

Each of the growth parameters in this equation has a substantive meaning. The intercept λ_{0i} represents the average status of a person at a particular time. The linear component λ_{1i} is the growth rate of a person, while λ_{2i} captures the curvature or acceleration in each growth trajectory. Hence, the subject profiles are assumed to be quadratic over time and this model comprises of different slopes for linear and quadratic effects of age but with common intercepts. The random effects here the intercept and the slopes (the linear and the quadratic terms of age) are estimated with each subject and the variance components are estimating the variation of the underlying mean response between subjects.

Further the following concepts are introduced:

1) Children's average mean; intercept (height/weight)	$E(\lambda_{0i}) = \beta_{00}$
2) The average slope for the effect of age on growth across children, also considered as the growth rate	$E(\lambda_{1i}) = \beta_{11}$
3) The quadratic term of (2) above also considered as the growth velocity	$E(\lambda_{2i}) = \beta_{22}$
4) Population variance among child means	$Var(\lambda_{oi}) = \delta_{00}$
5) Population variance among child slopes	$Var(\lambda_{1i}) = \delta_{11}$
6) Population variance among child growth velocities	$Var(\lambda_{2i}) = \delta_{22}$
7) Population covariance between slopes and intercepts	i) $Cov(\lambda_{0i}, \lambda_{1i}) = \delta_{10}$ ii) $Cov(\lambda_{0i}, \lambda_{2i}) = \delta_{20}$ iii) $Cov(\lambda_{1i}, \lambda_{2i}) = \delta_{21}$

ii) The level-2 model

This is the between-subject model and it allows both the intercept and the time-trend to vary by individuals. It is sometimes referred to as a "slopes as outcomes" model. Between-subjects (level-2) covariates can be included to explain variation in level2 outcomes, i.e., the subject's intercept and slopes. It can be expressed as:

$$\lambda_{0i} = \beta_{00} + u_{0i}$$
$$\lambda_{1i} = \beta_{10} + u_{1i}$$
$$\lambda_{2i} = \beta_{20} + u_{2i}$$

Where

β_{00} is mean height or weight for children i.e., it is the overall population intercept

β_{10} is average slope of age

β_{20} is average slope of square of age

The error terms u_{0i}, u_{1i} and u_{2i} represent intercept deviation and slope deviations for subject i respectively. In other words these are the random error terms at the second level in determining variation in $\lambda_{0i}, \lambda_{1i}$ and λ_{2i}. More significantly, they stand for unknown sources of variance in the response variable, and thus signify whether these are random contextual effects on the response variable that are not yet specified.

iii) The full model

The full model can be achieved by putting the values of λ's from model at level-2 in the level-1 model, i.e.,

$$Y_{ti} = (\beta_{00} + u_{0i}) + (\beta_{10} + u_{1i})(X_{ti} - D) + (\beta_{20} + u_{2i})(X_{ti} - D)^2 + e_{ti}$$

By arranging these terms, the final two-stage model can be written as:

$$Y_{ti} = \beta_{00} + \beta_{10}(X_{ti} - D) + \beta_{20}(X_{ti} - D)^2 + u_{0i} + u_{1i}(X_{ti} - D) + u_{2i}(X_{ti} - D)^2 + e_{ti}$$

------------- (3.1)

In the model, Y_{ti} is the response variable either the weight or the height measure, X_{ti} is the age in months, this is a polynomial curve of up to second order plus a level 1 residual, expressing the mean shape of the growth measure over time. We are assuming that individual children grow up at different speeds, i.e., all the coefficient values are allowed to vary at subject level with the random terms *u's* which are the deviations of each child's growth coefficients from the mean coefficients β. The *u's* are assumed to have zero means and a variance-covariance matrix of a multiple normal distribution.
To estimate the height and weight growth trajectories over time, it is important to select an appropriate variable to reflect time in our model. The selection of the time variable and its origin must be clear in the context of a study, e.g., in the present study scenario there may be at least two alternative time variables: time on the visit (rounds) and the age of the children. In the present study context and the questions that are posed here,

the age of the children at each twelve time points seems to be a better and logical choice of the time variable. It is also appealing from a clinical point of view as the physical growth of children is very much age dependent and also we can predict growth rates for various age groups. We also need to decide the origin of time; this issue will be discussed in detail in Section (3.4).

The model obtained as (3.1) has the usual linear regression predictor for the mean responses, but has two types of random error terms: between-subject errors and within-subject errors. All the observations on the same subject will have the same between-subject errors; their within-subject errors will differ, and can be correlated within a subject. Both within and between-subject errors are assumed independent from subject to subject, thus observations on different subjects are independent. In model (3.1), e_{ti} can be thought of as sampling error or random perturbations. The e_{ti} are typically taken to be independently and identically distributed with variance σ^2. In cases where the observations have a clear ordering or structure, some investigators alternatively assume that correlation among the e_{ti} is non-zero, and varies in a systematic way. For example, with equally-spaced points in time, one might assume simple autoregressive structure AR (1) for the variance of errors (see, e.g., Cnaan et al., 1997).

Hence, in the present scenario with unequally-spaced data, the within child error terms e_{ti} are assumed to be independent (i.e. the vector of within child error terms e_i has covariance matrix $\sigma^2 I$). This assumption implies that the level-1 residuals are uncorrelated. However, this assumption does not necessarily imply that the first-level observations within individuals are uncorrelated.

iv) Matrix formulation

A more compact representation of the model (3.1) can be done by using matrices and vectors. This formulation is particularly helpful in model programming and helps to summarise statistical aspects of the model. The model can be written as:

$$y_i = X_i \beta + Z_i u_i + e_i \qquad \textbf{(3.2)}$$

with N individuals and n_i observations. Here, y_i is the $n_i \times 1$ dependent variable vector for individual I and X_i is a (n_i x p) covariate matrix that characterises the systematic part of the response, e.g., depending on covariates and time. β is a (p x 1) vector of parameters usually referred to as fixed effects and contains population-specific parameters describing average trends.

Z_i is a (n_i x k) design matrix that characterises random variation in the response attributable to among-unit sources. u_i is a (k x 1) vector of random effects that contains subject-specific parameters. It describes how the evolution of the ith subject deviates from the average evolution in the population. Where k and p need not be equal. e_i is a (n_i x 1) vector of within-unit errors characterising variation due to the way in which the responses are measured on the *ith* unit.

Hence, the model given as (3.2) can more specifically be written in the matrix form as:

$$\begin{pmatrix} y_{i1} \\ y_{i2} \\ \dots \\ \dots \\ y_{in_i} \end{pmatrix} = \begin{bmatrix} 1 & X_{i1} \\ 1 & X_{i2} \\ \dots & \dots \\ \dots & \dots \\ 1 & X_{in_i} \end{bmatrix} \begin{bmatrix} \beta_{00} \\ \beta_{10} \\ \beta_{20} \end{bmatrix} + \begin{bmatrix} 1 & X_{i1} \\ 1 & X_{i2} \\ \dots & \dots \\ \dots & \dots \\ 1 & X_{in_i} \end{bmatrix} \begin{bmatrix} u_{0i} \\ u_{1i} \\ u_{2i} \end{bmatrix} + e_i$$

for the population and individual trend parameter vectors respectively. We now must make some assumptions about the distribution of the time specific disturbances and the individual trajectory parameters. Namely, that both u and e are normally distributed have zero expectations and that u and e are mutually independent, more formally:

$$e_i \sim N(0, \sigma^2 I_{ni})$$
$$u_i \sim N(0, \Sigma_u)$$

or in other words:

$$\begin{bmatrix} u_i \\ e_i \end{bmatrix} \sim N\left(\begin{bmatrix} 0 \\ 0 \end{bmatrix}, \begin{bmatrix} \Sigma_u & 0 \\ 0 & \Sigma_e \end{bmatrix}\right)$$

where Σ_u is the covariance matrix of the individual trajectory parameters (u) and Σ_e is the covariance matrix of the time-specific disturbances (e). Usually, in most of the analyses, Σ_u is unstructured (all variances and covariances between the random effects are freely estimated) and Σ_e is constrained to be diagonal, often with equal variances at each time point ($\Sigma_e = \sigma^2 I$),where I is an identity matrix. However, neither specification is strictly necessary.

The assumption regarding the independence of the errors is one of conditional independence. That is they are independent conditional of u_{0i}, u_{1i} and u_{2i}. With these random individual-specific effects, the population distribution of intercept and slope deviations is assumed to be a trivariate normal $N(0, \Sigma_u)$, with the random-effects variance-covariance matrix given as:

$$\sum_u = \begin{pmatrix} \delta_{00} & & \\ \delta_{10} & \delta_{11} & \\ \delta_{20} & \delta_{21} & \delta_{22} \end{pmatrix} = \begin{pmatrix} \text{var}(\lambda_{0i}) & & \\ \text{cov}(\lambda_{0i}, \lambda_{1i}) & \text{var}(\lambda_{1i}) & \\ \text{cov}(\lambda_{0i}, \lambda_{2i}) & \text{cov}(\lambda_{1i}, \lambda_{2i}) & \text{var}(\lambda_{2i}) \end{pmatrix}$$

As a result, it can be shown that the variance-covariance matrix of the repeated measures y is of the form:

$$V(y_i) = V_i = Z_i \Sigma_u Z_i' + \Sigma_e$$

3.3.3 Model fitting methods

Fitting hierarchical linear models implies that an appropriate mean structure as well as covariance structure needs to be specified. First, an appropriate covariance model is essential to obtain valid inferences for the mean structure, unless robust inference is used. This will be the case especially for missing data, as robust inference provides valid results under often unrealistically strict assumptions about the missing data process (Verbeke et al., 2000). The covariance structure may itself be of interest for understanding the random variation observed in the data. However, since it only explains the variability not explained by systematic trends, it is highly dependent on the specified mean structure. Also, an appropriate covariance structure also yields better predictions.

Inferences for β, u_i and covariance parameters in the Σ_u cannot be obtained from single maximum likelihood estimation based on the model (3.1 & 3.2). It has been shown that as the number of parameters increases with the sample size N, classical maximum likelihood estimates may be inconsistent. An alternative can be to treat the subject-specific parameters u_i as nuisance and to derive inferences for the remaining parameters from the conditional likelihood of the data Y_i, conditional on sufficient statistics for the u_i. In this section we will see how the various fitting methods apply to each of these components separately.

i) The likelihood function and approaches to its maximisation

The hierarchical linear or mixed models can be fitted by maximising the likelihood function for values of the data. The likelihood function L measures the likelihood of the model parameters given the data is defined using the density function of the observations. As we are dealing with both the fixed effects and the random effects so the likelihood function needs to be based on a multivariate density function for the observations. The likelihood function based on the multivariate normal density function is given as

$$L = \frac{\exp(-\frac{1}{2}(Y - X\beta)' V^{-1} (Y - X\beta)}{(2\pi)^{(1/2)n} |V|^{(1/2)}}$$

But, in practice, the log likelihood function is used in place of the likelihood function as it is simpler to work. The log likelihood function is given as:

$$\log(L) = k - \frac{1}{2}\left[\log|V| + (Y - X\beta)' V^{-1} (Y - X\beta)\right]$$

$$K = -\frac{1}{2} n \log(2\pi)$$

The values of the parameters that maximise the log likelihood can then be determined. Several approaches of fitting the mixed models which are based on maximising the likelihood function are available.

Some of the estimation approaches with some introduction are ML, REML, IGLS and Bayes estimation are given below while the numerical algorithm E-M is followed after that.

a) Maximum likelihood (ML)

The method is based on maximising the log likelihood with respect to the variance parameters while treating the fixed effects β as constant. After obtaining the variance parameter estimates, the fixed effects estimates are then obtained by treating the variance parameters as fixed and finding the values of β which maximise the log likelihood. However, this method has the effect of producing variance parameter estimates that are biased downwards to some degree. The bias is greater when small numbers of degrees of freedom are used for estimating the variance parameters.

b) Restricted maximum likelihood (REML)

ML estimates of variance and covariance components θ are biased downward. A method that yields estimates with smaller bias is the method of restricted or residual maximum likelihood (Harville, 1977). This method allows estimating the covariance parameters without having to estimate the mean first. It is known from simpler models, such as linear regression models that it provides better estimates than the classical maximum likelihood estimates (Verbeke et al., 2000). The REML likelihood function is given as:

$$\log REML\ L(\theta \mid y) = K - \frac{1}{2}\left\{ \log|V| - \log\left|X'V^{-1}X\right|^{-1} + (y - X\hat{\beta}) \right\}$$

Iterative methods are used to obtain the REML estimates. The REML likelihood is equivalent to having integrated β out of the likelihood for β and θ, for this reason sometimes REML is referred to as marginal method (Brown et al., 1999). It is because REML likelihood considers β is a parameter not a constant, so the resulting variance parameter estimates are unbiased. The values of β are then estimating in the same way as in ML.

Various algorithms are available to determine these estimates, e.g., EM (Expectation-Maximisation), Fisher scoring, IGLS (Iterative Generalised Least Squares) and RIGLS (Residual or Restricted IGLS). They are iterative which means that a number of steps are taken in which a provisional estimate comes closer and closer to the final estimate. When all goes well, the steps converge to ML or REML estimate.

c) Iterative generalised least squares

This method can be used iteratively to fit a mixed model and the results will be the same as those obtained using maximum likelihood. This approach obtains estimates of the fixed effects parameters β by minimising the product of the full residuals weighted by the inverse of the variance matrix. The residual product is given by $(y - X\beta)' V^{-1}(y - X\beta)$. The variance parameters are obtained by setting the matrix of products of the full residuals equal to the variance matrix, V_i, this gives

$$(y - X\hat{\beta})(y - X\hat{\beta})' = V$$

This will lead to a set of simultaneous equations that can be solved iteratively for the variance parameters. The resulting variance parameter estimates are biased downward and are the same as the ML estimates. An adaptation to IGLS which leads to the unbiased REML variance parameter estimates is restricted iterative generalised least squares (RIGLS), details can be found in (Goldstein, 1995, Section 2.5).

d) E-M algorithm

The EM (expectation maximisation) algorithm is a useful technique for finding maximum likelihood estimators for censored and incomplete data. Many iterative algorithms for computing maximum likelihood estimates are special cases of a very general computing algorithm called E-M algorithm, particularly in incomplete data setting (Dempster et al., 1977). To illustrate the concept, let y_{obs} denote the observed data and y_{mis} denote the missing data. The complete data y_{com} can be expressed as $y_{com} = (y_{obs}, y_{mis})$ is y_{obs} augmented with y_{mis}. Let the complete-data likelihood function of a parameter vector θ is denoted as $f(y_{com}, \theta)$ and its log-likelihood function is given as $L(\theta) = \ln(y_{obs}, \theta)$. The expected complete data log-likelihood is given as $Q(\theta\ \theta') = E\ \{\ln[f(y_{com}\ \theta)]\, y_{obs}, \theta'\}$.

Each iteration of the EM algorithm consists of two steps, the Expectation step and the Maximisation step, ie.,

E-step: Compute $Q(\theta, \theta^{(t)})$ as a function of θ.

M-step: Find $\theta^{(t+1)}$ such that $Q(\theta^{(t+1)}, \theta^{(t)}) = \max_{\theta} Q(\theta, \theta^{(t)})$.

Each iteration of the EM algorithm increases the likelihood function L (θ) and under mild conditions, the EM algorithm converges to a local or global maximum of L (θ). In statistical literature EM algorithm for the calculation of MLEs was introduced by Dempster et al. (1977). It was based on complete data and they illustrated that how this method can be used for the estimation of variance components in mixed-model analysis of variance. Further, Laird and Ware (1982) extended this method and showed that how this method can also be applied to calculate REML estimates through the empirical Bayesian approach. The EM algorithm is only used to estimate the random effects. Laird and Ware (1982) reported slow convergence of the estimators, that is why now a days, Newton-Raphson-based procedures to estimate all parameters in the model are mostly used. This procedure starts with some starting values for the parameters and these procedures iteratively update the estimates until sufficient convergence has been obtained. Sometimes, during fitting complex linear mixed models, it has been reported that the iterative process does not converge at all. This problem can be solved by specifying better starting values or by using other numerical procedures, e.g., Fisher scoring method. This method uses the expected Hessian matrix of the log-likelihood function rather than the observed one.

e) The Bayesian approach

Alternative to classical methods of fitting linear mixed models, Bayesian approach also provides interesting methods. Although, this approach is not very popular amongst the statistician but it has got some advantages over maximum likelihood methods. This approach has been considered by Harville (1974, 1976) and Dempster et al. (1981). Bayesian methods are mainly developed for use with random effects models. In this method, a flat prior has to be introduced for β and estimate θ from the marginal likelihood of y after integrating out β and u_i. It yields restricted maximum likelihood (REML) estimates for θ. The empirical Bayes estimates of β and u_i are the estimated means of the posterior distributions. Laird and Ware (1982) have shown that Bayesian approach leads to estimates of parameters and their variances which are identical to those proposed in a sampling theory context as alternatives to maximum likelihood estimates.

In a Bayesian analysis the distribution of the model parameters is used to obtain parameter estimates. This contrasts with the classical statistical methods which use the distribution of the data, not of the parameters to estimate parameters. The distribution of the model parameters is obtained by combining the likelihood function with a prior distribution for the parameters to obtain posterior distribution. The most popular methods of evaluating the posterior rely on simulation as a means of performing the integration. Such methods can be described as Monte Carlo methods. Posterior distributions can be used to yield exact Bayesian p-values, which are analogous to p-values resulting from classical significance tests. A potential disadvantage of using Bayesian approach is associated with defining convergence when simulation techniques are used, which is not a problem in ML.

3.3.4 Estimation

In HLM we need to estimate the fixed effects, the random effects and the variance parameters. This section briefly describes the estimation procedure for these three components of model.

i) Estimating the fixed effects

The fixed effects solution can be obtained by maximising the likelihood or REML likelihood by differentiating the log likelihood with respect to β. Once the variance parameters estimated, the fixed effects estimates are then obtained by treating the variance parameters as fixed and finding the values of β which maximise the log likelihood. If V_i are known then maximum likelihood involves minimising

$$(y-X\beta)' V_i^{-1} (y-X\beta) \Rightarrow \hat{\beta} = (X' V_i^{-1} X)^{-1} X' V_i^{-1} y$$

With V_i known it may be shown that sampling distribution is $\hat{\beta} \sim N\left\{\beta, (XV^{-1}X)^{-1}\right\}$, where $\hat{\beta}$ is best among all linear functions of y.

The same ML solution for β can also be obtained using generalised least squares (GLS). GLS provides the best linear unbiased estimator of β for mixed effects models. With this approach the product of the full residuals, weighted by the inverse of the variances is minimised by differentiation with respect to β.

The final result can be written as:

$$\hat{u}_{EGLS} = (X^{/}\hat{V}^{-1}X)^{-1}X^{/}\hat{V}^{-1}y$$

$$\hat{\beta}_{GLS} = (X^{/}V_i^{-1}X)^{-1}X^{/}V_i^{-1}y$$

and $Var(\hat{\beta}_{GLS}) = (X^{/}V^{-1}X)^{-1}$

In unweighted least squares[8] where $V = \sigma^2 I$, the GLS solution will be

$\hat{\beta} = (X^{/}X)^{-1}X^{/}$ and the variance is $(X^{/}X)^{-1}\sigma^2$.

ii) Estimation for the random effects

The vectors of random effects u_i may also be estimated, since they reflect how much the subject-specific profiles deviate from the overall profiles. Such estimates can then be interpreted as residuals, which may be helpful for detecting special profiles or groups of individuals evolving differently over time. The best linear unbiased[9] predictor of u_i is given as

$$\hat{u} = DZ^{/}V^{-1}(y - X\hat{\beta}_{GLS})$$

Estimates are shrunken compared with what they would have been fitted as fixed. Usually the variance matrices are unknown, so the generalised least squares estimators cannot be computed. In the method known as estimated generalised least squares, estimates of the variance matrices are substituted into the generalised least squares equations, ie.,

iii) Estimating variance parameters

For estimating variance parameters, a number of numerical procedures are available. ML and REML estimate variance parameter that maximise a likelihood function. ML and REML estimation both have the same merits of being based on the likelihood principle which leads to useful properties such as consistency, asymptotic normality and efficiency. ML estimation also provides estimators of the fixed effects, whereas REML does not. As mentioned by Verbeke et al. (2000), for balanced mixed ANOVA models,

[8] This solution is obtained from fitting fixed effects models using OLS.
[9] This is the maximum likelihood estimation of b, which is obtained by differentiating the log likelihood wrt b.

the REML estimates for the variance components are identical to classical ANOVA-type estimates obtained from solving the equations that set mean squares equal to their expectations. This implies optimal minimum variance properties and it shows that REML estimates in that context do not rely on any normality assumptions since only moment assumptions are involved (Harville, 1977; Searle et al., 1992).

Generally speaking, one may expect results from ML and REML estimation to differ more as the number of fixed effects in the model increases. An extensive literature is available on estimation of variance components but most of it in the context of ANOVA models (Laird et al., 1982). Harville (1977) treated both the optimality of various estimates and their computations. Variance parameters can be estimated by applying ML and least squares based methods. ML and REML both are used to obtain the variance parameters that maximise a likelihood function. An iterative process such as Newton-Raphson algorithms is required to estimate variance parameters as the solution cannot be specified by a single equation. This works by repeatedly solving a quadratic approximation to the log likelihood function, for details see Brown et al. (1999, Sec. 2.2.4).

Variance parameters can also be estimated by the iterative generalised least squares (IGLS), which sets the full residual products equal to the variance matrix and then

$$V = (y - X\beta)(y - X\beta)'$$

solving the resulting equations. This leads to a set of n x n simultaneous equations that can be solved iteratively for the variance parameters. The variance parameters are biased downwards.

3.3.5 Hypothesis testing

Several hypothesis tests are generally of interest in HLM. In general in SAS and in SPSS t-statistics are produced for the fixed and random effects while Wald Z is produced for the covariance parameters.

i) Hypothesis tests for fixed effects

The hypothesis of interest is of the form $H_0 : \beta_k = 0$. The test statistic is computed by taking the ratio of the ML (or REML) estimate to its estimated standard error as follows:

$$t = \frac{\hat{\beta}_k}{\sqrt{\{\hat{\mathrm{var}}(\hat{\beta}_k)\}}}.$$

ii) Hypothesis tests for covariance components

The hypothesis of interest is of the form $H_0 : \delta_{kl} = 0$. The test statistic is computed by taking the ratio of the ML (or REML) estimate to its asymptotic standard error as follows:

$$Z = \frac{\hat{\delta}_{kl}}{\sqrt{\{\hat{\mathrm{var}}(\hat{\delta}_{kl})\}}}$$

The asymptotic standard errors are computed from the second derivative of the likelihood with respect to covariance components.

iii) Hypothesis tests for random effects

The hypothesis of interest is of the form $H_0 : u_{kl} = 0$. The test statistic is computed by taking the ratio of the estimated random effect $\hat{u}_k$ to its estimated standard errors as follows:

$$t = \frac{\hat{u}_k}{\sqrt{\{\hat{\mathrm{var}}(\hat{u}_k)\}}}.$$

The above follows a t-distribution for balanced data and for unbalanced data as well.

3.3.6 Strategies of modelling the growth of children

In this section we outline how the growth curve model can be applied to answer the research questions posed in this chapter, i.e.,

1. Estimate a mean growth curve and the extent of individual variation around it
2. Model relations of person-level predictors to both status and change
3. Compare growth rates during different periods

In this scenario, the model mentioned as **(1)** above is an unconditional growth model where time is the only predictor. The model with person-level predictors is a conditional growth curve model first with regional and sex dummies and then the seasonal component would also be modelled. Finally, the model mentioned as in **(3)** is a piecewise linear growth model.

The discussion and analyses following this section will be based on these three points. A number of computer software are available to fit the hierarchical linear models, such as HLM, MLwin, LISERAL, SAS (PROC MIXED) and recently SPSS (Version 11.5 & 12). All the analyses in this chapter have been carried out by using the MIXED procedure in SPSS and PROC MIXED in SAS (Version 8.2)[10].

3.4 Why unconditional growth model?

This is the growth model as specified in (3.1) with time as the only covariate. Why to include time as the only predictor in the unconditional growth model? Time is considered as the fundamental predictor in individual growth modelling. This issue has been discussed by Willett et al. (1998) and they advocated paying more attention to modelling the effect of this structural predictor time as compared to modelling the substantive predictors[11]. Nevertheless, the effect of time describes the shape of the underlying developmental trajectory. It also gives insight on whether the growth is linear or not. Including the effects of time in the model can lead to more accurate summaries of complex development and facilitate the testing of interesting hypothesis about the effects of substantive variables.

[10] Interested readers can read a tutorial on SPSS MIXED procedure by Singer on: http://www.ats.ucla.edu/stat/spss/paperexamples/singer/default.htm

[11] For example, child level variables like incidence of disease, vaccination and parental education, household income etc.

Hence, specifying the effect of time in a sensible way at level-1 ensures that the individual growth parameters have meaningful substantive interpretations at the simplest level, perhaps as an initial status and a rate of change. These parameters then become the outcomes at level 2, permitting investigation of links between initial status and rate of change (Willett et al., 1998).

Following these guidelines, we now turn to the unconditional growth model as given below. This model includes the random effects, namely; intercept, a linear time slope and a quadratic time slope, while the linear and the quadratic terms of time are included also as fixed effects. An unstructured form is assumed for the 3x3 random effects matrix and the random errors are assumed to be independent over time. Specifying unstructured correlation structure means that we are treating the variance-covariance matrix for the intercepts and slopes as unstructured with a separate variance or covariance component for each of the elements. This model is given as equation (3.3) below:

$$Y_{ti} = \beta_{00} + \beta_{10}(X_{ti} - 24) + \beta_{20}(X_{ti} - 24)^2 + u_{0i} + u_{1i}(X_{ti} - 24) + u_{2i}(X_{ti} - 24)^2 + e_{ti} \quad \text{--------(3.3)}$$

3.4.1 Results of the unconditional growth model

a) Fixed effects

Fitting the basic model gives the estimated parameters of growth curve, the fixed effect results are reported in Table 3.3, and the random effect results are reported in Tables 3.4 & 3.5. Results indicate a typical pattern in growth amongst the children of rural Pakistan. The average height of a child of 24 months of age came out to be 75.15 cm with an average weight 9.59 kg, while the NCHS median height and weight values for 24 months old child are approximately 86 cm and 11.5 kg. It shows that the study children are shorter and lighter than the NCHS/WHO reference children.

The growth seems to be increased during the survey period with a rate of 0.85 cm in height per month and 0.19 kg in weight per month. But there is also a suggestion that the height and weight growth velocities came down as the child further proceeds in age as indicated by the negative sign of acceleration. This pattern is also evident from the descriptive statistics and also the graphs. An interesting characteristics of these data is the distinct phases in the growth patterns, i.e., relatively fast and nonlinear in early months, then slower and approximately linear later. As the mean intercepts, growth rates and the growth acceleration came out significant indicating that all the parameters are necessary for describing the mean growth trajectory.

Table 3.3: Estimated growth coefficients of weight and height of children in rural Pakistan

Coefficients	Height (cm)	Weight (kg)
Mean ht/wt at 24 months	75.15 (0.1800)**	9.59 (0.0400)**
Mean growth rate at 24 months	0.85 (0.0100)**	0.19 (0.0010)**
Mean acceleration at 24 months	-0.004 (0.0001)**	-0.001 (0.0001)**
Random effects (level-1)		
Residual variance	4.46 (0.0600)**	0.64 (0.0100)**

**significant at 1%, *significant at 5%
Standard errors are given in parentheses
Ht/wt stands for height/weight.
Number of cases: 15762

b) Individual variation in growth trajectories; Random effects results

Now we consider the nature of the deviations of the individual growth trajectories from the mean curve. Tables 3.4 & 3.5 report the variance-covariance matrix of the random effects for height and weight respectively.

Table 3.4: Estimated variance-covariance matrix of **height** growth coefficients at subject-level for unconditional growth model

	δ_{00}	δ_{11}	δ_{22}
δ_{00}	56.75 (2.300)**		
δ_{11}	0.06 (0.060)	0.06 (0.00300)**	
δ_{22}	-0.02 (0.001)**	-0.001 (0.00006)**	0.00002 (0.000001)**

Table 3.5: Estimated variance-covariance matrix of **weight** growth coefficients at subject-level for unconditional growth model

	δ_{00}	δ_{11}	δ_{22}
δ_{00}	2.43 (0.100)**		
δ_{11}	0.04 (0.003)**	0.003 (0.00010)**	
δ_{22}	-0.001 (7.45E-05)**	-4.2E-05 (3.4E-06)**	1.15E-06 (9.2E-08)**

**significant at 1%, *significant at 5%,
The figure written as –4.2E-05 means –0.000042 and similarly the other figures can be read.
Standard errors are given in parentheses

In the random effects variance-covariance matrix (Tables 3.4 & 3.5) for height and weight respectively, the first term on the principal diagonal is the variance of the intercept that is the status at 24 months. The second term on the principal diagonal indicates the variance of the growth rate, while the third term on the principal diagonal is the variance of the acceleration. These variance terms indicate the variation between children over time. The significant terms of these variances indicate that there is substantial amount of variation in growth between children over time. The positive diagonal terms in the covariance matrix indicates that there is additional random variation in the regression lines both between children and within children over time. Or in other words the regression line differs to a greater extent than would be expected as a result of the residual variation.

The negative covariance term shows the negative correlation between intercept and slope. It indicates that children with slower growth rates at the beginning of the survey had faster growth velocities later in survey. However, the magnitudes of the estimates reveal the degree of individual heterogeneity in both the intercepts and the slopes, e.g., approximately 95% of children were expected to have height and weight slopes in the intervals $0.85 \pm (1.96 \times 0.24) = 0.38$ cm to 1.32 cm and $0.19 \pm (1.96 \times 0.05) = 0.09$ kg to 0.29 kg respectively. These wide intervals actually show that some children had very slow growth acceleration and some had a relatively faster acceleration. Thus there is considerable heterogeneity in terms of children's initial levels of growth and in the changes across time.

In these variance-covariance matrices, the major interest is in looking at the variation in both intercepts and slope terms, which are found to be different from zero. It leads to the rejection of the null hypothesis and the conclusion that children vary significantly in their growth patterns and also there is significant variation in their growth velocities. Hence, there is a variation in both the intercepts and slopes that potentially could be explained by a level-2 (person level) covariate.

3.4.2 Fit of the model

How is the fit of the model, i.e., how best does the fitted quadratic growth model describe the data. For this the estimated population intercept $\hat{\beta}_{00}$ and slopes $\hat{\beta}_{10}$ and $\hat{\beta}_{20}$ can be used. The average height and weight across age groups can be estimated. These are displayed in Table 3.6 with the observed means at each age group. It can be seen that there is close agreement between the observed and the estimated means. Thus, the average change across time is very consistent with the posited quadratic growth curve model.

Table 3.6: Observed and the predicted means

		Age groups					
	0-6	6-12	12-24	24-36	36-48	48-60	60+
Height Observed	55	63	72	82	89	96	106
Predicted	55	62.8	71.7	81.5	88.8	96	106
Weight Observed	5.0	7.1	8.9	10.8	12.4	13.9	16.2
Predicted	5.2	6.9	8.8	10.8	12.4	13.9	16.2

We further investigated the fit of the model by plotting the observed height and weight trajectories with their predicted trajectories of three children aged from 2 to 39 months from round 1 to round 12. As it can be seen from the (Figures 3.5 a & b) that predicted height and weight trajectories almost overlap the observed trajectories, the solid lines. It seems that the quadratic growth curve model fits the data reasonably well. It also suggests that the basic model is adequate with the assumption that all growth coefficients vary randomly across subjects and the growth polynomial curve is applicable to every subject or child.

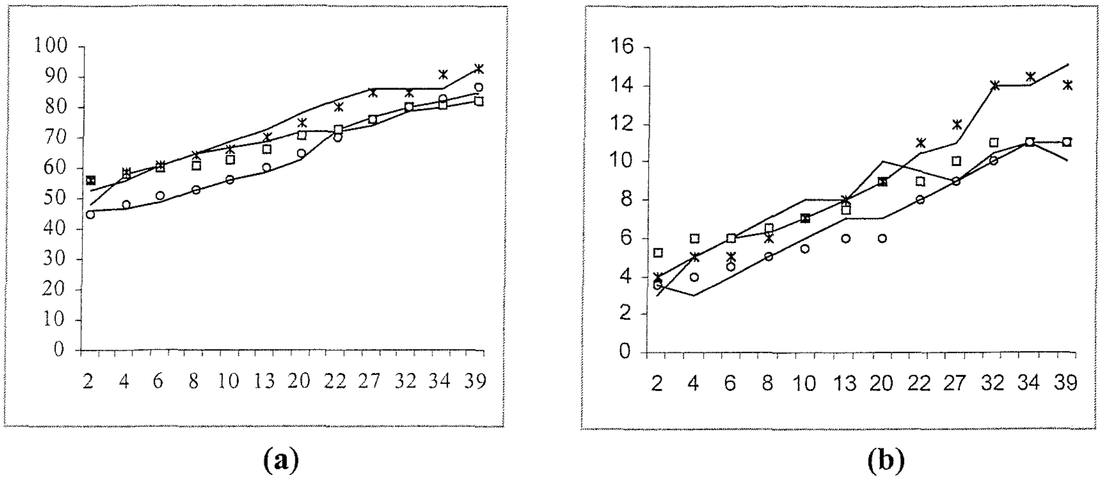


Fig 3.5: Observed versus predicted growth trajectories of three children; **(a)** represents the height trajectories and **(b)** the weight. The solid straight lines are for the observed values of three children and their predicted values are represented by the symbols □, o and × for the respective children.

3.4.3 Predicting growth velocities

We think in terms of size achieved at various ages; in terms of a baby growing steadily. As mentioned by Falkner (1966) that the word steadily is the deeply embedded misconception. Further, the changes that occur in the growing human can only be studied and understood if growth is regarded as a continuum. This means that we must study the velocity of growth. These velocities are by no means steady and we shall see how widely incremental growth varies at various ages. The amount of growth achieved depends on the time for which growth proceeds and on the speed of growth per unit time. The increments of growth are plotted against time. Such a curve shows the variation in the rate of growth with time, and is therefore known as a 'velocity curve'. Such information is naturally difficult to get, as every subject must report at regular intervals to be measured and in consequence gaps in the records are only too common.

From the table of fixed effects (Table 3.3) we can compute the growth velocities. The diversity of using a polynomial growth curve is that the growth velocities at various ages can be predicted (Bryk et al., 1992). The predicted growth velocities can be obtained by taking the first derivative of the basic growth model with time fitted in Table 3.3 and as given as the equation (3.3).

The average predicted growth velocity at age T can be calculated as:

Growth rate at age T= $\frac{dY_{ti}}{dX_{ti}} = \beta_{10} + 2\beta_{20}(X_{ti} - 24)$

By putting the values of fixed effects obtained from the model in this equation yields:

Height growth velocity at age T = 0.85 –(2*0.004) (age T - 24)
Weight growth velocity at age T = 0.19 – (2* 0.001) (age T - 24)

For example the height growth velocity at age 1 month is calculated as 0.85 – (2 *0.004) (-23) = 1.03 cm.

Figure (3.6) displays the average predicted monthly growth velocities for height while Figure (3.7) displays the average predicted monthly growth velocities for weight. It is evident that the growth velocities with age are decreasing; especially there is a steep decline in height growth velocities after 12 months. However, we need to compare the velocities of the study children with the normal growth velocities.

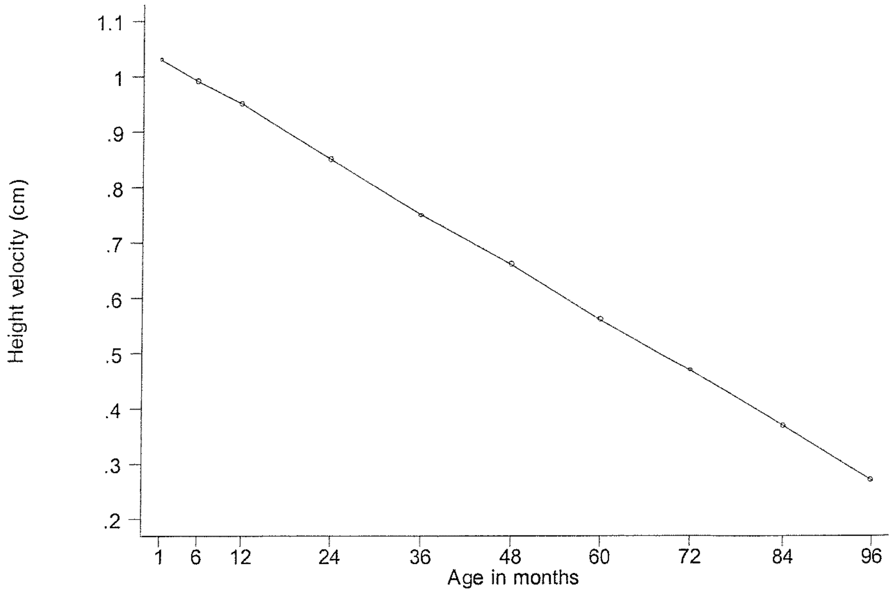


Fig 3.6: Predicted height growth rates with age

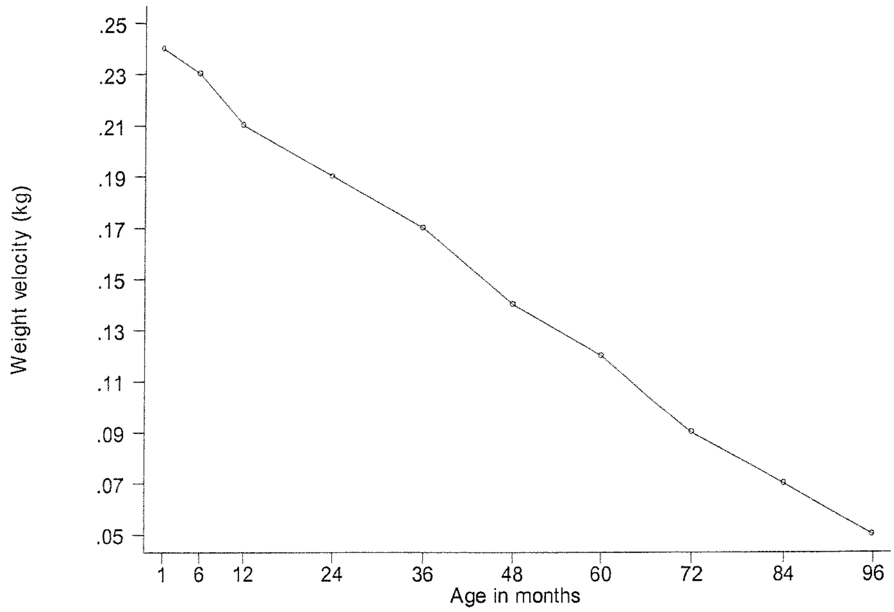


Fig 3.7 Predicted weight growth rates with age

The monthly predicted growth velocities can then be converted into the average annual growth velocities for height and weight. The yearly growth velocities for height (in cm) and weight (in kg) are given in Table (3.7).

Table 3.7: Annual average height and weight growth velocities

Child's age	Height growth velocities/year (cm)	Weight growth Velocities/year (kg)
1 year	12	2.52
2 year	10	2.28
3 year	9	2.04
4 year	8	1.68
5 year	7	1.44
6 year	6	1.08
7 year	4	0.84
8 year	3	0.60

For example, at the end of one year the growth velocity or the average annual growth increment is 12 cm and at the end of fourth year the velocity came down to 8 cm. However, the normal growth velocities in children during the first year are reported as 18 to 25 centimetres and during second year they are 10 to 13 cm and after that until puberty the average growth rate is 5 cm (Underwood, 1999; Sinclair et al., 1998). At the age of approximately 3 years most children enter a regular period of growth and grow at a steady annual rate for the next 9 years. This is the mid-growth period. This period is ended by the sudden onset of the only period in postnatal life when acceleration occurs, i.e., the adolescent growth spurt. In the remaining period of growth up to the end point when the annual increment is zero, there is central peak velocity followed by a reversal and a sharp deceleration period, comparable to that of the first three years of life (Falkner, 1966). However, during the adolescent spurt a very marked acceleration in velocity occurs with a peak at the middle of puberty and deceleration to zero again when adult size is reached. Usually, growth gradually slows down towards a halt as maturity is approached and it follows that the curve of growth from the ovum to the adult must be S-shaped.

Hence, if we compare the height growth velocities, we find the study children are far behind in their velocities especially during their first year compared to the normal rate of velocity. Despite the fact the first year of life is usually characterised by extremely rapid growth. The slower growth during first year amongst the study children might be an indication of small size of babies at birth due to intra-uterine growth retardation. However, in the absence of information on the size at birth, we were unable to take into account the birth size in our analysis. Although, during second year, the velocities were found very close to the normal velocities, however, it seems unlikely that children are catching-up growth due to slower growth in the first year. Hence, children gained height as a slower rate suggesting that growth deficiency during infancy increased the likelihood of slower growth through early childhood.

Unlike the norms of height velocities, norms for weight velocities do not exist. However, according to Sinclair et al. (1998) by the end of the first year the birth weight approximately triples, and by the end of the second year it has quadrupled. After this it settles down, like the growth in height, to a relatively steady annual increase, which is about 2.25-2.75 kg a year, until the onset of the adolescent spurt. During the spurt boys may add 20 kg to their weight and girls 10 kg. However, body weight does not reach its adult value until some time after adult height has been attained. Amongst the study children the average increment in weight between years is slower than the norms as indicated by looking at the weight velocities (Table 3.7).

Generally speaking, due to slower velocities during first year of children's life, it seems likely that such children are unlikely to make up loss as they further proceed in life. Although the velocities after first year seem to be closer to the normal height velocities but to make up the loss in their height growth rates which occurred during their first year they needed to grow with faster speed. These kinds of growth patterns are also reported by Habicht et al. (1974). They observed that children from different socio-economic and ethnic groups grow rather uniformly in height and weight during the first 3-6 months of life and after 6 months of age, the heights and weights of children from developing countries lag behind those of children from developed countries. They observed differences such as infectious disease, malnutrition are the most important environmental factors underlying the differences in growth patterns between well-to-do and poorer children.

3.5 Conditional growth curve model

3.5.1 Growth curve model with regional and sex dummies

After developing the unconditional growth model, fixed effects covariates can be added easily in the model. Our next goal is to explore the regional and gender differences on growth patterns. In Pakistan the geographic and the climatic differences between the study districts are significantly different. It may be hypothesized that children living at high altitude often have delayed growth, but whether growth retardation is related to altitude or other factors is not known. To fit a conditional model such as this, the fixed effects were comprised of the districts, i.e., Faisalabad, Attock, Dir and Badin respectively, their interactions with age and its square term, sex and its interaction with age and age square.

When such a model was fitted it was found that the interaction of the gender with age and its squared term did not come out significant and also the coefficients and their direction for the districts Faisalabad and Attock were same. Hence, in the final model we did not include these interaction terms of gender with age. Another decision was made to combine the two districts Faisalabad and Attock. Thus it makes sense as these two districts belong to the same province Punjab. The conditional growth curve model can be expressed as:

$$Y_{ti} = \beta_{00} + \beta_{10}(X_{ti} - 24) + \beta_{20}(X_{ti} - 24)^2 + u_{0i} + u_{1i}(X_{ti} - 24) + u_{2i}(X_{ti} - 24)^2$$
$$+ \beta_{30}\,Districts + \beta_{40}\,Sex + \beta_{50}\,(Districts \times age) + \beta_{60}\,(Districts \times age^2) + e_{ti}$$

Here the district is a categorical variable comprises of three categories instead of four after joining the two districts. Sex is taken as a binary variable, and female is a reference category. Like unconditional growth model we introduced three random effects namely, intercept, and slopes for age and its squared term. The results of the fixed effects are reported in Table 3.8.

Table 3.8: Differences of growth curve between districts

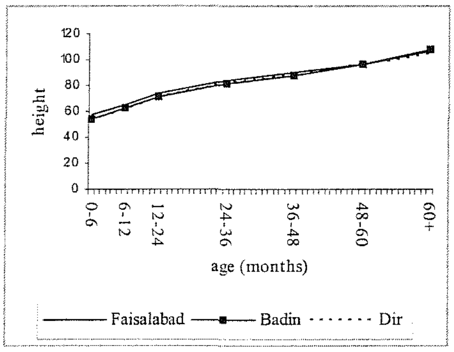
Coefficients	Height (cm)	Weight (kg)
Mean ht/wt at 24 months	72.2216 (0.3553)**	8.8637 (0.0727)**
Mean growth rate at 24 months	0.9847 (0.0109)**	0.1828 (0.0026)**
Mean acceleration	-0.0044 (0.0002)**	-0.0004 (5.77E-05)**
Districts		
Fbd & Att	4.3310 (0.4772)**	0.5979 (0.0978)**
Dir	2.6979 (0.4244)**	0.7698 (0.0871)**
Badin	Ref	Ref
Child is male	1.3408 (0.3278)**	0.5094 (0.0658)**
Districts * age		
(Fbd & Att)*age	-0.1821 (0.0168)**	-0.0093 (0.0040)*
Dir*age	- 0.2090 (0.0148)**	0.0168 (0.0035)**
Badin*age	Ref	Ref
Districts*age^2		
(Fbd & Att)*age^2	5.68E-05 (0.0003)	-0.0004 (9.00E-05)**
Dir*age^2	0.0013 (0.0003)**	-0.0007 (7.97E-05)**
Badin*age^2	Ref	Ref
Random effects (level-1)		
Residual variance	4.5090 (0.0646)**	0.6365 (0.0086)**

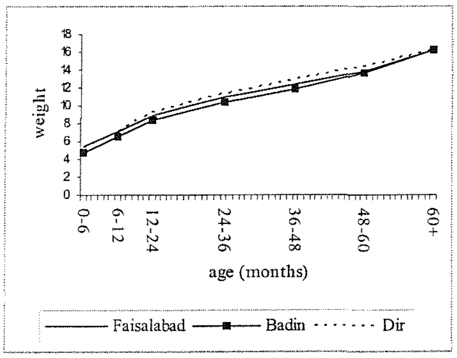
**significant at 1%, *significant at 5%
(Fbd & Att) stands for the joint effect of Faisalabad and Attock
Standard errors are given in parentheses
Number of cases: 15762

There is a clear suggestion that children of Badin district are significantly shorter and lighter than the other districts under study. Looking at the interaction terms of the covariates with time, we need to see whether the impact of time on outcome is different at different time points. When a predictor interacts with time its impact on the outcome is different at different time periods (Willett et al., 1998). By exploring interactions with time, one can determine whether a predictor's effect remains the same across the life span or whether it fluctuates with age. It seems that with age the height growth rates among the children in Badin are improving (Badin*age=0.985) as compared to other districts as their height growth rates are decelerating (as indicative from the negative sign).

The coefficients associated with the growth acceleration can be interpreted in the usual way. It is evident that as the children in Badin further proceed in age their height growth rates seems to be slowing down (-0.004) while the positive sign of height growth acceleration of other districts indicate improvement in height trajectories with age. However, the weight growth rates are found to be increasing in Dir and Badin districts compared to Faisalabad and Attock. On contrary, the negative sign of weight acceleration indicates that generally in all the study areas the weight growth rates are decelerating as a child proceeds further in age. The mean predicted height and weight values are plotted against various age groups (Fig. 3.8). These figures also reveal the same pattern as discussed so far in this section.

There is some suggestion of gender differences; it seems that boys are almost 1.34 cm taller and 0.51 kg heavier than that of girls. We did not find any significant affects of time on gender and growth.





Height **Weight**

Fig. 3.8: Mean predicted height and weight values of children by districts plotted against age of children.

3.5.2 Seasonality and growth

It is well known that the season of the year can influence the rate of growth in many children, e.g., Tanner (1989) established a seasonal effect in height growth and Goldstein et al. (1994) also fitted a seasonal component to a group of boys and they found considerable differences in the rate of growth between two major seasons summer and winter. The basic growth model can be extended by introducing two more covariates and their interactions with age and age squared. They are dummy variables for the summer (dry season) from March to June, and the winter season from October to

February separately, while monsoon from July to September is taken as the reference category. The interaction terms give the estimates of differences of these in terms of linear growth and growth acceleration. The conditional growth curve model with seasonal covariates is given as:

$$
\begin{aligned}
Y_{ti} &= \beta_{00} + \beta_{10}(X_{ti} - 24) + \beta_{20}(X_{ti} - 24)^2 + u_{0i} + u_{1i}(X_{ti} - 24) + u_{2i}(X_{ti} - 24)^2 \\
&+ \beta_{30}\, Seasons + \beta_{40}\,(Seasons \times age) + \beta_{50}\,(Seasons \times age^2) + e_{ti}
\end{aligned}
$$

Table 3.9 reports the results of the conditional model with seasonal covariates.

Table 3.9: Fixed effects estimates of height and weight with seasons

Coefficients	Height (cm)	Weight (kg)
Mean ht/wt at 24 months	75.134 (0.183)**	9.550 (0.034)**
Mean growth rate at 24 months	0.849 (0.007)**	0.187 (0.002)**
Mean acceleration	-0.004 (0.000)**	-0.001 (0.000)**
Summer	0.520 (0.050)**	0.120 (0.020)**
Winter	-0.300 (0.050)**	0.050 (0.020)**
Age*summer	-0.010 (0.003)**	-0.004 (0.001)**
Age*winter	0.010 (0.003)**	0.003 (0.001)**
Age^2*summer	0.0001 (0.000)	0.0001 (0.000)**
Age^2*winter	-0.000 (0.000)	-0.0001 (0.000)**

**significant at 1%, *significant at 5%
Note: Here monsoon is a reference category
Standard errors are given in parentheses
Number of cases: 15762

Results indicate that weight decreases significantly during the rainy season and increases during summer (dry) and winter. One possible explanation is that during the rainy season the chances of infection and diarrhoea are higher, which is a major cause of weight reduction. The weight growth rates come down during summer, while they increase during winter. It seems that the winter is not a favourable season for height growth, while it increases during summer. According to Sinclair et al. (1998) the first ever growth record was kept by Buffon of his son from his birth 1759 to 1777. Buffon was the first one to observe seasonal effects on growth and he also observed that growth occurred more in summer. Our results are in accordance what Buffon has observed several years ago.

3.6 Do growth rates vary between years?

Up to this point, the discussion has mainly been focused on describing the general shape of growth amongst the children of rural Pakistan by considering a quadratic growth curve model. These models have given us a general picture about the growth of study children, e. g., it has been seen that there is a decline in growth just after birth or most probably before the birth. However, we are also interested in knowing when the growth becomes faster and/slower during first three years of a child's life. To do this we use the piecewise linear models. Piecewise models for individual growth provide a means of dividing a time series into meaningful segments and capturing key features of change in each segment. In the present analysis, we employ a three-piece linear model for growth (Bryk et al., 1992). Furthermore, when an examination of the data suggests nonlinearity (Fig. 3.4), one option to consider is breaking up the curvilinear growth trajectories into separate linear components.

The approach of piecewise linear models is particularly important where we wish to compare growth rates during two different periods, e.g., is growth faster in period 1 than period 2. The piecewise linear model is in fact a growth curve model, having a number of linear segments (nodes). These are continuous functions whose slopes may change discontinuously at a number of values of t called nodes but which are linear. In brief, piecewise regression can be used to model changes during critical periods. This kind of evaluation of the growth from one period to next and so on can provide clues to the aetiology of age-specific growth patterns. This procedure has been used previously in literature of child growth to trace the specific age when the growth retardation actually starts, e.g., see Snijders et al. (1999).

By using the terminology of Snijders et al. (1999), the basic piecewise linear function is linear on a given interval (t_1, t_2) and constant outside this interval and can be defined as:

$$f(t)=\begin{cases} a & (t \leq t_1) \\ a+(b-a)\dfrac{t-t_1}{t_2-t_1} & (t_1 < t < t_2) \\ b & (t \geq t_2) \end{cases} \quad (3.3)$$

Often one of the constant values a and b is chosen to be zero. The nodes are t_1 and t_2. Boundary cases are functions by choosing $a = t_1$ and $b = 0$ and letting the lower node t_1 tend to minus infinity. Similarly choosing $a= 0$ and $b= t_2$ and letting the upper node t_2 tend to plus infinity. Each piecewise linear function can be obtained as a linear combination of these basic functions.

For ease of interpretation, the nodes are chosen on yearly basis, i.e., on Year I, Year II and Year III[12]. In this way the growth is assumed to proceed linearly during each year, but the growth rates may be different between the years. To make our results more meaningful and robust, we considered only a particular cohort of children who were in between one to twelve months of age during the first year of survey. Then this particular cohort was traced for the entire survey period, which is three years. In this way, for this cohort of children the minimum age is one month and the maximum is 36 months and we ended up with 250 children.

We hypothesise that height and weight growth rates increase with age but with different slopes from first year of life to the third year of a child's life. The choice of nodes sometimes will be suggested by the problem at hand or has to be determined by trial and error (Snijders et al., 1999). We assume that each child has a three-piece linear spline growth curve with a knot at the time after every 12 months from birth up to 36 months.

The ages of children from one to 36 months are broken down in intervals that are found most suitable according to the literature on child nutritional status, i.e., the first linear segment would be from 1-12, the second from 12-24 and the third from 24-36 months. Although, we are not employing a quadratic piecewise growth model, the three linear segments used in this are approximately equivalent to a quadratic model. These three segments enable us to capture change in children's growth rate in the first three years of

[12] Year I starts from July-September 1986 to June-August 1987, the second year, i.e., Year II is from December 1987-February 1988 to August-September 1988 and the third year i.e., Year III is from December 1988-February 1989 to July-August 1989

life. For example, the growth rate in Year II can be compared with the growth rate in Year I and as well as with Year III and vice versa. It means that the growth is assumed to proceed linearly during each age group but the growth rates may be different between the intervals. The variable of time, which is age in months, is centred from mean, which is 14 months. In this way the intercept is fixed at 14 months. This is achieved by using piecewise linear functions that all are equal to 0 for t= 14. The piecewise model can be expressed as:

$$Y_{ti} = \beta_{00} + \beta_{10}(a_1 - D) + \beta_{20}(a_2 - D) + \beta_{30}(a_3 - D) +$$
$$u_{0i} + u_{1i}(a_1 - D) + u_{2i}(a_2 - D) + u_{3i}(a_3 - D) + e_{ti} \qquad \text{......(3.4)}$$

Where a's are values of the time series segments for first three years as already been defined while the deviations are taken from the mean which is 14 months (D=14). The u's indicate that there are four random effects, one for the intercept and three for the slopes of a's. Hence, the results of the linear mixed effects piecewise model consists of two main parts, a set of individual intercepts and random effects and estimates of their means (fixed effects) and standard errors. Also, the correlations between the slopes and intercepts provide additional useful information, but our emphasis would be on discussing in detail the fixed effects, since these results address our primary research question. The results of fixed effects are reported in Table (3.10).

Table 3.10: Fixed effect estimates of the piecewise linear regression

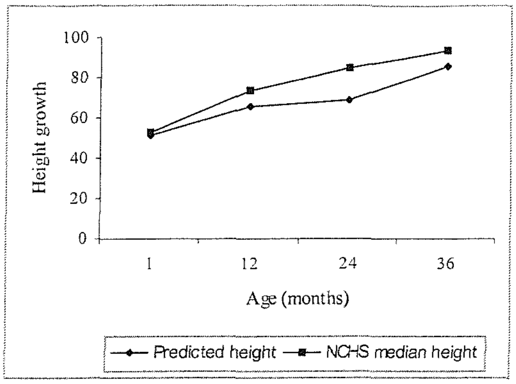
Coefficients	Height (cm)	Weight (kg)
Constant	68.06 (0.30)**	8.30 (0.060)**
(1-12 months)	1.19 (0.03)**	0.32 (0.005)**
(12-24 months)	-0.11 (0.02)**	-0.04 (0.050)**
(24-36 months)	0.82 (0.02)**	0.18 (0.005)**
Random effects (level-1)		
Residual variance	3.55 (0.16)**	0.43 (0.020)**

**significant at 1%, *significant at 5%
Standard errors are given in parentheses
Number of cases: 750

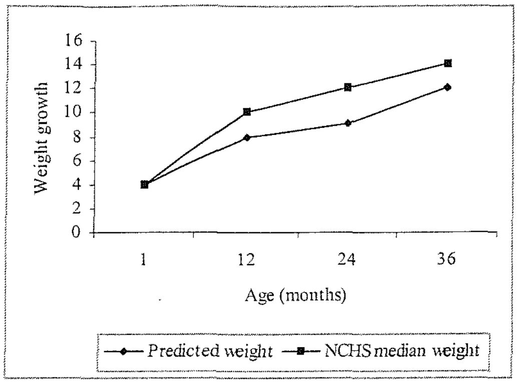
The average growth rate between 1 to 36 months is 0.63 cm per year. The growth rate during the first year of a child's life is found to be the highest as compared to growth rates in other age groups. Various factors can explain this higher growth rate, e.g., within this age period, most of the children are breast fed, so in this way they are consuming enough nutrients that are essential for growth. Secondly because of the breast-feeding the children usually are not as prone to infection as compared to those children who have been on solid food. Surprisingly, there is a steep decline in growth rate with age, i.e., with the increase in age the growth rate starts declining. A number of factors can explain this slow growth with age, e.g., incidence of infection, socio-economic factors etc.

The evidence presented here suggests that the average growth starts decelerating during the 'past 12 months' period. However, the process of growth deceleration might have started earlier before 12 months but it continues during the second year of a child's life. Again, in year three of a child's life, the child seems to be accelerating in the average growth. Generally speaking, it can be concluded that mostly rural Pakistani children as a group growing faster during their first year of life while there is a decline in children's growth during second year.

The predicted height and weight trajectories of children aged 1-36 months can be calculated by putting the values of the fixed effects from Table (3.10) for each node in the equation (3.3). It will give the predicted trajectories of height and weight at age 12, 24 and 36 months likewise it can be calculated at age one month. For example, for age 36 months, the predicted height trajectory can be calculated as 68.06+ (36-14) x 0.82= 86.1 (cm). These growth trajectories are shown in Figure (3.9). It seems that the children's average growth is increasing at a reasonable rate from the age one month up to the age 12 months then the growth starts decelerating up to 24 months. The height of a 12 months old child is predicted as 65.7 cm and the height of a 24 months old child is only 69.2 cm which is indicative that the growth rates have become very slow during the second year of life. After 24 months, growth starts accelerating which can be shown from the up-ward trend in the graph after 24 months.



(Height)



(Weight)

Fig 3.9: Predicted height and weight growth of children from age 1-36 months in comparison with NCHS median.

From Fig. (3.9), it can be seen that the study children's height and weight growth rates are much slower than the NCHS median height and weight. Although, the difference in heights and weights amongst the study children at age one month in comparison with NCHS values seem to be non-negligible, however, the difference in heights and weights become more evident as children further proceed in their lives.

There exists large variability in individual growth rates, all slope variances are between 0.05 and 0.22, so the between-child standard deviations in growth rate between these age groups are almost 0.5 cm (Table 3.11). The correlations between individual growth rates in different age groups are not that high ranging from –0.55 to 0.55. This is an indication that the growth rate fluctuates erratically from year to year.

Weight was also modelled using the piecewise linear function. The conclusions about the growth velocity in weight gain with respect to years are similar with that of height. The average weight of a 14 months old child was 8.3 kg, the average rate of growth in weight fluctuates around 0.2 kg per year over a period of three years. There is an increase in weight in children from birth to twelve months then it starts slow down during the second year of a child's life. Again, during the third year the children seem to be improved as far as their weight is concerned (Fig. 3.9).

Generally, the height growth rates appeared faster and more variable in the first year of life than later (Table 3.11) but, the situation is converse in case of weight growth rates

(Table 3.12). The growth appeared to be decelerated during the second year of a child's life but again there is some suggestion of increasing in growth during third year of life. Unfortunately our data do not permit us to investigate this fact further to relate the early growth with the growth during adulthood.

Table 3.11: Estimated variance-covariance matrix of **height** growth coefficients at subject-level

	δ_{00}	δ_{11}	δ_{22}	δ_{33}
δ_{00}	43.21 (3.08)**			
δ_{11}	1.65 (0.22)**	0.22 (0.02)**		
δ_{22}	0.33 (0.13)**	0.03 (0.01)**	0.05 (0.01)**	
δ_{33}	-1.31 (0.16)**	-0.04 (0.01)**	-0.04 (0.01)**	0.11 (0.01)**

**significant at 1%, *significant at 5%
Standard errors are given in parentheses

Table 3.12: Estimated variance-covariance matrix of **weight** growth coefficients at subject-level

	δ_{00}	δ_{11}	δ_{22}	δ_{33}
δ_{00}	1.84 (0.12)**			
δ_{11}	0.06 (0.01)**	0.004 (0.001)**		
δ_{22}	-0.003 (0.01)	0.001 (0.0005)	0.002 (0.001)**	
δ_{33}	-0.03 (0.01)**	-0.001 (0.001)	-0.002 (0.001)**	0.01 (0.001)**

**significant at 1%, *significant at 5%
Standard errors are given in parentheses

3.7 Some further investigation of the growth curve model

There are two aims of this section; first, is to further investigate the pattern of growth trajectories among the study children, and second, to investigate the impact of missing values on the estimates.

3.7.1 Comparing growth rates of two cohorts of children

It has been seen in the previous analysis that the height and weight growth rates are generally coming down especially after 12 months of age. In the unconditional growth model, the entire study children were taken into account and in the later analysis of piecewise regression only a particular cohort of children was considered. It would be of interest if we go further in investigating the growth rates of different age cohorts of children and in this way the growth rates of two cohorts of children can be compared.

Two cohorts of children are considered; *Cohort-I* comprises of children aged from 1 month to 12 months in round 1 and the same children are traced for all the twelve rounds, in this way we ended up with 87 children (1044 measurements). The *Cohort-II* comprises of children aged 12 months to 24 months in round 1 then they are traced for all the twelve rounds in this way we ended up with 80 children (960 measurements).

As an initial analysis, the change in height and weight is measured from round 1 to round 12 in the two cohorts separately and compared with the NCHS/WHO reference height and weight values. Table 3.13 lists the information.

Table 3.13: Changes in height and weight among children of two cohorts

Cohort	Age in Rd 1 & in Rd 12	Height in Rd 1 & in Rd 12	NCHS* height in Rd 1 & in Rd 12	Weight in Rd 1 & in Rd 12	NCHS* height in Rd 1 & in Rd 12
Cohort-I	1 mo & 36 mo	50 & 84 cm	53 & 95 cm	3 & 9 kg	4 & 14 kg
Cohort-II	12 mo & 48 mo	65 & 94 cm	73 & 102 cm	7 & 14 kg	10 & 16 kg

Note: 1) Here **Rd** stands for Round and **mo** for month

2) The height and weight values are the average values within a respective cohort (raw data).

In Cohort I, the minimum value is 1 and the maximum is 36.

In Cohort II, the minimum value is 12 and the maximum is 48

*Lohman et al. (1988).

It is clear that both height and weight growth rates are slower than the NCHS reference values and as a result the children are shorter and lighter than the reference children. In the younger cohort, the growth rate (34 cm) is faster than the older cohort (29 cm). But, in both the cohorts the children are far behind in their height and weight values than the NCHS values.

The question that needs to be addressed is whether the growth pattern that was estimated earlier in this chapter is persistent among children irrespective of the age and missing values[13]. Again the two above mentioned cohorts of children are considered and the growth rates are calculated by using the unconditional quadratic growth curve model. In this way two models are fitted one each for the two cohorts.

The height growth rates as obtained from the fitted models are plotted as shown in Figure (3.10). It can be seen that the growth rates among children of both cohorts are not very different from each other. Both the growth curves follow the same pattern that is declining with age especially a steep decline after 12 months of age is very obvious. Further, these predicted height growth rates could be compared with the one as shown as Fig. (3.6) which was obtained by considering all the children. Both the figures reveal that the age specific aetiology of the growth rates is generally the same for all the study children, which follows a specific trend which is persistent among the study children.

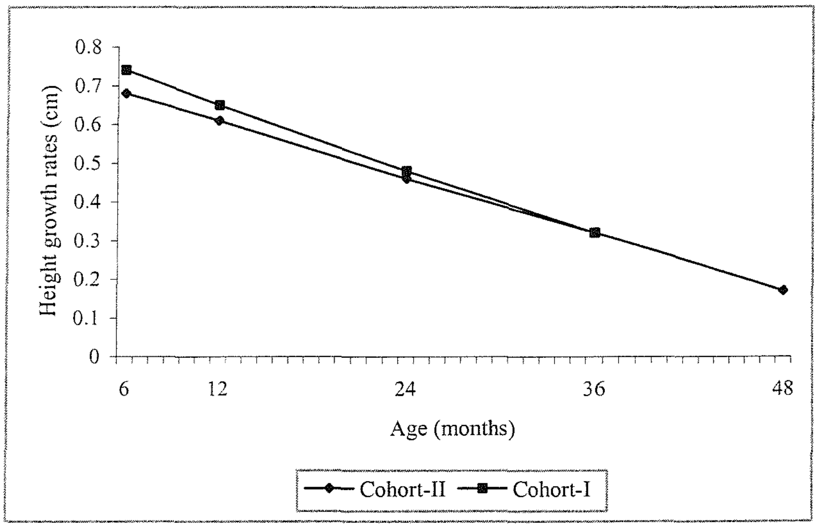


Fig. 3.10: Comparison of growth rates from two cohorts of children

3.7.2 Issue regarding the missing values

A characteristic of large-scale studies is that some of the intended measurements are unavailable for some time. One of the problems faced by this study is the absence of complete data for children for all the years. One way of dealing with this problem would be to analyse the observations with complete data (deleting observations with

[13] As in our analysis with unconditional growth model, we included the children of various ages from one

missing values). This option would however, lead to some substantial threats to the internal validity of the study. First is the loss of power of the study due to decreasing the sample size and secondly the generation of the biased estimates of the parameters of interest because the complete observations would be assumed to be representative of all observations made had there been no missing data, i.e. the selection bias.

To deal with the missing data, a variety of methods exist to convert an incomplete data set into a complete data set (Rubin, 1987; Little et al., 1987). However, firstly, the mixed procedure of models provides an alternative method of estimating the effects using the information available in the data at hand without actually filling in data values (Gibbons et al., 1993) and secondly, it is beyond the scope of this study. A random model estimates the effects as a function of the child's data and as a function of the data from the sample as a whole.

For children with more information, child-specific effects were influenced more heavily by that child's data. Conversely when there was little information from a given child, that child's child-specific effects were influenced more towards the group mean effects. Estimated children's slopes were based on available data for each child, augmented by information from data for all other children in the sample. The mixed model assumes that data available for each individual adequately represents that child's deviations from the estimated group trend line over the time frame of the study.

Consider the problem of missing data by predicting data values which are missing and then to obtain the model parameter estimates from the resulting filled-in or completed data set. For detailed discussion see Rubin (1987) and Little (1992). If we were to use the completed data sets in the usual way to fit a multilevel model the resulting estimates would be biased because the filled in data are shrunken and have less variation than the original measurements. Little (1992) discussed this problem.

It has already been seen from Sec. (3.2.1) that there were only 35% children who were followed in all the 12 rounds. What if we were to use the data comprises only completers? Based on the analysis presented in Section 3.7.1, we can arrive at two conclusions regarding the missing values. Two situations can be considered as: *Situation-I* is the one when we dealt with a large dataset comprises of missing values as

month to 67 months and also there were number of observations were missing.

well (Section 3.4.1) and the *Situation-II* is when we had the particular cohort of children with complete cases across time (Section 3.7.1).

In *Situation-I*, a very heterogeneous group was considered regarding the ages of the children. For example, there were some children who were 2 months old in the first round and on the other hand there were some children who were 48 months in the same round. In contrast, in *Situation-II*, two particular cohorts of children were considered; the cohort-1 comprised of children aged 1-12 months in round 1 and then they were followed up to round 12 and in cohort-2 children were 12-24 months in round 1 and followed up to round 12. In this way we are dealing with the complete case situation with no missing data.

We need to compare Figures (3.6 & 3.10) with each other, i.e., to compare the growth curve trend in both the figures. Both the figures reveal a very similar pattern in growth curves which is an indication that irrespective of the missing values, the parameter estimation and prediction is not affected. Hence, including such cases with missing values did not have any drastic impact on the results of both fixed and random effects. It is because the way HLM is formulated and also its data fitting and estimation methods. Our analyses regarding both situations reveal that the general trends in growth curve are similar. Hence, it does not make any significant difference whether to include complete cases of a particular age group or to consider incomplete or complete cases with heterogeneous ages. However, it would be vital to explore whether there is any significant statistical difference in the results obtained from both situations. For this purpose, the standard errors obtained in both the situations can be compared. Table 3.14 reports the standard errors obtained from Situation-I and Situation-II (cohort-2, as the results of S.E are very similar in case of both cohorts, so we are reporting the results of only one cohort).

Table 3.14: Standard errors obtained from Situation-I and II

Coefficients	Situation-I Coeff (S.E)	Situation-II Coeff (S.E)
Mean Intercept	75.15 (0.18)	86.32 (0.58)
Mean Slope of linear term	0.85 (0.01)	0.75 (0.02)
Mean Slope of the quadratic term	-0.004 (0.0001)	-0.01 (0.001)
Residual variance	4.46 (0.06)	2.39 (0.13)
No. of cases	15762	960

Note: Here we consider the results obtained by taking height as the outcome variable.

From the Table (3.14), it can be seen that in the analysis which retains only the complete cases the standard errors are raised. The analysis which uses a particular cohort with no missing value without adjusting for the uncertainty of the predicted values tends to underestimate the level 1 variance and also changes the fixed parameter estimates markedly. The corrected analysis using the full missing data procedure as expected gives standard errors which are somewhat smaller than the analysis which simply omits level 1 units with missing data. This finding is in accordance with Goldstein (1995). Hence, the *Situation-I* has been preferred over *Situation-II*. Thus, most of the analyses in this chapter were based on the all available data of height and weight[14] due to the reasons mentioned above.

It shows that HLM does not require either the same number of occasions per individual nor that measurements are made at equal intervals, since time is modelled as a continuous function (Longford 1987; Goldstein et al., 2002). It means that we can combine data from individuals with very different measurement patterns some of whom may only have been measured once and some who have been measured several times at irregular intervals. Nevertheless, multilevel modelling or HLM approach to fitting repeated measures data is to be preferred to other regression methods based upon a multivariate formulation assuming a common set of fixed occasions (Albert, 1999).

[14] Each subject at least has at least two observations.

3.8 Conclusions and discussion

The main purpose of this study was to look at the growth trajectories of children in rural Pakistan in a longitudinal perspective. The main findings as listed below:

- ***Age-specific effects*:** The quadratic growth curves fitted to data indicate that although the growth rates of children seem to be increasing with age but with a slower rate.

- ***In comparison with NCHS reference*:** The height and weight measures of study children are far less than the children from the international reference population (NCHS/WHO).

- ***Growth velocities*:** The predicted average growth velocities indicate a slower growth during first year of a child's life.

- ***Do growth rates vary between years?*** On a particular cohort of children it is found that growth rates do vary between years during early childhood. It was found that growth rates start decelerating during post-twelve months period, however, there is some evidence of growth acceleration during post-24 months period.

- ***Is gender an issue*?** Although, the boys are found to be better in their height and weight measures but they are not different from girls as far as their growth rates and acceleration are concerned.

- ***Seasonal effects*:** It is found that height growth rates are higher in summer (dry) than in monsoon and winter while weight growth rates are higher in winter and summer and lower in monsoon. With age height growth rates slower down in summer but higher in winter.

- ***Regional variations*:** Generally, children from Badin district are shorter and lighter than children of other study districts. However, the pattern that emerged from the graph of the predicted growth rates reveal that with age there is no significant differences in height and weight amongst the children of study districts.

3.8.1 Discussion

This chapter serves a dual purpose: to explain the methodology and the advantages of hierarchical linear models for longitudinal growth data and to demonstrate the model's utility in answering a question of public health interest. Researching children's growth in a longitudinal perspective has caught a lot of attention of researchers both in medical and social sciences.

Although, there are some problems in the data used in the present study. For example, it suffered from missing values, the spacing between visits was not uniform and the time-span of the survey was very short (three years). But, one of the hallmarks of the HLM is that it can accommodate the missing values and the unequal survey design as well. Some of the issues related with growth could not be captured due to the short-span of survey such as; the link between early growth retardation with the growth during adulthood, the age at which growth reaches its peak and when growth stops (height growth). Nevertheless, on the basis of the information available, we managed to draw statistically valid estimates about various aspects of children's growth which have already been discussed in the chapter.

The statistical techniques used in this chapter have been appeared in the growth curve literature with a variety of terms, including the random effects model (Laird and Waire, 1982), multilevel and the general mixed-linear models (Goldstein, 1986), as well as the hierarchical linear models (Strenio et al., 1983). A number of advantages have been mentioned by a number of researchers on the use of growth curve models. Recent developments both in theory and also in computer software provide us a powerful tool for analysing the longitudinal growth data.

As mentioned by Bryk et al. (1992), the potential advantages of using HLM over the traditional Multivariate Repeated Measures (MRM), namely; the model explicitly represents the individual growth at level-1, while in an MRM model individual variation in growth is not directly modelled but rather appears in the interaction of repeated occasions by subjects. Secondly HLM is generally more flexible in terms of its data requirements because the repeated observations are viewed as nested within the person rather than as the fixed set of all persons as in MRM. In HLM both the number of observations and the spacing among the observations may vary and to handle missing values in HLM is not a problem. Thirdly, the HLM permits flexible specification of the covariance structure among the repeated observations and provides methods for direct hypothesis testing about possible determinants of this structure. There are also some shortcomings of HLM and the present study which will be discussed in the last chapter on the conclusions in this thesis.

Age of the child remained our focal point most of the time to probe the age-related aetiology of growth. Hence, mostly time or age remained the only predictor in analysis. One strength of HLM is allowing a repeated measure variable such as time to be treated as random and nested within the upper-level units. Then time is the defining level-1 variable while subject defines level-2. Another strength is that this lower-level random variable can be regarded as continuous. Now the repeatedly measured response can be modelled over time as a continuous curve rather than a series of abrupt changes. Besides the number of potential advantages of the longitudinal studies, handling the missing values is not very straightforward. There is a debate in the literature whether to include the complete data with missing values or the data with only complete cases. In this study we demonstrated two things; firstly we have seen that the standard errors are smaller in case of complete data (including missing values) analysis as compared to complete case analysis. The second concern was in looking at the trend of the growth curve and we found that the growth rates and the growth acceleration are not very different in case of both the analyses. Nevertheless, all our analyses based on unconditional and conditional growth models are based on the complete data (with missing values).

Next comes the issue that how accurate is the choice of applying growth curve models to the data under study. To do this, we compared the means both from the observed and the estimated values (Sec. 3.4.2). The estimated mean values of height and weight are found to be very close to the observed values. It shows that the selected model fits the data reasonably well.

Generally, the height and weight measures of the study children found far less than the NCHS/WHO reference. To examine the growth patterns and velocities we applied growth curve models. The predicted velocities amongst the study children during their first year of life were found in deficit when compared with the normal growth velocities of children. In normal children the growth velocities were usually fastest during first year then they start slowing down, however the slower growth amongst the study children during first year may indicate growth retardation of children in utero. It may be an indication of poor nutrient intake and/or exposure to morbidity[15].

The techniques presented in this chapter demonstrate how height and weight velocities can be calculated by using a growth curve model. Growth curve models offer an effective means of estimating mean growth, patterns of variation and the timings and association of developmental events. The correlation between the random parameters within a given level are important because they provide a basis for estimating an individuals' growth curve when only limited data are available.

The points of policy implications that emerge from the findings of this chapter are: there should be some sort of child growth monitoring programme in the rural health centres so that if a child's growth is found to deviate from the reference growth curve then that child should be immediately treated. Researchers from the social science and the public health discipline should be trained in applying growth curve modelling techniques on height and weight data so that any abnormality in growth patterns can be observed and treated. In future, there is a need of collecting anthropometric data on frequent basis (on monthly basis during first year) and such children should be followed until their puberty period. In this way the growth patterns can be studied comprehensively from infancy to adulthood.

The next chapter presents an overview of the socio-demographic composition of a typical rural Pakistani household. This chapter mainly deals with working out the poverty in study areas.

[15] The effects of various covariates on a child's growth is illustrated in Chapter 6.

Chapter 4

Household economics

4.1 Introduction and background

This chapter discusses the role of household as a central place in determining the health and economic well-being of the individuals. The child health framework places household in the central place and links child nutritional status with various household characteristics. The household status of economic well-being is usually determined by poverty. Indeed, poverty is one of the most influential risk factors for ill health, and ill health can lead to poverty. During the discussion about the determinants of child health (Chapters 1 & 2), it has been seen that poverty is one of the underlying factors, which is having a direct impact on child nutritional status. Hence, it seems prudent to explore the poverty dynamics in the study areas. In the future chapters, the relationship between the nutritional status and poverty will be explored. Therefore, our main interest is not only in studying poverty, but also to use it as a measure of well-being in the human nutrition context[1].

In most developing countries, poverty has been associated with the state of deprivation with reference to socially accepted norms of basic human needs. So at the first instance, it is important to determine what the basic needs are. Basic needs can be defined broadly as what is necessary for survival. Thus, broader definitions of basic needs may include essentials such as clothing, housing, health, education and other goods and services considered necessary to basic needs of living.

Frequently, the poverty line is expressed in terms of an income level that a household or individual would require purchasing a minimum basket of goods and services that are deemed necessary to sustain a physical and social existence. Within this approach, the narrowest promotes the definitions or calculations of income or expenditure levels needed to fulfil the nutritional requirements for maintaining life. Hence, in many countries, the minimum cost to fulfil basic needs is used as the basic criteria for poverty. Hence, the formulation of a poverty measure requires decisions about several issues in addition to the concept and method by which to set and update the thresholds and the appropriate definition of family resources.

The broad aim of this chapter is to investigate the household's economic well-being. This chapter addresses these research questions *1)* what is the composition of a typical rural household in Pakistan? *2)* how many households are living below the poverty line and why they are poor? 3*)* is poverty a static condition and if no what kind of movements of households takes place between two time points? and finally 4*)* what are the determinants of this movement of households from one welfare state to the other?

The organisation of this chapter is such that the first section focuses on the household composition, which is thought to be an important predictor of health, nutrition and well-being of household members. The second section focuses on poverty measures their definitions and scope. A detailed picture of household expenditure pattern is presented in the next section and also what constitutes the basic need. The last three sections are specifically concerned with the incidence of poverty in study areas and its correlates that are helpful in determining who is poor and why. The longitudinal nature of data allows exploring of the mobility of households from one welfare state to another between two time points. This issue is discussed in the last part of the chapter, which also focuses on estimating who is transient poor and who is chronic poor.

4.2 Household composition in rural Pakistan

In order to comprehend the dynamics of consumption expenditure in the sampled households, it is essential to understand the structure of a typical rural Pakistani household and its role as a social unit. Using the household as a frame of reference, one could usually see two types of households in Pakistani setting, nuclear households and extended households. Nuclear households are usually comprised of a father and/or a mother with their unmarried children, while extended households include the members of the nuclear households and also other relatives. In our sample, a high proportion of children and elderly persons[2] indicate that almost all of the study households are

[1] It is investigated in Chapter 6.

[2] In the social context of Pakistan, the presence of elderly people in a household is considered as blessing and also the concept of old homes does not exist at all in Pakistan.

extended households. Generally, in a Pakistani setting, the presence of elderly in a household is associated with grandparents and according to the customs in Pakistan; the decision-making process within a household might accommodate the old members in recognition of their experience and also sign of respect for elderlies. For instance, the experience of grandmothers can be used in child rearing and nurturing.

While working on Philippine household structure, Castillo (1977, cited in Garcia, 1990) found some elements that characterise an extended household. These include: relatives of the nuclear household living with them or close to them; formal pooling or joint ownership of resources; recognition of common responsibilities; joint productive or consumption activities; and use of the extended household as a reference group in decision making. In view of the extended families context in Pakistan, it is difficult to work out the income of household, as mostly the labour is self-hired amongst the members of the same household. Due to this reason and other reasons as well, consumption expenditure has been given preference over income in this study.

In rural Pakistani setting, the role of the head of household is very significant, usually the head is male and this is the person who manages the family finances. The head is the person who takes decisions about the children's education and even what to eat. This role becomes more significant when wife is not educated or not contributing towards the income of the house. Many studies have demonstrated that if a woman is involved in the earning process then she can have influence on household decision-making. Roldan's (1982) case study of home-based female domestic outworkers in Mexico City showed that the extent of women's autonomy within the household can be associated with the percentage of her income contribution in the household.

Table 4.1 reports some household characteristics of rural Pakistan. In the sample, the percentage of wives that are primary or more educated is extremely low, (only 4 percent). The women in Faisalabad seem to have some autonomy in household decision making processes, as in Faisalabad seven percent of head's wives are primary or more educated. If the percentage of working women[3] in Faisalabad is considered, it is the highest in all the districts, which is 17 percent. It has been shown in some previous studies that income directly earned by women is more likely to be allocated to expenditures related to food, schooling, clothing and other children's need than would

[3] We are considering only those who women who are in paid employment and who are heads' wives.

be observed in the case of household income mainly earned by men (Garcia, 1990). Generally, the proportion of working women in the entire sample is only five percent while only 2 percent women were found to be working in districts Dir and Attock.

Table 4.1: Household characteristics at a glance

Characteristics	All	Faisalabad	Attock	Badin	Dir
Average h'hold size	8	7	6	8	10
	(4)	(3)	(2)	(4)	(5)
H'hold with children (%)	75	65	56	86	87
Average proportion of children wrt h'hold size	0.22 (0.20)	0.17 (0.21)	0.16 (0.18)	0.25 (0.18)	0.26 (0.21)
Average proportion of elderly wrt h'hold size	0.09 (0.14)	0.15 (0.19)	0.12 (0.16)	0.07 (0.12)	0.06 (0.08)
Average proportion of earners wrt h'hold size	0.33 (0.23)	0.42 (0.28)	0.37 (0.24)	0.29 (0.16)	0.29 (0.21)
Extended families (%)	66	55	70	66	70
Extended families with children (%)	72	63	70	73	74
Average head's age (years)	48	51	47	43	50
	(13.89)	(14)	(13)	(13)	(14)
Average wife's age (years)	41	46	41	36	42
	(12.40)	(12)	(11)	(12)	(12)
Head is primary or more educated (%)	35	43	41	27	31
Wife is primary or more educated (%)	4	7	8	2	2
Wife is working (%)	5	17	2	3	2
Head is male (%)	99.6	100	100	98.8	100
H'holds with electricity (%)	38	77	51	1.2	74
H'holds with tap water (%)	17	13	0	0	55
H'holds with flush (%)	5	9	4	0	10
House is pakka (%)	20	43	56	4	26
No. of h'holds	930	180	200	275	275

Note: 1- h'hold. household, wrt. with respect to, 'pakka' means a concrete house
2- Figures in parenthesis are the values of standard deviation
3- Wife means head's wife
4- Wife is working considers only the paid work.

Surprisingly, Attock has the highest proportion of women with primary or more education and the average household size is only 6 members per household, the lowest in all the districts. The average household size in the entire sample is 8 with a lot of regional diversity. Dir district has an average household size of 10 with 87 percent households with children of age six or less. If we consider Badin and Dir districts, these two districts have more than 85 percent of households with children under the age 6 years and in these two districts women with primary education or more are just 2 percent. One possible explanation of such a low rate of women education in these two districts can be given by considering the geographical location of the region and the taboos associated with women in those societies. Usually in those areas, women are not allowed to leave their homes. Whereas, Atock is the district to the north of Punjab and this region is characterized by high rural-urban integration, strong linkages with the services sector and the dependence on remittance incomes due to the high incidence of domestic and overseas migration. The overall levels of literacy and education are high in this region as compared to other regions of Pakistan. This has a positive impact on female education as well.

Considering the rural setting of the sample areas, surprisingly not many households are found to be involved in agricultural related occupations. This finding is consistent with Alderman et al. (1993). Only 59 percent of the heads of households have agriculture as their primary occupation compared to 41 percent of heads having some other profession. Indeed, this 59 percent is not a very significant figure in the rural setting of an agrarian economy like Pakistan, where it is expected that a higher proportion of households to be involved in agricultural occupations. Some studies (World Bank, 2002; Adams and He, 1995; Alderman and Garcia, 1993) have noted the increasing importance of non-farm income for rural households in Pakistan. On the extended sample of rural households, World Bank (2002) observed a high dependency on non-farm sources of income in rural Pakistan. About 44 percent of rural households were found depending on non-farm sources of income in 2001. Among them 40 percent belong to lowest income group and 45 percent from highest income group. However, for landless households, this study finds a considerable share of non-farm income in total income (73%).

The sources of income vary from farm-based activities to non-farm activities. Table (4.2) reports the sources and share of income in total income. It includes crop profit, which includes profit from all crop production including home production and crop by products plus returns to agricultural labour. Income from livestock includes net returns from traded livestock plus an imputed value of home-consumed livestock. Income from rent, which includes rents received from ownership of assets such as land, machinery and water. Income from non-farm activities, which includes wages from any unskilled, non-farm activity such as construction, self-employment, government employment and non-farm private sector wages and finally income from transfers which includes pensions, internal and international remittances and *zakat*[4].

From Table 4.2, it is clear that only 23 percent share in total household income comes from crops. In Attock, the share of non-agricultural activities is 65 percent, which is the highest amongst the selected districts. The main reason of such a low share of farm-based activities in Attock is that this is an arid area where land is not as fertile. This comparatively lower proportion of heads involved in agricultural activities may indicate a transformation from agricultural to non-agricultural sector. This may also be a result of large scale migration towards Middle Eastern countries in late 1970s that is reflected in the higher dependence on remittance income by various studies (Adams et al., 1995). Nevertheless, most of the households heavily rely on the remittances, both national and international. Livestock also occupies a significant place in the income share, which was highest in Dir district. This district is in the North West Frontier Province (NWFP), comprises of mostly mountainous area and green fields.

Table 4.2: Income share by different sources in percentages

Region	Sources of Income and their share in total income (%)					
	Crop Profit	Livestock	Rent	Agricultural wages	Non-farm activities	Transfers
All	23	15	13	1	32	16
Faisalabad	33.4	13.4	15.4	1.4	28	8.4
Attock	10	13	11.3	0.4	45.3	20
Badin	35.3	16.4	18.3	2	22	6
Dir	16	17	7	0	31	29

Notes: i) This table is adapted from Alderman et al. (1993).
ii) The numbers are percentages

[4] Payment to the poor.

4.3 Measuring poverty in study areas

There are number of conceptual approaches to the measurement of well-being. The most common approach is to measure economic welfare based on household consumption expenditure or income. Three approaches are usually used in setting poverty lines, subjective, absolute and relative. The subjective approach refers to the position of an individual or household in relation to an income just sufficient to ensure the satisfaction of an individual or household expenditure. Absolute poverty refers to an individual's or household's position in comparison to the cost of certain items that are consistent with the minimum standard of living. Usually, the absolute poverty approach is based on a caloric and minimum consumption basket. On the other hand, relative poverty refers to an individual's position compared to the average income or expenditure. This approach sets the poverty line at one half, two third or any other percentage of the average income or expenditure.

Absolute thresholds also generally carry the connotation that they are developed by experts with reference to basic physiological needs (e.g., nutritional needs) for one or more budget elements. Relative thresholds as commonly defined are developed by reference to the actual expenditures (or income) of the population. Relative thresholds are often criticised on the grounds that the choice of the expenditure or income cut-off is arbitrary or subjective rather than reflecting an objective standard of economic deprivation. It is also argued that relative poverty thresholds do not provide a stable target against which to measure the effects of government programmes because they change each year in response to real increase or decrease in consumption levels. In practice however, relative poverty thresholds are not so different from thresholds developed according to expert standards of need.

Measuring poverty solely in terms of income or consumption can be misleading, especially in Pakistan that exhibits extremely poor social indicators[5]. Whatever approach is used should be viewed in human development perspective. Nevertheless, in developing countries like Pakistan many more people are denied basic human opportunities than are denied income. The World Bank (1990) has also defined poverty as the inability to attain a minimal standard of living. Usually two approaches are used under the umbrella of absolute poverty, these are caloric-based poverty (also known as food poverty) and the basic need approach. A caloric-based poverty line is usually

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[5] For example see Chapter 1.

defined in terms of minimum caloric requirement then it is converted into minimum food expenditure to acquire those calories. This poverty approach is used by Greer and Thorbecke (1986). On the other hand in the basic need approach the poverty line is typically set to represent the expenditure (or income) required to attain some minimum level of welfare, so the line is meant to reflect the cost of a given reference level of utility or standard of living that defines the threshold to poverty.

Usually, the minimum level of welfare is set as the nutritional requirements, supplemented by an allowance for basic needs and uses the consumption expenditure as the measure of welfare. Hence, the basic purpose in drawing a poverty line is to define a consumption level that is sufficient in purchasing the minimum standard of nutrition and other necessities.

Focusing on absolute poverty allows the use of the nutrient recommended daily allowance (RDA) as the basis for setting a poverty line. As mentioned by Greer et al. (1986) despite the problems of varying nutrient needs in the population the RDA can be used because they represent typical needs based on sampling large groups of people. The calorie RDA can generally be used as a single nutrient requirement for absolute poverty measurement. Nutritionists have found that with only some exceptions individuals eating sufficient calories automatically meet their protein needs. Hence, poverty line estimates based on this method assure consistency in terms of calorie requirement in the sense that on average people at the poverty line will have the same food-energy intakes. However, by relating the energy intake with consumption expenditure, the method implicitly regards that consumption expenditure is a better welfare indicator.

What comprises of the basket of basic needs? The choice varies from country to country and even culture to culture. The consumption basket should include food as well as non-food items, which are mentioned as basic necessities under the Constitution of Pakistan. It says, "…..the state should also provide basic necessities of life, such as food, clothing, housing, education and medical relief to all citizens" (Government of Pakistan, 1972). Thus, the cost of non-food elements of the consumption basket is determined by assuming that those households whose food expenditure is equal to the food poverty line should also satisfy their other basic needs.

Therefore, the present study uses the absolute-poverty approach. Central to the notion of absolute poverty is the concept of a poverty line, which is used to arbitrarily demarcate the poor from the non-poor. The poverty line is a normative concept. It represents the amount of money or purchasing power that a household should have at a particular time and place in order to attain a minimum level of living or to satisfy the basic needs of its members quantified as a specific basket of goods and services. Hence, the poverty line can be defined on consumption space based on normative nutritional daily per capita requirements and other non-food basic consumption requirements. Nevertheless, an absolute poverty approach defines poverty in terms of a given level of income or consumption, which is equally relevant for people wherever they may be. This is usually done by defining a poverty line as the lowest amount of money sufficient to purchase the amount of food necessary for a minimally adequate diet. This approach is often used by the World Bank as well in defining the people living below the poverty line.

Thus, whatever the approach is used poverty has traditionally been defined in economic terms. By and large, health status has not been an element in the definition. Rather health has entered into thinking about poverty primarily as a service to be delivered to those who are found to be poor on the basis of income or expenditure criteria. World Bank (1990) defined the poor in economic terms and included health programmes among the social services recommended for helping the poor.

The next section provides an overview of households' expenditure patterns and the basket of basic needs, which will be used in determining the poverty threshold in this study.

4.3.1 Household consumption expenditure

In order to avoid the use of defective income data, poverty lines in many countries are derived on the basis of information on consumption expenditure, which is deemed to be more reliable than income data. Although, it has been argued that the use of expenditure instead of income ignores the savings. However, the justification can be given, as usually the households close to the poverty line do not have any savings. Hence, the expenditure at this level is almost equal to income. Also expenditure is more stable than income over time because of measurement error. Working on Pakistan data, Havinga et al. (1989) found expenditure data to be more reliable than income data. In a study based on Household Budget Surveys in European Union (EU), Zaidi et al. (2001) found the expenditure-based results give more robust poverty line compared with income. How much measurement error is in the expenditure variables? While working on Pakistan IFPRI data, Alderman et al. (1993) have done a detailed exercise on the incidence of measurement error in the income and expenditure variables and they concluded that consumption does not change very much when incomes fluctuate. This implies that households are able to protect their consumption levels from short-term changes in income. This protection most probably is through household savings.

Household consumption expenditure refers to the total final consumption expenditure on goods and services by households during a certain period. Although there are many dimensions to poverty and deprivation, there is a wide agreement on the value of using consumption aggregates as a summary measure of the economic component of the standard of living which is usually measured by poverty (Deaton et al., 1999). Taking consumption expenditure as a proxy of income, Deaton argued that in most of the industrialised countries, living standards and poverty are assessed with reference to income, not consumption. Both for rich and poor countries, it has been an established fact that consumption is not closely tied to short-term fluctuations in income and that consumption is smoother and less variable than income.

One more argument is that if data are collected over different periods of time then the average level of consumption must equal to the average level of income and in this situation the choice does not matter towards which measure to use. Also, in agricultural setting where income of the households varies from year to year, ranking of households by income could be less stable as compared to the ranking by consumption. In situations like in rural Pakistan, where major source of income is agricultural based or people are self-employed, it's very difficult to get accurate income data.

Data on expenditures, including food were collected in every round at a much disaggregated level. The questions asked included money spent on a particular item during the week before the survey by the household. All together there were about 70 different questions on household expenditure, including food and non-food items. Both food and non-food items were grouped together. Grouping of commodities was done in such a way as to retain the homogeneity of items. The definition of food expenditure here in this study covers not only cash food purchases from the market but also the imputed values of food consumed from the household's own production and also food received as gifts and wages. As much as 40 percent of food is consumed by own production or gifts or received as in kind payment, hence it is important to impute price values for such food items. For imputation of such price values, we followed the strategy what has been described by Deaton et al. (1999). According to them, "...with a choice of prices, the best choice is usually the one that offers the closest approximation to the amount actually paid. Except where there is a large choice of quality, the values reported by the household are likely to be better guide than market prices. When such data are not available, the analyst can construct prices from the data for other households, and use the median price paid by other households in the same sub-region". We filled up the missing prices of food items with district level averages of the prices of various food items which were given in the data. The given prices in the data were those of food purchased by households from the market. Hence, in the present study, the prices are calculated (imputed), where required, by taking the average prices which are available in the survey for every district separately. This process is done at every round. For example, in imputing the price of wheat for own production or received in kind or as gift, we averaged the price of wheat (per kilogram) which was given in the data for such households who have purchased wheat from the market. This procedure is done at every round for each district separately.

When we talk about basic needs, it is important to take into consideration other aspects that have a bearing on the quality of life. Many studies have demonstrated the problem of estimating the expenditure on non-food components at household level. In the first instance, there is no consensus regarding what constitutes the non-food component. Definitions of non-food items vary not only from country to country but also between various geographical areas within the same country.

Which expenditure should be included in the consumption expenditure? It is a debatable question, for example whether to include spending on weddings. There are some arguments of not including such spending in the household consumption expenditure as money spent on weddings mainly gives utility to the guests not the spender. Alternatively one might think that wedding expenditures are rare and exceptional events, which shed little light on the living standard on the living standard of the household (e.g., see Deaton et al., 1999).

In this study, we included expenditure on food, education, travelling, medical care, electricity, gas and fuel. Like Alderman and Garcia (1993) we did not include expenditure on housing as in our sample mostly the families were living in their own houses and in rural Pakistan setting it is very difficult to impute values for such households. We also did not include expenditure on some durable items like TV, fridge etc. This is consistent with Deaton et al. (1999) and Alderman and Garcia (1993). As these items are bought at a certain point of time and consumed over a period of time. On the other hand consumption should only include the amount of a durable good that is eaten up or consumed during a short period. Hence, in our study we ought not to include durable items in consumption expenditure to avoid an upward bias. Some other expenditures will be considered as savings in present study, such as, loan repayment, purchase of tractor, land for agriculture purposes, or house. The distribution of household expenditures is shown in Table 4.3. This table reports the average values of the expenditure share across the districts.

Table 4.3: Percentage share of food and non food items to the household consumption expenditure

District	Food	Fuel	Transport	Medical	Clothing	Schooling	Miscellanies
Faisalabad	68	4	7	6	6	1	8
Attock	67	6	6	6	7	1	7
Badin	73	1.6	3	9	8	0.4	5
Dir	64	6	10	7	6	1	6
All	68	4	7	7	6	1	7

Note: The values are in percentages.

It is evident that a very large proportion of household budget (i.e., 68%) is spent on food. Higher budget shares on food means lower shares for other basic household necessities. Smaller food shares indicate higher standard of living. A considerable regional variation has been seen in the expenditure share of both food and non-food items. For example the food expenditure share by the households of district Badin is 73 percent, which is the highest amongst selected districts. This very high spending on food shows a very low standard of living, which is further evident by looking at the high share on medical care and very low spending on education. As the poorer people spend more on food, therefore, the percentage of spending on food in total household consumption expenditure is a good indirect indicator of poverty.

Among non-food items, the share of expenditure groups like, transport, medical care, clothing, and fuel is fairly large. But, if we consider the occupation of head of the household there is a great variation in the expenditure pattern (Table 4.4). For example, generally if the head of the household is associated with agricultural related work then on average such households spend about 70 percent of their total budget on food and only 0.78 percent on children's education. On the other hand, average spending of the salaried persons on food is 64 percent, while on children's education they spend about 2 percent, which is the highest in all the occupation categories.

Table 4.4: Expenditure patterns (in percentage) of households by the education and occupation of the head of household

Head of household	Food (%)	Medical care (%)	Education (%)
Education			
Primary or above	64	7	1.4
No education	69	8	0.7
Occupation			
Farmer	70	7	0.8
Casual service	67	7	0.8
Govt. job	64	7	1.7
Private work	64	8	1.2
Business	64	7	1.2
Unemployed	68	7	0.8

Note: The values are in percentages.

This pattern of consumption expenditure pattern holds across all districts and occupation groups. The high proportion of budget on medical care shows generally poor health conditions in rural Pakistan. A very low spending of the household budget on children's education indicates the low priority to education; this figure is also a reflection of the allocation of budget to education at national level[6]. A high spending on travelling and transport is an indicative of long distances to clinics, schools, government offices and also work place from the households.

A considerable variation can be seen in the expenditures on food and non-food items by the level of education of head of household (Table 4.4). It is evident that heads with primary or more education spend less amount of money on food purchases as compared to uneducated heads of the household. One very obvious difference is found in the spending on children's education. For example, this share is 1.44 percent when the head of the household is educated and it is only 0.73 percent in case of uneducated head.

4.3.2 Equivalence scales

A number of studies have demonstrated that the economies of scale and the use of equivalence scale influence the results of the study. Households differ in size and composition and so a simple comparison of household consumption can be quite misleading about the well being of individuals in a given household. Most researchers realise this problem and use some form of normalisation. The purpose is to take into account the demographic composition of the household and to assign weights in accordance to every individual of the household. One of the basic assumptions in the computation of equivalence scales is that household's well-being at a fixed level of income or expenditure, is an inverse function of the household size. This means that as the household size increases the household expenditure must also increase to maintain a constant standard of living. Poverty lines are adjusted across demographic groups. One approach to set the demographic composition of household is to set the line in one reference group and then derive the remaining thresholds using an equivalence scale to account for the varying needs of different sized families.

One criterion is based on fixing the nutritional requirements of different types of people and the other criterion includes household consumption behaviour. In developing countries it is common to find equivalence scales in use, which are based on the different nutritional requirements of persons of different ages and gender. It might be the case that a child below the age of five years is deemed to require only about one-third of the calories of an adult male in order to be able to function normally.

There are a number of different ways of calculating equivalence scales for Pakistan as being used in a number of studies (Zaidi et al., 1993; Ercelawn, 1990; OECD, 1982 and Wasay, 1977). The implications of different equivalence scales have been explored by Lanjouw and Ravallion (1995). It appears that equivalence scales may matter in cross-country comparisons of poverty, while within country comparison practically does not make any difference in results (Lancaster et al., 1999). In these scales age and gender

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[6] The national budget allocation to education and medical sectors is under 2%.

specific calorie requirements are used. These scales have been used for cross-sectional datasets. Baulch et al. (2003) while analysing the IFPRI panel data used WHO equivalence scales to take into account the time factor and the fact that the majority of household size growth came from a larger number of children (Dercon, 1998). Present study uses the WHO scales which shall be called as Adult Equivalent Units (AEU). These are given in Table 4.5.

Table 4.5: Adult equivalence units (AEU)

Age (years)	Male weight	Female weight
0	0.33	0.33
1	0.46	0.46
2	0.54	0.54
3-4	0.62	0.62
5-6	0.74	0.70
7-9	0.84	0.72
10-11	0.88	0.78
12-13	0.96	0.84
14-15	1.06	0.86
16-17	1.14	0.86
18-29	1.04	0.80
30-59	1.00	0.82
60+	0.84	0.74

Source: Quoted in Dercon and Krishan (1998) and based on WHO equivalence scales and also used by Baulch et al. (2003) for the IFPRI Pakistan Panel survey.

4.3.3 A brief review of the previous studies on absolute poverty in Pakistan[7]

In Pakistan, several studies have been done so far to look at the poverty dynamics in country, starting with the pioneer work by Naseem (1973). By the mid-1970s and early 1980s the focus of work shifted to estimating the extent as well as the trends in poverty related to the absorption of a minimum diet based on nutritional requirements (Malik, 1993). Naseem (1977) defined a poverty line in constant 1959-60 prices of a consumption basket yielding 2100 calories and constructed lines permitting the intake of 95 percent, 92 percent and 90 percent of the minimum required calories. Malik

[7] As we are not dealing with the relative approach of poverty, hence in this section the focused would be only on studies where the absolute poverty approach was used.

(1993) pointed out that this work suffers from two serious limitations. First it is based on grouped data rather than actual observations and secondly the conversion of the surveyed distribution of income/expenditure based on households to one of per capita income/expenditure is built on fairly drastic assumptions. Irfan et al. (1984) estimated the rural poverty by using a poverty line. This study assumes 2550 calories per day per adult equivalent unit as a requirement, as also suggested by the Nutrition Cell of the Planning Division of Pakistan (Khan et al., 1980). They determined an income based poverty line of Rs. 109 per capita per month in 1979 prices.

Ercelawn (1990) used a concept of under-nourishment to define absolute poverty and presents estimates of absolute poverty in Pakistan. He estimated calorie expenditure functions for calculating the poverty line. This poverty line is based on the monthly expenditure that a household needs to fulfil the daily calorie intake of 2550 KCal per AEU. Similar methodology has been used by Federal Bureau of Statistics, Pakistan.

Per capita consumption expenditure that is necessary to fulfil the minimum caloric requirements of a household is a commonly used indicator of setting poverty line in Pakistan (Shirazi, 1994; Ahmad et al., 1990; Ercelawn, 1990; Irfan et al., 1984). A useful survey of previous poverty studies undertaken in Pakistan has been reviewed in Malik (1993). Kemal (2001) reports that in Pakistan the studies carried out in the 1970s and 1980s have rarely focused on poverty gap and Foster-Greer-Thorbecke (FGT) indices, rather the focal point was on examining the head count measure only.

Poverty transition is an approach to understand the concept of poverty and it is used to assess how many people or families enter in and exit out from poverty between two time points. However, only one such study is based on Pakistan, which was carried out by Baulch et al. (2003) using the IFPRI data. They used a relative poverty line by implying the poverty line of Rs[8]. 2000 per AEU in 1986 rupees, which represents the lowest quintile of the income distribution in the first year of the panel. Then they constructed the transition matrices between the movements in and out poverty for each year.

There is a general consensus in literature that poverty in Pakistan has increased in the 1990's as compared to previous decade (Kemal, 2001). The major reason was slowing

[8] Rs. stands for Rupees which is the Pakistani currency.

down the economic growth rates in 1990's which were around 4 percent and which used to be 6 percent in 1980's. In poverty literature of Pakistan, one can see a decline in poverty rates from the mid 1970s to the mid 1980s, but all these studies have used the income based poverty. On the other hand Pakistan's record in social sector has not been very impressive, so income poverty in Pakistan's situation cannot fully capture the true face of deprivation.

4.3.4 Why to use basic-need poverty?

Within the framework of the absolute poverty, there are two broad approaches of calculating poverty line, which are: the food-based approach and the basic-need approach. The question is of making a choice between the basic need approach and the food poverty approach. The difference between these approaches lie in defining the expenditure; food based poverty considers only the food expenditure and the basic need considers the expenditure on basic needs. Restricting the poverty criterion to food expenditure have some advantages such as the data may be more reliable because of easier recall compared to data on non food items. On the other hand, by acquiring food poverty criteria means that we are identifying poor only on the basis of food and which of us would wish to live by bread alone.

Consider a family classified as non-poor under the food poverty criteria but its total resources are so meagre that it achieves adequate food expenditure only by reducing the share of non-food consumption to intolerably low levels under prevailing patterns of consumption. In this case placing such family as non-poor can be misleading. The conceptual framework of child health gives a considerable importance to the household resources along with poverty, which are considered as crucial determinants of child health. Hence, for this study, the basic need approach has been preferred and all the analyses in this and forthcoming chapters are based on this approach. Such a poverty line guarantees that the poverty comparisons made are consistent in the sense that two individuals with the same level of welfare are treated the same way.

4.3.5 How many are poor?

According to Ercelawn (1990) a suitable definition of poverty in the perspective of Pakistan rests on the concept of necessary minimum resources to acquire a socially acceptable food bundle that would provide the required calories. In order to incorporate food and non-food needs, the relationship between caloric intake and household consumption expenditure can be explained by caloric-consumption function as described by Greer et al (1986). The absolute poverty approach used in this study is based on the approach used by a number of researchers in poverty studies in Pakistan (Hussain, 2003; ADB, 2002; Qureshi et al., 2000; Arif et al., 2000; Jafri et al., 1995; Shirazi, 1994; Malik, 1993; Ercelawn, 1990; Ahmad et al., 1990 and Havinga et al., 1989).

The basic-need poverty line is calculated by using the food energy intake method. This method estimates the level of consumption expenditure that is necessary to meet the minimum energy requirements through the consumption of food along with other non-food items. It is the minimum amount of food an individual must consume to stay healthy. It can be measured in terms of the nutritional characteristics of the food, e.g., calories, or the monetary value of the foods (Greer et al., 1986). Sen (1978) has provided a strong argument for using a monetary poverty line as it allows the individual the freedom to choose how or even whether to satisfy his or her basic needs. Thus a caloric-expenditure function indicates that with an increase in income or expenditure, food energy intake also rises. This relationship can be expressed by the following regression model:

$$C = a + b \log E \qquad (4.1)$$

Where C is the daily calorie intake per adult equivalent unit and E is the monthly consumption expenditure per adult equivalent unit while the recommended daily allowance (RDA) is taken as the cut-off point. The threshold of caloric requirement is set at 2550 Kcal in AEU per day by The Pakistan Nutrition Cell (Khan and Khan, 1980). The IFPRI data contains information on food consumed by households. This information was collected at every round by asking questions on food consumed by the household members during the last week prior to the interview. The quantities of food consumed are also recorded. We calculated the food consumption at household level into calories by using the Food consumption tables for Pakistan (Government of Pakistan, 1985). The food consumption comprises of food purchased from the market, food received as gifts and wages and the food consumed from own production. The poverty line Z is the estimated cost of acquiring the calorie RDA represented here as R and can be expressed as:

$$Z = e^{(R - \hat{a}) / \hat{b}}$$

Where $\hat{a}$ and $\hat{b}$ are the coefficient estimates of a and b obtained after regressing the caloric consumption over the log of expenditure from eq. (4.1). This poverty line works under certain assumptions, such as (i) all individuals face identical prices and (ii) there is a common dietary taste pattern across regions and space. Thus given a common set of tastes and preferences shared by a group, i.e., same goods basket consumed in all the provinces. This type of semi-logarithmic function has been used by Prais et al. (1955). They used it in calculating the family budgets of UK and it gives best result when the food items are used. There are potential advantages of using a semi-logarithm function over using a linear or log-log relationship, such as the t-statistics are highly significant and R^2 was higher than using any other relationship (Greer et al., 1986).

Our analysis is also based on the similar assumption since our sample is a rural and there is very little variation with respect to taste and prices across the study regions. Lanjouw (1998) also advocates for calculating a poverty line based on one consumption basket for the low-income households. With regard to food choices amongst the study households, it has been observed that mostly they centred around the staple food which is cereals in all the districts except Sindh where the major source of food is rice[9]. There is not much difference in the nutrient composition of wheat and rice, e.g., the calories for one kilogram portion of wheat are 3490 KCal and that of rice for the same quantity are 3460 KCal (Govt. of Pakistan, 1985). Even, if there is a difference in the food consumption behaviours across regions however, calculating different poverty lines is not justified (Bidani et al., 1994).

Having taken the decision about calculating the poverty line, the next step is related with the actual calculations. Recall from Chapter 1 that there were in total 12 rounds taken place in collecting the data under study. To which 6 rounds were in year 1 and 3 rounds each in the subsequent years. The starting year of the survey, which we shall call Year I begins from July-September 1986 to June-August 1987, the second year, i.e., Year II is from December 1987-February 1988 to August-September 1988 and the third year i.e., Year III is from December 1988-February 1989 to July-August 1989. Instead of calculating the poverty line on round basis, i.e., for every round separately, we preferred to calculate poverty on yearly basis. In this way we calculated the poverty line for Year I, by fixing the prices for Year I. To calculate the poverty line for Year I, we averaged the expenditure on household basis across the six rounds in Year I. Furthermore, a household is classified as poor on the basis of whether its average expenditure calculated in this way is less than the poverty line. The purpose of calculating poverty line in this way is due to unequal time between survey rounds. However, by averaging the expenditure across the year means averaging positive and negative noise present in data from a single round. Or in other words, usually the rural households manage to smooth their consumption over the year and also in this way we are avoiding taking the seasonal variations in the consumption. Hence averaging expenditure over a year gives a better measure of a household's living standards.

The analysis in this study focuses on poverty at household level, i.e., if the household is deemed to be poor all its members are counted as poor. The poverty line is calculated in per adult equivalent unit in 1986 constant Rupees (prices) as also done by Baulch et al. (2003). The rural poverty line for the study households worked out to be Rs. 262 with $\hat{a}=-3800$ and $\hat{b}=2626$ (Table 4.6). The amount Rs. 262 was the expenditure that a person required to acquire minimum 76500 KCal in AEU per month or in other words a person required to spend Rs. 8.7 in order to acquire 2550 KCal in AEU per day. This is the minimum amount of caloric requirement (2550 KCal) that a person in rural parts of Pakistan needs to acquire per day. Based on this estimate of expenditure, it is found that 29 percent of the households have monthly consumption expenditure less than the calculated poverty line, i.e., Rs. 262. In other words 29 percent households are found unable to meet their minimum caloric requirement and are living below the poverty line. This estimate worked out very similar as reported in other studies based on rural Pakistan covering the period 1986-89 (Jafri, 1999; Malik, 1988).

[9] A detailed description of food choices in the study districts is given in Chapter 5.

Table 4.6: Regression results used for calculating the poverty line

Parameters	Coefficient (SE)
Constant	-3800.02 (115.70)**
Log of expenditure	2626.37 (85.04)**
R-square	0.37
No. of observations	875

**Significant at 1% level

The evidence of poverty in this study is presented on yearly basis. By calculating the poverty rates on yearly basis, we thereby lose some of the details of the patterns that may exist with respect to poverty in between the rounds. However, there is a widespread acceptance of the view that families can smooth consumption and accommodate fluctuations in income over the period of a year. For example the current U.S. poverty rate is an annual rate (US Census Bureau, 1996). Nevertheless, the use of panel data does offer considerably more detail than can be observed through cross-sectional data. In particular, it allows to examine the relationships between household events and differences in the probabilities of transition into and out of poverty, as would be presented in the next section.

From this section it has been learnt that almost 29 percent of the households were living below the poverty line during 1986-87. However, it does not reveal any information that how many households have changed their status of economic well-being in between 1986 to 1989, how many households remained poor for the entire period, and how many become nonpoor when previously they were poor. The mobility of households from one welfare state to another in a span of time would be explored in the later sections of this chapter.

4.4 Who are the poor?

The most important use of poverty measurement is not just the overall statistics, but its use in describing the poor and poverty as a first step in analysing poverty, its correlates and causes. It is usually called poverty profile. Poverty is not merely an economic issue, it is also an issue related with human dignity. Hence, the concept of poverty has to be linked with the broader spectrum of socio-economic parameters, including health, education and standard of living. Having measured poverty one wants to better understand its causes (Ravallion, 1996). Standard practice is to estimate the poverty profile giving the decomposition of an aggregate poverty measure by population sub-groups, such as region of residence and educational level. Such poverty profiles have been widely used to inform efforts to make public spending policies more pro-poor. An increasingly common practice is to construct the poverty profile in the form of a regression of the individual poverty measure against a variety of household characteristics. This approach uses a number of social indicators to assess poverty. Hence, a probit or a logit regression model is usually employed. A dichotomous variable representing whether the household is poor or not is taken as the response variable and it is regressed over a number of explanatory variables thought to be the correlates of poverty.

Also, in terms of government policies towards alleviating poverty, it is important to explore which variable is negatively related with poverty and which is positively. For example if larger household size is one of the significant factors of becoming poor then government policies should be targeted towards population programmes. On the other hand if education seems to be negatively related with poverty then there should be more investment on education by the government. Hence, to regress the poverty on a number of explanatory variables is not only to get some results rather to understand these results and to give more attention on such factors which contribute in reducing poverty.

This section attempts to model the poor in terms of various socio-economic variables; their summary statistics is given in Table 4.7. Household variables cover demographic composition (household size, the number of elderly over 60 years of age, the number of children below 6 years of age. the age of head of household), human capital (the level of education of the head of household, number of earners in a household, physical capital (area of land owned), occupation (whether the head of household is a farmer) and region of residence. Unlike some other studies on the determinants of poverty, we did not include the variable dependency ratio (usually defined as the children below 16 years and elderly above 60 years of age) in our analysis. Rather we preferred to use two separate variables one for children aged below 6 years and elderly aged 60 or above. The reason is that in rural Pakistan, one can see lot of children aged 16 or below in earning process, so in this way theoretically speaking they are not economically dependent on their families, same is the case with elderly.

Simple logistic model is used to explore the relationship of the explanatory variables with the state of well being of households. According to the logistic regression models, the household is poor given a vector of independent variables X_i, such that

$$\log\left(\frac{p_i}{1-p_i}\right)=\beta_0+\beta_i X_i$$

Where β_0 and β_i are unknown parameters, p_i indicates if the household is poor and takes a value 1 otherwise it is zero[10]. The logistic regression model for the odds is of the form:

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

The logistic model can also be written in terms of the underlying probability of a success outcome, i.e.,

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

The results are presented in Table 4.8 and these are the regression results for the Year I (1986-87)[11].

4.4.1 Key features of the explanatory variables

Household size, number of children and elderly

Large family size is thought to be related with poor standards of living. The issue of household size is relevant to a major inconsistency between the widely held views that the poor have large families. It has been proved in earlier studies that households with more children experience a higher risk of living in poverty than those households without or with few children (Falkingham, 2000).

The preliminary analysis between the poverty and the number of children less than six years of age has revealed a link between these two factors. Number of children in a

[10] For a detailed discussion on logistic regression see Hosmer et al. (2002).

household increases the risk of poverty, for example, only 21 percent households were found poor with no children. This figure rose up to 29 percent when there were less than four children in a household and with four or more children the head count ratio increased to 38 percent. So, targeting large households with children may represent an option for reaching the bulk of the poorest. Elderly people above 60 years of age also depend financially on the other members of the household. It has been seen in a study based on Tajikistan, that the risk of poverty is greater for people living in a household containing one older person as compared to household containing none or two (Falkingham, 2000).

Education, age and occupation of the head of household

It is thought that the risk of being poor is inversely related with the level of education. Especially, in the settings of rural Pakistan where the role of the head of household is very significant. Hence, the education of the head of the household directly related with the well being of the household. In present study, households with uneducated heads were 34 percent. These households are more likely to be poor as compared to other households with some education. For households with a head who had college/university education only in 9 percent cases were found living below poverty.

Amongst the study households, the poorer households were usually those who were involved in non-farm casual service and artisan work. In such cases the rate of poverty was 40 percent.

Consumer durables and assets

Landholding in rural Pakistan is considered as a valuable asset. This variable is included as an explanatory variable because it is believed that landholding reduces the risk of being poor. Acreage was positively skewed. Analyses with and without the logarithm transformation of acreage yielded similar results. However, the results without the log transformation are reported only. Table 4.7 reports the summary statistics of the variables used in the analysis.

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[11] It is to be noted that for the remaining two years, we got similar results as we got for year 1, so we are reporting the results for the year 1 only.

Table 4.7: Summary statistics of the variables used in the model

Variable	Mean	SD
Age of the head of household (yrs)	47.89	13.96
Head is primary or above (1=yes, 0=no)	0.34	0.47
Household is poor (1=yes, 0=no)	0.29	0.45
Household size	8.10	4.04
No. of children in a hhold	2.12	2.00
No. of elderly in a hhold	0.63	0.80
Number of earners in household	2.41	1.48
Head is farmer (1=yes, 0=no)	0.55	0.49
Land ownership (in Acres)	9.56	12.53

4.4.2 The determinants of being poor

The results of the analysis are reported in Table 4.8. Most of these results are in accordance with the results of previous studies on the correlates of poverty in Pakistan both by using the IFPRI data or another data source (Baulch et al., 2003; Kemal, 2001; Qureshi et al., 2000; Adams et al., 1995,). For example, the education of the head of household was found to have significant impact on the state of well being of household. A household is 34 percent times more likely to be poor if the head of household is educated below primary or completely illiterate. A person with primary or more education has a better odds of being non-poor than an uneducated or less educated person.

Table 4.8: Covariates of being poor in Year I

Covariates	Coefficients	Odds ratio
District		
Faisalabad	Ref	
Attock	-0.15	0.86
Badin	2.08**	7.97
Dir	-0.18	0.83
Age of head of household	0.01	1.01
Education of head is primary or more		
Yes	-0.41*	0.66
No	Ref	
Head is farmer		
Yes	-0.81**	0.44
No	Ref	
Number of earners in a household	0.02	1.02
Household size	0.24**	1.27
Number of children in a household	-0.15	0.86
Number of elderly in a household	-0.64*	0.53
Landholding of a household (Acres)	-0.09**	0.91
Constant	-2.49**	
No. of observations	841	

* Significant at 5% level ** Significant at 1%

The results indicate a significant link between the household size and the risk of being poor. It seems that a unit change in household size increases the log odds of poverty by 0.24, on average. Thus, the addition of one member in a household changes the odds of being poor multiplicatively by a factor equal 1.27. Equivalently, we may say that the addition of one member in a household size, increases the odds of being poor by 27 percent, holding all other variables constant. The effect of a continuous variable on a dependent variable can also be expressed in terms of a median effective level; i.e., the outcome of interest has a 50% chance. For example, a household has a 50% chance of being poor at the household size of 10 members (2.49/0.24). Hence such households with more than 10 members on average are more likely to face poverty. Lanjouw and Ravallion (1995) observed that there is a considerable evidence of a strong negative correlation between household size and consumption per person in developing countries.

Surprisingly, there were no adverse effects of the proportion of elderly people in a family and poverty; rather the findings indicate that households with elderly people have 47 percent less chances of becoming poor. It seems that a unit increase in number of elderly in a household decreases the log odds of poverty by -0.64, on average. Thus, with the increase of one member of age 60 or above in a household changes the odds of being non- poor multiplicatively by a factor equal 53. Equivalently, we may say that with the addition of one member of age 60 or above in a household decreases the odds of being poor by 47 percent, holding all other variables constant. In terms of a median effect effective level, a household has a 50% less chance of living below the poverty line if it comprises of almost 4 elderly people (2.49/-0.64). One possible explanation is that in rural Pakistan, as very few people are engaged in government jobs, there is no concept of retirement in self-employment or agriculture related activities. Most of the elderly people with good health continue to contribute in the family income through farming, self-employment, or any other private work. Adams et al. (1995) also reported the number of male adults in a household decreases the risk of being poor.

There was no significant impact of number of earners in a household, so it seems important to investigate what they are earning and what is their major source of income. The primary occupation of the head of household has a significant impact on the state of well being of families. If the head is farmer then the chances of such household were 56 percent lower to become poor as compared to those households whose heads were not in farming profession. This can be explained by the fact that farm households can fulfil minimum food requirements through the consumption of own production and therefore have lesser chance to fall in poverty. No adverse or favourable impact of the number of children in a household on the welfare state of a household was found. In literature of developing countries, there is a large argument that household with more children can achieve a given level of welfare at lower expenditures.

A significant relationship between the landholding and poverty is explored. It seems that an acre increase in the area of land owned, decreases the log odds of poverty by 0.09, on average. We may say that with one acre increase in land owned by a household, decreases the odds of being poor by 9 percent. Looking at the place of residence, we find that living in Badin increases the risk of becoming poor as compared living in Faisalabad. Higher education does appear to be protective factor as people with some higher or technical education degrees can have a better chance in the labour markets and better earnings, which automatically translates into a better standard of living. Results indicate that if the head of household is educated up to primary level at least, such households are 34 percent more likely not to live below poverty line compared to households with heads below primary level education or no education, holding all other covariates constant. Unlike Baulch et al. (2003) no significant relationship between the age of head of household and the well being of households was found.

It is important to check how robust these results are to the choice of poverty line or poverty threshold. Thus, the main concern is establishing the sensitivity of these results to the choice of poverty line. Baulch et al. (2003) have done such exercise by using the same data set. In the current study the threshold points are ranging from 2100 to 2400 Kcal to work out the percentage of households living below poverty line. Then the logistic regression with the same explanatory variables as used before is run for Year I. The results are presented in Table 4.9.

Table 4.9: Sensitivity analysis with respect to the choice of poverty cut-off points

Covariates	Poverty line (Kcal)			
	2100	2200	2300	2400
Districts				
Faisalabad (Ref)				
Attock			**[1]	*[1]
Badin	*	**	*	**
Dir				
Age of head of household				
Education of head is primary or more (1=yes, 0=no)				*
Head is farmer (1=yes, 0=no)		*	*	**
Number of earners in a household				
Household size		*	*	**
Number of children in a household				
Number of elderly in a household				
Landholding of a household	**	**	**	**

* Significant at 5% level ** Significant at 1%
[1]The sign of coefficient is negative

Overall the results seem reasonably robust to the choice of poverty line. The variables which are sensitive to the choice of poverty line are education of the head, household with children and living in Attock. Almost same findings are reported by Baulch et al. (2003) on the same data set. Results with setting the poverty line with a cut-off 2300 and 2400 indicate that living in Attock decreases the risk of becoming poor but this effect become insignificant for the cut-off 2550 calories (Table 4.8). It is evident that the role of head's education becomes more significant in reducing poverty when the higher caloric norms are set in calculating the poverty line. The physical capital variable i.e., the landholding is insensitive to the choice of poverty line. Also living in Badin came out to significant with all the poverty lines used in this analysis.

The effects of larger families and if the head is farmer become significant for the higher poverty lines. One conclusion can be drawn from this analysis is that by keeping in mind the average caloric consumption across all sample areas, the choice of 2550 Kcal per AEU (Table 4.8) proved to be the most suitable cut-off point. As very few variables were found to be significant for the lower poverty lines and in this way the occurrence of poverty and its causes could be underestimated. However, it is worth noticing that with the shift in the threshold level, the poverty rates change drastically. For example, with a cut-offs 2100 Kcal, 2200 Kcal, 2300 Kcal and 2400 Kcal, the percent of households found poor are 4%, 6%, 11% and 18% respectively. These poverty rates correspondent to poverty lines; Rs. 176, Rs. 193, Rs. 210 and Rs. 230 respectively.

4.5 The dynamic nature of poverty

Poverty analysis in Pakistan has tended to focus on poverty usually at a point in time and there has been very little in the way of analysing poverty dynamics, i.e., investigating the welfare movements of a set of households or individuals over time. Analysis of movements of a household's welfare over time provides useful insights into what determines movements into and out of poverty and why some households remain poor. In longitudinal studies, it is possible to obtain quantitative as well as qualitative measures of living conditions and to distinguish between transitory and permanent deprivation. Hence, it is possible to work out those who are poor over a period of time or who have moved out from poverty or who have entered into the state of poverty. Longitudinal data provides an opportunity to determine whether poverty is a short-term situation or persists over a long period. From policy point of view such distinction is very important, because transitory poverty is a phenomenon that tends to solve itself, while permanent poverty is a deeper problem. Both types need different targeting policies. In Pakistan, because of data limitations, very little work has been done on this important dimension of poverty that looks into and examines dynamic processes of poverty that how a household to falls into or escapes from poverty. This is largely because of the paucity of the type of survey data needed for this kind of analysis.

It has been hypothesised that usually poverty is a temporary phenomenon. This hypothesis has been confirmed in some longitudinal studies based in South and East Asian countries. It has been seen that in eight villages in southern India in the late 1970s and in early 1980 that around a quarter of poor households moved out of poverty from year to year (Walker et al., 1990). A decomposition of poverty into its transient and chronic components for households in rural Pakistan found that transitory poverty dominated (McCulloch et al., 2000). Before going into the details of available literature, there is a need to define what is meant by poverty transition. Whenever a household's income crosses the poverty line that household makes a poverty transition (Baulch et al., 2003). Hence, an increase in income or expenditure that moves a household over the poverty line is defined as an exit or movement out of poverty, while a decrease that moves a household's income or expenditure below the poverty line is defined as an entry or movement into poverty.

This section highlights the movements into and out from poverty by using two methods; firstly, by constructing poverty transition matrices between two years, and secondly by looking at such movements across expenditure quintiles. The construction of poverty transition matrix is based on the spells approach which involves identifying the poverty status of households in the different time periods under investigation.

4.5.1 Poverty transition matrices between two years

Poverty transition, between two periods can be traced by constructing a poverty matrix, which makes it easy to calculate the simple probabilities of entering into and exiting out of poverty between two periods of time. The probability of exiting poverty is simply the number of households exiting poverty divided by the number of households who were poor in the previous period. To carry out this analysis we restricted our sample to those households who were interviewed in all the rounds of the survey and had information on expenditure, which yielded 566 households. Recall from Sec. 4.3.5, the incidence of poverty has been calculated for Year I, which was achieved by averaging consumption expenditure over a year. To trace the movements of households from one welfare state to another in between three years, we also averaged the consumption expenditure for Years II and III separately. Then households were identified as poor whose consumption expenditure is below the poverty line (Rs. 262) in Years II & III.

From Tables 4.10a to 4.10c, evidence is presented on upward mobility (moving out of poverty) and downward mobility (moving into poverty) and persistent poverty (staying poor). Table 4.9a reports the number of households that were poor in 1986-87 (Year I) and exited poverty in 1987-88 (Year II) and those households that were non poor in 1986-87 and became poor in the next near, i.e., those households entering in poverty. Same calculations are done for 1987-88 (Year II) and 1989-90 (Year III) and between the first and the third year.

Table 4.10a: Poor/non-poor transition matrix between 1986-87 and 1987-88

1986-87	1987-88		Total
	Poor	Non-poor	
Poor	86	51	137
Non-poor	56	373	429
Total	142	424	566

This table reports the welfare state of households in two years, i.e., 1986/87 to 1987/88. About 15 percent of the households remained poor in these two years, while 9 percent households escaped poverty and 10 percent non-poor households entered into poverty in 1987-88. Generally speaking, 19 percent households moved from one welfare state to another, either from poor to non-poor or from non-poor to poor status. Similarly the transition matrix between 1987/88 and 1988/89 and between the first year of the survey and the third year was also worked out and given in Tables 4.10b and 4.10c respectively.

Table 4.10b: Poor/non-poor transition matrix between 1987-88 and 1988-89

1987-88	1988-89		Total
	Poor	Non-poor	
Poor	76	74	150
Non-poor	64	352	416
Total	140	426	566

Table 4.10c: Poor/non-poor transition matrix between 1986-87 and 1988-89

1986-87	1988-89		Total
	Poor	Non-poor	
Poor	81	63	144
Non-poor	63	359	422
Total	144	422	566

The crude probabilities of entering into or exiting from poverty are calculated, which are given in Table 4.11. The transition rates can be defined as

$$P_{jk} = \Pr(y_{i1} = j, y_{i2} = k)$$

$$P_{kj} = \Pr(y_{i2} = k \mid y_{1i} = j)\frac{P_{jk}}{P_{j+}}$$

where $P_{j+} = P_{j1} + P_{j2}$

And P_{kj} are transition rates for $k \neq j$, i.e., below the poverty line can take 1 otherwise 0. Therefore

$$P_{10} = \text{entry rate}, \quad P_{01} = \text{exit rate}$$

The entry and exit probabilities were calculated by using the above relationship and are reported in Table 4.11.

Table 4.11: Entry and exit probabilities

Year	Probability of entering poverty	Probability of exiting poverty	Percentage of households moving
Year I to II	0.13	0.37	19
Year II to III	0.15	0.49	24
Year I to III	0.15	0.44	22

A lot of mobility can be seen between Year II and Year III when 24 percent households changed their status of well-being. This suggests poverty is not a static condition rather it keeps on changing provided if the surrounding socio-demographic conditions also change. Therefore, it seems optimal to investigate the determinants contributing in changing the status of well-being of the families.

The panel nature of data also allows estimating the duration of a particular household remained in poverty. Table 4.12 reports the proportion of households remain poor for at least one year, two years and three years or did not remain poor at all.

Table 4.12: Duration of households of being in poverty

Duration	Entire sample
% not in poverty in any year	56
% in poverty in at least 1 year	44
Poor for 1 year (%)	20
Poor for 2 years (%)	14
Poor for 3 years (%)	10
No. of total h'holds	566

In the entire sample about 44 percent of the population remained poor for at least a year. This rate seems to be very high, but out of this percentage 10 percent of the households remained poor for the entire three-year period. Hence, it can be concluded that although, poverty is a serious issue in rural Pakistan, generally it is transitory, i.e., the households were not as desperately poor. Similar sorts of findings were also reported by Baulch et al. (2003) while using the same data set.

4.5.2 Determinants of becoming poor and non-poor

It is important to understand the factors that influence a household to enter into or move out from poverty between two points of time. It is deemed necessary to use such a model that can make it possible to estimate the key elements of the process of falling into or coming out from poverty. In this study, we use logistic model to examine the correlates of becoming poor or non-poor. In this model, the dependent variable is coming into poverty and going out from poverty between year t and t+1. Maddala (1983) has used the logistic model to examine the probability of entering and exiting poverty separately. The transitions between Years I and II are modelled by using logistic regression separately for moving into and moving out of poverty.

The model for the entry rate is given as:

$$\text{Logit}\left[\Pr(y_{i2}=1 \mid y_{i1}=0, x_i)\right]=\alpha_0 + x_i\beta_0$$

Similarly the model for the exit rate can be written as:

$$\text{Logit}\left[\Pr(y_{i2}=0 \mid y_{i1}=1, x_i)\right]=\alpha_0 + x_i\beta_0$$

The results of moving into poverty and moving out from the poverty are presented in Tables 4.13a and 4.13b.

Table 4.13a: Regression results of moving into poverty from Year I to II

Covariates	Coefficients	Odds ratio
Districts		
Faisalabad	Ref	
Attock	0.22	1.25
Badin	-0.48	0.62
Dir	-0.77	0.46
Age of head of household	0.01	1.01
Education of head is primary or more		
Yes	-0.83^{*}	0.43
No	Ref	
Head is farmer		
Yes	0.42	1.51
No	Ref	
Number of earners in a household	-0.14	0.86
Household size	0.17^{**}	1.19
Household with children		
Yes	0.01	1.01
No	Ref	
Number of elderly	-0.26	0.77
Land ownership	-0.03^{*}	0.97
Constant	-3.14^{**}	
No. of observations	561	

Table 4.13b: Regression results of moving out from poverty from Year I to II

Covariates	Coefficients	Odds ratio
District		
Faisalabad	Ref	
Attock	-0.24	0.79
Badin	1.31^{*}	3.70
Dir	0.71	2.03
Age of head of household	0.01	1.01
Education of head is primary or more		
Yes	-0.60	0.55
No	Ref	
Head is farmer		
Yes	-0.55	0.58
No	Ref	
Number of earners in a household	-0.09	0.92
Household size	0.07	1.02
Household with children		
Yes	-0.09	0.91
No	Ref	
Number of elderly	-0.40	0.67
Land ownership	-0.02	0.98
Constant	-2.69	
No. of observations	561	

*significant at 5% level, **significant at 1% level

It seems that a unit change in household size increases the log odds of moving in poverty from Year I to Year II by 0.17, on average. Thus, one member increase in household size changes the odds of being poor multiplicatively by a factor equal 1.19. Equivalently, we may say that a unit increase in household size increases the odds of becoming poor by 19 percent. Land ownership significantly decreases the probability of being poor. Households with an educated head have a lower risk of entering into poverty between Years I and II. However, the age of the head of household, number of earners, children and old people in a household did not have any significant impact on the household to enter in poverty and move out from poverty. District Badin is the only district where the chances of escaping from poverty are higher as compared to other districts of our sample.

4.5.3 Determinants of chronic and transient poverty

Poverty may be chronic or temporary. When previously non-poor households become poor for the first time, it is often difficult to determine whether they will experience temporary or chronic poverty. Information in Table 4.12 can be expressed in determining households who were poor for sometimes (transient poor), who were poor always (chronic poor) and who were never poor (Table 4.14). Hence, chronic poverty may be described as the state of being poor over an extended period of time. The transient poor are those who move in and out of poverty during the period being investigated.

Table 4.14: The status of well-being during three years of survey from 1986-89

Status of well-being	No. of h'holds	% of h'holds
Never poor	315	56%
Transient poor	194	34%
Always poor	57	10%
Total	566	100%

From the table it is apparent that amongst the households in rural Pakistan poverty is usually a transient phenomenon (34 percent) as compared to the persistently poor households (10 percent). Similar sort of findings were also reported by Baulch et al. (2003) while using the same data set.

Using this information the determinants of the status of well-being can be estimated. The Ordered Logistic Regression (OLR), a statistical technique, that can be used with an ordered (from low to high) dependent variable. The dependent variable in the current situation is the status of poverty with three categories:

1= never poor

2= transient poor

3= chronic poor

OLR has the form:

$$\text{logit}(p_1) = \log \frac{p_1}{1-p_1} = \alpha_1 + \beta' x$$

$$\text{logit}(p_1 + p_2) = \log \frac{p_1 + p_2}{1 - p_1 - p_2} = \alpha_2 + \beta' x$$

$$\vdots$$

$$\text{logit}(p_1 + p_2 + \ldots + p_k) = \log \frac{p_1 + p_2 + \ldots + p_k}{1 - p_1 - p_2 - \ldots - p_k} = \alpha_k + \beta' x$$

where $p_1 + p_2 + \ldots + p_k = 1$

In this model, P_1 is the probability of never poor, P_2 is the probability of transient poor and P_3 is the probability of chronic poor.

This model is also known as the proportional-odds model because the odds ratio of the event is independent of the category. The odds ratio is assumed to be constant for all categories. Exponentiated ordered-logistic regression coefficients can be interpreted as odd ratios, it is the ratio, given a one unit increase in the covariate, of the odds of being in a higher rather than a lower category. For this purpose, the STATA command *ologit* was used but it does not give the odd ratios. For calculating the odd ratios and predicted probabilities STATA macro was used known as SPost[12]. The ordered logit coefficients can be interpreted with regard to the cut points, which are given as Cut1 and Cut2 in (Table 4.15). In ordered logistic regression, Stata sets the constant to zero and estimates the cut points for separating the various levels of the response variable. The same set of explanatory variables is used that was used in exploring the determinants of entering

[12] SPost can be downloaded from this web-site: http://www.indiana.edu/~jslsoc/spost.htm

into and exiting from poverty. Table 4.15 reports the determinants of the poverty status during the survey period by using the OLR.

Table 4.15: Determinants of chronic and transient poverty

Covariates	Coeff	S.E	Odd ratios
Districts			
Faisalabad	Ref		
Attock	0.73*	0.34	2.07
Badin	1.58**	0.29	4.88
Dir	0.01	0.32	1.02
Hhold size	0.20**	0.04	1.22
No. of earners	0.05	0.08	1.05
No. of children	-0.05	0.06	0.95
No. of elders	-0.36**	0.14	0.70
Land ownership			
Yes	-1.27**	0.20	0.28
No	Ref		
Age of head	-0.00	0.01	1.00
Head is primary			
Yes	-0.84**	0.22	0.43
No	Ref		
Head is farmer			
Yes	-0.24	0.20	0.78
No	Ref		
Cut1	0.83	0.50	
Cut2	3.43	0.53	
R^2/Psedue R^2	0.19		
Log-likelihood	194.79		
No. of hholds	566		

*significant at 5% level, **significant at 1% level
Reference category for the dependent variable is 'never poor'.

It is clear from Table 4.15 that with an addition of one member in household size, the household is 22 percent more likely of being in chronic poor category versus transient and never poor, holding all other variables constant. Likewise, living in Attock and Badin increases the likelihood of belonging to chronic poor category versus transient and never poor as compared to living in Faisalabad. If the head of household is primary or more educated, the chances of belonging to chronic poor category versus transient and never poor decreases to 57 percent. The land ownership decreases the chances of a household to be chronically poor by 72 percent. The households with elderly people are 30 percent less likely to belong to chronic poor category.

ORL provides only one set of coefficients for each independent variable. Therefore, there is an assumption of parallel regression. That is, the coefficients for the variables in the equations would not vary significantly if they were estimated separately. The intercepts would be different but the slopes would essentially be the same. To test the proportional odds assumption i.e., whether the coefficients are equal across categories, the procedure *omodel*[13] has been used. The value for chi-square is obtained as (14.44), which is not significant with a probability 0.21. These results suggest that the proportional odds approach is reasonable, i.e., the multiple equation nature of ordered logistic regression with different constants and coefficients is an appropriate choice in the present situation. Generally speaking, it has been found that the determinants of chronic and transient poverty are same in rural Pakistan, similar kind of findings were also reported by Deininger et al. (2002) while working on Uganda by using the multinomial logistic regression.

In order to be able to derive more information from the estimated coefficients, the probabilities of the selection of important explanatory variables are calculated and presented in Table (4.16). The predicted probabilities for a household with a given characteristics of being in a particular category are calculated by holding other variables constant at their mean values.

Table 4.16: Predicted probabilities for three categories of the outcome variable

Covariates	Never Poor	Transient Poor	Chronic Poor
Farmer			
Yes	0.59	0.36	0.05
No	0.53	0.40	0.06
Primary			
Yes	0.70	0.27	0.03
No	0.50	0.43	0.07
Land			
Yes	0.67	0.29	0.03
No	0.36	0.52	0.12

Table (4.16) presents the predicted probabilities of the dichotomous variables in the model against three categories of the outcome variable. Being or not being in a farm-related occupation does not have any significant impact on the poverty status. The

[13] http://ideas.repec.org/c/boc/bocode/s320901.html

probability of belonging to never poor category is higher if the head is primary or more educated. Furthermore, the probability is lower of belonging to transient or chronic poor category if the head is primary or more educated. Similarly, the probability is higher for a household to be never poor if it possesses a land.

Results presented in Table 4.15 indicate a strong association between chronic poverty and bigger household size. It would be of interest to explore further this association with the change in household size. We estimated the probabilities for three categories of the outcome variable of a household changing its size from 4 to 30 members by using *prgen* command in STATA. The graph (Fig. 4.1) reveals a strong negative relationship between the household size and the poverty status by setting other covariates at their average values. It is clear from the graph that the probability of a household to never face poverty decreases with the increase in the household size. However, the probability to face chronic poverty increases with the increase in the household size.

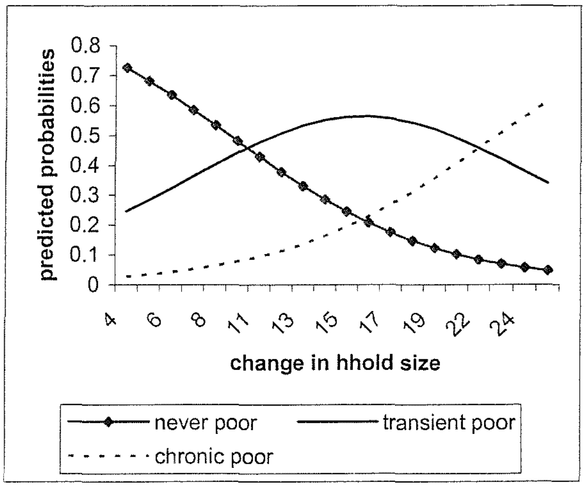


Fig. 4.1: Relationship between the status of well-being with the change in household size

4.5.4 Expenditure quintiles transition matrices

Although, Table 4.12 indicates that many more households moved out of poverty than moved into during 1986 to 1989, which is 44 percent as compared to 15 percent. The point of interest is here how the movements of households took place between various expenditure quintiles. Table (4.17a) reports the movements of households from one expenditure quintile to another quintile from Year I to Year II. This transition matrix allows considering the minor movements of entering or exiting from one quintile to another, even if the household is not changing its welfare state. In a similar way the expenditure quintile transition matrices between years II and III and between years I and III are constructed and given as Table 4.17b & c.

Table 4.17a: Expenditure quintile transition matrix between Years I and II

Expenditure Quintile Year I	Expenditure quintile Year II					Total
	Bottom Quintile	2	3	4	Top quintile	
Bottom quintile	**70**	23	9	7	6	115
2	22	**35**	42	10	4	113
3	21	27	**27**	29	13	117
4	4	15	23	**27**	40	109
Top quintile	3	7	12	35	**55**	112
Total	120	107	113	108	118	566

Table 4.17b: Expenditure quintile transition matrix between Years II and III

Expenditure Quintile Year II	Expenditure quintile Year III					Total
	Bottom Quintile	2	3	4	Top quintile	
Bottom quintile	**53**	32	18	14	2	119
2	29	**35**	21	14	8	107
3	11	30	**29**	19	21	110
4	8	11	30	**41**	21	111
Top quintile	6	11	13	33	**56**	119
Total	107	119	111	121	108	566

Table 4.17c: Expenditure quintile transition matrix between Years I and III

Expenditure Quintile Year I	Expenditure quintile Year III					Total
	Bottom Quintile	2	3	4	Top quintile	
Bottom quintile	**60**	24	21	8	3	116
2	20	**41**	22	17	11	111
3	13	32	**30**	27	15	117
4	3	17	21	**42**	**28**	111
Top quintile	6	6	15	31	53	111
Total	102	120	109	125	110	566

The transition matrix between Years I & II shows that about 40 percent of households (214 in number) remained in the same expenditure quintile in both years. These households are shown on the principal diagonal of the matrix by bold letters. The expenditure ranking of another 40 percent of households moved up or down by one quintile between years I and II. These households are shown by the grey-shaded cells in the transition matrix. Hence, 134 households moved into a richer expenditure quintile, while 107 households moved into a poorer quintile. The remaining 20 percent of households moved up or down by two or more expenditure quintiles, with 49 households moving up and 62 moving down. A small number (3) of households moved from the richest to the poorest quintile and 8 households from the poorest to the richest quintile.

By looking at Table 4.17b, it is evident that, again 40 percent households did not change their expenditure quintile from Years II to III. While, 93 houses moved into a richer quintile as compared to previous year and at the same time 104 households moved into a poorer quintile. There were 75 households, who moved into two or richer quintile during year II and III, while 60 households moved into two or more poorer quintiles. The rate is almost negligible of a household to move from the poorest to richest or richest to poorest quintile.

Similarly, from Years I to III, almost 40 percent households did not change their expenditure quintile. In total 101 households moved into a richer quintile and 104 moved out from a richer quintile during this period. While, 75 households moved into two or more richer quintile as compared to 60 households moved into two or more poorer quintiles. In summary, 31 percent households moved into a richer quintile and 29 percent moved into a poorer quintile during years I and III.

Generally speaking, there is much mobility within the expenditure quintile of a household from one year to the next in all the expenditure quintiles. However, most of these movements are not very large. There is relatively, little long-range mobility into richer or into poorer quintile during two years. As almost 40 percent of the households stay in the same quintile, while about 30-40 percent stayed in the neighbouring quintile and at the most in 20 percent cases households changed their quintile drastically. Thus, by considering household movements in terms of poverty from one year to next year does not indicate that the minor movements of households from one expenditure quintile to another are ignored.

4.6. Conclusions and discussion

The main findings of this chapter are listed below:

- ***How many are poor?*** Poverty was found widely spread in study areas and almost 29 percent of the households were living below the poverty line for the year 1986-87.

- ***Who are the poor?*** Poverty is found to be associated with factors like bigger household size while factors such as head's education, being in farm related occupation, landholding and elderly people reduce the chances of a household to be poor.

- ***Is poverty a static condition?*** The longitudinal nature of the data allowed exploring the change in poverty status in between years. It was found that almost 34 percent households have experienced poverty for at least one year and only 10 percent for the entire period of three years indicate that although poverty is wide spread but it is not as severe. Households where the head was educated at least up to primary and having land were very unlikely to move into poverty from Year I to II while larger household size contributes in chronic poverty. Households in Badin district had good chances of moving out poverty.

- ***Transition matrices based on expenditure quintiles:*** To trace the minor movements of households from one welfare state to other, expenditure transition matrices were constructed in between years. It was found that there were not very drastic movements of households from bottom to top quintiles and vice-versa in between the survey years.

4.6.1 Discussion

In the present study an attempt has been made to explore the dynamic characteristics of poverty by utilising the panel nature of data more effectively. The conventional cross-sectional data sets are less than ideal for analysing the issues concerning the dynamics of poverty, including its state of dependence and for dealing with certain problems of endogeneity (Ravallion, 1996). There has been some progress in analysing cohorts from repeated cross-sectional surveys. However there is still a high return to longitudinal data sets, particularly for the analysis of poverty dynamics as they help in understanding why some people do much better than others in escaping poverty.

The poverty phenomenon is not easy to analyse in view of several conceptual and measurement difficulties involved. No universally accepted definition and approach of poverty is available and similarly serious differences exist for the usefulness of various methods of measurement of poverty. However, poverty is a multidimensional concept which focuses on various aspects of deprivation, which can be viewed from both absolute and relative notions. In the least developed countries the relative concept is not appropriate because even a person having a median level of income may live in semi starvation condition, in such a situation the poverty needs to be worked out by absolute approach. Defining the basic needs and their minimum levels remain areas of much controversy. It is possible that generally, per capita expenditure in richer areas tends to be higher than per capita expenditure in poorer areas, the resulting poverty lines even when using the same benchmark calorie requirement, will tend to be higher in the former. While the difference may be due to the fact that prices are generally higher in the more progressive areas, preference for superior or more expensive sources of calories and other items of expenditure also pulls the poverty line upwards.

It has been demonstrated previously that in the study of poverty, the subject of nutrition is of primary interest for number of reasons. Firstly, food is the basic requirement to meet certain level of calories and above all for survival. Secondly consumption of essential nutrients at sufficient level leads to better health, which in turns leads to better earning opportunities. It also works the other way round, e.g., better earning means better chances of consumption of food and enough nutrients.

Nevertheless, poverty measurement should be based on a comparison of resources to needs, so a person or family is identified as poor if its resources fall short of the poverty threshold (Foster, 1998). In USA, the National Academy of Sciences Panel on Poverty measurement (NAS) recommended the basis for the official poverty thresholds for the US be expanded to include food, shelter and clothing and expenditure data should be used to develop a threshold. Previously in US the poverty approach was the monetary based. The current measure in US was originally developed during 1960s, which uses income as measure of welfare (see Constance et al., 1995).

In the present study, the use of absolute line is preferred, which is expressed in terms of consumption required to maintain a family in good nutritional health as to satisfy minimum conventional needs adopted by World Bank (1990). The consumption expenditure as welfare measure is selected instead of income, because in developing countries consumption expenditure is a better indicator of the current standard of living and also long-term average well-being. In the choice between income and expenditures, a number of issues should be taken into consideration. According to Sen (1992) income is an appropriate measure to use when the interest is in evaluating the capabilities of individuals to participate in society. On the other hand consumption is a better measure when one's interest is in assessing the standard of living. It has been argued that consumption is a more reliable indicator of the permanent material resources of individuals than income. There are various welfarist approaches based on demand analysis, including equivalence scales, which true to deal this problem. This study uses the equivalence scales especially derived by WHO. There are some who argue in favour of using the direct calorie intake method in working out the poverty. It is probably the easiest way of calculating poverty. Poor households are defined as those households with per capita energy intake less than the standard per capita requirement of energy. However, there are several arguments, such as this method measures undernourishment not poverty, which entails deprivation in all other aspects of welfare other than calorie intake.

The evidence of poverty across three-year period suggests that the issue of persistent or chronic poverty is of high relevance to the current socio-economic policies. The percentage of population that remains poor throughout the period under study[14] (10%) represents a high proportion of rural population remain poor during that period of time. On the other side 56 percent households were never lived below the poverty line and 34 percent lived for at least one year below the poverty line during this three year of period. This high mobility of households from one welfare state to other shows that to some extent households managed to move out from poverty after one year. So while the poor are always with us, most remain in poverty only temporarily or in other words, the poverty problem in Pakistan is not of chronic nature also reported by other studies (Baulch et al., 2003). McCulloch and Baulch (2000) while working on rural Pakistan by using the same IFPRI data conducted simulations to find out the effect of income

[14] This figure is exactly the same as also calculated by Baulch et al. (2003) by using the income as welfare measure by using the same dataset.

smoothing measures and increases in mean income on poverty reduction. It was found that income-smoothing measures would have a greater effect on poverty reduction than would an increase in mean incomes because of the large transitory component in total poverty.

Factors contributing a household to live below poverty line, factors contributing households to enter or exit from poverty and factors contributing households to be transient or chronic poor are almost uniform through out. There is strong evidence in saying that generally speaking poverty is related with social class and education. Household size, education level of head of household, landholding and region of residence are the strongest determinant of the state of well-being. The data do not provide any information about losing a job between two time points, got divorce or re-married, so such information could not be used in the present analysis. The information on the movements of households from one welfare state to another would be used in linking these movements with the changes in nutritional status of children in between time points. This aspect will be investigated in Chapter 6.

Some issues need to be resolved for further studies on the movements of households from one welfare state to another, such as the impact that measurement error has on existing estimates of poverty dynamics needed to be better assessed. The few studies that do exist suggest that its influence is pervasive and leads to an upward bias in the number of poverty transitions (Luttmer, 2001 and McCulloch et al., 2000).

In this study, like other studies on poverty dynamics, the movements of households over time are traced in between years not within year (i.e., inter-year not intra-year). A number of reasons of conducting inter-year analysis have been mentioned in Sec. 4.3.5. Although, by doing so we are not denying the importance of conducting intra-year poverty analysis. However, 'poverty' and 'not poverty' are not discrete states like, for example, employment and unemployment. Hence, a person who exits poverty may go from just below the poverty line to just above, with no real changes in living standards as a consequence. This fact has been demonstrated in Sec. 4.5.4, where the movements from one expenditure quintile to another over the period of time have been constructed. It was seen that although there were movements in between the expenditure quintiles, usually the magnitude of movements were of small in nature. Short-term poverty is a meaningful concept, while it is impossible to be poor for only one day, no matter how limited one's resources and quite possible to get by for a week in the face of limited resources. It has been seen that the shorter the accounting period, the higher the poverty rates. Therefore, poverty rates estimated on 4-month period are usually 1 or 2% greater than poverty rates estimated on yearly basis. No evidence is available about the extent to which short-term poverty measures might produce not only different levels but also different trends over time in comparison with an annual measure. However, if someone wants to develop a short-term poverty measure to supplement the annual measure a major issue would be to determine how short a period would be appropriate. The main argument against a monthly period is that it overestimates true hard-ship.

The next chapter is about household food consumption patterns. It discusses the major sources of nutrients acquisition from various sources of food, its relevance with income and the determinants of caloric and protein acquisition amongst the study households.

Chapter 5

Household food consumption patterns

As mentioned earlier that the thrust of this research is related with child nutrition. Nevertheless, there is a strong link between hunger and malnutrition. It has been hypothesised in Chapter 1 that child nutritional status is influenced by household factors. Hence, it seems prudent to extend the investigation from the previous chapter towards probing more in the household food consumption patterns. In the previous chapter a comprehensive picture of a typical rural household was presented. A link was found to be established between food, expenditure (proxy for money) and the poverty. It was shown that how the food-based poverty approach in absolute term seems to be an appropriate choice in the present study scenario. The present chapter specifically addresses the food and nutrient consumption at household level.

The research questions that are posed in this chapter are ***1)*** what are the major sources of nutrients from the food consumed by the study households? ***2)*** is there any link between the household food consumption patterns and the household expenditure? ***3)*** what are the determinants of caloric and protein acquisition? and finally ***4)*** what are the determinants of consuming inadequate calories?

The chapter starts by giving an introduction and background of the problem then the descriptive analysis of the household food consumption is presented followed by looking at the link between food consumption and the household expenditure. The next part of the chapter discusses the determinants of household food consumption by using the generalised estimating equation (GEE) and finally the chapter examines the factors affecting inadequate dietary intake.

5.1 Household nutrient consumption

5.1.1 Background

Poor nutrition is the immediate cause of a number of chronic diseases. A root cause of poor nutrition is the type of food consumed which can be a result of poverty. In the previous chapter, the food based approach was used to work out how many households were living below the poverty line in rural Pakistan. This is in accordance with the views of Deaton (1997) that this food based poverty approach seems to make sense especially in situations where people do spend more than two-thirds of their incomes (expenditures) on food. Even this share of food consumption does not fall down in the upper quintile of expenditures. This is why food availability needs to be evaluated within the context of poverty. The World Bank Position Paper on Poverty and Hunger (World Bank, 1986) added an "active level" concept to these goals, stating that "food security must assure access by all people at all times to enough food for an active and healthy life". The United Nations General Assembly in 1966 defined and formalised the right to food as a basic human right, which had already been mentioned in the Universal declaration of human rights of the United Nations in 1948.

The UNICEF's conceptual framework of child health that has been adapted in this study and which was outlined in Chapter 1, links food security along with other factors to the nutritional status of children. Indeed, food insecurity is a prime cause of undernutrition and about one fifth population of developing countries suffer from chronic undernutrition (FAO, 1992). Nonetheless, food security is a necessary but not a sufficient condition for nutrition security. Nutrition security can be defined as a balance between biological requirements in energy and nutrients and the quantity and quality of food consumed. Millions of chronically undernourished people are trapped in a vicious cycle, i.e., not getting enough food and therefore they are not able to lead a healthy life and as a result being unable to either produce or procure required food. Hence, the inter-relationship between poverty, hunger and food security is of particular importance.

The U.S. Agency for International Development (USAID) defines food security as "when all people at all times have both the physical and economic access sufficient to meet their dietary needs in order to lead a healthy and productive life" (USAID, 1992). There are three dimensions to this definition of food security: availability, access and utilisation of food. 'Availability' means that food is available to the population during a given period; 'access' means that the population is able to acquire food; and 'utilisation' means that the population has sufficient nutritients during a given period of time. Hence, there are various dimensions of food security and one of them is to look at the food consumption at household level. The aim of this chapter is to consider specifically the component *utilisation* in the perspective of food security in exploring the various factors affecting the nutrient consumption at household level.

5.1.2 Household food security

Food security at the household level may be measured by direct survey of dietary intake or food consumption. Nutrient consumption is calculated by using the food recall data at household level. Food quantities (consumed both from purchases, own production or received in-kind) are converted into nutrients by using the Pakistan Food Consumption Tables (Government of Pakistan, 1985). There are some potential disadvantages as to this method as discussed by Strauss et al. (1998). They argue that this method assumes that no food is wasted, i.e., everything that is available is converted into nutrients. Secondly, in surveys it is very difficult to take into account all meals that are not consumed by household members themselves but given to guests etc and all such meals eaten outside the house. To overcome such problems, they suggested the use of dietary intake rather than consumption.

In literature, one such example is available when the information was collected both by using 24-hour recalls and calorie availability from a recall of purchases for a month (Bouis et al., 1992). The survey was conducted over four rounds, and the household averages of daily recalls of calorie consumption in AEU were very similar with the food consumption based on a monthly recall. Therefore, in the absence of dietary data, the food consumption data can be used.

The IFPRI data contains information on food consumed by households. This information was collected at every round by asking questions on food consumed by the household members during the last week prior to the interview. The quantities of the food consumed have also been recorded which were then converted into nutritive values (calories and proteins) by using the Food Consumption Tables for Pakistan (Government of Pakistan, 1985). The food consumption comprises of food purchased from the market, food received as gifts and wages and the food consumed from own production.

Generally, the sampled households are consuming 2380 KCal in per capita[1] terms and 2741 KCal in AEU. Alderman and Garcia (1993) while working on the same Pakistan panel data mentioned that the caloric consumption in those parts of Pakistan is higher than in a number of neighbouring countries. Generally, during the last few decades, the caloric consumption in Pakistan has been increased from 1753 KCal per capita in 1961 to 2447 KCal per capita in 1998 (FAO, 2000). However, on the other hand, all previous studies present a high prevalence of malnutrition, particularly among children in Pakistan. This situation emphasises the need to explore the household food consumption patterns and its determinants.

Food data were collected on 38 food items. Owing to the large number of food items on the market, food must usually be grouped. There is no standardised system for the grouping but the main groups are cereals, meat, fish and vegetables. The inclusion of all commodities within a few main groups requires the combination of commodities that may be different in composition, use, and price.

In the present study the food items are divided into various food groups. The food grouping was done by keeping in mind the homogeneity between various food items, e.g., the group 'Cereals' comprised of wheat, maize and other cereals, 'Rice' included all types of rice, 'Legumes' comprised of all the pulses, 'Vegetables & fruits' comprised of fresh vegetables and fruits, 'Meat & fish' comprised of protein consumed from animal sources and it includes of meat, chicken and eggs, 'Milk' comprised of all sort of milk product, 'Fats' consisted of edible oil and ghee consumed, and 'Sugar' comprised of raw sugar consumed.

It is of interest to explore how much the share of calories and proteins in daily household food consumption do come from various food groups. We considered only two nutrients, calories and proteins. Tables 5.1 and 5.2 report the share in calories and proteins by food groups and regions.

[1] This figure is very closed to the one reported by Alderman and Garcia (1993), which was 2400 KCal per capita.

Table 5.1: Sources of calories (in %) by food groups and regions

Region	Cereal	Rice	Legumes	Veg & fruit	Meat & fish	Milk	Fats	Sugar	Total
Entire	34.3	28.3	1.5	1.4	1.5	12	11	10	100
Faisalabad	49	6	1	2	1	17	15	9	100
Attock	45.5	5	1.5	2	1	15	17	13	100
Badin	17	58.5	1.5	1	1	8	8	5	100
Dir	39.5	18.5	1.5	2.3	3	13.2	9	13	100

Table 5.2: Sources of protein (in %) by food groups and regions

Region	Cereal	Rice	Legumes	Veg & Fruit	Meat & fish	Milk	Total
Entire	43.5	24.5	3.5	1.5	6	21	100
Faisalabad	58.5	4.5	3.5	2.5	3	28	100
Attock	58.5	4.5	3	2	6	26	100
Badin	23.5	52	4	1.5	5	14	100
Dir	47	15	3.5	2.5	10	22	100

Note: The food groups fats and sugar are not mentioned as they do not provide proteins at all.

Although, mostly the people are consuming enough calories and proteins as far as the recommended daily allowance[2] (RDA) is concerned, but, by looking at what are they consuming, presents another scenario. For example, in the entire sample, meat, vegetables and fruits each contribute only one percent of the calories. For proteins only six percent share comes from meat. Nutritionists call such dietary patterns a poor quality diet. Poor quality diet means a diet that contains only a few animal products, fruits and vegetables and comprise primarily of staples, cereals or legumes (Allen et al., 1991). The diet eaten in the sampled households have very little diversity. Nevertheless, the food eaten is predominantly cereals with little or no intake of animal products and vegetables and fruits. Although, the caloric and the protein requirements have been met, the low consumption of meat and vegetables do suggest a deficiency of some micronutrients.

[2] Here 2550 Kcal in AEU is used as the caloric RDA in rural Pakistan (Khan et al., 1980)

Mostly, the food choices are centred on wheat and rice in Punjab, NWFP and Sind respectively. There is not much difference in the nutrient composition in wheat and rice, besides rice is not a good source of vitamin A. The consumption of milk products is quite high in these parts of Pakistan. This does indicate that most of the households are having enough livestock.

5.1.3 Link between diet and disease

The link between diet and various diseases has been emphasised in various studies. It has been suggested that perhaps 35 percent of all types of cancer may be linked to dietary factors (Doll & Peto, 1981). The protective effects of some dietary factors contribute to the difficulty in firmly establishing the link between cancer and diet. For example, a high fibre diet has been associated with low rates of colon and stomach cancer, vitamin C may protect against stomach cancer, and vitamin A against cancer of the lung and oesophagus (Kevany, 1984). Similarly, recommendations to eat a generous amount of vegetables and fruits (National Research Council, 1989) are supported by epidemiological data, primarily relating to cancer incidence. In more than 200 case-control or cohort studies, persons consuming higher amounts of these foods were less prone to various cancers (Doll & Peto, 1981).

Only one percent share in total calories comes from fruits and vegetables among the rural households in Pakistan. What possible consequences of this food consumption pattern can have on the health status of people in rural Pakistan? In the absence of any such study in Pakistan, we are unable to provide such evidence. However, a number of studies based on different countries have reported adverse consequences of consuming less vegetables and fruits on health later in life. A comparison of the dietary habits in United States as compared to Greece and Japan in the 1960s, shows that grains, legumes and other vegetables formed the basic diet in Japan and Greece (Willett, 1994). The consumption of red meat and eggs were not very frequent. On the other hand the dietary habits in U.S. were almost reversed. However, the incidence of diseases like coronary heart diseases in Japan and Greece were very low in comparison with U.S.

Although, our data do not provide information about the maternal dietary consumption during pregnancy, the general household dietary pattern suggests that maternal diet may also comprise a very low portion of animal products. In a study in Kenya and Mexico, it was seen that maternal diet variables, particularly the energy from fat and animal source proteins predict the size of toddlers indicating that household diet is one of a constellation of factors that affects child development (Calloway et al., 1988).

5.1.4 Link between food consumption and household socio-demographic factors

It is vital to find out which household level factors have an impact on the food consumption pattern in rural areas of Pakistan. Table (5.3) presents the average caloric and protein consumption by various household characteristics. It seems that the caloric and protein consumption decrease with the increase in household size, e.g., the caloric consumption in households with the household size more than 15 members decreases up to 35 percent as compared to households with household size 5 or less (Table 5.3). The descriptive statistics show that mother's education seems to have more profound effects on household food acquisition than the husband's education. Further, the caloric and protein consumption increases with the increase in mother's education.

The caloric and protein acquisition changes dramatically with the type of profession of the head. It is more likely that if the head is in farm related occupation then the household food acquisition is highest as compared to any other profession. If the head is unemployed then it decreases the food consumption. The regional variation can be seen in the caloric and protein consumption. The caloric and protein consumption seems to be highest in districts Faisalabad and Attock and lowest in Dir district.

Table 5.3: Food consumption by household socio-demographic factors

H'hold characteristics	Average caloric cons[1] (SD)	Average Protein cons[2] (SD)
H'hold size		
- 1-5	3529 (2323)	93 (65)
- 6-10	2763 (1138)	73 (35)
- 11-15	2390 (957)	62 (29)
- 15+	2311 (904)	60 (24)
Wife's edu.		
- Primary or more	3541 (1690)	98 (50)
- Below Primary	2862 (1565)	75 (45)
Head's edu.		
- Primary or more	3091 (2076)	83 (58)
- Below Primary	2784 (1227)	72 (37)
Head's occupation		
- Farm related	2988 (1363)	78 (41)
- Service	2818 (1963)	75 (56)
- Business	2811 (2416)	75 (61)
- Unemployed	2524 (1413)	66 (40)
- Others	2553 (1428)	68 (43)
District		
- Faisalabad	3222 (1505)	91 (46)
- Attock	3281 (2491)	90 (69)
- Badin	2852 (813)	66 (22)
- Dir	2415 (1187)	67 (35)

Note: h'hold stands for household and edu. stands for education.
[1]Caloric consumption in AEU (KCal)
[2]Protien consumption in AEU (gm)

5.1.5 Seasonality and food consumption

Because cereals and rice dominate rural households' diet, their distinctly seasonal production drives seasonal movements in food prices and consumption. Hence, it may be hypothesised that the household food consumption in rural parts largely depends on the food availability and the harvesting and planting seasons of staple foods. Table 5.4 reports the cropping season of the main staple wheat with the average caloric acquisition for these seasons.

Table 5.4: Share of caloric consumption by cropping and harvesting seasons of wheat*

Cropping season (wheat)	Caloric consumption+
Harvesting	2296 (2786)
Post harvesting	2542 (3097)
Pre harvesting	2270 (2759)
Planting[1]	2535 (3076)
Pre-planting	2398 (2913)

*The detail of rounds associated to various harvesting seasons are as below:
Harvesting: 5, 8 & 11; Post harvesting: 6; Pre harvesting: 4, 7 & 10; Planting: 2 & 3 and Pre-planting: 1, 9 & 12.
[1]Rice harvesting season as well
Figures in parenthesis are for caloric consumption in KCal in AEU terms.
+It is in per capita

The variations in caloric acquisition patterns can be seen by cropping seasons of wheat. It seems that the caloric acquisition goes up immediately after the harvesting of wheat. It is because, the households have enough wheat to consume both from own production and also from market. The lowest caloric consumption can be seen during pre-harvesting period when the availability of food is usually very poor. During the planting of wheat, the caloric consumption did not go down, as the same time the harvesting of rice takes place. Hence, households start eating rice instead of wheat. There is also seasonal variation in prices which explains this seasonal variation in food consumption. In the post-harvest season when staples fall in prices it may make sense for households to stock up on staples, that is to say acquiring enough calories when it is relatively cheap to do. This pattern does indicate the presence of seasonal variation in the caloric consumption in rural Parts of Pakistan.

5.1.6 Income and food acquisition

There is a great debate in the literature on whether caloric consumption increases with income. The general understanding is that food insecurity and hunger are primarily the result of poverty. It has been hypothesized that with the increase in income (expenditure), the households start acquiring more adequate diet, which results in acquiring more calories. The income elasticity with respect to food expenditure exceeds the elasticity for calories among poor households considerably. Even people at low-income levels want to increase the variety and quality of their diets. As a result the poor buy more expensive foods per calorie as their income rise (Alderman, 1986).

Higher income levels are usually regarded as a prerequisite for the improved nutritional status of households. However, there are numerous studies that conclude that increases in income will not result in substantial improvements in nutrient intakes (Bouis, 1994; Bouis et al., 1992; Garcia, 1990; Behrman et al., 1987). However, spending on food may increase the quantity of food but not necessarily the quality of food (in terms of acquiring balanced diet). Because family income is difficult to measure precisely in large scale surveys, the total monthly household expenditure[3] was used as a proxy for income. Table 5.5 reports the caloric consumption in AEU with expenditure quintile (AEU).

Table 5.5: Calories in AEU per day, by expenditure quintile (in AEU)

Region	Expenditure Quintile				
	1	2	3	4	5
Entire	1969 (164)	2417 (164)	2776 (164)	3176 (164)	4106 (164)
Faisalabad	1945 (33)	2559 (33)	2963 (33)	3397 (33)	4361 (33)
Attock	1544 (34)	2429 (34)	2928 (34)	3450 (34)	4903 (34)
Badin	2403 (49)	2690 (49)	2969 (49)	3272 (49)	3740 (49)
Dir	1428 (48)	2020 (48)	2400 (48)	2733 (48)	3268 (48)

Note: Numbers in brackets are the number of households.

The households in the lowest expenditure quintile consume almost half the calories compared to those in the highest quintile. Nevertheless, the calorie consumption of the poor is substantially lower than that of rich, it leads to the view that poverty is characterised by a low absolute intake of calories. This trend can also be observed from Fig (5.1).

[3] Chapter 4 discusses in detail the computation of household expenditure.

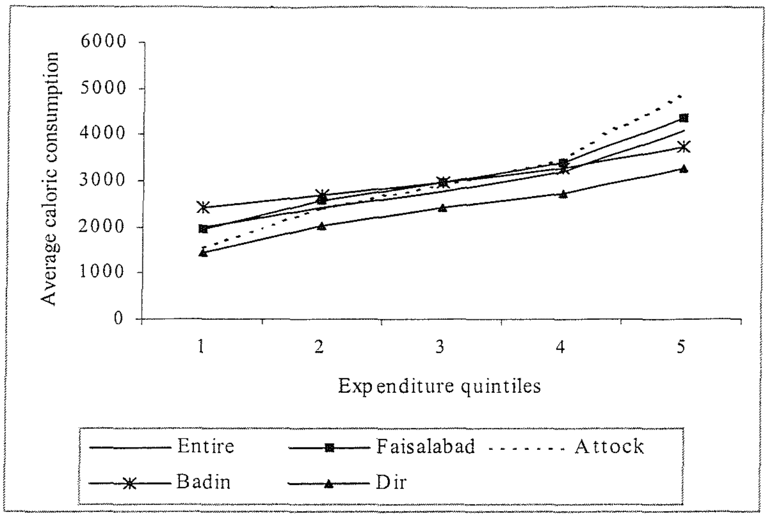
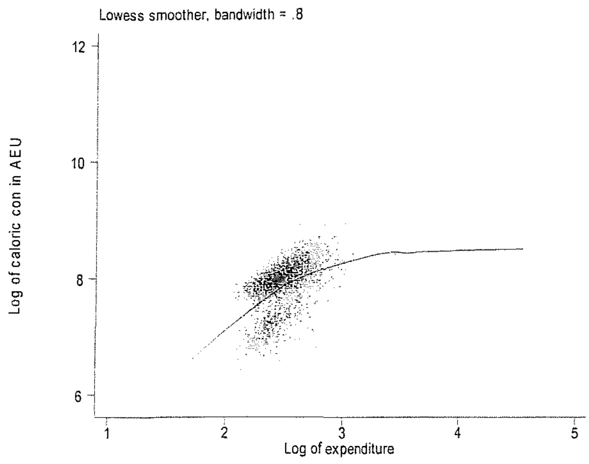
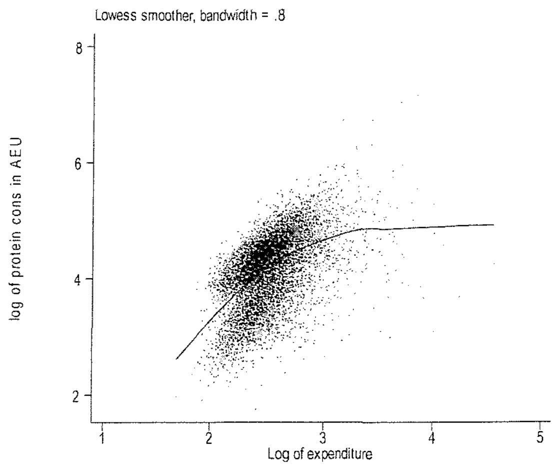


Fig. 5.1: Average caloric consumption by expenditure quintiles: a regional comparison

To look at the mean trend of per head caloric and protein consumption (in AEU) with per head household consumption expenditure (in AEU), the lowess smooth curves are plotted Fig (5.2). The graph shows that caloric consumption increases with the increase in income up to a certain point and then it comes down and finally it stabilises at a certain caloric level. Nevertheless, the curves slope upwards because we assume greater income/expenditure is translated into more calories, but may tail off once an adequate level of calories has been achieved after some level of expenditure. When household income goes up, calorie availability within the household may be maintained more or less constant through substitutions within and between food groups. Similar findings were reported by Behrman et al. (1987). They could not reject the hypothesis that there is no link between caloric intake and household expenditure while working on rural India.



a) Caloric consumption with expenditure



b) Protein consumption with expenditure

Fig. 5.2: Lowess curve of caloric and protein consumption in AEU with household expenditure in AEU

Another area of interest is exploring the diversification in diet with the increase in household expenditure. It is usually believed that the consumption of cereals actually goes down as income increases. Hence, it can be hypothesised that most of the caloric share in diet of richest households come from sources like vegetables, fruits and meat products. Table 5.6 reports the share of calories from food groups by expenditure quintile.

Table 5.6: Percentage share of calories from various food groups by expenditure quintile

Exp Quin[1]	Cereal	Rice	Legumes	Veg & fruit	Meat & fish	Milk	Fats	Sugar	Total
1	33.5	31.5	1.5	1.2	1.3	10	12	9	100
2	34.5	29.5	1.5	1.2	1.3	11	12	9	100
3	34.5	28.5	1.5	1.3	1.2	12	11	10	100
4	33.5	26.5	1.5	1.5	2	13	12	10	100
5	33.5	25.5	1.5	1.5	2	14	12	10	100

[1]Expenditure quintile
Figures are in percentages

The relative contribution of calories from the various food groups is fairly stable across each of the five expenditure groups. This pattern suggests that in these regions, as income increases, people are consuming more of the same diet rather than changing to a different mix of foods. From the table, it can be observed that the major source of calories comes from staple diet in all the expenditure quintiles. The food budget allocation for the entire sample indicates that cereal (included rice) accounted for over 60 percent of total food expenditures while vegetables, fruits and meat only over 1 percent.

This food consumption pattern does indicate that higher income not necessarily translates into consumption of a balanced diet in rural Pakistan. It has been demonstrated that with high income levels in the industrial countries, nutritional intake and health status can deteriorate because of the rise in the consumption of 'junk food' that often accompanies rising income (Edwards et al., 1979). This scenario presents a situation where although, on one hand, poor households are not consuming enough calories, on the other, affluent households are not necessarily consuming a balanced diet.

Results obtained from both the Tables 5.5 and 5.6 suggest that with the increase in income, the overall caloric consumption also increases, but no evidence is found that increase in income also improves the overall quality of diet[4]. This finding is contrary to that of Behrman (1995), who stated that as income increases, people purchase more expensive foods that are richer in micronutients than the staples. A number of studies have suggested that as income rises, the households mostly purchase additional taste that does not necessarily mean a higher quality food (Behrman et al., 1988; Behrman et al., 1987).

There is now a consensus that total caloric availability provides only limited insight into how the availability of micronutrients within households responds to changes in income. However, when household income drops, calorie availability within the households may be maintained more or less constant through substitutions within and between food groups, while the consumption of essential micronutrients may decrease as the households consume less meat, vegetables, eggs and milk (Behrman, 1995).

[4] That is people may switch to higher value foods that are not necessarily be rich in their caloric composition.

5.1.7 Link between food and poverty

If households are spending most of their income on obtaining food, then households may achieve temporary food security at the cost of substantial asset disposal and future indebtedness. Similarly, if a household uses all its resources in meeting the food demands, may face food insecurity in the future as compared to households which use small amounts of their resources in maintaining the current food security. It has been seen in Chapter 4 that the households generally spend almost 70 percent of their budget on food. When the proportion of food expenditure relative to the total expenditure was plotted against the expenditure quintiles, it was found that spending on food decreases with the increase in the expenditure quintile. Hence, households, which belong to the lowest quintile, spend most towards their food (Fig. 5.3).

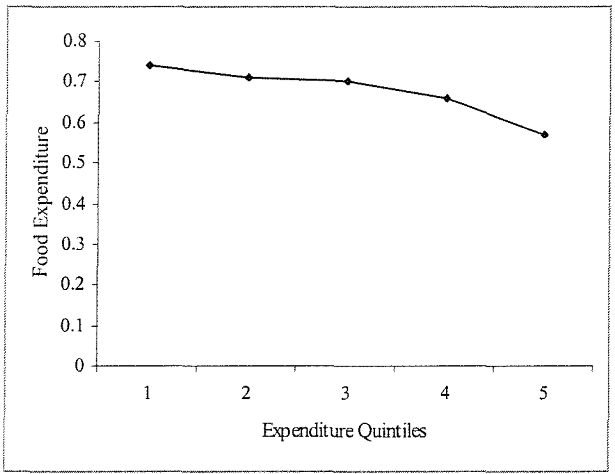


Fig. 5.3: Proportion of food expenditure relative to the expenditure quintiles

In this situation, the food-based poverty approach seems to make sense. One attractive definition of poverty is that a person is poor when he or she does not have enough to eat or in economic terms when they do not have enough money to buy the food that is required for basic subsistence (Deaton, 1997). Hence, in a condition like in Pakistan where people spend more than two-thirds of their incomes on food, a hunger or food based definition of poverty makes sense (Deaton, 1997). Even this share of food consumption does not fall down significantly in the upper quintile of expenditures. The relationship between nutrient intake and expenditure in poor countries is the link between economic development and the elimination of hunger. In other words one may think that food is the first necessity and people whose income does not permit them to buy enough food would spend almost everything on food.

5.2 Determinants of nutrient consumption

In the last section it has been seen how the nutrient acquisition changes with the household socio-demographic composition. This section discusses the determinants of caloric and protein acquisition among the households in rural Pakistan. The understanding of the determinants of nutrient intake and the influence of nutrition on performance is critical in designing policies to alleviate hunger and malnutrition (Behrman et al., 1988).

Generalised estimating equation (GEE) techniques are used to look at the determinants of nutrient consumption. As, mentioned earlier the two nutrients that are considered in this study are caloric and protein consumption in AEU terms. Although, other micronutrients are also important for specific nutritional concerns, food policy analysis usually examines calories and proteins because deficiencies in these are highly related with malnourishment (Garcia, 1990). In the following section, an introduction of the generalised estimating equation (GEE) is presented.

5.2.1 Generalised estimating equation (GEE)

Models for the analysis of longitudinal data can be considered a special case of generalised linear models, with a peculiar feature that the residuals terms are correlated, as the observations at different time points in a longitudinal study are taken on the same subject. The analysis of clustered data is complicated by the correlation that typically exists among responses. However, traditional regression methods assume that all outcomes are independent. It is the extension of quasi-likelihood to longitudinal data analysis. The method is semi-parametric. GEE method is generally used to estimate population-averaged effects.

The GEE as proposed by Liang & Zeger (1986) and Zeger and Liang (1986) form the basis for a regression methodology that accounts for correlated outcomes. They introduced generalised estimating equation (GEE) to account for the correlation between observations in generalised linear regression models. One aspect of their approach builds upon previous methods of variance estimation developed to protect against inappropriate assumptions about the variance (Huber, 1967; White, 1982). GEE is used to characterise the marginal expectation of a set of outcomes as a function of a set of study variables. In a marginal model the analyst is interested in modelling the marginal expectation as a function of explanatory variables. The method accounts for the correlation between observations in generalised linear regression models by use of empirical (sandwich/robust) variance estimator. It allows between subject comparisons. It uses moment methods to estimate covariance. In using GEE, we need to specify a model for the mean, for the covariance and we need to choose variance from Gaussian, Poisson or binomial distributions and also decide the correlation structure.

With a single observation for each subject ($n_i = 1$), a generalised linear model (GLM) can be applied (McCullagh & Nelder, 1989) to obtain such a description for a variety of continuous and discrete outcome variables. GLMs are a standard method used to fit regression models for univariate data that are presumed to follow an exponential family distribution. With longitudinal data, however the correlation among values for a given subject must be taken into account (Liang & Zeger, 1986).

Consider the GEE models given below, as introduced by (Liang & Zeger, 1986).

$$g(\mu_i) = g(E[Y_i]) = x_i^/ \beta$$

where x_i is a p x 1 vector of covariates for the ith subject, and β is a p x 1 vector of regression parameters. This link function relates a monotone differential function of μ_i to $x_i^/ \beta$. GLM allows for linear as well as non-linear models under a single framework. It is possible to fit models where the underlying data are normal, inverse Gaussian, gamma, Poisson, binomial, geometric and negative binomial by suitable choice of the link function g (.). The estimate of β and their standard error will be consistent (i.e., unbiased for large sample size), and if the specification of the covariance matrix V_i is correct they will be efficient (i.e., minimum variance). Describe the variance of Y_{ij} as a function of the mean

$$V(Y_i) = V(\mu_i)\,\phi$$

ϕ is possibly unknown dispersion parameter and V (.) is the variance function that is determined by the specific probability distribution.

a). Estimating marginal mean model

The GEE estimator of β is found as the solution to the generalised estimating equation

$$\sum_i D_i' V_i^{-1} k_i = 0$$

where $k_i = (Y_i - \mu_i)$

where $\mu_i = g^{-1}(X_i \beta)$ and $D = \frac{\partial \mu_i}{\partial \beta_i}$

This equation in a more familiarised form can be expressed as

$$S_\beta(\beta) = \sum_{i=1}^{m} \left(\frac{\partial \mu_i}{\partial \beta} \right)^j \text{var}\,(Y_i)^{-1}(Y_i - \mu_i) = 0$$

The extra term generalised distinguishes these as estimating equations that accommodates the correlation structure. The quantity $S_\beta(\beta)$ can be viewed as a multivariate version of the quasi-score function first proposed by Wedderburn (1974). This equation can be used to estimate the regression coefficients for any choices of link and variance functions, whether or not they correspond to a particular member of the exponential family.

The solution to the GEE gives a consistent estimate of β that is asymptotically multivariate normal with a covariance matrix. The maximum likelihood estimator of the p x 1 parameter vector β is obtained by solving the estimating equations (as given above) for β and it can be solved iteratively by the Fisher scoring or Newton-Raphson algorithm. In MLE, the score equations are the slope of the log-likelihood and finding where the slope is zero is equivalent to finding the maximum. GEE is the maximum likelihood score equation for multivariate Gaussian data and for binary data from a log-linear model when V (Y_i) is correctly specified.

The GLM estimating equations are obtained by maximising the likelihood function of the exponential family (McCullagh & Nelder, 1989). Liang and Zeger (1986) demonstrated that provided D_i, V_i, and k_i are evaluated at consistent estimators of α and

ϕ. The solution $\hat{\beta}$ to the GLM estimating equations is asymptotically multivariate normal with mean equal to β and covariance matrix

$$\sigma^2 \left[D_i' V_i^{-1} D_i\right]^{-1}$$

This covariance matrix is consistent even if V_i is specified incorrectly.

b). Estimating working correlation matrix

In addition to this marginal mean model, we need to model the covariance structure of the correlated observations on a given subject. The covariance matrix of $\mathbf{Y}_i$ has the form $\sigma^2 \mathrm{V}_i$, where

$$V_i = \{\text{diag } [V(\mu_{i1}), \cdots, V(\mu_{in_i})\}^{1/2} \times R_i \{\text{diag } [V(\mu_{i1}), \cdots, V(\mu_{in_i})]\}^{1/2} \tag{5.1}$$

where R_i is a correlation matrix among the outcomes measured at different times on the same individual. The covariance matrix of all N outcomes $Y_i = [Y'_1, \cdots, Y'_i]'$ is block diagonal $\sigma^2 \mathrm{V} = \sigma^2$ diag $[V_1, \ldots, V_I]$. The equation can also be expressed as

$$V_i = \phi A_i^{1/2} R(\alpha) A_i^{1/2} \tag{5.2}$$

which will be equal to cov $(\mathbf{Y}_i)$ if R (α) is indeed the true correlation matrix for the $\mathbf{Y}_i$ then V_i will be the true covariance matrix of $\mathbf{Y}_i$. Where $\mathbf{A}_i$ is a diagonal matrix of variance functions $\boldsymbol{v}$ $(\boldsymbol{u}_{ij})$ as the jth diagonal element as defined in (5.1), and $\boldsymbol{R}$ $(\boldsymbol{\alpha})$ is the working correlation matrix of $\mathbf{Y}_i$ indexed by a vector of parameters α, ϕ is a GLM dispersion parameter. The working correlation matrix is not usually known and must be estimated. It is estimated in the iterative fitting process using the current value of the parameter vector β to compute appropriate functions of the Pearson residual

$$e_{ij} = \frac{y_{ij} - \mu_{ij}}{\sqrt{v(\mu_{ij})}}$$

while the dispersion parameter is estimated as

$$\hat{\phi} = \frac{1}{N - p} \sum_{i=1}^{m} \sum_{j=1}^{n_i} e_{ij}^2$$

where N is the total number of measurements and p is the number of regression parameters.

Zeger and Liang (1986) referred to $\mathbf{V}_i$ as a working matrix because it is not required to be correctly specified for the parameter estimates and the estimated variance of the parameter estimates in marginal regression model to be consistent. However, they showed that there can be important gains in efficiency realised by correctly specifying the working correlation matrix. In fact the GEE approach treats the time dependency as a nuisance and a working correlation matrix for the vector of repeated observations from each subject is specified to account for the dependency among the repeated observations. The working correlation is assumed to be the same for all subjects, reflecting average dependence among the repeated observations over subjects.

Several working correlation structures can be specified including independent, exchangeable, autoregressive and unstructured. An independent working correlation assumes zero correlations between repeated observations. An exchangeable working correlation assumes uniform correlations across time. An autoregressive working correlation assumes that observations are only related to their own past values through first or higher order autoregressive (AR) process. If the mean model is correct, the correlation structure may be misspecified, but the parameter estimates remain consistent.

The choice of which correlation structure to select is important. Generally if the number of observations per cluster is small in a balanced and complete design then an unstructured matrix is recommended. If observations are mistimed then a structure that accounts for correlation as a function of time (stationary or auto-regressive) is recommended. For datasets with clustered observations there may be no logical ordering for observations within a cluster and an exchangeable structure may be most appropriate. If the number of clusters is small then the independent may be best. Comparisons of estimates and standard errors from several different correlation structures may indicate sensitivity to misspecification of the variance structure.

For the present analysis, the structure of working correlation matrix used in GEE is exchangeable with an identity link function. For data sets with clustered observations, an exchangeable structure may be most suitable (Horton et al., 1999). It has been seen that the use of the exchangeable working correlation matrix with measured data and identity link function is equivalent to a random effects model with a random intercept per cluster. Hence, we have specified exchangeable correlation structure with an identity link function in the analyses presented in this chapter. The dependence between repeated observations is taken into account by robust variance estimation.

5.2.2 Results of the determinants of nutrient consumption by using GEE

This section discusses the results of the determinants of caloric and protein consumption at household level by using GEE. The analyses are carried out by using the *xtgee* command in STATA (Stata, 2001). The dependent variables are log of caloric and log of protein consumption in AEU. On the right side of the equation, besides specifying other controlled variables, we also specified log of household expenditure in AEU. The advantage of using log-log specification is that the coefficients of log expenditure are the caloric-expenditure elasticities, i.e., the percent change in the dependent variable, given the percentage change in household expenditure (Hoddinott et al., 2002). A number of household's related covariates are added in the model that are thought to be related with nutrient acquisition at household level. These covariates included log of household expenditure in AEU, husband's and wife's education, husband's occupation, consumption from own production, wife's age, household size, number of visitors who ate food with the visiting household during last week (prior to survey), prices of some district food items[5], dummies for regions and survey rounds. Table (5.8) reports the results obtained from the generalised estimating equation (GEE) while the descriptive statistics of the variables used in the regression analysis have been reported in Table (5.7). Means and SD are reported for continuous variables, and frequency distributions for categorical variables. If the correlation between two variables is found high then only one variable has been retained in the model. Simple correlations between variables in the GEE model did not have to exceed 75% (correlation coefficient less than 0.75).

[5] Readers are directed to read Chapter 4 for a complete description of the price data.

Table 5.7: Descriptive statistics of the variables used in the GEE model

Covariates	No. of cases	Mean	SD
Log of caloric cons	9950	7.85	0.49
Log of protein cons	9950	4.18	0.57
Log of h'hold expenditure	9950	5.51	1.50
Own production	9950		N/A
Yes	6965	70	
No	2985	30	
Head is primary or more	9950		N/A
Yes	3393	34	
No	6557	66	
Head's occupation	9922		N/A
Service	1213	12	
Business	801	8	
Unemployed	275	3	
Others	1199	12	
Farm related	6434	65	
H'hold size	9950	8.12	4.13
Wife[1] is primary or more	9950		N/A
Yes	400	4	
No	9550	96	
Wife's[1] age (years)	9165	40.92	12.39
No. of visitors[2]	9950	0.54	0.79
District prices (Rs[3]) of:			
Rice	9920	4.00	0.12
Sugar	9929	5.00	0.82
Wheat	9941	3.00	0.23
No. of hholds	850		

Note: Means and SD are reported for continuous variables, and percentages for categorical variables.
[1]Senior female in the household, usually the wife of the head of household.
[2]Number of visitors who ate with household last week.
[3]Rs stands for Rupee which is a Pakistani currency.
N/A stands for not applicable.

Table 5.8: Determinants of caloric and protein acquisition; results obtained from GEE

Covariates	Caloric acquisition Coeff (Semi-robust SE)	Protein acquisition Coeff (Semi-robust SE)
Log of h'hold expenditure	0.859 (0.036)**	0.967 (0.041)**
Head is primary or more		
Yes	0.005 (0.017)	0.012 (0.019)
No	Ref	Ref
Head's occupation		
Service	-0.100 (0.024)**	-0.119 (0.029)**
Business	-0.063 (0.028)*	-0.063 (0.032)*
Unemployed	-0.087 (0.062)	-0.100 (0.072)
Others	-0.096 (0.028)**	-0.119 (0.032)**
Farm related	Ref	Ref
H'hold size	-0.015 (0.002)**	-0.013 (0.002)**
Wife is primary or more		
Yes	0.107 (0.029)**	0.136 (0.033)**
No	Ref	Ref
Wife's age (years)	0.001 (0.000)*	0.001 (0.001)*
Own production		
Yes	0.275 (0.021)**	0.369 (0.026)**
No	Ref	Ref
No. of visitors	0.001 (0.000)*	0.002 (0.001)*
Districts:		
Attock	-0.013 (0.026)	-0.042 (0.030)
Badin	0.097 (0.024)**	-0.068 (0.026)**
Dir	-0.197 (0.026)**	-0.209 (0.030)**
Faisalabad	Ref	Ref
Rounds:		
Round 1	Ref	Ref
Round 2	0.068 (0.014)**	0.043 (0.016)**
Round 3	0.018 (0.016)	-0.026 (0.018)
Round 4	-0.017 (0.016)	-0.077 (0.018)**
Round 5	-0.035 (0.017)*	-0.081 (0.019)**
Round 6	0.098 (0.016)**	0.066 (0.019)**
Round 7	-0.008 (0.018)	-0.076 (0.020)**
Round 8	-0.110 (0.019)**	-0.182 (0.022)**
Round 9	-0.019 (0.019)	-0.008 (0.021)
Round 10	-0.114 (0.019)*	-0.130 (0.021)**
Round 11	-0.103 (0.022)**	-0.172 (0.023)**
Round 12	-0.045 (0.019)*	-0.085 (0.022)**
District prices of:		
Rice	-0.001 (0.003)	-0.002 (0.003)
Sugar	0.012 (0.005)**	0.003 (0.006)
Wheat	-0.030 (0.022)	-0.051 (0.026)*
Intercept	5.570 (0.122)**	1.762 (0.143)**
No. of hholds	850	850

*significant at 5%, **significant at 1%
Standard errors are given in parenthesis.

As far as the main factor is concerned, i.e., the household expenditure in AEU terms, it came out significant. There is a strong suggestion that with the increase in household expenditure the nutrient consumption also increases. Recall from Section (4.3.1) from Chapter 4 that the share of food expenditure is almost 70 percent. The coefficients of log expenditure for caloric and protein acquisition are 0.86 and 0.97 respectively. It means that 1 percent increase in expenditure is associated with 0.86 percent increase in caloric consumption (AEU). Similarly 1 percent increase in expenditure is associated with 0.97 percent increase in protein consumption. Higher caloric-expenditure elasticity indicates that even the poor households have a tendency to shift to higher priced sources of calories as income increases. The elastic estimates also indicate that elasticity of protein is higher than that of calories, however, the preliminary analysis presented earlier in this chapter indicates that most of the protein share does not come from meat.

As far as the education of head of household is concerned, it does not have any impact on nutrient consumption. But, wife's education does have positive and significant impact on nutrient consumption. In rural Pakistan setting, the kitchen matters are usually taken care of by women, i.e., what to cook and how to cook. Hence, if a woman is educated at least to primary level, she can decide what kind of food can contribute towards the better nourishment of the household members. A number of studies have outlined the importance of mother's role in household productivity (e.g., see Becker, 1981b). Some studies have indicated that mother's education may play an important role in determining household nutrition and health (Behrman and Wolfe, 1984b). Some of the studies suggest that the schooling of mothers is a partial proxy for unobserved family endowment (Behrman et al., 1980, Behrman & Wolfe, 1984b). The quantity and quality of the consumption of foods by individuals depends on the mother's decision-making status, her access to information, her time burdens, and her education. We also tried including 'if mother is literate' and found that it does not have any impact on food acquisition.

The impact of mother's (or senior wife) education on household's caloric and protein acquisition can be estimated as $e^{0.107}$ and $e^{0.136}$ for calories and protein respectively. This yields 1.112 and 1.146 or in other words the caloric and protein consumption increases by 11 and 15 percent respectively if mother is educated up to primary, holding other variables constant. These results indicate a significant and positive impact of mother's education on household food consumption behaviour.

On similar lines, the impact of own production on caloric and protein acquisition can be estimated. For instance, in the table (5.8) the effect of consuming from own production on the caloric acquisition is 0.275, exponentiating, we obtain 1.32. It means that households who consume food from their own production, acquire 32 percent more calories than those who do not consume food from their own production. On similar lines, such households are found to acquire 45 percent more proteins who consume food from own production ($e^{0.369} = 1.45$). Nevertheless, the results of own production on caloric and protein consumption indicate a positive and significant association. These results are in accordance with a study done in South Africa where it has been found that households with home production had lower odds of being in the food poverty or in low energy availability or in food insecure groups compared to those households with not home production (Rose et al., 2002). However, readers must be cautious in interpreting the results of own production as this variable is an 'objective variable' which only says that whether a household consumes food from own production or not. It does not provide any information about the quantity and quality of food and its monetary value. Nevertheless, this aspect needs some further research.

Food insecure households in different areas may belong to different socio-economic and demographic groups. Food deficient households tend to be larger and to have a higher number of dependants and a younger age composition. Larger households tend to have lower consumption of calories and proteins. The World Bank (1975) cites three studies which indicate a negative correlation between family size and average nutrition in Nigeria, Thailand and India. The results indicate a negative association between household size and caloric and protein acquisition. It means that bigger the household size, less the food consumption which in turn reduces the caloric and the protein acquisition in such households. We also tried including some household demographic variables such as, number of elderly, proportion of children and proportion of male and female adult children in a household.[6] However, besides household size no other demographic variable came out significant.

There is a suggestion that if the head is in a farm related profession, the chances of consuming more nutrients are higher than for households in any other profession. This is consistent with the observation that 70 percent of the households consume food from

[6] Eventually these variables were taken out from the model.

their own production. On the other hand, outside farm related occupation, the purchasing power of households may be low so that food consumption is reduced.

It can be hypothesised that changes in food prices are likely to alter the composition and level of nutrient intake, increasing the nutrient intake of some nutrients and reducing consumption of others. About the impact of prices on the consumption of essential food items, it is found that with the increase in sugar prices, the caloric consumption also increases. With the increase in wheat prices, the protein consumption decreases and with the decrease in wheat prices the protein consumption increases.

Some of the food recorded in the survey is consumed by visitors not household members. It may be hypothesised that the net effect of visitors is negligible because amounts of foods recorded by households acquiring more food to feed visitors are counterbalanced by amounts recorded by households acquiring less food because they have members visiting other households. To see whether there is any impact of visitors on acquiring nutrients, we included this variable in the regression equation. The number of visitors is found to have significant and positive impact on the household nutrient acquisition. From Table (5.8), it can be seen that the standard deviation corresponding to 'visitors' is very small (0.79). Hence, the effects of the variable 'visitors' on caloric and protein consumption are very small and they are not of substantive importance in looking at the determinants of food consumption. This finding is in accordance with the results obtained previously by Bouis et al. (1992) and Alderman et al. (1993).

It is crucial to monitor changes in diet constantly with time. It has been observed earlier in this chapter that the caloric acquisition follows a seasonal component. Due to this reason, a dummy for every round is included in the model to pick up if there are any seasonal related effects. It seems that the caloric consumption increases during summer (round 6) and autumn (round 2), while decreases during winter (round 10) and spring (rounds 8 & 11). One possible explanation can be given by considering the planting and harvesting season in Pakistan. The harvesting season of wheat is started in spring (April to May), so by the start of summer the households have enough wheat to consume that in turn increases the caloric consumption. On the other hand, the planting season of wheat starts in October and it goes until December, hence, the caloric consumption during winter decreases due to scarce of wheat in many areas. Nevertheless, there is indication that caloric consumption in rural Pakistan mostly depends on the planting and harvesting seasons of wheat. This situation becomes significant in those regions where the households consume largely from own production, such as Faisalabad and Attock.

The working covariance matrices of caloric and protein consumption have a correlation 0.19 on their off-diagonals.[7] These are the residuals correlation values. The estimated within-subject correlation coefficient is 0.19, means the correlation between two measures of caloric and/or protein consumption on the same household is 0.19 (in two time points separated by approximately 4 months) after adjusting for the covariates.

5.3 Acquiring inadequate nutrition

A household can be regarded as food secure if it is able to consume a minimum quantity and quality of various adequate balanced diets on a regular basis. However, it is a matter of international debate as to what should be considered an adequate and balanced diet for different groups of individuals in a society. A large variation in defining food norms exists ranging between 1400 and 2800 KCal per capita and therefore is subject to value judgement (Maxwell et al., 1992). Consumption of balanced diets is crucial as it is the practical prescription for consumption of a basket of food items, which is likely to provide all the required nutrients to the human body.

Most commonly, nutrient rather than food intakes are the basis of evaluation of nutritional status. Nutrients are essential for health. The amounts considered essential or desirable are based on the results of depletion and replacement studies of individual nutrients and the consequences for the health of the subjects. Such studies form the basis of recommended daily allowance (RDA). It is of interest to investigate how many households are consuming calories below the RDA, which is 2550 KCal in AEU per day for rural Pakistan population. Generally, in the entire sample almost 39 percent households are consuming calories less than the recommended daily allowance. As mentioned by Garcia (1990) that there can be several reasons why the observed intake falls below the RDA. The most common reason cited in literature is that of poverty or the inability of people to buy the necessary food items to consume enough nutrients. A regional variation in the patterns of acquiring inadequate food can be observed, e.g., in Dir district almost 53 percent people are consuming calories less than the recommended

[7] We got the same off-diagonal correlation for caloric and protein consumption because of the high correlation between caloric and protein consumption (0.95).

dietary allowance. Hence, it is crucial to determine the determinants of underconsumption of nutrients. Here we are only considering caloric acquisition, as the cut-off points are clearly defined[8]. We used the probit generalised estimating equations (GEE) for the dichotomous variable. The dependent variable is whether the household is consuming less than 2550 KCal per day in AEU (yes = 1) or (no = 0). Table 5.9 reports the results obtained from the GEE model.

Table 5.9: Probit GEE estimates of underconsumption of calories at household level

Covariates	Caloric consumption < 2550 Kcal (per day in AEU) Coeff (Semi-robust SE)
Log of h'hold expenditure	-4.05 (0.212)**
Head is primary or more	
Yes	-0.09 (0.097)
No	Ref
Head's occupation	
Service	0.67 (0.129)**
Business	0.44 (0.139)**
Unemployed	0.42 (0.273)
Others	0.27 (0.159)
Farm related	Ref
H'hold size	0.05 (0.011)**
Wife is primary or more	
Yes	-0.21 (0.202)
No	Ref
Wife's age	0.005 (0.004)
Own production	
Yes	-1.12 (0.111)**
No	Ref
No. of visitors	-0.00 (0.004)
Districts:	
Faisalabad	Ref
Attock	0.33 (0.119)**
Badin	-0.097 (0.127)
Dir	1.06 (0.130)**
District prices of:	
Rice	0.04 (0.015)**
Sugar	-0.10 (0.031)**
Wheat	0.17 (0.125)
Intercept	9.82 (0.709)**
Households	850

*significant at 5%, **significant at 1%
Standard errors are given in parenthesis.

[8] For example for protein the RDA is very ambiguous, different people have used different limits. Also it has been seen in the last section that the determinants of acquiring calories and protein are very similar.

Again, income is a major factor in the consumption of enough nutrients. Results indicate that the probability of underconsumption is higher for such households whose consumption expenditure is low. Such kinds of results have already been reported by Garcia (1990) by using the Philippines longitudinal data. It can be seen that larger households usually have a deficit in caloric consumption. If the head of household is not in a farm related occupation then the chances are increased for a household to have underconsumption of calories. Surprisingly, education of husband and wife, number of visitors and wife's age are not significant factors in underconsumption of calories.

Living in Attock and Dir increases the chances of consuming fewer calories than RDA. On the other hand living in Badin decreases the chances of households to consume fewer calories than the RDA. Surprisingly, from Table 5.3, it has been noted that households from Attock district consume more calories than households from any other study district. However, the results of Table 5.9 indicate that living in Attock increases the chances of consuming fewer calories than the RDA. This situation may be indicative that there are some households in Attock district who are consuming more calories and lots of other households who are consuming less calories. Due to the reason that fewer households consume more calories give a high average figure of calories consumption in Attock district. This situation may be an indicative of income inequality in Attock district. Nevertheless, this aspect needs some further research. About the effects of prices, results indicate that with the increase in rice prices, the chances also increase for a household to consume fewer calories than the RDA.

5.4 Conclusions and discussion

The main conclusions of this chapter are listed below:

- ***Food consumption*:** Generally the households in rural Pakistan consume enough calories and proteins. However, the major source of food consumption is mostly the staple food and only one percent share in total calories come from animal products.

- ***Link between food and income***: Although, the caloric consumption increases with the expenditure quintile and poor households tend to consume fewer calories than the households in the richer quintile. But, generally the diversity in food consumption patterns more or less remains similar from the bottom quintile to the top quintile.

- ***Determinants of food consumption***: It was found that wife's education at least up to the primary level has a positive and significant impact on food consumption at household level while father's education does not have any impact. The caloric and protein consumption increases with the increase of the household expenditure while it decreases with the increase of household size. Further if the head is in farm related occupation it increases the chances of consuming more calories and proteins and being unemployed decreases the consumption.

- ***Covariates of acquiring calories less than RDA***: Households consuming less calories than the RDA tend to be larger in size, economically poor, not in farm related profession, and living in Attock or Dir districts.

5.4.1 Discussion

The purposes of this chapter were to explore the food consumption patterns in rural Pakistan, to look at the determinants of caloric and protein consumption and also the determinants of caloric underconsumption. It was found that although, the caloric consumption in study areas of Pakistan was very high, and this higher caloric consumption does not appear to be translated into food diversification. The major source of household caloric consumption is staple food, i.e., cereals and rice. It is very surprising that with the increase in income the households do not tend to consume a better quality diet, although they tend to consume more calories, but mostly from cereals. Generally, the consumption of vitamin rich foods like vegetables and fruits was very low and also meat consumption was found to be very low among this rural population.

The analyses presented in this chapter support the preference of using the food-based poverty approach in this thesis (also see Chapter 4, Section 4.4). Food is one of the most important basic needs and it has been seen that the poor households have to spend almost 70 percent of their total budget on food acquisition. The further analysis of food consumption patterns amongst the households reveal that the major source of caloric consumption is from cereals and a very little share of calories in their food comes from meat and vegetables.

This study suffers from the fact that food consumption is based on 38 food items on which questions were asked. It seems that not enough information has been collected on all the various types of food which the rural households in Pakistan consume. Also, the potential shortcoming of the present study is that we had to rely on the 'food consumption' data not on the 'dietary-intake' or '24-hours recall' survey. It has been argued that such kind of surveys such as the food consumption lead to upwardly biased estimates of the calorie-income elasticity (Bouis, 1994 & Bouis et al., 1992) as such survey may overestimate the caloric consumption within wealthier households, since it is common for such households to provide meals to servants and employees. In contrast, it may underestimate the caloric consumption of poorer households if food is consumed outside the household. In the absence of dietary data, such kind of food consumption data can be used as previously been used by a number of people[9].

However, there are also potential disadvantages of using 24-hours recall data. As such surveys do not reflect individual's usual intake. The 24-hour recall data, hence, cannot be used to classify the subjects according to their intake or therefore to estimate who is likely to be at risk. Most people in individual-based studies are unable to give an accurate description of all foods they consume. In studies on household level, the record keeper does not usually know exactly what other household members consume.

Similarly there are some limitations in the use of dietary data. For instance, some dietary surveys only cover some parts of food intake. Hence, in this the information is only collected on the intake of foods selected for their importance to the particular objectives of the surveys. The results cannot be used for calculating the intake of total energy or nutrients not covered by the surveys.

[9] This chapter and also Chapter 2 have provided literature review on such studies.

Generally, for poor rural households, food availability translates into increased intakes of high calorie staple foods. Hence, such households often cannot obtain the necessary dietary variety to meet their nutrient needs. Efforts to alleviate malnutrition through improved programmes of food security should also be aimed particularly at ensuring diet quality in conjunction with promoting appropriate dietary behaviour.

In summary, food insecurity is not only a function of poverty or less purchasing powers, but also associated with the type of employment and household size. If the head of household is in farm related occupation then the household is likely to consume sufficient calories, mostly from own production. Larger households tend to be food insecure in terms of caloric acquisition. Furthermore, such households with women educated up to the primary level tend to consume more calories and proteins. Therefore, government policies should target educating women in rural areas.

The next chapter presents the analyses on child nutritional status, its determinants and also establishes a link between the changes in poverty status with the changes in child nutritional status.

Chapter 6

Individual and household level factors affecting children's nutritional status

The present study so far has focused on understanding the household role in explaining child nutritional status. For this, the socio-economic status of well-being of households was worked out (Chapter 4) which is thought to be highly related with child nutritional status. Also, an overview about the food consumption patterns was presented (Chapter 5) which is also considered as an important determinant of nutrition. This chapter aims to investigate child nutritional status and various factors associated with it.

It has been argued that child nutritional status is highly related with the status of well-being of households. The longitudinal nature of the data allows us to study the temporal changes in the nutritional status of children from one time to another. In Chapter 4 the movements of households from one welfare state to another and vice-versa in a three year period were calculated. It would be of interest to investigate whether there is a change in children's nutritional status with the change in the status of economic well being of their families.

This chapter addresses these specific research questions: *1)* how do children change in their nutritional status over time? *2)* what factors are important in predicting this change and whether they are different for stunting and wasting? *3)* do children living in the same household share the same health? and *4)* how does the nutritional status of a child change with the change in the economic status of a household?

Earlier studies in Pakistan on child nutritional status have failed to recognise the importance of examining patterns of socio-demographic disparities within and between the households. One of the crucial hypotheses that is intended to be tested in this chapter is that children living in the same household share the same health. To do this, household is taken as another level in our model so we have a 3-level analysis. There are very few studies so far that have done the 3-level longitudinal and multilevel analyses (Boardman et al., 2002; Ai, 2002; Guo et al., 1999). A longitudinal and multilevel model has a lot to offer to the child nutritional research area because it enables us to draw on more than one perspective in our attempt to understand various factors that might be related with household differences in the outcome variable.

Another contribution of this study is in the area of poverty and child nutritional status. To date there has not been any such study addressing the link between the poverty trajectories of households over a period of time with the trajectories of child nutritional status in Pakistan. To the best of our knowledge this is the first of its kind of research focusing on Pakistan addressing child nutrition by conducting multilevel modelling which allows taking into account household as a separate level, and also linking poverty trajectories with child nutritional status trajectories.

The chapter starts by providing an overview of the nutritional status amongst the study children followed by a description of a 3-level hierarchical linear model for studying the determinants of child nutritional status. Finally the focus would be on investigating a link between poverty and child nutritional status.

6.1 Overview of child nutritional status

In keeping with much the literature on child health in developing countries, we also rely on the use of the anthropometric measures. Most studies of economics and determinants of child health have adopted anthropometric indicators as measures of child health. The interest here is in modelling the long-term and the short-term nutritional status, which are stunting (low height-for-age) and the wasting (low weight-for-height). Stunting is also considered as an indirect measure of living standards, while wasting is an indication of the current nutritional status of children in a population. Nutrition scientists recommend the use of weight-for-height rather than weight-for-age in most circumstances because the latter is highly sensitive to uncertainty with respect to the child's precise age in months, and therefore may bias the extent of the nutrition problem (Garcia, 1990). Keller (1983) used correlation analysis to show that weight-for-height and height-for-age are virtually independent of each other. However, regressing weight-for-age on weight-for-height and height-for-age in several populations with varying prevalence of malnutrition, Keller found very high coefficient of determination (between 0.95 and 0.98). He concluded that deficits in weight-for-age are a composite of deficits in weight-for-height and height-for-age and also studying weight-for-age does not add any additional information to that provided by studying the other two indicators, i.e., HAZ and WHZ. Child nutritional status is usually represented by the Z-scores. The Z-scores are calculated by the following formula:

$$\textbf{Z-score} = \frac{\textit{child's weight or height} \; - \; \textit{median value of reference population}}{\textit{standard deviation of the reference population}}$$

So, the Z-score is the child's height or weight expressed as the number of standard deviations above or below the median for children in the reference population of the same age and sex. We used ANTHRO software (Version 1.02) to calculate the Z-scores. This software is provided by the Division of Nutrition of the Centres for Disease Control and Prevention and the Nutrition Unit of the World Health organisation (Sullivan et al., 1999). In Chapter 2 (Sec. 2.1.1), it has been mentioned that there are some problems with the current NCHS/WHO international growth reference. However, the efforts of collecting and compiling new international reference are under way and it was expected to be completed in year 2005 (de Onis, 2005). Until the new reference is developed, the NCHS/WHO growth reference curves will remain the reference values recommended for international use.

The most common cut-off point is –2Z-score, i.e., two standard deviations below the median values of the international reference. This is the cut-off risk level used to differentiate malnourished children from these adequately nourished. Children, whose height-for-age and weight-for-height Z-scores fall below this point, i.e., -2Z-score are therefore considered, stunted and wasted respectively. A detailed discussion about the reference population and interpretation of Z-scores has been provided by (Dibley et al., 1987; Dibley et al., 1987).

Weight-for- height and height-for-age therefore may convey different information about the current living standards. It has been seen in a study based in Uzbekistan that there is a very weak correlation between these two measures (Micklewright et al., 2001). It is because the factors associated with these two measures are considerably different, e.g., low weight-for-height may be due to a deficit in energy and low height-for-age may be affected by the quality of the diet as well (Ricci et al., 1996; Victora, 1992; WHO, 1986). Nevertheless, the concepts of stunting and wasting are expressed to represent two different forms of protein-energy malnutrition in childhood. Wasting a deficit in weight relative to height, it was originally defined as an acute situation, indicating recent weight loss. Stunting, a deficit in height relative to a child's age, was proposed as an indicator of longstanding or chronic malnutrition (Waterlow, 1972 & 1973). Hence, both the measures, i.e., wasting and stunting[1] are used in this chapter to explore the determinants of malnutrition. We will be using HAZ and WHZ to denote height-for-age and weight-for-height Z-scores respectively.

An overview of the nutritional status of the study children is given in Table 6.1. The figures indicate that during 1986-89 the prevalence of malnutrition amongst the children in study areas of rural Pakistan was very high. The average proportion of stunted children under study was close to 52 percent and almost 12 percent children were found wasted. Besides that a lot of regional variation with respect to the prevalence of stunting and wasting can be seen. These figures are very close to the one obtained from the Pakistan Demographic and Health Survey which is a nationally representative survey; according to PDHS (1992) the proportion of stunted and wasted children was 50 and 9 percent respectively. The slight difference in the prevalence rates of PDHS compared to our estimates is due to the fact that PDHS included children up to age 60 months while our sample comprise of older children as well. There are substantial inter-district variations in the malnutrition levels of children; it varied between 44 percent in Faisalabad to 62 percent in Dir for stunting. On the other hand, the prevalence of wasting was found highest in Badin district. The table reveals no gender differences in the prevalence of malnutrition.

[1] The terms stunting and wasting are used interchangeably with low height-for-age and low weight-for-height respectively.

Table 6.1: Percentage prevalence of stunted and wasted children in sample areas

	All areas	Faisalabad	Attock	Badin	Dir
% of stunted (both sexes)*	52	44	47	57	62
% of stunted (males)*	52	40	47	59	64
% of stunted (females)*	52	47	48	54	61
% of wasted (both sexes)*	12	8	15	17	7
% of wasted (males)*	12	9	15	17	7
% of wasted (females)*	12	7	14	17	7
Nutritional status at the first round (n= 1242)					
% of stunted (both sexes)	51	44	46	56	62
% of wasted (both sexes)	11	9	14	17	8

*For all the children in all the 12 rounds, no. of cases 15762.
Note: These figures do not include children died during the course of survey.

What could be concluded about the severity of the problem of malnutrition amongst the study children by considering the figures reported in Table (6.1)? The World Health Organisation (1995) proposed a classification of anthropometric deficits in populations according to the prevalence of stunting and wasting for children. Regarding the prevalence of stunting, the severity is low when less than 20 percent of children are stunted; medium when 20-29 percent children are stunted and high when the prevalence is between 30-39 percent and very high when the prevalence is more than 40 percent. For wasting, WHO proposed a severity index for malnutrition in emergency situations. The situation will be acceptable when the prevalence is under 5 percent; poor if it is between 5-9 percent, serious if it is between 10-14 percent and critical if it is above 15 percent. By considering these guidelines by WHO, it can be concluded that the prevalence of malnutrition, i.e., stunting and wasting amongst the children in rural Pakistan is of high nature. Therefore, it seems prudent to investigate the background factors causing stunting and wasting among children.

It is worth noticing that the first part of Table (6.1) reports the prevalence rates of stunting and wasting of all the children in all the twelve rounds. Hence in this way, the table actually reports the prevalence rates by number of cases not by number of children. To get a clearer picture we also calculated the prevalence rates of stunting and wasting for the children at round one, i.e., the cross-sectional analysis. These figures are reported in the bottom part of the table, which has been shown in grey colour. However, it can be seen that the prevalence rates of stunting and wasting in both the parts of table are very similar. We also calculated the prevalence rates at every round separately and the similar patterns for stunting and wasting were observed (results are not shown here).[2]

The IFPRI data also report the number of children dead during survey period. There were 50 children who were reported dead; however, the reasons of children's death are not reported. It was emerged from the given information that 56 percent children who dead were females and the median age at the time of death was 11 months to which there were 55 percent children under the age 12 months and 16 percent under the age one month. Further, it was found that as much as 82 percent dead children were stunted to which 54 percent were severely stunted while 9 percent children were wasted. These high figures of stunting amongst the children who dead during the course of survey make rural Pakistan a perfect setting to study the causes of malnutrition among children.

6.1.1 Link between the nutritional status and age

The development of undernutrition typically follows a pattern that is closely related to the age of the child. Hence, it is important to explore the nutritional status of children by their age. The estimates of the nutritional status by age of children in rural Pakistan are presented in Figures 6.1 & 6.2 for stunting and wasting respectively. Although the onset of stunting is most often evident during the first 2 years of life, it may start even during the first months of life. The nutritional status of children usually starts getting worsened after 4-6 months. Hence, the slower growth velocities[3] during first year of a child's life may be attributable to poor nutritional status during this period of age. This pattern, i.e., the prevalence of stunting gradually increases in children from birth to approximately two years of age when it tends to level off has also been observed previously (Victora, 1992; WHO, 1986). The prevalence of stunting amongst females seems to be lower than their male counterparts up to the age 24 months. However, after 24 months, the prevalence of stunting seem to be decreased slightly in males up to 48 months after that no significant difference is evident amongst males and females. It has been observed

[2] It should be noted that similar results were obtained by Alderman & Garcia (1993) by using the same data, when they calculated the prevalence rates of stunting and wasting for round 3.

that many stunted children will never achieve their full growth potential and will mature into stunted adolescents and adults (Martorell et al., 1994).

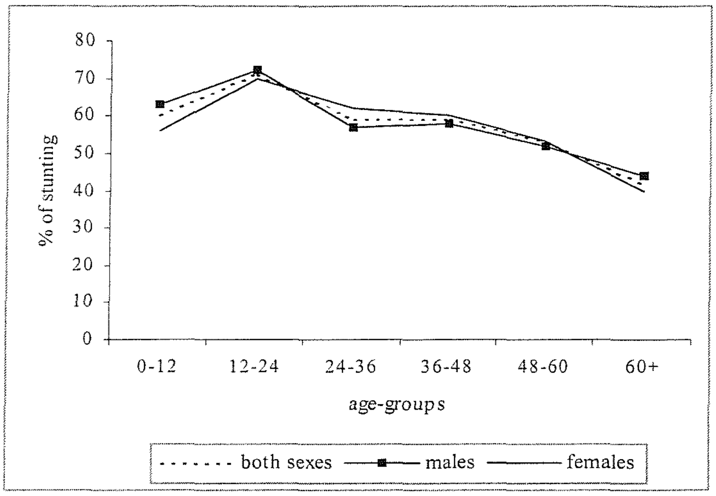


Fig. 6.1: Prevalence of stunting

No. of cases= 15762

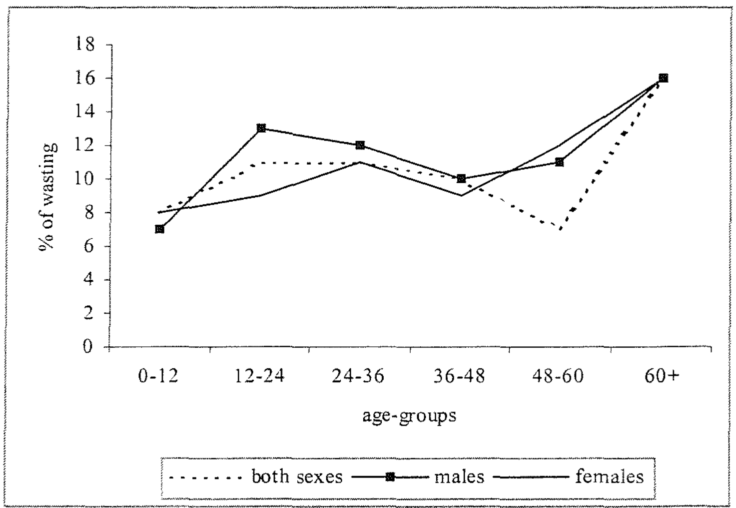


Fig. 6.2: Prevalence of wasting

No. of cases= 15762

On the other hand the levels of wasting are found more variable than stunting and is highest among children aged five years or more. However, in children age less than 60 months, wasting is found most prevalent between 12 to 24 months of age when dietary insufficiency and diarrhoeal diseases are most frequent (WHO, 1986). Wasting indicates the short-term nutritional status or in other words the current nutritional status and it usually occurs due to the immediate weight loss in body. It seems that quite a considerable number of children are exposed to infection and disease at this age group.

[3] Already been discussed in Sec. 3.4.3.

It is also vital to explore the time series trend of height-for-age and weight-for-height Z-scores with the ages of children. This serves two major purposes; first the general trend of Z-scores can be seen over time and secondly it can be explored if there are within-child and between-children variations. Figures 6.3 & 6.4 show these trends for height-for-age and weight-for-height Z-scores respectively of randomly selected children.

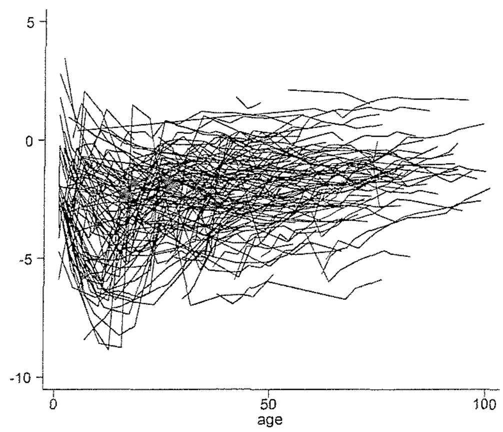


Fig. 6.3: Height-for-age against age

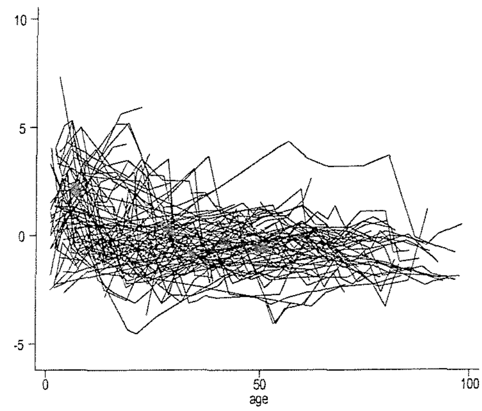


Fig. 6.4: Weight-for-height against age

No. of cases= 1500

In these plots, each child's HAZ and WHZ scores are represented by a separate line which is plotted against child's age. One can see that these Z-scores are changing with age, sometimes going up then coming down. Hence, a considerable variability can be observed. Thus, it seems important to take into account these variations while modelling the Z-scores. The incomplete lines are showing the missing values. From the figures, it is apparent that with age the height-for-age Z-scores are increasing while the weight-for-height Z-scores are decreasing. These characteristics are also evident by looking at the lowess smooth HAZ and WHZ plots against age (Fig. 6.5 and 6.6).

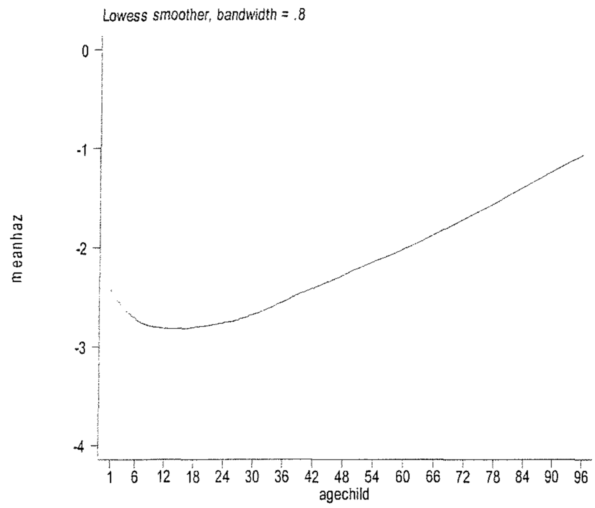


Fig. 6.5: Lowess curve of mean HAZ against age

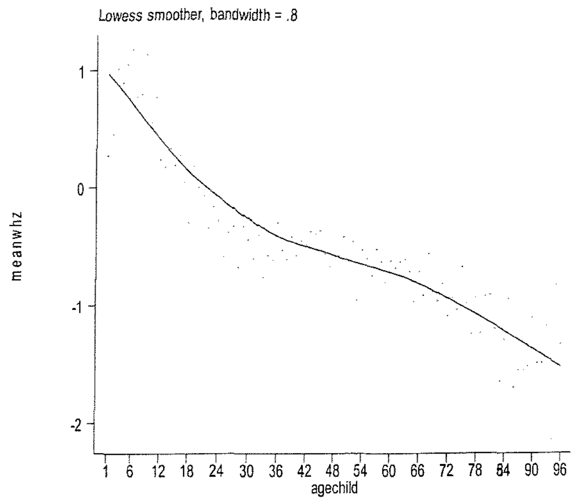


Fig. 6.6: Lowess curve of mean WHZ against age

(No. of cases= 15762)

From the Fig (6.5), it is evident that the average HAZ scores of children up to 6 months of age are approximately up to –2.5 then there is a sharp decline in Z-scores up to age 24 months and after that the HAZ scores appear increasing. This is a typical age-pattern in HAZ scores observed in developing countries (Martorell et al., 1986). However, this pattern is not evident in case of average WHZ scores against age. The weight-for-height Z-scores are found highest up to the age six months then they seem to decrease and were at their lowest in an age interval of 12 months to 24 months. This is the same age when the HAZ scores were also found lowest. From Sec (3.6), it was found that the height and weight growth rates seem to be decelerated around age 12 months and there was acceleration in growth around when children enter in third year of their life. These patterns of HAZ and WHZ scores with age have also been reported in other studies (Ibrahim, 1999; ACC/SCN, 1992) by using three different nationally representative data sets in Pakistan.

6.1.2 Variations in nutritional status by the region of residence

Is there any impact of living in a particular region on the nutritional status of children? To do this, the graphs are plotted on the prevalence of stunting and wasting by districts (Fig. 6.7 & 6.8) respectively. The rate of stunting was found at its highest in district Dir, while it was found lowest in Faisalabad. This pattern is in accordance as reported by other studies in Pakistan (ACC/SCN, 1992; PDHS, 1992).

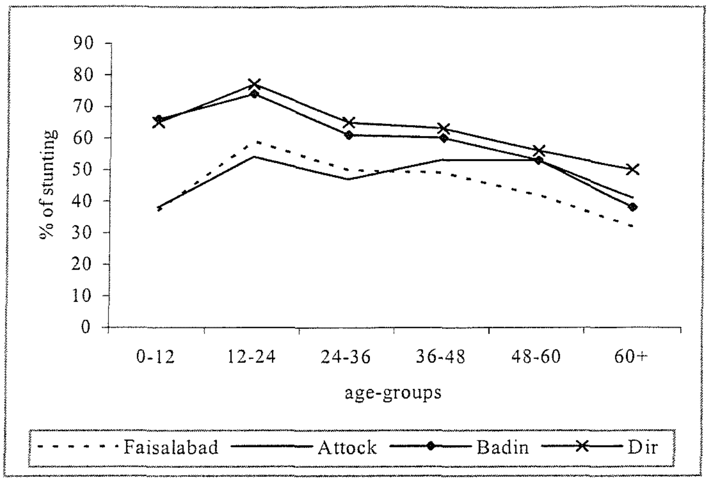


Fig. 6.7 Prevalence of stunting by districts
No. of cases= 15762

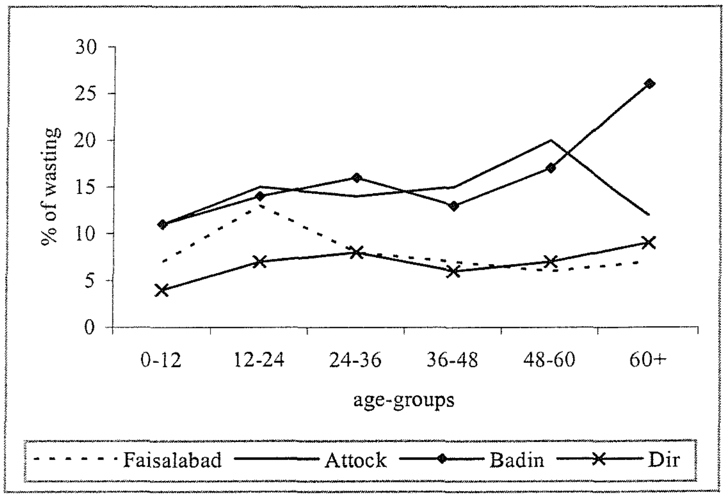


Fig. 6.8: Prevalence of wasting by districts
No. of cases= 15762

Generally, the pattern of stunting is persistent across the districts, although the rates vary significantly between districts. The rates of stunting between the ages 18 months to 24 months seem to be most prevalent then they start decreasing. Like stunting, the prevalence of wasting is found at its peak from 18 to 24 months of age. But, unlike stunting, the wasting follows different patterns for districts. For example, besides Dir district, wasting rates seem to be increasing with age in three districts, i.e., Faisalabad, Attock and Badin. Generally, the prevalence of wasting appears to be more variable with age, which is evident by looking at ups and downs in the percentage figures of wasted children by their ages. Thus, it seems vital to investigate such regional variations in HAZ and WHZ scores of children. These patterns of stunting and wasting by districts indicate that there exists regional variations in child nutritional status and hence, it is important to consider the districts in the analysis of determinants of child malnutrition.

6.1.3 Child nutritional status and household characteristics

Conditions within the household are thought to be related with child nutritional status. Univariate associations of various household characteristics related with physical environment of household with child's height-for-age and weight-for-height Z-scores are given in Table 6.2.

Table 6.2: Associations of child nutritional status with various household characteristics in percentages

NS	Electricity		Flush		Pakka[1]		Fridge		Tap water	
	Yes	No	Yes	No	Yes	No	Yes	No	Yes	No
Stunting	56	44	12	17	47**	58	61	55	61	54
Wasting	9**	21	12	17	12**	18	5**	18	4**	19

* Chi-square is significant at 5% level ** significant at 1%
Values are in percentages
NS. stands for nutritional status
[1]Pakka stands for a concrete house.

Table (6.2) reports the percentage of stunted and wasted children under various household environmental variables and also states whether these associations are significant or not by using chi-square statistic. From the table it seems that in case of stunting only one variable describing household physical environment has significant association and this variable is whether the house is 'pakka'. Almost 47 percent children are found to be stunted if they belong to household which is 'pakka' as compared to 58 percent such children who do not belong to a 'pakka' house. On the other hand other variables, such as house is electrified, having flush, fridge and tap water supply do not have significant associations with height-for-age Z-scores. However, a number of variables seem to have significant associations with weight-for-height Z-scores. If the household is electrified then the children are less prone to have low weight-for-height scores compared to households without electricity (9 percent as compared to 21 percent). Similar is the case if household is having fridge, supplied by tap water and house is pakka. It is usually thought that unsafe drinking water and other housing conditions are also associated with child nutritional status. Esrey et al. (1985) in an extensive review of 67 studies from 28 countries shows that improved water supply and sanitation reduces diarrhoea by 16-37 percent.

6.2 Three-level hierarchical linear model

The sampling design of the data under consideration is a stratified random sampling, although the districts are selected purposively but from each district the villages are selected at random and then from each village households were selected randomly. Further, there is a nesting of children within households. Standard analysis of longitudinal survey data often fails to account for such kind of complex nature of the sampling design. Individuals within the same groups of the hierarchical structure are likely to be similar owing to their shared circumstances, e.g., children in the same households share the same socio-economic status. This group homogeneity results in intra-class correlation and thus dependency amongst the observations of individuals. Hence, violates the assumption of independence inherent in standard statistical modelling procedures. Ignoring the nesting at higher levels can give rise to some serious consequences. For example, biased estimation of the model coefficients, larger residuals and a poorer fit, misleading significance tests, and exaggerated proportion of variance within subjects and misleading estimation of proportion of variance among subjects.

The best way to analyse multilevel data is an approach that represents within-group as well as between-group relations within a single analysis. Very often it makes sense to use probability models to represent the unexplained variability within and between groups as random variability (Snijders, 1999). For example, we are not only interested in the unexplained variability between households, rather we are also interested in measuring the between children unexplained variability nested within households. This can be done by using a 3-level hierarchical linear model (also commonly known as the multilevel model).

6.2.1 Building a three-level model

In Chapter 3 (Sec. 3.3), a detailed description has been given about the hierarchical linear model building procedure with up to two levels in which measurement occasions were at the level-1 and the children at level-2. This section describes the hierarchical linear model for up to three levels. In analysis presented in this chapter, we fit a 3-level random intercept model, in which the variability from household to household is represented by the random intercept. It is achieved by fixing the slopes, i.e., by fitting random intercept model. This is referred to as the household effect, which we treated as the random effect and which is represented as a variance. For this reason such kind of model also known as the variance components model. Such a model assumes that all children in a household are subject to the same household-specific random effects, that is, any two children in a household would be correlated to the same degree.

The three levels of the data hierarchy are listed below:

Level-1: Measurement occasions (time)
Level-2: Children
Level-3: Households

i) Level-1 model

This is the within-child model where the outcome variable Y of child i in a household j at time t is represented as:

$$Y_{tij} = \lambda_{0ij} + \lambda_{1ij}(X_{tij} - 24) + \lambda_{2ij}(X_{tij} - 24)^2 + e_{tij}$$

This is a quadratic within-child model where the deviations of age are taken from 24 months so in this way the intercept is fixed at 24 months.

ii) Level-2 model

This is the between-child model and given as:

$$\lambda_{0ij} = \beta_{00j} + u_{0ij}$$
$$\lambda_{1ij} = \beta_{10j} + u_{1ij}$$
$$\lambda_{2ij} = \beta_{20j} + u_{2ij}$$

Where

β_{00j} is the intercept for household j in predicting child level differences in HAZ and WHZ (i.e., mean HAZ and WHZ of children within households.

β_{10j} is the intercept for household j in predicting child-level differences in the effect of X (i.e., the average effect of X within households).

β_{20j} the quadratic effect of β_{10j}

u_{0ij} is the random effect for intercept.

(λ_{0ij}, λ_{1ij}, λ_{2ij}) are the intercept for child i in household j, the effects of X (e.g., age of a child i in j household) on nutritional status and finally the quadratic term of the effects of X respectively.

iii) Level-3 model

At this level, the level-2 intercepts are represented as depending on the household's characteristics. This is the model at household level and given as:

$$\beta_{00j} = \gamma_{000} + \nu_{00j}$$
$$\beta_{10j} = \gamma_{100}$$
$$\beta_{20j} = \gamma_{200}$$

Where γ_{000}, γ_{100} and γ_{200} are intercepts at the family level for the β s at the child-level. ν_{00j} is random effect reflecting the deviation of family j.

iv) The combined model

If now we substituting for the β s at level-2 using the level-3 model

$$\lambda_{0ij} = (\gamma_{000} + \nu_{00j}) + u_{0ij}$$
$$\lambda_{1ij} = \gamma_{100}$$
$$\lambda_{2ij} = \gamma_{200}$$

Now we can substitute for the λ s in the level-1 model to get the full 3-level model.

$$Y_{tij} = (\gamma_{000} + \nu_{00j}) + u_{0ij} + ((\gamma_{100} + \nu_{10j}) + u_{1ij})(X_{tij} - 24) + ((\gamma_{200} + \nu_{20j}) + u_{2ij})(X_{tij} - 24)^2 + e_{tij}$$

By rearranging the equation:

$$Y_{tij} = \gamma_{000} + \gamma_{100}(X_{tij} - 24) + \gamma_{200}(X_{itj} - 24)^2 + u_{0ij} + \nu_{00j} + e_{tij}$$

..(6.1)

Equation (6.1) is a three-level random intercept model. There are a number of sources of error in the three-level model. Each one stands for a different source of random effect. For example, the variance of ν_{00j} reflects family variance in the nutritional status, while the variance u_{0ij} reflects child level variance in the nutritional status. Hence, σ_e^2, σ_u^2 and σ_ν^2 are the variances at measurement, child and household levels respectively. Hence, in the present scenario with unequally-spaced data, the within child error terms e_{tij} are assumed to be independent (i.e. the vector of within child error terms e_i has covariance matrix $\sigma^2 I$).

These models have been developed to allow for the hierarchical structure of the data by incorporating variation at all levels simultaneously. In this way the variation in the dependent variable that is not explained by the regression equation is divided according to the level within the hierarchy that it represents. There can be some adverse consequences of ignoring the higher level in the model such as:

- Inefficiency in estimation of parameters which can lead to negative bias in estimation of standard errors (leading to more significant results than there should be).

- Exaggerated proportion of variance within-subjects and misleading estimation of proportion of variance among-subjects due to the fact that the household level is ignored in the modelling procedure.

We ended up with 870 such households where at least one child was residing at the time of survey with almost 1300 children on average (with at least two observations). The details of clustering of children within a household are listed in Table (6.3):

Table 6.3: Clustering of children within households

Children per h'holds	No. of h'holds	Percent of h'holds
1	190	22.0
2	250	29.0
3	205	23.0
4	115	13.0
5 or more	110	13.0
Total	870	100

6.3 Modelling the determinants of child malnutrition

6.3.1 The determinants of child malnutrition

The determinants of child nutritional status have been derived from the child health framework adapted from the UN's Children's Fund (already been described in Chapter 1). This child health framework comprises of three levels, i.e., immediate, underlying and the basic. Table 6.4 reports the variables along with their means and standard deviations for the immediate, underlying and the basic levels as defined by the child framework. The interest lying in specifying the variables in separate levels as to explore the variability explained in the nutritional status by every level separately. The choice of variables was made by considering that variables should be conceptually appropriate on the basis of previous research, theoretically significant, they should have comprehensive time series and if the correlation between two variables is found high then only one variable has been retained in the model. Simple correlations between variables within levels of the conceptual framework of child health did not have to exceed 75% (correlation coefficient less than 0.75).

Dependent variables

Height-for-age and weight-for-height Z-scores are taken as the dependent variables[4] and separate models are run on them, as they must have at least some different causes. The means and standard deviations of stunting and wasting are calculated as –2.34 (1.88) and –0.35 (1.63) respectively. Following is a brief description of the explanatory variables included in the model at various levels of child health framework. The descriptive statistics of these variables are presented in Table 6.4.

Table 6.4: Means and standard deviations of variables used in the analysis

Variables	No. of cases	Mean	SD
Outcome-variable:			
Height-for-age Z-scores	15762	-2.34	1.88
Weight-for-height Z-scores	15762	-0.35	1.63
Immediate-level:			
Child's age	15762	16.56	24.44
Child's age squared	15762	871.83	1069.00
Still breastfeeding (Ref= no)	4301	31	
Yes	9574	69	N/A
Had diarrhoea (Ref= no)	12593	80	
Yes	3148	20	N/A
Had illness (Ref= no)	11594	74	
Yes	4074	26	N/A
Child is male (Ref= no)	7723	49	
Yes	8039	51	N/A
Underlying-level:			
Household-level			
Household size	15762	10.84	5.50
Expenditure per AEU (Rs.)	10305	354.73	345.00
Caloric consumption per AEU (Kcal)	10305	2741.00	988.00
Protein consumption per AEU (gm)	10305	70.00	30.00
Household is electrified (Ref=no)	13437	62	
Yes	1832	38	N/A
Mother-level			
Mother's age (years)	15560	29.58	7.83
Mother is literate (Ref=no)	13870	82	
Yes	1891	12	N/A
Mother's height (cm)	13804	151.45	6.24
Basic-level:			
District price of sugar (Rs per kilogram)	10305	10.35	0.83
District price of wheat (Rs per kilogram)	10305	2.83	0.42
District price of rice (Rs per kilogram)	10305	5.61	1.85

Note: Rs stands for Rupees (Pakistani currency); N/A for not applicable.
Means and SD are reported for continuous variables, and percentages for categorical variables.

[4] These are taken as the continuous variables.

Immediate-level

At immediate-level, we included variables representing child's age, gender, child's exposure to morbidity and whether the child was still breastfeeding at the time of survey. At this level, strictly speaking with the exception of breast-feeding all other variables do not denote inputs into nutrition, but rather the outcome of investments in other aspects of health that influence the productivity of inputs into nutrition (Alderman et al., 1993). It becomes evident from Sec (6.1.1) that child's nutritional status fluctuates with child's age. Hence, to capture age-specific effects, child's age and its squared terms are included. To avoid multicollinearity, deviations in the age variables were taken from 24 months as also done in Chapter 3.

Two indicators of health status are used to describe the morbidity patterns in the sampled children. First, whether or not child had an episode of diarrhoea in the past two weeks: this information was collected for all the 12 rounds. The question asked was, "did the child have diarrhoea in last two weeks". Second, whether or not the child had any other illness in the past two weeks, this information was also recorded in all the 12 rounds. The question asked was, "did the child have any other illness in last 2 weeks". The next question asked was "type of illness", such as cough, flu, fever, measles, accident or malaria and other health complaints. However, in the present analysis, we did not include the type of illness rather we just included the illness variable as a dichotomous variable (had illness or not). The reason for not including the type of illness is that of missing values, e.g., if a child was found to have illness, not in all the cases has the type of illness also recorded. As reported by Alderman & Garcia (1993) that when taking illness histories (both diarrhoea and other illness), respondents were asked, "where did you take the child first?" followed by, "who did you see next?" if a subsequent visit to another health provider was made. The interview also recorded availability, costs, and distances of the various medical care services.

The relation between infection and nutrition and in particular the effect of diarrhoeal diseases on childhood growth has been intensively investigated (Guerrant et al., 1992 & Becker et al., 1991). Diarrhoeal diseases are among the main health problems of preschool children in developing countries. Therefore, it is vital to include these two measures of morbidity, i.e., diarrhoea and morbidity in the model, so that their impact on child nutritional status can be investigated. It has been well documented that while modelling child nutritional status, health status of child must be taken into account otherwise such models may yield biased coefficients (Heller et al., 1979). For this reason, two dummies are included in the model, one each for diarrhoea and illness. According to PDHS (1992) in Pakistan almost 27 percent of the under-five deaths were associated with fever and about 17 percent were associated with diarrhoea. The NHS (1996) reports that cough and fever affects over one in five children under five years of age. Similarly, frequent occurrences of diarrhoea is very common in Pakistan and almost 20-30 percent children were found to have an episode of diarrhoea during last two weeks while during a course of a year a child on average had 5 to 12 episodes of diarrhoea. Diarrhoea is usually caused by one of a number of food- or water-borne pathogens. The exposure of high proportion of study children to diarrhoea indicates inadequate sanitation arrangements, improper drinking water and lack of personal hygiene amongst the sampled households.

The prevalence of diarrhoea among the study children was found reasonably high, almost one-quarter of the children were found to have diarrhoea two weeks prior to survey. It is found most prevalent from six months of age to two years. It seems to peak from 6 months to 12 months (Fig. 6.9). This is the age when the child is usually introduced to weaning food so the chances of food contamination become higher and as a result a child becomes prone to infection. The incidence of diarrhoea seems to be lower after the 24 months. These age-specific infection rates amongst children are also reported by Arif and Ibrahim (1998) by using the PIHS (Pakistan Integrated Household Survey) which is a nationally representative sample.

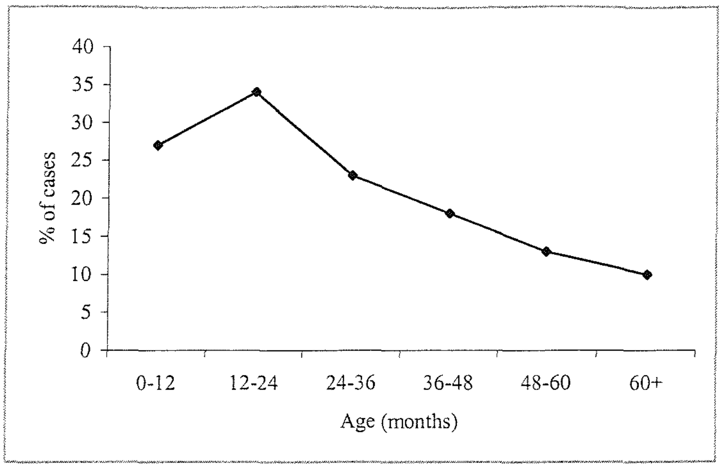


Fig. 6.9: Incidence of diarrhoea by age

Further, the patterns of diarrhoea and other illness vary greatly between districts. For instance, in Badin district nearly 28 percent children had reported illness as compared with about 20 percent in the two Punjab districts. Similarly in Dir district almost 30 percent children were found to have diarrhoea, compared to 13 percent in two Punjab districts. These regional differentials in diarrhoea are in accordance with the one reported by other studies in Pakistan (Arif and Ibrahim, 1998). These regional variations by districts indicating that the causes of morbidity are affected by locational factors, it might be attributable to the infrastructure and/or various household characteristics.

Diarrhoea was found most prevalent during the monsoon season (25 percent as compared to 16 percent during winter and significant at 10% level by using chi-square statistic). Amongst the study households, it has been found that the chances are significantly higher for a child to have diarrhoea if that household is having tap water connection. This situation indicates either a poor water supply amongst the study households or poor hygienic conditions within a household. Having a flush or not in a household does not have significant impact of exposure to diarrhoea. Surprisingly, male children are found to have higher prevalence rates of diarrhoea than their female counterparts (21 percent versus 18.6 percent, significant at 10% level). These gender differences in diarrhoea have also been observed by Arif et al. (1998). Another surprising fact that emerged from the IFPRI data is that no significant differences are observed in seeking the medical treatment amongst male and female child when they are found to have diarrhoea.

A child was found to have diarrhoea on average for 5.16 days while almost 40 percent children were still found to have diarrhoea at the time of survey. The nutritional status of a child can deteriorate due to a long episode of diarrhoea. Further, malnutrition lowers the body's ability to resist infection by undermining the functioning of the main immune-response mechanism. This leads to prolong, more sever and more frequent episodes of diarrhoea (UNICEF, 1998). As many as 60 percent of such children who had diarrhoea received treatment from a private clinic as compared to 6 percent from a government hospital. However, a child received medical treatment as an average after 3 days of having first episode of diarrhoea. The mean cost on treatment for the first visit was found to be Rs. 38.00. The Basic Health Units in the rural areas are responsible to provide ORS for children to overcome the dehydration occurs in children due to lose motions and vomiting. According to IFPRI data only 50 percent of such children who had diarrhoea were given to ORS to which only 36 percent children got free ORS. However, the mean duration of having diarrhoea was found to be five days irrespective whether the child was given ORS or not which further indicates an inadequate drinking water supply to rural households. These health seeking characteristics indicate an inadequate government health services in the rural areas and as a result the poor households either have to consult a private doctor or does not receive any medical treatment at all due to the fact that they cannot afford to pay the doctor's fee.

Information on breastfeeding was collected on every round for every child. Generally speaking, breastfeeding was universal in the study areas and almost 92 percent of the children of aged up to 24 months were breastfed during survey period, this figure is very close to the one reported by the PDHS (1992) according to which 94 percent children were found to be breastfed in Pakistan. In the sampled children, from the age six months, mothers usually start giving buffalo milk to infants, usually diluted with water[5]. However, this practice can be associated with higher prevalence rates of diarrhoea among children. Generally, the mean weaning age of a child was reported as 7.6 months by NHS (1996). This indicates that most of the mothers in Pakistan are not well aware of children's proper diet according to their age. To investigate the effects of breastfeeding on child nutritional status a dummy variable to represent whether a child is still breastfeeding (at the time of survey) or not is included in the model. However, no

[5] The information on the weaning food is only collected for the youngest and second youngest children in a household and only for one round.

information was given about the weaning age, hence, no conclusions could be drawn about the 'exclusive breastfeeding status' from the data.

The sex of a child is also important to include in the model as to capture if there are gender related differences in child's nutritional status. To capture such differences, a dummy variable for child's sex is included in the model (male=1, female=0).

Underlying-level variables

Household-level

The second category of explanatory variables is at the underlying level. Conditions within the household are thought to be important determinants of child health (Barrera, 1990). Following is a brief description of the variables used in the model which specify at the underlying-level.

Household food consumption is an important determinant of child nutritional status. Insufficient food consumption is one of the primary causes of malnutrition. In the absence of individual-level food intake, food input can be proxied by the household consumption of nutrients consumption per adult equivalent. The adult equivalent[6] for each family is calculated using the nutrient consumption by sex and age specified by WHO. In the IFPRI survey, information was collected on food consumption during the week before the survey date in all the 12 rounds. The food consumed by household members then is converted into nutrients by following the Food Consumption Tables for Pakistan. The average caloric consumption per day and in per capita terms is 2380 KCal and in AEU it is 2741 KCal[7]. Two variables representing logarithm of caloric and protein consumption are included in the model.

Household size is also included in the explanatory variables. It is expected that bigger households would have larger child care burdens for the mother, but one can also argue that the older children can share this burden of looking after their siblings (Garcia, 1990). Household expenditure is included in the model as a proxy of wealth. It is expected that with higher the household expenditure the better would be child nutritional status. The variable representing household expenditure has been log transformed before entering in the model. One more variable to control the socio-

[6] Readers are directed to see Sec. (4.3.2).

[7] For a detailed discussion see Sec. (5.1.2).

economic status of a household is also included in the model; it is whether the house is electrified.

In IFPRI data the information was collected on variables on household's water source, latrine facility and the physical structure of household. From the IFPRI data, it is found that only 17 percent of the households had tap water supply, only 4 percent had flush, 14 percent had fridge and only 19 percent were concrete households (*pakka*). However, this information was collected only for one round and in the rural Pakistan situation, we expect that these variables are time varying not time-invariant. Hence, these variables were not included in this longitudinal analysis of the determinants of child malnutrition[8].

Mother-level

The parents' ages and education levels, particularly the mother's might be expected to have a positive impact on the nutrition of small children (Thomas et al., 1991; Barrera, 1990; Behrman et al., 1984b). For a long time it has been known that there exists a strong relationship between the education level of women and the health of their children. It has been argued that although education of mothers does not have any direct effect on children's heights, it is a proxy for unobserved background variables. Previous studies have shown an inconsistency in the association between maternal education and child nutritional status across socioeconomic levels. This may be because the beneficial effects of education are only significant when resources are sufficient but not abundant.

It has been argued that maternal education exerts a stronger effect in households of intermediate socioeconomic status, where formal education equips mothers to make decisions about the allocation of limited resources, than in villages where resources were either inadequate or overabundant (Reed et al., 1996). Reed and colleagues also observed that child nutritional status showed a general improvement up to the Level 3 category (3-4 years) of maternal education, then declined in Levels 4 and 5 (highest). It is speculated that the decline in nutritional status observed among children of the most educated mothers reflects the tendency of these women to be employed, with child care responsibilities allocated to an older sibling.

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[8] For univariate associations of such variable with stunting and wasting see Table 6.2.

Previous studies of the determinants of child health in Pakistan have mostly been limited to investigating the impact of maternal schooling only and as a consequence largely have not considered skills and also have ignored alternative routs to acquire skills. In the present study we investigate the effects of mothers' literacy status along with other variables on the nutritional status of children. Although in the food consumption analyses[9], we opted to include mother's education variable as represented by her school education (up to primary level). However, it has been seen previously that mother's schooling did not appear to substantially improve child health outcomes although it did improve nutritional intakes of children (e.g., Behrman & Wolfe, 1987). We have included a dummy in the regression model representing whether a mother is literate or not. Only 12 percent mothers were found to be literate.

Mother's age has been included as a proxy for her experience in child caring and rearing. It can be argued that older mothers should have improved child caring practices. Mother's height is also included in the model to control genetic endowments.

Basic-level

It is interesting to know how child nutrition responds to the changes in some essential food items. To capture such effects, at basic level, the district prices of some essential food items have been included, comprised of wheat, sugar and rice. Three variables representing the prices for one kilogram amount of these three commodities have been included in the model[10]. However, evidence related to market prices on child's nutritional status is ambiguous. Barrera (1990) found no impact of essential food items on HAZ scores. To control for regional variations, we included dummies for the sample districts in the model. However, some other information on village infrastructure could not be captured in the multivariate regression analysis due to two reasons: firstly, such information is only collected in one round and secondly, this cross-sectional information suffers from missing values.

[9] Chapter 5 (Sec. 5.2.2).

[10] Chapters 1 & 4 describe how the prices have been calculated.

6.4 How to model the conceptual framework of child health?

In order to better understand the effects of immediate, underlying and basic level variables on child nutritional status, a number of 3-level hierarchical models were run on the data. The basic purpose was to explore the variability explained by each level of child health framework towards explaining the variation in child height-for-age and weight-for-height Z-scores in comparison with the intercept only model. The SAS procedure PROC MIXED (SAS, 1999; Littell et al., 1998; Singer, 1998; Littell et al., 1996) is used to fit the three-level hierarchical linear models. In this model the measurement occasions are nested within children and children are nested within households. The details of these models are as follows:

Model 1: Intercept only model (null model).
Model 2: The model covering the variables at the immediate level
Model 3: The model covering the variables at the underlying level
Model 4: The model covering the variables at the basic level
Model 5: Full model, i.e., Model 2+Model 3 + Model 4

Models 2-4 are compared with the Model 1 (intercept only model) to determine the variability explained by every level of child health framework in explaining child nutritional status. The variability explained is calculated by the procedure given by (Bryk et al., 1992, page 147). According to this procedure, the variability explained is calculated as the difference between the parameter variance (estimated from the null model) relative to the parameter variance of the model from which comparison is made and finally this difference is divided by the variance obtained from the null model. For example, the variability explained in HAZ by Model 2 which is at the immediate level can be calculated as: (1.07 - 0.81)/1.07 = 0.24 or 24%. It means that almost 24 percent of the total variability in HAZ scores is attributable to factors at immediate-level. In a similar way, variability explained by every level and also the full model is calculated which is reported in Table (6.6) while the variances are reported in Table (6.5) and the fixed effects results are reported as Tables 6.7 & 6.8.

Table 6.5: Residual variances obtained from various models

Models	Variance	
	HAZ	WHZ
Model 1	1.07^{**}	1.14^{**}
Model 2	0.81^{**}	1.04^{**}
Model 3	0.98^{**}	1.08^{**}
Model 4	1.03^{**}	1.12^{**}
Model 5	0.74^{**}	0.99^{**}

* Significant at 5% level ** Significant at 1%

Table 6.6: Variability explained by various levels of the conceptual framework

Models	Variability explained	
	HAZ	WHZ
Model 2	24%	9%
Model 3	8%	5%
Model 4	4%	2%
Model 5	31%	13%

In case of both height-for-age and weight-for-height Z-scores, models involving the immediate level variables explain the most of the variability towards child nutritional status. The model as stated earlier, comprises of factors such as child's age, breast-feeding, and child had diarrhoea or other illness. This finding that most of the variability in the child health framework is attributable to the factors at immediate level is in accordance with some other studies on child nutritional status (Fernandez et al., 2002; Shell-Duncan et al., 2000). However, most of the variability is captured by the full model, i.e., the model that comprises of all the variables at the three levels of child health framework. It is also an indication that all the variables are important to retain in the final model (given in Table 6.4). Besides that we also observe that the coefficients and the standard errors did not change drastically in the final model as compared when they were modelled separately in their respective levels. Hence, further discussion will be based on the results of the final model.

6.4.1 Fixed effects results from a three-level model

The results of the fitted models are reported in Tables 6.7 and 6.8 for HAZ and WHZ Z-scores respectively. The discussion follows from these tables would be mainly focused on the results of the final model (Model 5).

Table 6.7: Fixed effects results for height-for-age

Fixed effects	Model 2	Model 3	Model 4	Model 5
Immediate-level:				
Child's age (in months)	0.016			0.0193
	(0.001)**			(0.001)**
Child's age^2	0.0005			0.002
	(0.000)**			(0.001)**
Still breastfeeding (Ref= no)				
Yes	0.135			0.129
	(0.026)**			(0.027)**
Had diarrhoea (Ref= no)				
Yes	-0.113			-0.134
	(0.026)**			(0.028)**
Had illness (Ref= no)				
Yes	-0.066			-0.086
	(0.024)**			(0.024)**
Child is male (Ref= no)				
Yes	-0.028			0.015
	(0.098)			(0.104)
Underlying-level:				
Household size		0.044		0.014
		(0.008)**		(0.007)*
House is electrified (Ref= no)				
Yes		-0.246		0.022
		(0.1650		(0.194)
Log of caloric consumption		0.347		1.360
		(0.223)		(0.238)**
Log of protein consumption		-0.762		-1.513
		(0.198)**		(0.211)**
Log of H'hold expenditure		0.155		0.122
		(0.072)*		(0.069)*
Mother's age		0.132		0.015
		(0.007)**		(0.007)*
Mother's height		0.005		0.008
		(0.011)		(0.010)
Mother is literate (Ref= no)				
Yes		0.933		0.741
		(0.229)**		(0.199)**
Basic-level:				
Dist. price of sugar			0.247	0.196
			(0.014)**	(0.014)**
Dist. price of rice			-0.002	0.018
			(0.009)	(0.009)*
Dist. price of wheat			0.066	-0.079
			(0.052)	(0.049)
Districts				
Faisalabad			0.811	0.747
			(0.175)**	(0.217)**
Attock			0.882	0.921
			(0.216)**	(0.266)**
Badin			0.131	0.213
			(0.128)	(0.215)
Dir (Ref)				

Standard errors are given in parenthesis. * Significant at 5% level ** Significant at 1%
Valid no. of cases: 10305.

Table 6.8: Fixed effects results for weight-for-height

Fixed effects	Model 2	Model 3	Model 4	Model 5
<u>**Immediate-level:**</u>				
Child's age (in months)	-0.022			-0.023
	(0.001)**			(0.001)**
Child's age^2	0.000			0.002
	(0.000)			(0.001)
Still breastfeeding (Ref= no)				
Yes	-0.147			-0.121
	(0.029)**			(0.030)**
Had diarrhoea (Ref= no)				
Yes	-0.091			-0.094
	(0.030)**			(0.032)**
Had illness (Ref= no)				
Yes	-0.078			-0.053
	(0.027)**			(0.028)**
Child is male (Ref= no)				
Yes	-0.113			-0.089
	(0.077)			(0.078)
<u>**Underlying-level:**</u>				
Household size		0.009		0.013
		(0.007)		(0.007)*
House is electrified (Ref= no)				
Yes		0.493		0.152
		(0.107)**		(0.131)
Log of caloric consumption		-1.167		-1.409
		(0.233)**		(0.273)**
Log of protein consumption		1.209		1.440
		(0.207)**		(0.242)**
Log of H'hold expenditure		0.019		0.035
		(0.075)		(0.079)
Mother's age		-0.058		-0.013
		(0.005)**		(0.005)**
Mother's height		0.021		0.011
		(0.007)**		(0.007)
Mother is literate (Ref= no)				
Yes		- 0.358		-0.207
		(0.150)*		(0.137)
<u>**Basic-level:**</u>				
Dist. price of sugar			- 0.161	-0.122
			(0.014)**	(0.016)**
Dist. price of rice			-0.044	-0.037
			(0.009)**	(0.011)**
Dist. price of wheat			0.063	0.091
			(0.052)	(0.053)
Districts				
Faisalabad			-0.733	-0.789
			(0.135)**	(0.149)**
Attock			-0.848	-0.914
			(0.170)**	(0.190)**
Badin			-1.036	-0.829
			(0.098)**	(0.148)**
Dir (Ref)				

Standard errors are given in parenthesis. * Significant at 5% level ** Significant at 1%
Valid no. of cases: 10305.

6.4.2 Discussion on the fixed effects

Immediate-level:

The coefficients of age and its quadratic terms indicate that the child's age is a major factor in determining the child's nutritional status. In previous studies a strong relationship has been observed between child anthropometric measures and age (Behrman et al., 1988). We plotted the lowess smooth curve of the predicted values of height-for-age and weight-for-height Z-scores against age (Fig. 6.10 & 6.11) to see their mean effects. It seems that children's weight-for-height Z-scores were usually better during infancy but they come down with the increase in age. On the other hand, the trend in the mean predicted values of height-for-age is upward indicating that the prevalence of stunting seems to decrease with age. It seems that the height-for-age Z-scores increase with age (Fig. 6.10).

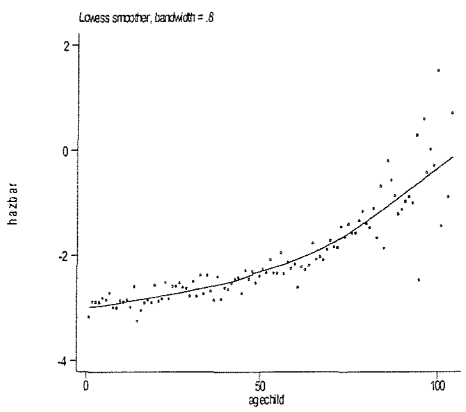

Fig. 6.10: Lowess smooth curve of predicted values of HAZ against age

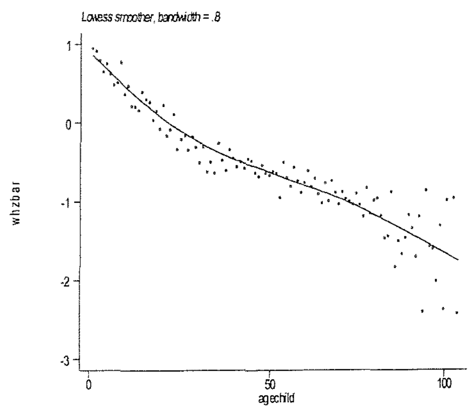

Fig. 6.11: Lowess smooth curve of predicted values of WHZ against age

The status of breastfeeding was found to have a positive impact on the child's height-for-age Z-scores which indicates the long term nutritional status. Research shows that the exclusively breast-fed children usually grow more quickly during the first three months of life (Dewey, 1998; Garza et al., 1994). In the absence of contraceptive use it also lengthens the birth interval, which is strongly related to infant and child survival. Surprisingly, 'still breastfeeding' status was found to have a negative impact on the short-term nutritional status (low weight-for-height). Similar sort of finding was also reported by Madise et al. (1999) when using weight-for-age Z-scores amongst the children of sub-Saharan Africa. Some studies on the determinants of child nutritional status find a negative association between child health and duration of breastfeeding

(Wolfe & Behrman, 1982). The relationship between breastfeeding and child health benefits is not linear. Both short and prolonged durations of breastfeeding can have adverse effects on child health. A shortened duration of exclusive breastfeeding can cause children to be exposed by germs from prepared food and milk bottles. Prolonged breastfeeding means the consumption of nutrients is not sufficient, as with time the mother's milk does not remain adequate to fulfil the child's nutritional requirement. Further, children who are already ill suckle less and as a result consumes less milk and in this way unable to meet the nutrients requirement.

The IFPRI data under study do not allow to explore the duration of breastfeeding, however according to PDHS (1992) the median duration of breastfeeding was 20 months amongst the Pakistani children while the practice of exclusive breastfeeding was not very common. The information about the weaning food that emerged from Demographic and Health survey which is a nationally representative survey is that the average weaning age is 7.6 months. Hence, in this way mothers usually start weaning quite late and the type of food which is given to young child is not nutritionally adequate. Usually, in rural areas mothers give fresh milk by diluting it with water and this dilution with water increases the chances of contamination and as a result exposure to infection. The other solid foods, which are given to babies, are usually rice, bread and in rare cases banana. In this way children are unable to consume enough nutrients and as a result they start losing growth. The effects of breastfeeding on child health are thought to be age-dependent, to capture such effects, we also included interaction terms of breastfeeding with age and age-squared but none of these terms came out significant.

The IFPRI survey has collected data on the duration of breastfeeding and the age of weaning for the youngest child in the family but only for round 12. The average weaning age amongst the study children was found to be 7 months. We applied OLS regression to such children aged from 1 month to 24 months (n= 230) and we found that exclusive breastfeeding up-to 4 months age have positive and significant impact on height-for-age Z-scores but its impact on weight-for-height was non-significant. It was also found that if the weaning food was introduced to a child before 4 months then it decreases the HAZ Z-scores. Exclusive breastfeeding after 4 months did not have any significant impact on the nutritional status although its coefficient was negative.

The results show that recent episodes of illness and diarrhoea have a negative affect both on height-for-age and weight-for-height indices. The negative impact of diarrhoea on weight-for-height Z-scores indicates a sudden weight loss due to the loss of essential micronutrients from the body. It has been shown in a study in Peru that children ill with diarrhoea 10 percent of the time during the first 24 months were 1.5 cm shorter than children who never had diarrhoea (William et al., 2003). Infection adversely affects nutritional status through reductions in dietary intake and intestinal absorption, increased catabolism and sequestration of nutrients that are required for tissue synthesis and growth. On the other hand, malnutrition can predispose to infection. Martorell (1980) reported that fully weaned Guatemalan children reduced their energy intake by 30% during acute infections, whereas Brown et al. (1985) found that Bangladesh children who were still breastfeeding reduced their intake by only about 7 percent suggesting that breastfeeding may provide some protection against diarrhoea. We also included the interaction of diarrhoea with age and its squared term which did not come out significant.

The nutritional status of girls is shown to be no worse than that of the boys in our analysis. This result suggests that there is not significant difference in the nutritional status of boys and girls. These results are in accordance with some other studies, e.g., in Morocco nutritional status of girls found not different from boys (Glewwe, 1999). In fact, in a recent study in Pakistan, it was found that male children were two times more malnourished than girls (Qureshi et al., 2001). However, to capture gender differences effectively, one needs to have data on intra-household resource allocation.

Underlying-level:

Household-level variables

Household size is found to be positively related with child nutritional status. Does this mean that the bigger the household size, the better the nutritional status of a child? This finding of positive and significant association of household size with child's nutritional status seems somehow to deviate what the literature on child's health and nutrition says. Large household size is widely regarded as a risk factor for malnutrition in developing countries, particularly for infants and young children. However, we need to explain this association in the context of a typical rural Pakistani household's composition. It was seen in Chapter 4 (Sec. 4.4.2) that number of elderly decreases the chances of a household becoming poor and increases the chances of escaping poverty. To see whether the presence of elderly actually increases the chances of better child health and nutrition, we included a dummy variable representing households with elderly and without elderly. However, we did not find any significant impact of the presence of elderly in a household on child nutritional status.

A number of studies indicate the effect of the mother's autonomy on child nutritional status (e.g., see Garcia, 1990). It has been seen that in such households with mother's autonomy, children tend to have better nutritional status (Garcia, 1990; Doan et al., 1990). However, some studies have shown that besides the mother's autonomy, it is the availability of other potential child-care substitutes, particularly the grandmother, that influences child nutrition rather than household structure. We have already seen from Chapter 4 (table 4.1) that there are almost 72 percent household with extended family set up which also have children. Hence, it seems more probable that an extended household means more members, i.e., bigger household size. An extended family set up indicates two things; firstly, more adult women who share the burden of daily household chores and as a result the mother of a child has more time to pay appropriate attention to her child. Secondly, an extended family set-up may indicate more economically active household members. This aspect has been shown by Senauer et al. (1991) while working on rural Philippines' longitudinal data. According to them "household full income is a function of wage rates and the number of economically active members, this variable may be reflecting a full-income effect".

However, our data do not allow the exploration of the effects of mother's autonomy and grandmother's influences on child nutritional status. Nevertheless, this aspect gives rise to an in-depth qualitative research to look at the intra-household resource allocation. Griffiths (1998) in her detailed investigation based on three Indian states found that in the state of Uttar Pardesh, in extended families where mother-in-law is also residing, children were less prone to low weight-for-age Z-scores. We also tried including some other household demographic variables such as, number of elderly, proportion of children and proportion of male and female adult children in a household.[11] However, besides household size no other demographic variable came out significant.

[11] Eventually these variables were taken out from the model.

Household expenditure is taken as a proxy of wealth. It seems that with the increase in household expenditure in AEU terms, the height-for-age Z-scores also start increasing while its effect on WHZ scores is not significant. Among the study households, it is found that those households consuming from own production have higher expenditure in AEU. Consuming from own production means consuming enough calories and proteins which has positive impact on child's HAZ scores, as it has been noted from Chapter 5 (Table 5.7). The household expenditure can also be taken as a proxy of poverty; the average expenditure in AEU for non-poor households is found to be Rs. 434 while for poor families the average expenditure is Rs. 192. In other words, this relationship indicates that there is a link between poverty and poor nutritional status. The association of height with income has been documented in the literature. Height therefore is a function of proximate determinants such as diet, disease and the quality of the living environment, and ultimately is a function of income (Steckel, 1995). Unlike conventional measures of living standards based on output, height is a measure of consumption that incorporates or adjusts for individual nutritional needs; it is a net measure that captures not only the supply of inputs to health but demands on those inputs (Steckel, 1995).

It is worth mentioning here that the regression models include of household expenditure as well as household caloric and protein consumption. It has been seen already in Chapter 5 that there is a strong positive association between expenditure and nutrient consumption. Hence, in this way, the coefficients on expenditure might also be showing the caloric and protein consumption effects. How big are these effects? For this, we re-estimated regression models by excluding caloric and protein consumption. We found no big impact of caloric/protein consumption on the coefficients of expenditure after excluding these two variables; the means (sds) are [0.156 (0.064)** and 0.038 (0.073) for HAZ and WHZ respectively]. In case of HAZ, there is an increase of 0.034 and in case of WHZ it is 0.003. Thus, the change in expenditure variable after excluding the effects of caloric and protein consumption is negligible. These results show that the effects of household expenditure on child nutritional status are independent that of caloric and protein consumption.

Two different kinds of nutrients were also included in the model, namely calories, and protein. As the nutrient consumption is not at child level rather these are at household level, hence instead of per capita consumption these are expressed in AEU terms by assigning the weights according to age and sex. In case of height-for-age Z-scores, the caloric consumption was found to have a positive and significant impact on child nutritional status, while the negative sign of the protein consumption is something strange. On the other hand, protein consumption has positive impact on the weight-for-height Z-scores, while the effect of caloric consumption was found to be negative. One needs to keep in mind that the information on nutrient consumption is at household level not at individual level. However, in the absence of individual dietary intake, such average food consumption at household level can be used as a proxy of individual dietary intake.

There has been much discussion in literature about the impact of protein deficiency on human growth (for a detailed discussion see Golden, 2002). In his article Golden mentioned a study by Picou, who examined the rate of protein turnover in severely malnourished patients. He surprisingly found a much higher rate of protein synthesis in the malnourished than that in the recovered children. Further explanation of this result is given by Golden as "......although the children Picou studied were still anthropometrically malnourished, they were in fact in the early phase of catch-up growth, where a high rate of protein synthesis would be expected". Hence, higher levels of protein do not contribute in lowering the height growth rates of children, rather it does indicate that if a malnourished child was given a diet rich in protein, then the positive effects of protein on growth cannot be seen immediately.

Mother-level variables

Our analysis shows a positive and significant effect of mother's literacy on child's height-for-age Z-scores while its effects on weight-for-height Z-scores are insignificant. In rural Pakistan, a mother's education, even basic literacy, also strongly influence the health and nutritional status of her children. Literate mothers have taller children. Glewwe (1999) argues that literacy and numeracy skills acquired assist mothers in diagnosing and treating child health problems. It has been argued that educated women might be more likely to take advantage of local clinics and nutrition programmes and they are more likely to adopt sanitary, nutrition and health practices which have direct link with child growth (Thomas et al., 1991). It has been seen previously that mother's time, energy, knowledge, and her own health along with the resources at her command are critically important to the survival and healthy development of each of her children during the first few years of their lives (Mosley et al., 1995). Some studies have demonstrated the importance of mother's schooling in determining household nutrition and health (Behrman and Wolfe, 1984b). There is good deal of evidence that children of better-educated mothers are healthier and our results are consistent with this. In a study based on rural Sindh (Pakistan), it was found that mother's education is highly related with better HAZ scores (Shah et al. 2003).

Our results indicate that mother's age has a significant and negative effect on weight-for-height. This finding shows that children with very young mothers tend to have lowest chances of being wasted. Results indicate that, e.g., with an additional 10 years in mothers' age, WHZ scores will fall down to –0.13 Z-scores. It seems that the effects of mother's age on children's WHZ scores are of moderate size. On contrary, the effects of mother's age on child height-for-age Z-scores are positive. This means that with the increase in mother's age, the height-for-age Z-scores also get better. These results become more evident by considering some figures; children's average HAZ scores of those mothers aged less than or equal to 30 years are –2.53 as compared to –2.09 HAZ scores for children whose mothers are older than 30 years. In this way children of older mothers are found to have better HAZ scores than those children of young mothers. Poorer nutritional outcomes (particularly stunting) of children to very young mothers are consistent with a number of interpretations. According to Strauss (1990) if a woman gets married at very young age and have more children for rearing at that young age then this could represent a quality-quantity trade-off. Childcare does not only include feeding but also protecting the child from unsanitary conditions and providing a clean and healthy environment. Thus, it seems that comparatively older mothers are capable of utilising effectively their experience in child rearing and childcare which appears in better HAZ scores.

Surprisingly, we do not find significant effect of mother's height on child nutritional status. Body size is strongly influenced by genetic inheritance as well as by the environmental; factors of interest such as family resources and housing conditions. It is to be noted when mother's height was included alone in the model (bivariate-model) with HAZ and WHZ, the associations were significant. We found a positive and significant association of mother's height on HAZ and WHZ scores. The coefficients and SEs are [0.025 (0.008) & 0.025 (0.007) for HAZ and WHZ respectively, significant at 1% level]. However, when all the other variables are included in the model this association became non-significant. These results indicate that socio-economic and socio-demographic environment are more important determinants of child health and nutrition than the genetic endowment. It has been seen in previous studies that if the living conditions remain same, young children from most ethnic groups show rather similar linear growth potential (Martorell, 1985; Habicht et al., 1974). However, it is less true for weight. The variability in child growth across nations is due much more to social, demographic and economic factors, than to genetics (Beaton et al., 1990 and Osmani, 1992). However, it has been seen in previous studies that genes explain most of the variance in individual's heights (Tanner, 1994).

Basic-level:

Coefficients for districts indicate a regional variation in explaining child nutritional status. For example, it was found that living in Faisalabad and Attock increases the chances of better height-for-age Z-scores as compared of living in Dir. On the other hand, living in Faisalabad, Attock and Badin decreases the chances of better Z-scores for weight-for-height as compared of living in Dir. These results are in accordance with the ones we got for height and weight measures in Chapter 3.

The prices of the food items, which are believed to be critical sources of nutrients, are found to have a significant impact on children's health. With the increase in sugar prices, the height-for-age Z-scores also increase. On the other hand, the weight-for-height Z-scores seem sensitive to sugar prices. As the price of sugar goes up, the Z-scores go down and with the decrease in prices they go up. Evidence related to the effects of market prices on child height-for-age is ambiguous. Senauer & Garcia (1991) also obtained similar sort of results of the effects of prices on HAZ and WHZ Z-scores, argued that the positive impact of sugar and rice prices on HAZ is surprising, however, such positive effects have been obtained in a number of previous nutrition and health studies and can be explained by strong substitution effects between foods. While working in Bangladesh, Foster (1990) finds that child height is negatively correlated with changes in rice prices.

6.4.3 Fit of the model

One way of looking at the fit of the model is to plot the predicted values against the observed or the real values of the data (Fig. 6.12). These plots show the lowess smooth curves of predicted mean and observed means of HAZ and WHZ scores separately. The model fits the data reasonably well except for an over fitting of HAZ at the age around 75 months. The possible reason may be having few measurements at this time point with some very large or very small observation. This departure in the observed and in the predicted values may indicate of considering other functional forms of age, e.g., the log transformation as also mentioned in Chapter 3. In the present research, we were unable to explore this aspect of age due to time constraints, however, this point gives rise a direction for future research. In case WHZ scores, no significant departure in predicted values as compared to the observed was seen.

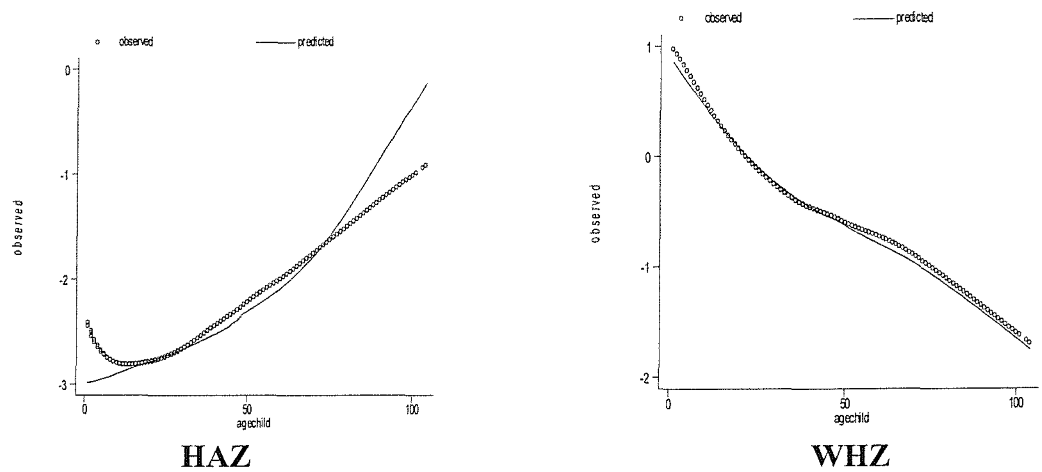

Fig 6.12: Lowess smooth curves of predicted values of height-for-age and weight-for-height Z-scores in comparison with the observed values. The solid thin line represents the predicted values and the broken thick line is for the observed values.

6.4.4 Results of the random effects

In longitudinal analysis it is vital to assess the variance components that can be used in calculating the proportion of variance. Partitioning the variance is not simply of technical value; rather the apportioned variances are of substantive interest in much of social and biomedical research. The residual variances obtained from Model 5 (final model) for HAZ and WHZ scores are reported in Table (6.9).

Table 6.9: Residual variances obtained for HAZ and WHZ from a three-level model

Random effects	Residual variances	
	HAZ	WHZ
σ_e^2 (level-1)	0.741**	0.991**
σ_u^2 (Level-2)	2.479**	1.334**
σ_v^2 (Level-3)	0.456**	0.098**

* Significant at 5% level ** Significant at 1%

The variance associated with household level is significantly different from zero. This indicates that there are significant dissimilarities in child nutritional status even after adjusting for a number of individual and household level socio-economic and demographic factors. For the three-level variance component model under study, the total variance for each response is constant and equal to the sum of the variances at every level. Therefore, the variances of the dependent variables (HAZ and WHZ Z-scores) are decomposed into three sources: between children nested in the same household (σ_u^2), variation between the households (σ_v^2) and the residual (σ_e^2). Variances at level-1 denote within-child, at level-2 between-children and at level-3 between households respectively. The proportion of variance at the three levels can be calculated as given below:

Level-1 (within-child): $\dfrac{\sigma_e^2}{\sigma_e^2 + \sigma_u^2 + \sigma_v^2}$.

Level-2 (between-children): $\dfrac{\sigma_u^2}{\sigma_e^2 + \sigma_u^2 + \sigma_v^2}$

Level-3 (between households): $\dfrac{\sigma_v^2}{\sigma_e^2 + \sigma_u^2 + \sigma_v^2}$

The values of proportion of variance at various levels are reported in Table 6.10.

Table 6.10: Proportion of variance at various levels

Levels	Proportion of variance	
	HAZ	WHZ
Within child (level-1)	20%	41%
Between children (level-2)	67%	55%
Between household (level-3)	13%	4%

Table (6.10) reports the proportion of variances obtained from the residual variances, i.e., the variances not explained by the covariates in the model. Table shows that large chunk of the variance (67%) is between individuals within households compared to 13% between households. This indicates that if we randomly select two children from the same household, it will be more likely that their HAZ and WHZ scores will be different, i.e., heterogeneous. However, HAZ and WHZ scores within a child seem to be more correlated over time, which is some how we expect. The findings of this study are similar to the findings of some other studies in developing countries. For example, (Madise, 1999, 1997; Griffiths et al., 2004, 2002 & Griffiths, 1998) found a clustering effect of household and concluded that the nutritional status of children is correlated within a household, although the child level variance accounted for a higher proportion of the variance than the household. These findings indicate that there is a lot of variation in the nutritional status between children nested within households, but the variation is greater between children living in different households than those living in the same household. However, our findings indicate that there is a lot of variation in the nutritional status between children nested within a household which is in line with Tanner (1994). Tanner (1994) argues that variation in height is also present among siblings (except identical twins). Recent studies show that underweight or stunting can coexist with overweight and obesity within households in developing countries (e.g., Doak et al., 2005). In literature such households are referred as 'dual burden households' which can be defined as "a household in which a person (or persons) in the household is overweight and another is underweight, reflecting the dual burden of overweight and underweight clustering within a single household" (Doak et al., 2005).

Nevertheless, the non-significance of the residual variance at household level suggests that household level mechanisms may have an affect on individual health, although somewhat these household level mechanisms do not seem to be related to the factors identified at the three levels of the conceptual framework. Such household level variation in child nutritional status or health may potentially be accounted by other household factors such as the intra-household resource allocation, and/or higher aggregate level factors such as local neighbourhood conditions related to deprivation both in economic and health terms. This aspect needs further research.

In summary, the existence of a non-zero proportion of variance, resulting from the presence of more than one residual term in the model, means that traditional estimation procedures such as the 'ordinary least squares' (OLS) which are used for example in multiple regression, are inapplicable. It has been already seen that the final model explains the most of the variability in case of HAZ and WHZ Z-scores. To which, most of the variability is attributable to the model comprises of variables at the immediate-level. To the best of author's knowledge this is the first of its kind of analysis in Pakistan which directly measures such household level variation in child nutritional status. The results indicate that further research into similarities or dissimilarities in child nutritional status between household members needs to be carried out. In theory it is possible to consider more complex multilevel structures such as multiple membership models that would facilitate the analysis of change at an individual and household level.

The next section discusses the link between the poverty trajectories and the trajectories of the child nutritional status.

6.5 Link between child nutritional status and the status of economic well-being

The aim of this section is to investigate the association between poverty and child nutritional status as indicated by the child health framework in Chapter 1. The distinction between chronic poverty and transient poverty is rarely made in the substantial literature on poverty in Pakistan as well their effects on child nutritional status. In the literature much of the information and consequences of childhood poverty is based on cross-sectional evidence. Such data only provide information at the point when the data are collected, but they offer no direct information on a number of dynamic aspects of childhood poverty. However, very few studies have investigated the effects of histories of poverty on the histories of child health or nutritional status. Although, both short- and long-term economic deprivation may affect the nutritional status of children differently, long-term deprivation would be expected to have larger adverse effects.

The purpose of the analysis presented in this section is to demonstrate the impact of never poor, transient poor or chronic poor on child nutritional status. Hence, it can be hypothesised that children who are persistently poor more likely at higher risk of many adverse health outcomes. In this particular analysis, low height-for-age or stunting and low weight-for-height (wasting) are used to indicate child malnutrition. In Chapter 4, we presented the movements of households from one economic state to another at one time point to another. We have already seen substantial variations in families' economic histories. For some families poverty is short lived and for some its a life time span. The question that needs to be answered is which child nutritional status is sensitive to chronic and/or transient poverty; is wasting associated with transient poverty and stunting with chronic poverty? To the best of author's knowledge, still, research on child nutrition is unable to recognise the impacts of chronic and transient poverty on the temporal changes in child's nutritional status. Although, it is usually hypothesised that malnutrition is closely associated with poverty[12], however, mostly the research is unable to recognise the fact that how the movements of households from one welfare state to another affect the nutrition and health of young children. The principal objective of this section is to investigate the impact of the temporal changes in household's economic well-being on the temporal changes in child's nutritional status.

6.5.1 Why is it important to study the link between trajectories of poverty and child's nutritional status?

In the late 1970s, the British government commissioned a study on social inequality and health status. A major conclusion of this research, known as the Black Report was that biological programming of adult health status occurs to a great extent during the foetal and infant stages of development (Vagero et al., 1995). Since then a lot of attention has been paid to explore the early life situation of poverty and its consequences on health later in life. Poverty has been shown to negatively influence child health and development along a number of dimensions. Despite the extensive literature available that addresses the relationship between poverty and child health and development, as yet there is no consensus on how poverty should be operationalised to reflect its

[12] A review of studies has presented in Chapter 2.

dynamic nature (Aber et al., 1997). Previous research suggests that if poverty occurs early in life, it has detrimental effects on children's future life chances (Duncan et al., 1996).

Nevertheless, there is a two-way link between poverty and health. Poverty is one of the most influential risk factors for ill health but the relationship can also be reversed. How much does a child's health change with the shift in poverty status? It can be hypothesised that poor children have more poor nutritional status than non-poor children. It is also important to know whether the length in which their families live in poverty increases the risk of being in poor health. Hence, the effects of poverty on child's health cannot be measured adequately unless we take into account the poverty trajectories.

How much does the child's health and nutritional status change with the change in the families' economic well-being? It has been seen in this study that even in a very short period of three years the status of well-being of families was not static[13]. A great mobility of households from one welfare state to another was observed during three year survey period (1986-89). Children's physical health is affected by their families' poverty histories. Poor children have more health problems than non-poor children. Further, the disadvantages that poor children face increase with the length of time that their families are poor (Duncan et al., 1994). Such a conceptualisation suggests the possibility that poverty can influence where children's health trajectories begin and/or the shape they take in the future.

Researchers interested in the effects of poverty on children have used models that predict nutritional status at one point in time. However, by doing so, they fail to acknowledge that children have histories of nutritional status just as they have histories of poverty. How those histories of nutritional status respond to changing economic circumstances is unclear. Rises and falls in families' economic circumstances may be mirrored in the proximal experiences that lead poor children to develop malnutrition, continuing experience or moving in poverty can put a child at greater risk of malnutrition as compared to moving out from poverty. Although, both short-term and long-term economic deprivation may affect the nutritional status of children, however, long-term deprivation would be expected to have larger effects and should be a higher priority for social and health policy.

[13] The concept of poverty trajectories has already been discussed in detail in Chapter 4 (Section 4.5.1).

In this section the main interest lies in exploring the relationship between poverty histories and children's nutritional status trajectories. The background assumption is that children who have a history of poverty have more chances of being malnourished than other children who are found never poor. In this regard a number of hypotheses can be tested based on the work done by McLeod et al. (2000, 1996 and 1993) in studying the relationship between poverty and mental health trajectories. The main research hypothesis in this study is to see the effects of being persistently poor, transitory poor or being never poor on the temporal changes in children's short- and long-term nutritional status. The main interest of using two measures of nutritional status is to see whether poverty histories affect differently on stunting and wasting.

6.5.2 How does children's nutritional status change during survey period?

While working on the link between mental health and poverty histories, McLeod et al. (1993) observed that most of the conclusions of the effects of poverty on mental health were drawn from the analyses that rely on measures of poverty at a single point in time. Most of such analyses assume that the current status of poverty captures all theoretical relevant variation in economic experiences when predicting mental health. However, that assumption cannot be tested without also measuring poverty history as currently poor families are disproportionately likely to have been poor for a long time and vice versa (Bane et al., 1986 & Corcoran et al., 1985). In United States theories of child development have argued that persistent poverty leads to high levels of psychopathology and poor self-concepts among children (Spencer, 1988).

It can be assumed that like poverty, the nutritional status of children is not a static condition. It would be of interest to explore that over a period of three-year period how many children have changed their nutritional status and for how long they have been malnourished. The dichotomous rather continuous measures of height-for-age and weight-for-height are used to study the effects of poverty on the odds of being at the low end of the respective distributions as a way of identifying children at greatest risk of poor health. The longitudinal nature of data makes it possible to track child nutritional status over time. The idea is to look at the 'spells of change' in child malnutrition. In this way, a spell is the change in child's nutritional status between any two years, e.g., a stunted child may remain stunted from year 1 to 2 or a nourished child may become malnourished or alternatively there is no change in child's nutritional status.

Transition matrices on becoming malnourished, remain malnourished and improving in their nutritional status are constructed between Years I & II, Years II & III and between Years I & III. Only those cases with complete data were included in the analysis, a decision which yields a final sample of 803 children in each year (803*3= 2409 cases). Nutritional status trajectories can be defined in a similar way as the poverty trajectories were defined in Chapter 4. Hence, there can be three such nutrition related movements: moving out from malnutrition to better nutrition, moving into malnutrition from better nutrition or remain unchanged.

The question is how to identify a child as malnourished. Recall from Chapter 1 that there were in total 12 rounds taken place in collecting the data under study. To which 6 rounds were in year 1 and 3 each in the subsequent years. The starting year of the survey, which we shall call Year I starts from July-September 1986 to June-August 1987, the second year, i.e., Year II is from December 1987-February 1988 to August-September 1988 and the third year i.e., Year III is from December 1988-February 1989 to July-August 1989. Also from Chapter 4 (Sec. 4.3.5), we know the advantages of calculating, e.g., poverty on yearly basis by averaging the consumption expenditure of all the rounds taken place over a year period. To be in line with this approach, here, as the purpose is to associate the temporal changes in child's nutritional status with the temporal changes in poverty status over time. It seems sensible to average the HAZ- and WHZ-scores on yearly basis by children.

In this way, we know that there would be some children with fewer measurements and some would be with more measurements, averaging Z-scores on yearly basis can provide an overall picture of children's nutritional status over a year. Then, these average Z-scores are used to identify children as stunted and wasted in comparison with the thresholds. For example, the most common cut-off point is two standard deviation below the median values of the international reference. Hence, children are classified as stunted and wasted if their Z-scores fall below –2Z-scores. So, after identifying a child as e.g. stunted or not stunted in Year I, the same child was followed in Years II & III and then classified accordingly. The purpose of classifying children as malnourished in this way seems to be due to unequal survey design, however, by averaging the Z-scores across the year means averaging positive and negative noise present in data from a single round.

By doing so, the results are more comparable with the movements of households from one welfare state to another over a course of three years. However, these results cannot be compared with the results on child nutrition[14] which was based on 'survey rounds' not on years. The importance of associating children's nutritional status over a short period of time, e.g., 3 months with the poverty status over the same period cannot be denied.

These changes in nutritional status are reported in Tables 6.11 to 6.13 for height-for-age and in Tables 6.14 to 6.16 for weight-for-height.

Table 6.11: The status of stunting of children from Year I to Year II

Year I	Year II		Total
	Stunted	Normal	
Stunted	376 (47%)	134 (17%)	510 (64%)
Normal	58 (7%)	235 (29%)	293 (36%)
Total	434 (54%)	369 (46%)	803 (100%)

Table 6.12: The status of stunting of children from Year II to Year III

Year II	Year III		Total
	Stunted	Normal	
Stunted	344 (43%)	84 (10%)	428 (53%)
Normal	30 (4%)	345 (43%)	375 (47%)
Total	374 (47%)	429 (53%)	803 (100%)

Table 6.13: The status of stunting of children from Year I to Year III

Year I	Year III		Total
	Stunted	Normal	
Stunted	297 (37%)	161 (20%)	458 (57%)
Normal	120 (15%)	225 (28%)	345 (43%)
Total	417 (52%)	386 (48%)	803 (100%)

Normal means children who are not stunted according to NCHS standard.

The matrices reveal that a considerable number of children remained stunted from Year I to Year II, which is 47 percent. Furthermore, this figure seems to be decreased slightly from Year II to Year III as between this period 43 percent children were found stunted. It is interesting to note that almost 17 percent children moved out from stunting to normal height-for-age Z-scores from Year I to II, while in the same period 7 percent children with normal HAZ scores became stunted. From Year I to II almost 24 percent changed their health status, either from normal HAZ scores to stunting or from stunting to better HAZ scores. Similarly, from Year I to III, almost 37 percent children remained stunted and only 28 percent children are found to have HAZ within normal range (Table 6.13). Hence, there is a suggestion that like the status of poverty the nutritional status is not a static condition, especially during childhood. Similarly, the status of wasting in between years is presented from Tables 6.14 to 6.16.

Table 6.14: The status of wasting of children from Year I to Year II

Year I	Year II		Total
	Wasted	Normal	
Wasted	37 (5%)	21 (2%)	58 (7%)
Normal	88 (11%)	657 (82%)	745 (93%)
Total	125 (16%)	678 (84%)	803 (100%)

Table 6.15: The status of wasting of children from Year II to Year III

Year II	Year III		Total
	Wasted	Normal	
Wasted	72 (9%)	49 (6%)	121 (15%)
Normal	19 (2%)	663 (83%)	682 (85%)
Total	91 (11%)	712 (89%)	803 (100%)

Table 6.16: The status of wasting of children from Year I to Year III

Year I	Year III		Total
	Wasted	Normal	
Wasted	32 (4%)	41 (5%)	73 (9%)
Normal	88 (11%)	642 (80%)	730 (91%)
Total	120 (15%)	683 (85%)	803 (100%)

Normal means children who are not wasted according to NCHS standard.

It would be of interest to explore that for how many years a child has lived in poor health during the survey period. To do this the duration of being stunted and wasted during the survey period is calculated (Table 6.17). In line with the poverty trajectories,

[14] E.g. the results presented in the earlier part of Chapter 6.

nutritional status trajectories can also be defined in terms of the onset and offset of malnutrition over time: never malnourished, sometimes malnourished and always malnourished.

Before we proceed further, it seems essential to remind ourselves of the way poverty has been calculated. Recall from Chapter 4 (Sec. 4.3.5)[15] that basic-need poverty approach in absolute terms has been used. This poverty approach takes into account the household consumption expenditure and caloric consumption in adult equivalent units and uses the caloric norms as a cut-off point to identify the poverty line. The poverty line was calculated for Year I, which was achieved by averaging the expenditure over Year I. Similarly, the consumption expenditure was averaged for Years II & III and the households were classified as poor or non-poor. Poverty transition matrices were constructed by following the same households over a period of three years and the movements of households were recorded from one welfare state to another. After working out poverty transition matrices, the interest is to see how these movements of households from poverty to non-poverty and non-poverty to poverty affect the nutritional status of children.

Table 6.17: Duration of children of being stunted and wasted from 1986-89

Status	Stunted	Wasted
Never	28%	80%
Sometimes	35%	16%
Always	37%	4%

It is found that 37 percent children remained stunted for the entire survey period, which is 3 years, while 28 percent children have never faced stunting. Thus, it can be said that 37 percent children are found 'chronically stunted[16]' while 4 percent children are 'chronically wasted'. On the other hand, 72 percent children faced stunting for at least one year and 20 percent children are found facing wasting at least once during the survey period and 80 percent children never faced wasting.

[15] For a detailed discussion, readers are directed to read the relevant chapter.
[16] These children can also be termed as 'persistently stunted (or wasted).

Researchers have long argued a link between poverty and child health. Here our interest is not only in exploring this link rather to see that how much the duration of being poor of the household has an impact on the duration of being malnourished. Miller et al. (1994) observed that deficits in nutritional status among long-term poor children might be underestimated if measures of current poverty status are used as proxies for persistent poverty. As a result, the importance of income in determining child well-being may have been understated by comparisons based upon short term (i.e., single year) measures of income. The link between poverty and nutrition trajectories is reported in Table (6.18).

Table 6.18: Associations between the status of stunting and wasting with the poverty status from Year I to Year III.

Status	Never		Sometimes		Always	
	Stunted	Wasted	Stunted	Wasted	Stunted	Wasted
Never poor	30%	83%	37%	14%	33%	2%
Transient poor	26%	81%	31%	15%	42%	4%
Chronic poor	25%	72%	37%	21%	38%	6%

The table reports the change in child's nutritional status with the change in poverty status of household. It is apparent that the chances are slightly higher for children to face poor nutritional status who belong to poor households as compared to non-poor households. Hence, poverty is likely to have adverse significant effects on height-for-age nutritional status (chi-square= 9.16, significant at 5% level of significance). It seems more likely that such households who have faced poverty at least once during the course of survey are unable to make up the economic loss immediately which has adverse effects on child's long-term nutritional status (low height-for-age).

It might be of interest to explore further that whether poverty status is also associated with a child's short-term nutritional status (low weight-for-height). Table (6.18) also reports the link between wasting and poverty. There seems to be an association between poverty status and wasting (chi-square= 12.3, significant at 1% level of significance). Nevertheless, wasting is a short-term nutritional status and if a household is unable to meet its basic-needs then it may have adverse effects on child nutritional status which is measured as weight-for-height.

Further, it can be explored if a child is stunted then whether that child is also wasted; in how many cases a child has never faced stunting and wasting, in how many cases a child was stunted but not wasted and in how many cases a child was wasted but not stunted. Also how do the trajectories of wasting and stunting link with the trajectories of poverty? This bivariate relationship of stunting and wasting with poverty status is reported in Table (6.19).

Table 6.19: Bivariate relationship of stunting and wasting with poverty status

Status	Never wasting & stunting	Never wasting but stunting	Never stunting but wasting	Sometimes both
Never poor	23%	63%	7%	6%
Transient poor	21%	63%	9%	7%
Chronic poor	11%	67%	12%	10%

From the table, it is apparent that children who belong to never poor households are less likely to face poor nutritional status (stunting and wasting both). However, stunting seems to be more widely spread amongst children relative to wasting, almost 63 percent children were found to be stunted at least once who did not face wasting. At the same time, such children who were wasted for at least once but never had stunting are not negligible either and again they seem to be highly related with poverty. From the table, it seems that poverty is associated with the joint effect of wasting and stunting (sometimes category). It came out significant on 6 degrees of freedom with chi-square= 14.0 and significant at 5% level. Nevertheless, we find evidence of substantial disadvantages in nutritional status among young children belong to poor families.

6.5.3 Modelling trajectories of poverty and health

In the previous section it is observed that always-stunted children belong to transitory poor households and always-wasted children belong to chronic poor households. The major interest here is to model the change in nutritional status of children by controlling the change in the status of economic well-being of households. We conducted the ordered logistic regression (OLR)[17] to see which category of economic status is associated with which nutritional status. The outcome variable is child's nutritional status as measured as change in stunting and wasting, hence two separate regression models are run. The outcome variable has the following ordered categories:

1- Never stunted (or wasted)
2- Sometimes stunted (or wasted)
3- Always stunted (or wasted)

The independent variable is the poverty status again with three categories:
1- Never poor
2- Transient poor
3- Chronic poor

Ordered logistic regression (OLR) provides only one set of coefficients for each independent variable. Therefore, there is an assumption of parallel regression. That is, the coefficients for the variables in the equations would not vary significantly if they were estimated separately. The intercepts would be different but the slopes would essentially be the same. To test the proportional odds assumption i.e., whether the coefficients are equal across categories, the procedure *omodel*[18] has been used. The chi-square values obtained for stunting and wasting are found to be non-significant at 2 df (chi-square= 5.83 & 1.85 for stunting and wasting respectively). These results suggest that the proportional odds approach is reasonable, i.e., the multiple equation nature of ordered logistic regression with different constants and coefficients is an appropriate choice in the present situation.

The results of the ordered logistic regression are reported in Table (6.20).

[17] For a detailed description, the readers are referred to Sec. (4.5.3).
[18] http://ideas.repec.org/c/boc/bocode/s320901.html

Table 6.20: Link between poverty and nutritional status trajectories: results of the ordered logistic regression[1]

Covariates	Stunting		Wasting	
	Coeff (SE)	OR	Coeff (SE)	OR
Poverty status:				
Transient	0.29 (0.14)**	1.34	0.17 (0.22)	1.19
Chronic	0.21 (0.19)	1.23	0.67 (0.21)**	1.95
Never	Ref		Ref	
Cut 1	-0.82 (0.10)		1.62 (0.13)	
Cut 2	0.66 (0.10)		3.54 (0.21)	
No. of children	803		803	

Standard errors are given in parenthesis.
* Significant at 5% level ** Significant at 1%
[1]Reference category for the dependent variable (s): never stunted (wasted)

The odds of being in the 'chronically stunted' versus 'sometimes and never stunted' are 1.34 times greater for children in the 'transient poor' households compared to children who were never poor during three year period. However, the results indicate that there is not a much difference in the coefficients of 'transient poor' and 'chronic poor' (0.29 and 0.21 respectively). Therefore, it could be interpreted that the two categories 'transient and chronic poor' are not very much different from each other but different from the reference category (never poor). Hence, poverty whether chronic or transient found to be associated with stunting. On the other hand, the odds of being in the 'chronically wasted' versus 'sometimes and never wasted' are 1.19 times greater for children in the 'chronically poor' households compared to never poor households. These results of OLR also endorse the preliminary results (Tables 6.18).

These findings suggest that stunting is associated with poverty (does not matter whether it is chronic or transient) and wasting with the transient poverty. Thus, lack of provision of basic-needs may have adverse effects on child's nutritional status, and lowers the HAZ/WHZ scores. It has been seen previously that the average height in the 19th century is sensitive not only to the level of income but to the distribution of income and the consumption of basic necessities by the poor (Steckel, 1995).

We further investigated some household characteristics that thought to underpin the significant associations that we got from the poverty and nutrition analysis. We found that almost 90 percent of the total chronically wasted children belong to Badin district while in Faisalabad and Dir districts no chronically wasted child was found. From Sec. (4.5.3), we have already seen that living in Badin and Attock increases the chances of becoming chronic poor which in turn increases the chances of a child to be chronically wasted. Further, we compared some other characteristics, such as the average household expenditure in AEU for such children who never had low weight-for-height Z-scores it was found Rs. 271 while for chronically wasted children the expenditure in AEU was Rs. 261. Similarly, the average caloric and the protein consumption for chronically wasted children were found much lower as compared to never wasted children (2630 KCal and 60 mg versus 2738 KCal and 70 mg respectively). The average weight-for height score for children who never had wasting was found –0.11 as compared to –3.82 (who always had wasting).

In case of stunting status, it has been found that most of the 'chronically stunted' children belong to Dir district. It has been seen already from Table (6.7) that children from Dir district are more likely to be stunted relative to any other study district. Again, the average caloric and protein consumption is lower for chronically stunted children as compared to never stunted children. Similar is the case with average household expenditure. The average height-for-age Z-scores of never stunted children were found to be –0.60 as compared to –3.75 for always stunted children. However, these effects (household expenditure, size and household caloric acquisition) were not included in the ordered logistic regression model due to the reason of endogeniety with the poverty status variable in the model[19].

Although, there is a dearth of studies on the issue of association between poverty and nutrition trajectories, hence we are not in a position to compare our results with previous studies. However, various aspects of poverty, pathology, and psychological effects on child nutrition can further explain the results (Table 6.20). These explanations are given below.

Pathological processes behind stunting and wasting

Furthermore, to interpret the results, we need to consider the physiological mechanism that triggers a child to face malnourishment. One should keep in mind that we have already seen that these measures; i.e., wasting and stunting convey different meanings (Tables 6.7 & 6.8). Stunting is a result of a slow down in skeletal growth (WHO, 1986) and hence, shortness is a pathological process. On the other hand, wasting describes thinness, so low weight-for-height may be due to a reduction in soft body tissues or due to a small body skeletal. Sometimes stunting and wasting are referred to as chronic and acute malnutrition respectively. Nevertheless, stunting can also occur due to short-term changes, such as the seasonal fluctuations in height growth (Nabarro et al., 1988). However, it is important to recognise that past events both short- and long-term can produce stunting. Hence, chronic malnutrition does not need to be caused by 'some chronic cause'. The term acute malnutrition is usually used to indicate wasting which usually occurs as a consequence of acute starvation and/or severe disease. However, children may also be thin due to chronic dietary deficiency or chronic infection/disease. Nevertheless, Victora (1992) cautioned interpreting stunting and wasting as chronic and acute conditions. For instance by considering the fact that wasting can be chronic, i.e., a wasted child can be wasted for a longer period of time and in this way that child can be referred as 'chronically wasted'.

Epidemiological evidence suggests that the first response to a nutritional and/or infectious insult is a weight loss (wasting) followed by retardation in linear growth (stunting) (Walker et al., 1996). If the insult persists, children will cease to grow in height and will lose weight, thus augmenting the process of wasting (Martorell, 1985). Finally if children survive they become chronically wasted. Hence, if the same household becomes poor again then the chances are higher for an already wasted child to remain wasted at another time point. Nevertheless, longer the duration in poverty of a household, increases the likelihood for a child to be wasted persistently.

Explanation of the results by the concept of poverty

To interpret the results of OLR (Table 6.20), we need to remind ourselves how the poverty was calculated in this study. A basic-need poverty approach has been used in this study which takes into account the household consumption expenditure and the

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[19] It is because the way poverty has been calculated in this study; which takes into account the food and the expenditure consumption at household level by considering the AEU which further takes into account

caloric consumption by adjusting age and sex of household members. Hence, in this way poor people are those who are unable to meet the minimum nutrient intake (RDA). What are the health implications of remaining poor for sometimes or remaining poor always during the course of survey? Wasting is usually occurred due to sudden lack on food consumption or any adverse impact of infection or morbidity on child's health. Hence, less food consumption has immediate adverse affect on child's weight-for-height Z-scores, i.e., it immediately lowers WHZ scores. Thus, if a household is found persistently poor during the three year survey period then it increases the likelihood for a child to be wasted chronically. It seems when the household becomes poor the first time then it is more likely to unable to provide sufficient food to a child and as a result the chances are higher for a child to decrease in weight-for-height Z-scores.

The possible explanation of the association between the poverty and stunting can be given by considering the fact that stunting relates to a long-term nutritional status. Hence, if a household becomes poor at one point of time, it is more likely that a child is unable to consume a balanced diet. It has been seen that the frequency of consumption of animal products (meat and milk) are positively associated with children's height (Golden, 1988). However, children who consume mostly vegan type of diet consisting of grain cereals, vegetables, pulses, with only small amounts of cooked fruits and occasionally some meat are found shorter and lighter (Dagnelie et al. 1994). The analysis presented in Chapter 5, indicates that the caloric consumption among the study households mostly come from cereals and very few calories they consume from meat. Consider the situation that the same poor household at time (t-1) becomes non-poor at the next time point (t+1), although, the household can now fulfil its nutrient requirement. However, the chances become very slim for a child (of that household) to overcome the damage that has already been done with his/her height-for-age Z-scores at some point of time (in t-1 year). In conclusion, we observed that poverty whether transitory or persistent have adverse effects on child nutritional status (whether short- or long-term).

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the household size and age and sex of the members.

6.6 Conclusions and discussion

The main findings from this chapter are listed below:

- ***Children's nutritional status*:** Generally the prevalence of stunting and wasting amongst the study children was found to be very high which is 52 percent and 12 percent respectively. These figures are very close to the one obtained from other nationally representative surveys conducted during that period of time when IFPRI survey was conducted.

- ***Age-specific effects on nutritional status*:** It was found that height-for-age Z-scores increase with age while the weight-for-height Z-scores decrease. The prevalence of stunting and wasting was found at its peak around 2 years of age.

- ***Child-level variables*:** Morbidity and diarrhoea were found to contribute in decreasing the height-for-age and weight-for-height Z-scores markedly. The effects of breastfeeding on HAZ are positive but on WHZ negative.

- ***Household-level variables*:**

- It was found that households with more members tend to have well nourished children.
- Children's height-for-age Z-scores get better with the increase in household expenditure but its effect on weight-for-height is negligible.
- Mother's age is positively associated with HAZ but negatively with WHZ.
- Mother's education is positively related with the child's height-for-age Z-scores.
- Mother's height did not have any impact on child nutritional status.

- ***Region of residence*:** Living in Faisalabad and Attock increases the chances of better nutritional status in terms of height-for-age Z-scores as compared with living in Dir. On the other hand living in Dir increases the chances of better weight-for-height Z-scores as compared to other three districts.

- ***Nesting of children within household*:** Dissimilarities in HAZ and WHZ Z-scores amongst the children living in the same household have been found.

- ***Being poor and being malnourished*:** It has been found that over the period of three years; persistently stunted children are found to belong to poor households while persistently wasted children are found to belong to chronic poor households.

6.6.1 Discussion

Previously some research has been done towards developing an understanding of the causes and consequences of child malnutrition, but substantial gaps remain about the size and distribution of health and nutrition status, the impact of health and nutrition on socio-economic development and appropriate nutritional policy. The present chapter addresses these issues. There were two major purposes of conducting the analyses presented in this chapter: firstly, to investigate the determinants of child malnutrition and secondly, to investigate the temporal changes in child nutritional status with the temporal changes in the economic well-being of the study households.

Anthropometry offers many advantages over other indicators of nutritional status such as biochemical and clinical analysis. This is because body measurements are sensitive over the full range of malnutrition, are easily comparable across time and location (Martorell et al., 1984). Similarly, the average values of children's heights and weights also reflect accurately the state of a nation's public health and the average nutritional status of its citizens (Micklewright et al., 2001; Eveleth and Tanner, 1990; Sen, 1985). Due to these reasons, human growth is recognised as a sensitive barometer of social change which Tanner (1994) has described as 'mirror of society'.

We modelled the determinants of child malnutrition by linking the biological and socio-economic factors with the child health. As also noted by Garcia (1990) that the empirical relationship between child nutritional and health status and the various biological and social and household factors is not easily unravelled. It might be because the nutritional status change itself is a dynamic process and mostly the measurement of outcome as well as its determinants are only proxy variables for the actual state and causes of nutritional status (Srinivasan, 1981). Detailed Knowledge of the mechanisms linking the behavioural factors affecting food consumption to children's health is useful from a policy point of view. This has been emphasised in a number of studies (Martorell et al., 1986; Mosley & Chen, 1984). The estimation of such relationship is complicated, as the socio-economic environment of the households must influence the variables selected to represent health.

The findings of this chapter are in accordance with the literature on nutrition and child growth as seen during the last decade that food consumption and disease are the important determinants of child nutritional status (Alderman et al., 1993 & Mata et al., 1977). This shift in the causes of malnutrition has brought about an increased emphasis on public health as part of the effort to improve child nutrition and growth. In developing countries, the diarrhoeal diseases are clearly associated with physical growth retardation (Martorell et al., 1975). However, children from well to do families with plenty of food available, quickly make up the losses caused by infrequent episodes of illness and as a result may catch-up in their growth. Hence, catch-up growth becomes limited by recurrent infection and poor diet. There is general agreement that the small body size of children in developing countries is largely a result of poor diets and frequent infections (Martorell et al., 1984).

Results of the multivariate analysis indicate that socio-economic and socio-demographic conditions within the household are important determinants in explaining child nutritional status. We found a positive relationship between the household size and HAZ and WHZ scores. It does not necessarily mean that children belong to bigger households have better nutritional status. It seems more likely that an extended family set up usually means a larger household size which is found to have positive impact on child nutritional status. This finding is of policy consideration and indicates the importance of extended-family set up in a rural Pakistani setting. Another important finding that emerged from the results is the age of mother; results indicate children to older mothers are more likely to have higher height-for-age Z-scores. The policy implication is that government or NGOs should try to stop the custom of girls marrying at very young ages, which is particularly common in rural areas of Pakistan. Mother's literacy status alone appears to be the crucial skill for raising child health. This suggests that providing basic literacy in rural Pakistan could substantially raise child health and nutrition.

The most important contribution of this research is in the area of child nutritional status by using the 3-level longitudinal multilevel model. As in accordance with Tanner

(1994) that children living in the same household does not necessary to have similar nutritional status as measured by height-for-age and weight-for-height Z-scores.

If we were to employ a traditional longitudinal model (2-level) in which children are nested in the measurement occasions then in that case we would give more attention to individuals and little on the social contexts in which the individuals are located. For instance, such models may be able to explain the variability between children but they cannot address that how much variability is attributable to the social context such as household. This kind of impact of the social context can only be studied by employing a higher level model. Ignoring such natural hierarchy in the data may lead towards underestimating of the standard errors as a result of ignoring the clustering of individuals. Diez-Roux (2000) articulated the idea that individuals may be influenced by their social context is a key notion in the social sciences, and has led to much debate and empirical research on the interactions between attributes of groups and attributes of individuals.

Another significant contribution of this chapter in child health literature is establishing a link between mobility within poverty of the household and its consequences on the changes in child's HAZ and WHZ Z-scores. It is found that chronic poverty is associated with wasting and poverty (both transient and chronic) with stunting. Generally speaking, we found that being poor whether chronic or transitory puts a child at high risk of malnourishment (stunting or wasting). Poverty experiences of a household may affect in various directions on child's nutritional status, such as income volatility also often creates emotional stress for parents, which can in turn lead them to be less nurturing with their children than are parents with greater income stability. While income directly influences the availability of food, health care, and housing, financial strain also hinders child development through distinct mechanisms.

Because of economic limitations, poor parents have more difficulty providing intellectually stimulating facilities which are thought to be essential for children's developments. Hence, the government policies should not only target chronic poor households but include transitory poor households as well. One more policy implication that cam out from the analyses presented in this chapter is that any nutrition intervention programme should be planned in line with poverty alleviation programme. Thus, the health policies should be pro-poor which requires a fundamental shift in the present health policies in Pakistan. However, at the same time, a considerable number of malnourished children were found to belong to never poor households (Table 6.18). These results present a situation that poor households tend to have chronically stunted or chronically wasted children (statistically significant), and at the same time never poor household also have malnourished children. This situation indicates other household factors accounting for poor nutritional status among the study children. In Chapter 5, we have already seen that most of the share in calories and proteins do come from cereals and very little share comes from meat, vegetables and fruits (about 1 percent). This low share of calories or proteins from e.g., meat did not seem to increase with the increase in household expenditure. Hence, non-poor households although consume more calories, it does not mean that they also consume a balanced diet. Children while growing require some essential nutrients and minerals and some of them are consumed from meat products. Therefore, one of the reasons of poor nutritional status, especially amongst children belong to non-poor households may be attributable to poor dietary intake which is so much reliant on cereals. This findings indicate that there is a need of pro-poor health policies at the same time, a need emerges of providing nutrition education to particularly women that what to eat to consume a nutritionally balanced diet.

Generally, the results of this study indicate that the causes of stunting and wasting are different. The bivariate correlation between HAZ and WHZ Z-scores indicate a negative association between these two indicators (Pearson Correlation = -0.51 and significant at 1%). Such kind of results have been previously reported in some studies (Fernandez, 2001; Ricci et al., 1996; Victora, 1992; WHO, 1986). However, wasting and stunting certainly share some common biological process leading to wasting and stunting, such as insufficient energy intake and infections. When energy intake is deficient both wasting and stunting would ensue; given enough energy, accompanied by control of infections, wasting would be reduced but linear growth might still be constrained by other limiting factors. This implies that deficits in wasting and stunting result, at least in part, from different causes. Our results support this statement as has been reported in other studies (Victora, 1992). However, it is likely possible that the association between stunting and wasting cannot be detected in epidemiological studies using anthropometric indices to measure nutritional status. Fernandez (1999) argued of examining biochemical markers of nutritional deficits in order to study the underlying biology of the association between wasting and stunting. Although, our data do not permit us in exploring the biological process that triggers causing wasting and stunting, but we were able to explore the socio-economic and demographic processes within a household that can cause wasting and stunting among children.

Why is it important to investigate nutritional and poverty experiences of children during their childhood? It is generally assumed that childhood experiences set the stage for lifetime experiences. Yaqub (2002) underlines the importance of childhood period as saying, "childhood is seen as foundational for individual development, both physiologically and psychologically, and is taken to define lifetime socio-economic potential". This statement of Yaqub is an endorsement that is pointed out by Sen (1999) "...capabilities that adults enjoy are deeply conditional on their experiences as children". The higher prevalence of poor nutritional status among poor children may have consequences not only for their immediate health, but may also interfere with learning ability and school performance and may be an important link between poverty experienced in early childhood and in adulthood (Duncan et al., 1994). Children who are stunted or wasted have lower scores on tests of cognitive development, even when long-term income is controlled. Furthermore, wasting in early childhood has well-established effects on later morbidity and mortality (Rivera et al., 1988 and Grantham, 1995).

From the findings of the analyses presented in this chapter, it can be inferred that social and food security policies which improve incomes of the poor households as well as access of women to education and health care would reduce both poverty and malnutrition. The future research on nutrition and poverty in Pakistan should concentrate on investigating the long-term consequences of being malnourished and being poor during childhood later in life. In this regard, various functions during adulthood can be studied, such as cognitive and motor development, education attainment levels, participation in the labour market and various diseases later in life.

Chapter 7

Conclusions and discussion

The present study addresses the principal research question 'how do time, individual and household factors and levels influence child nutritional status?' This question has been investigated using a child health framework. The framework describes child nutritional status as an outcome of an array of socio-economic and bio-medical factors at child, household and community levels. The study has systematically investigated factors at various levels of the framework, and their effects on child nutritional status have also been examined. To accomplish this, a range of statistical modelling techniques have been used.

Longitudinal data collected by the International Food Policy Research Institute (IFPRI) have been used to study the temporal changes in household socio-economic status, child physical growth trajectories and temporal changes in child nutritional status. These data were collected from 1986 to 1989 and are based on the rural areas of Pakistan. Almost seventy percent of the total population of Pakistan lives in rural areas, and almost fifty percent of the total labour force is involved in agriculture-related activities. Clearly, it is very important to have an understanding of the rural population's health and economic status, so that proper policies can be planned to combat malnutrition and economic deprivation in rural parts of the country. Accordingly, the objectives of this chapter are firstly, to summarise the important findings of the study; secondly, to discuss the policy implications of the results; and finally to explore the caveats for the present study and areas for future research.

7.1 Summary of important findings

This section presents the summary of important findings of the thesis.

Height and weight growth trajectories of the study children

The analyses of the patterns of growth and timings of growth retardation amongst the study children were reported in Chapter 3. The analyses were performed using the growth curve modelling approach. There is a dearth of studies on children's physical growth patterns by using the growth curve models in the developing countries with particular reference to South Asian region. Nevertheless, the results of this study can be compared with a longitudinal study done by Yang and Leung (1994) which was based on children from China. In their sample of children, the maximum age was 24 months. They used the growth curve modelling techniques to examine the growth trajectories of children and also in predicting the growth velocities up to age 24 months. We found great similarities in predicted growth velocities between rural Pakistani and Chinese children. Both the groups of children found to exhibit similar growth patterns up to age 24 months, e.g., the predicted height growth velocities up to age 12 months were approximately 12 cm and the predicted weight velocities were approximately 2.5 kg. Yang et al. (1994) also concluded that children grew faster in their height and weight up to about 10 months, then slowed down with slighter lower velocity after 1 year. These results are in line with the results of the present study.

The main findings that emerge from the analyses of physical growth trajectories of children are summarised below:

- The study children are in deficit in their height and weight measures compared to NCHS/WHO reference population. The quadratic growth curves fitted to data indicate that although the growth rates of children seem to be increasing with age but with a slower rate. Further, the predicted average growth velocities indicate a slower growth during the first year of child's life.
- In a particular cohort of children some evidence of growth acceleration is found during the third year of children's life after a growth deceleration in the second year of life.

Incidence of poverty amongst the study households

The child health framework gives a central position to the household in explaining child nutritional status. Two chapters (Chapters 4 and 5) examine the household characteristics that are thought to be important determinants of child health. A comprehensive overview of household composition and household economics is reported in Chapter 4, while Chapter 5 deals with household food consumption patterns. The main purpose of Chapter 4 was to investigate the status of the economic well-being of the study households. This chapter also provides an overview of the composition of a typical rural Pakistani household.

The main findings that emerge from Chapter 4 are summarised below:

- As much as 29 percent of households were found to be living below the poverty line, of which 34 percent of households were found to be transitory poor and 10 percent chronic poor over a three year period.
- Bigger household size was found to be associated with being poor, becoming poor and being persistently poor, while head's education, elderly people in a household and land holding were found to decrease the chances of a household becoming poor.
- It was found that even in a short period of three years the poverty status of the study households was not static and much economic mobility was observed.

The food consumption patterns amongst the study households

A description of the food consumption patterns at the household level is presented in Chapter 5. Household food security is one prerequisite for nutrition security. Diet diversity has been identified as one of the measures of food insecurity (Smith, 2003). In a study based on 11 countries, it has been seen that dietary diversity is associated with child nutritional status (Arimond et al., 2004). They selected two countries from Asia: Cambodia and Nepal (Nepal is situated in South Asia with Pakistan). The results obtained for both the countries indicate a low dietary diversity score (2.8 each out of possible 0-7) while low dietary diversity score found to be associated with low HAZ scores. The results of this study and the present study are indicative of possible low dietary diversity in South Asian region. Nevertheless, this aspect needs further research. This is an important area of research, so as to proper policies can be made towards combating malnutrition in the region.

The main findings that emerge from the analyses of Chapter 5 are listed below:

- The average caloric consumption is considerably higher than the RDA amongst the study households. However, food choices are mostly centred around consuming more cereals and less meat and vegetables.
- The factors positively affecting the acquisition of calories and proteins are: wife's education and age, head is farmer, household expenditure, consuming from own production, while bigger household size decreases the chances of acquiring calories and proteins.

The determinants of child malnutrition

Child nutritional status has been examined in Chapter 6 by using the factors identified at various levels of child framework. Child health framework gives a central position to household mechanisms in explaining child malnutrition. Both in chapters 5 & 6, we tried including some household demographic variables such as, number of elderly, proportion of children and proportion of male and female adult children in a household.[1] However, besides household size no other demographic variable came out significant. The non-significant associations of the demographic composition of a household with HAZ and WHZ scores probably indicate a household comprises of both malnourished (stunted and/or wasted) and also overweight persons. To supplement this statement, we can take help from the results of the random-effect part of the multilevel model, which indicates heterogeneity in HAZ and WHZ scores of two randomly selected children from a same household. Recent studies show that underweight or stunting can coexist with overweight or obesity within households in developing countries (e.g., Doak et al., 2005). In literature such households are referred as 'dual burden households' which can be defined as "a household in which person in the household is overweight and another is underweight, reflecting the dual burden of overweight and underweight clustering within a single household" (Doak et al., 2005). Due to time limitations, the phenomenon 'dual burden household' could not be explored in the present study. Thus, stratifying the demographic composition of a household by children/adults or elderly most probably cannot reveal the true picture unless the household is classified as 'overweight' or 'underweight' or 'dual burden'.

Another, most probable reason of not getting significant results of household demographic composition, is the fact that household has been assumed to be

[1] Eventually these variables were taken out from the model.

homogenous unit in our study. However, inequalities in the distribution of resources within the household itself gives rise to recognise heterogeneities in resources within a household. It has been seen in a study in India and Bangladesh that the allocation of food within a household favours fathers and boys (Chen et al., 1981) and this contributes to a higher rates of mortality among young female children. Thus, to have proper understanding of various matters related with gender and resource allocation within a household, we emphasise a need of an in depth intra-household resource allocation study in Pakistan.

The main findings that emerge from the analysis of child nutrition are listed below:

- Generally, the prevalence of malnutrition among children was found to be very high: almost 52 and 10 percent children were found to be stunted and wasted respectively. The causes of stunting and wasting are generally found to be different; this is also indicated by the negative correlation between them (-0.51). However, some common factors are also found such as exposure to diarrhoea or any other illness, and household size.
- The results of a three-level model show that children living in the same household tend to have dissimilarities in their nutritional statues.

The link poverty status of a household and child nutritional status

The longitudinal nature of the data allowed the exploration of child nutritional status from one time point to the next through the investigation of how many children remained malnourished throughout the survey period, how many were malnourished for some time, and how many never became malnourished. The purpose of the analyses was to associate the economic status of families within a three-year period with temporal changes in child nutrition within the same three-year period. These analyses were presented in Chapter 6 (Sec. 6.5). The main findings that emerged from this analysis are listed below:

- Like poverty, child nutritional status is not static, however, 37 percent of children were found to be persistently stunted throughout survey period indicates that stunting is of chronic nature in the study areas.
- Chronic stunting is found to be associated with poverty and chronic wasting with chronic poverty.

7.2 Conclusions and policy implications

In order to combat malnutrition amongst the children in rural Pakistan, a number of policy recommendations have emerged from the findings of this study; these are discussed below with respect to the child health framework.

Targeting factors at the immediate level. The significant associations of child-level factors specified at the immediate level highlight the importance of targeting factors such as diarrhoea and other illnesses in order to combat malnutrition amongst children in rural Pakistan. Hence, health policies that result in a reduction of diseases such as diarrhoea, as well as in an improvement in the quality of the available health infrastructure, will also contribute positively to nutritional outcomes. Similarly, improvement of the sources of drinking water in rural areas is likely to reduce malnutrition among children. Another point of policy implication that emerged from the findings is the importance of breastfeeding and especially exclusive breastfeeding, which is not very common in Pakistan. There should be programmes from both government and the NGOs to educate women about the importance of exclusive breastfeeding.

Our results also indicate age-specific effects on child physical growth. Therefore, it is also crucial to monitor height and weight growth amongst children on a regular basis. This target can be achieved by training doctors/nurses or health workers in monitoring the growth of infants and young children on a regular basis. In this way, any serious irregularities in growth patterns can be identified and proper remedies can be found for treating growth retardation.

Targeting factors at the underlying household level. Effective programmes and policies to alleviate malnutrition require an understanding of the underlying determinants. The factors that are specified at the underlying levels are various clusters of factors, such as household food security, household socio-economic and demographic characteristics and mother-level factors. Therefore policy implications are discussed with regard to these three clusters for those associations that emerged as significant and are given below:

- **Household food security.** The results of study indicate that despite consuming higher calories than the RDA, a large majority of rural population is not nutritionally secured. We found that food choices are mostly centred around cereals. The consumption of food that has higher contents of protein, essential minerals and vitamins, such as, meat, vegetables and fruits is very low. Inadequate consumption of essential micronutrients can be related to various diseases, such as various types of cancer, anaemia, blindness and brain dysfunction. Furthermore, nutrient deficiency during childhood can lead to lower participation in the labour force in later life. Therefore, there is a need to educate the masses about healthy eating habits. This also draws the attention of concerned authorities for price-watch of essential food items to make proper food available to the poor people.

- **Various household characteristics.** The positive association between bigger household size and child nutritional status does not mean that bigger the household, better will be the nutritional status. Our results indicate that the association in question is usually due to an extended family set-up in rural areas of Pakistan. The extended family system remains Pakistan's important social safety net (World Bank, 1995). The results also indicate that the presence of elderly reduces the chances of a household to live below the poverty line, it is because in rural Pakistan, mostly elderly males remain economically active. Policy implication from this finding is a need of government interventions for the benefits of elderly and also to involve elderly people, both males and females, in government poverty alleviation programmes, so that their experiences can be utilised. However, the results of poverty analysis indicate that bigger household size increases the chances of being poor and entering into poverty. This indicates the need for the proper promotion and implementation of family planning programmes and expanding the outreach of these services for people in rural areas.

- **Mother-level factors.** Mother's education is found to be associated with better HAZ scores and adequate caloric acquisition, hence the government should promote girl's education and, considering social constraints in rural areas, there should be separate schools for girls where free education can be provided.

- **Regional variations.** Results indicate provincial differentials in child nutritional status, hence nutrition and health programmes should be planned and implemented on a provincial basis, considering the social and cultural constraints of each province separately.

Poverty as a root cause of malnutrition. The results indicate that in rural Pakistan generally poverty is not a static condition. Even in a short period of three years, a number of households have changed their economic status either from poor to non-poor or from non-poor to poor. Furthermore, there were some households who remained poor throughout the survey period. These are the chronic poor: those who suffer poverty for many years, often for a lifetime, and who are likely to transfer their poverty to their children. Thus the effects of poverty, in chronic cases, may be intergenerational.

Much recent research has pointed to the importance of looking at differences among the poor to understand why they are poor and to help them improve their situation. For instance, appreciating the differences between chronic and transient poverty is important for policy. Where poverty is mainly chronic, policy should target investment at the geographical, physical and the human assets of poor households, and when poverty is largely temporary and the poor are drawn from a much larger group of vulnerable households, then the emphasis should be on broader interventions that support households during hard times (e.g., drought and economic shocks) such as social safety nets[2], insurance and credit programmes.

The results in these analyses show clearly that how an understanding of the forces that cause a household to live below the poverty line can inform development policy. They suggest starting points for ensuring that the transitory poor along with the chronic poor are included in research and development action. Expanding such knowledge is a policy priority. At the same time, the factors that allow households to escape from poverty need to be a focal point of government action for poverty alleviation[3]. This target of alleviating poverty can be achieved by making and implementing proper economic reform policies for the agricultural as well as non-agricultural sectors in rural areas. These results suggest strengthening of household resource base, i.e. food and other relevant livelihood needs, through investment projects that can expand and improve the

[2] Such as the proper and transparent system of giving *Zakat* to poor from Baitul-Mal.

productivity of rural households through increased output, raised incomes and awareness about education, health, nutrition and hygiene.

Alleviating poverty is important as results indicate an association between poverty and poor child nutritional status. Poor families are at greater risk of not providing their children with sufficient food, care and basic necessities of life, and this generally results in children with poor nutritional status. Hence, to achieve the target of having a well-nourished population, particularly children, it is vital to alleviate poverty first.

7.3 How the findings of this research fit in the existing policies of Pakistan?

In recent years in Pakistan, a number of poverty alleviation programmes have been planned and implemented such as, Poverty Reduction Strategy of Pakistan (PRSP) (Govt. of Pakistan, 2003). In parallel lines, Planning Commission has undertaken a comprehensive plan of combating poverty and malnutrition in country, called as Medium Term Development Framework (MTDF: 2005-10) (Govt. of Pakistan, 2004). These poverty alleviation programmes aim to broaden and deepen the development process in ways that enlarge the basis of achieving high rate of economic growth with a combination of mutually reinforcing factors. These include a high rate of economic growth, which have translated directly or indirectly into increase in disposable incomes and strong commitment to investments in the social sectors, especially health and education.

The Planning Commission, Government of Pakistan, is also in a process of planning the Nutrition Policy (2005-10). The important pillars of this policy are: household food security, promoting mother and infant nutrition and community nutrition programmes. This Nutrition Policy introduces 'Tawana[4] Pakistan Programme' (Strong Pakistan Programme). This scheme outlines a plan of a nutrition package (school meals) to school going girls of aged 5-9 years in 26 high poverty districts all over the country. The Government of Pakistan also has a National Health Policy (NHP) (Govt. of Pakistan, 2001). Most of the goals of NHP are overlapped with the Nutrition Programme. Both the nutrition and health policies also highlight a need of exclusive breastfeeding up to age 6 months.

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[3] Such as the recently started Poverty reduction programme by the Govt. of Pakistan (Govt. of Pakistan, 2003).

The present research rightly fits in the ongoing debate of combating poverty and malnutrition in country. Most of the findings of this research have already been addressed in the Poverty Reduction Programme (PRP), and the Government Health and Nutrition Policies. At one hand, it is surprising that the findings of this 15 years old data set still hold in the current situation of Pakistan. It is because, the situation with poverty and nutrition in Pakistan has not been changed, and rather in some sectors it has been deteriorated. Thus, most of the points that emerge from this study have been given due attention and consideration in almost all the future and ongoing policies of Pakistan. It should be kept in mind that this study has used IFPRI panel data which is not a nationally representative sample but it can be taken as representing the rural population of Pakistan. The rural population comprises of almost 70% of the total population of Pakistan. Thus, the findings of this study can still be used in making policies for the deprived and poor people, especially the rural population.

There is one aspect that needs more attention from the policy makers is a matter of food security. The Nutrition and Health policies emphasise providing either school meals to a small sample or providing nutrient supplements such as, iodised salt and flour fortification with iron to masses. The question is how effective will be such nutrition policies? The results of the present study indicate a lack of dietary diversity amongst the people in rural Pakistan. This result has an important policy implication in view of the present situation in Pakistan. There is some evidence that food-based approaches (dietary change) to combating nutrient- and micronutrient- deficiencies are likely to be more sustainable than chemical supplementation, such as vitamin A tablets (Neumann et al 1993).

In summary: Within the framework of child health, malnutrition should be viewed as one important manifestation of a larger development problem. However, the goal is not only to eliminate the symptoms but also to address the development problem itself. This is not to diminish the importance of malnutrition and child health in any way, but only to be clear that the way in which these manifestations are addressed is also important. From this perspective, interest in alleviating micronutrient malnutrition would be regarded as attacking the manifestations but in most cases doing little to address the root causes which lie in the larger development problem. In attempting to assess the extent to which how this framework of child health can be implemented, it is necessary not only

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[4] Tawana means a physically strong and healthy person.

to describe it in its own right but also to clarify precisely how it differs from other views as it has been examined in this study. This will provide valuable clues for assessing the extent to which the framework has been adopted.

Targeting the factors specified at various levels of child health framework has broader policy implications particularly in achieving the government poverty and malnutrition reduction programmes. These government programmes are further linked with achieving the MDGs. As three of the eight Millennium Development Goals (MDGs) are explicitly health related. Because malnutrition underpins both child mortality and poverty, policies and programmes that improve nutritional status are key to achieving these MDGs. This is a virtuous circle, in the sense that a healthy population leads to good achievements in education, then to improved employment opportunities and increased economic development.

7.4 Recommendations for future research and caveats (boundaries) of the study

Future research either on child nutrition or on any other issue using the IFPRI panel data could be focused on some of the issues that emerged from the results of this study. Some recommendations for future research are listed below:

- One of the caveats of this research, which is common to all longitudinal studies, is the problem of sample loss due to number of reasons, such as, unavailability of respondents, non-response and etc. Any future research should focus on filling the missing values by appropriate methods of imputation[5]. This kind of exercise has never been done with this IFPRI data set.

- We perceive a need for conducting in-depth qualitative research to address issues such as food consumption patterns, eating habits and taboos, gender discrimination and intra-household resource allocation.

- An area which can be of interest to policy makers is the study of the consequences of child nutritional status during adulthood, i.e. to see whether a malnourished child becomes a malnourished adult and to evaluate the

[5] Interested readers can read a report by Tabassum and Holt (2004) in which they have imputed the missing values of a time series data by using various models ranging from OLS to multilevel models.

consequences of childhood malnutrition for cognitive functions and labour force participation in later life. For this purpose, long time-series data from childhood to adulthood will be required.

- Another area which needs further research with regard to Pakistan is the consequences of maternal nutritional status on child nutritional status.

- At several occasions our results indicate the positive effects of an extended family set-up on child's well being and better nutrition. Hence, any future research should investigate the factors such as the effects of extended families on child's well-being. Further, if the family is extended then what kind of relatives are living in a household, what is the impact of living with, e.g., mother-in-law as Griffiths (1998) has investigated this issue in three Indian states.

- The results of the three-level analysis indicate that further research into similarities/dissimilarities in child nutritional status between household members needs to be carried out. In theory it is possible to consider more complex multilevel structures such as multiple membership models that would facilitate the analysis of change at an individual and household level.

- Although this study has extensively used hierarchical linear models for the longitudinal data, this has been achieved by assuming a constant error-correlation structure over the period of time. A future study could explore the possibility of employing a within-error correlation structure.

- The results of food consumption analyses indicate a lack of dietary diversity amongst the study households. The future research should address the matter that how diet diversity can be associated with child nutritional status in Pakistan.

- 'Nutrition transition' is a new concept started emerging a decade ago. It is therefore, seems imperative that future studies on nutrition in Pakistan should consider this aspect, particularly by stratifying households as 'dual burden' which comprised of both 'underweight' and 'overweight' persons. This classification of households is important in view of public health interventions.

- We strongly feel that data collection on socio-economic and health and nutrition indicators should be a regular exercise in Pakistan. Young researchers should be involved in studies of nutrition and the socio-economic aspects of public health, and their findings should be dealt with seriously by government officials. Making policies is not enough; rather, the implementation of policies is the key factor in developing countries like Pakistan, where due to changes of government, policies change very quickly and hence are unable to obtain the desired results.

Finally, we feel that the effects of some of the variables on child nutrition indicators could not be captured in this study due to the unavailability of some variables in the data set. For instance, no longitudinal information was collected on the duration of breastfeeding for every child. In the absence of this information we were unable to take into account factors such as the impact on child nutritional status of exclusive breastfeeding up to age 4 to 6 months, of breastfeeding after 6 months of age, and of age at weaning. Similarly, we were unable to capture the impacts of maternal nutrition on child nutrition as no information was collected on mother's nutritional status during pregnancy. At the underlying level, due to the unavailability of longitudinal information on a number of household physical environmental factors, e.g., water source and latrine facility, we were unable to capture the impacts of such factors on child nutrition. Again, a number of variables at the community level could not be included in the regression analysis due to missing values. Nevertheless, despite these limitations, we believe that this study contributes significantly to the literature of child health and nutrition and also demonstrates grounds for policy formulation.

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