HEALTH AND NUTRITIONAL STATUS OF THE HMARS OF AIZAWL DISTRICT, MIZORAM

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A SUMMARY OF

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SUMMARY

Health is an important input for the development of human resources and the quality of life necessary for the overall development of the community or country as a whole. In this connection, the World Health Organization has defined health as "a state of complete mental and social well being and not merely the absence of diseases or infirmity" (WHO, 1971). Although it may not be possible to attain all such types of well-being as referred to in this definition, the WHO's constitution says, "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political, economic and social condition." As such, health is a holistic concept, and one may define health in any manner relating to either one or all physical, mental and well-being of an individual, or a population, according to one's expediency of study. From an anthropological point of view, one may look into health as a state of well-being due to the interplay between socio-cultural and biological factors - environmental and genetic factors (Kar, 2000).

In order to measure the health status of a population, one needs to take into consideration certain health parameters, which are generally considered as health indicators, although the method of measuring may vary from one study to another (Gwatkin, 2000). Park (1995) has listed a number of health indicators under different categories, viz., *mortality rates, morbidity rates, disability or illness and injury rates, nutritional status, health care and delivery indicators, family planning and epidemiological policies, social and mental health indicators* (e.g., include suicide, homicide, acts of violence and crimes, road traffic accidents, juvenile delinquency, alcohol and drug abuse, smoking, and the like), *environmental indicators* (e.g., physical

and biological environmental conditions in which diseases occur like air and water pollution, radiation, solid wastes, noise, exposure to solid substances in food and drinks, etc.), *socio-economic indicators* (e.g., population growth, per capita income, per capita expenditure, per capita gross national product, level of unemployment, literacy rates, family size, number of persons per room, per capita calorie availability, social security and welfare services), and *health policy indicators* (e.g., GNP spent on health services, water supply, sanitation, housing, community development, and so on).

It is, therefore, obvious that there are a large number of health parameters, and for that reason, it is often argued that health status is a function of many biological and socio-environmental factors. Accordingly, it is not simple to assess the health status of the population, especially in the case of individual research as it requires a technical knowledge from different fields or disciplines. "This is because health, like happiness, cannot be defined in exact measurable terms. Its presence or absence is so largely a matter of subjective judgment" (Park, 1995). Nevertheless, selection of few sensitive, specific and reliable parameters is also meaningful especially for screening or identifying the health problems of a specific population at a given point of time, which are required for immediate intervention. From the biological anthropological point of view, demographic variables (e.g., fertility, mortality and reproductive wastage), self-reported morbidity, nutritional anthropometry of adults, growth and nutritional status of children, and haematological traits including blood pressure and hemoglobin content are commonly used as health indicators of population (Khongsdier, 1996). These health parameters are in turn influenced by numerous biosocial factors. An attempt to understand the relationship of these health parameters with various socio-economic factors like educational level, occupation, income and expenditure of the household, etc., may be very helpful in understanding the health status of a population.

In the present thesis, we shall deal with the health status of the Hmar population of Aizawl District, Mizoram, with respect to certain selected health parameters such as demographic variables, anthropometric variables, growth and nutritional status, morbidity and hemoglobin level. An attempt will be made to look into the interrelationship between these health parameters and their association with age, sex, economic condition and educational level. With this end in view, we propose to undertake a study on the health and nutritional status of the Hmars of Aizawl district in Mizoram, taking into consideration the following objectives:

1. To describe the demographic structure of the Hmar population of Aizawl district of Mizoram.
2. To understand the growth and nutritional status of children aged 2 to 10 years, using selected anthropometric measurements and indices in relation to socio-economic conditions.
3. To understand the health and nutritional status of adults in terms of anthropometric variables, hemoglobin level and morbidity pattern, and to find out the possible relationship between these health variables and certain socio-economic factors.

MATERIALS AND METHODS

Study Area and Population

The present study was carried out in Aizawl District of Mizoram during the months of September to December 2001. The state is predominantly dominated by tribal groups like Lushais, Pawis, Paites, Raltes, Pang, Kukis, Hmars, etc. In the present study, we shall deal with the Hmars of Aizawl district. The Hmars have their own dialect, which has a close affinity to the Lushais and invariably resemble Paites and Kukis. Linguistically, they belong to the Kuki-Chin family. It was the Christian missionaries who introduced the Roman script to the Hmar language in the 19th Century.

The Hmars are divided into 24 clans and each of these clans is again divided into about 180 sub clans/families. Clanship does not regulate marriage rules and an individual can select his mate from any clan including his own. Widow re-marriage is not uncommon. Being a patriarchal society, the father heads the family and lineage is traced through the male line. The general rule of inheritance is that the youngest son gets the lion share of parental property. Women are not allowed to inherit any property. Agriculture is the main occupation of the Hmars. Some are also engaged in weaving, handicraft, business and services.

The data for the present study were collected from four villages, namely, Tinghmun, Zohmun, Sakawrdai and Ratu, Darlawn Block in rural areas of Aizawl district, Mizoram by means of simple random sampling (Census 2001). According to this sampling method, the list of 20 villages and their population in Aizawl District was first prepared based on the information from Indian Census 1991 and T.R.I. 1992.The random numbers given in Snedecor and Cochran (1967) was used for selecting the required number of sample villages. No random sampling was applied for selection of subjects/informants from each of the selected villages due to operational difficulties in the field. An attempt was made to cover 410 households, that is, about 45% of the total 914 households in all four selected villages.

Demographic Data

The nature of demographic data collected for the present study was based on those parameters suggested by the World Health Organization Working Group (WHO, 1964, 1968; Mahadevan, 1986). The entire demographic data were collected through pedigrees and schedules from all the four hundred households in the four villages, namely, Tinghmun, Zohmun, Sakawrdai and Ratu. Information on age, sex, marital status, tribe, religion, occupation, income, education, community affiliation, place of birth, place of residence, etc. was collected from the head of the household or elder member who was capable of furnishing all the relevant information as per household schedule.

The fertility schedule was completed by filling-in the information on the number of conceptions, number of live births, number of reproductive wastages (abortion and still births), sex, present age, age at death, birth order, etc. from all the ever married women. Pedigrees were also collected from cross-checking of data on reproductive history of the mothers. Sometimes, information given by the mothers was cross-checked from their respective husbands. It may be mentioned that great difficulties were experienced in the assessment of age particularly that of the elderly women, since many of them were not aware of their real age. Consequently in such cases, the age was estimated with the help of other persons in the household/village. So, there could be some mistakes, in some cases, in the estimation of age.

Data on Adult Body dimensions

Some selected anthropometric measurements from the basic list of measurements, recommended by the International Biological Programme (Weiner and Lourie, 1981) were taken into consideration for the purpose of the present study. Following are the anthropometric measurements taken on 978 adults aged 20 years and above of both sexes wearing light apparel.

Weight (Kg)

Height (cm)

Sitting Height (cm)

Biacromial Diameter (cm)

Bi-iliac Diameter (cm)

Mid Upper Arm Circumference (MUAC)

Chest girth (inhaled) (cm)

Chest girth (exhaled) (cm)

Besides the above measurements, following indices were computed for adult males and females in order to assess the nutritional status.

1. Body mass index = weight (kg)/height $(m)^2$
2. Cormic index or relative-sitting height = sitting height (cm)/ height (cm)

Data on Growth and Nutritional Status of Children

The present study of physical group was based on a cross sectional sample of Hmar boys and girls aged between 2-10 years. Following are the anthropometric measurements taken on 255 boys and 252 girls:

1. Weight (Kg)
2. Height vertex (cm)
3. Sitting height vertex (cm)
4. Bi acromial Diameter (cm)
5. Bi iliac Diameter (cm)
6. Mid upper arm circumference (Left arm) (cm)

An attempt was made to follow as far as possible the standard techniques of taking the measurements as described in Weiner and Lourie (1981). For assessing the nutritional status of children, we had taken three anthropometric indices – weight-for-age, height-for-age and weight-for-height - which are considered as the indicators of nutritional status. These indices were derived as z-scores of the international standard or reference, i.e., the growth reference of the WHO/U.S. National Centre for Health Statistics (WHO, 1983, 1995). Body mass index (BMI = weight in kg/height in meter squared) was used for assessing the nutritional status of adult males and females (WHO, 1995).

Data on Morbidity and Hemoglobin Level

Data on haemoglobin content of 551 adults were collected using Sahli's Haemometer by following standard techniques (WHO, 1980). The cut-off points of 13.0 g/dl and 12.0 g/dl were taken for screening the adult men and non-pregnant women, respectively (WHO, 1968). Data on morbidity were based on "self-reported illness experience" of a subject as generally adopted in surveys, which did not involve a clinician (Strickland & Ulijaszek, 1993; Garcia & Kennedy, 1994; Strickland & Tuffrey, 1997). SRM is also more preferable from the point of view that a clinical diagnosis involves much time, cost and technical expertise, which are not always possible when carrying out community-based studies in developing countries including India.

Socio-economic Categories

In the present study, three important socio-economic variables were taken into consideration. These include religion, monthly income of the households and educational level. These socio-economic variables were classified arbitrarily into different groups and/or categories with a view to understanding their influence on the health traits of the study population. Our classification may be briefly described as follows:

Income groups: Data on household income were collected directly from the head of the household and they were cross-checked taking into consideration some aspects of socio-economic conditions like housing condition, types of occupation, land holding, and monthly expenditure. The interval estimation based on standard deviation of the per capita monthly income of household was adopted for classifying the three economic groups (Khongsdier, 1997), which is as follows:

Above ($\bar{X} + 4SD/\sqrt{N}$) = High income group (HIG)

($\bar{X} - 4SD/\sqrt{N}$) to (Mean + $4SD/\sqrt{N}$) = Middle income group (MIG)

Below ($\bar{X} - 4SD/\sqrt{N}$) = Low income group (LIG)

Educational Level: The data on educational attainment of individuals in the present study were arbitrarily classified as follows: The category **No education** includes those individuals who were unable to read and write and those who had no education but could read or write their names. The individuals who attended school up to standard V were grouped into **Primary** level of education. The individuals with education of standard VI and above are included in the category of **Secondary level** of education due to inadequacy of data.

Statistical Analyses

The data collected for the present study are quantified and analysed statistically, using SPSS Window software. The data are presented in terms of means, standard deviation, standard error and proportions or percentages. The differences between two means were tested, using t-student test, while the differences between more than two means were determined, using one-way analysis of variance (ANOVA). Analysis of covariance was also carried out for testing the differences among means, allowing for the effects of other covariates. The differences between proportions were tested, using chi-square test. Multiple regression analysis was also carried out for understanding the effects of socio-economic factors on demographic parameters and growth patterns of children. Logistic regression analysis was used for analyzing the effects of maternal age, education, income and religion on infant mortality.

FINDINGS OF THE PRESENT STUDY

The findings of the present study were presented in three chapters. In chapter III, we deal with the demographic characteristics of the three religious groups. The growth and nutritional status of children are presented in Chapters IV, whereas adult body dimensions and health status was given in Chapter V.

DEMOGRAPHIC CHARACTERISTICS

The findings on important demographic characteristics of the study population are as follows:

1. According to Sundbarg's classification of population, a population is said to be *progressive* when the number of persons in relation to the total population

are 40.0%, 50.00% and 10.00% in the age groups 0-14, 15-49 and 50 + years, respectively. The population is referred to as *stationary* if these frequencies are 33.00%, 50.00% and 17.00%, respectively; while the frequencies of 20.00%, 50.00% and 30.00%, respectively, are the characteristics of *regressive* population (Khongsdier, 2005). Following these classifications of population, the Hmar population is categorized as *progressive type.*

2. The over all sex ratio, i.e., the number of males per 100 females, is found to be 95.22 which is lower than the ideal sex ratio of 1:1, despite the absence of statistical significance ($\chi^2 = 1.56$, d.f. = 1, $p > 0.05$).
3. The mean age at marriage is significantly higher in males (25.84 ± 0.29 years) than in females (20.78 ± 0.19 years) as generally observed in other populations (Khongsdier, 2005). The mean age at marriage among the Hmar married women of the present study is higher than those reported for many populations of Assam (Sengupta and Gogoi, 1995), but it is more less similar to that reported for the War Khasi and Khynriam Khasis (Khongsdier, 2001; Mukherjee, 2002).

Fertility and Mortality

1. The mean live birth per mother of all ages was 4.67 ± 0.13. In comparison with the recent reports on some populations in Northeast India, the fertility rate among the Hmars of the present study seems to be fairly high.
2. The age specific fertility rate seemed to reach its peak point in the age group 25-29 years. The total fertility rate (6.10) was much higher than that reported recently for some populations in Northeast India. It is similar to those reported for the Khasi sub-groups which had the highest fertility rate in Northeast India (Mukherjee, 2002; Khongsdier, 2005c). It may be mentioned that the adoption rate of modern family planning methods is very low (about 6%) in the present population.
3. The infant mortality rate (i.e., number of deaths before 1 year of life per 100 live births) was found to be 2.83%, which was the lowest in comparison with some populations in Northeast India.

4. The prevalence of reproductive wastage (4.12%) appears to be moderate in the present population (spontaneous abortion rate = 2.86% and still-birth rate = 1.26%). In comparison with most recent data for populations from Northeast India, the prevalence of reproductive wastage among the Hmars was higher than that among the Mukloms of Arunachal Pradesh (Sarkar, 2002), similar to the Sanga and Wanang Kochs of Garo hills (Murali, 2002), but lower than many other populations (Sengupta and Kalita, 2001; Mukherjee, 2002; Khongsdier, 2005c).
5. The mean number of live births to women who married by the age of ≤ 19, 20-24 and ≥ 25 years is 4.85, 4.66 and 4.31, respectively. It is seen that the mean number of live births decreases with the increase in the mean age at marriage, despite the absence of statistical difference ($F = 0.914$, d.f =2,437, $p > 0.05$).
6. It is found that the unadjusted mean of live births decreases significantly with the increasing educational level of the mothers ($F = 32.27$, d.f. = 2, 437, $p < 0.0001$). Adjusting for maternal age and household income, these differences in live births between educational groups of mother disappeared ($F = 0.93$, d.f. = 2, 437, $p > 0.05$). This indicates that the effects of education on live births are compounded by maternal age and household income. For example, it is likely that most educated mothers are in the lower age group, whereas illiterate mothers or mothers without educational background are more in the older age groups, thereby resulting in sampling variation. From this point of view, the ANCOVA test is very helpful in determining how an independent variable (e.g., maternal age in the present analysis) alone could influence the dependent factor (e.g., live birth in the present analysis).
7. It is observed that the unadjusted mean live births are 5.10 ± 0.17, 4.22 ± 0.28 and 3.97 ± 0.28 in the low, middle and high income groups, respectively, and these differences are statistically significant ($F = 7.57$, d.f. = 2, 437, $p < 0.001$). The higher mean live births in the lower income groups as compared to high income groups are statistically significant even after adjusting for maternal age and education ($F = 6.15$, d.f. = 2, 437, $p < 0.001$). This indicates that household income is very important in regulating fertility rate in the present population.

8. Results of multiple regression analysis was also carried out to have a better understanding of the relationship between live births/surviving children and socio-economic conditions. It was observed that maternal age was positively associated with live births ($b = 0.129 \pm 0.008$, $t = 16.42$, $p < 0.0001$) and surviving children ($b = 0.104 \pm 0.008$, $t = 13.45$, $p < 0.0001$). It was also found that maternal age at marriage was negatively associated with live births ($b = -0.120 \pm 0.025$, $t = 4.84$, $p < 0.001$) and surviving children ($b = -0.110 \pm 0.024$, $t = 4.55$, $p < 0.001$). In addition, household income was also negatively associated with live births ($b = -0.365 \pm 0.122$, $t = 2.99$, $p < 0.003$) and surviving children ($b = -0.327 \pm 0.120$, $t = 2.74$, $p < 0.006$). On the other hand, we failed to get a significant relationship between maternal education and live births as well as surviving children. Thus, it may be concluded that the role of maternal education is not clearly perceptible in the present analysis. Instead, maternal age, age at marriage and household income are very important factors for controlling live births and surviving children.
9. With respect to infant mortality, it was observed that infant mortality is negatively associated with maternal age ($b = -0.029 \pm 0.011$, $t = 2.62$, $p < 0.009$) and negatively associated with maternal education ($b = -0.052 \pm 0.026$, $t = 2.00$, $p < 0.05$). On the other hand, the effect of household income on infant mortality is not clearly perceptible in the present study. Thus, maternal age and maternal education seem to be very important factors in controlling infant mortality in the present population. It also indicates that household income alone may not be sufficient to bring down death rates, if maternal education is not taken into account.

GROWTH AND NUTRITIONAL STATUS OF CHILDREN

In the present study, we have considered the growth of children aged 2 to 10 years of age. The main purpose is to assess the nutritional status of children in relation to other demographic and socio-economic conditions of the study population. However, an attempt was also made to assess the growth status of these Hmar children in relation to their coevals at a given age in other populations including the recommended growth references and/or standards. In this regard, we have taken into consideration only some important anthropometric variables like weight and height, which are also reported for few populations in Northeast India, such as War Khasis (Khongsdier, 1996), Khynriam Khasis (Mukherjee, 2002), Assamese Muslims (Begum and Choudhury, 1999) and Kalitas (Choudhury and Bhuyan, 1994).

It may be noted here that in India we do not have the recommended growth references and/or standards. Although the data collected by the Indian Council of Medical Research (ICMR, 1972) are old and unrepresentative of all sections of the Indian population, we used in the present study simply to understand the growth status of the Hmar children, but not as a target or standard of growth that one should assess the children's growth in the present study. As a matter of fact, we used the NCHS/WHO growth references (WHO, 1983) for assessing the nutritional status of children as internationally recommended.

Weight

It is observed that the Hmar boys are above the 50^{th} percentile of the ICMR growth references from 2 to 10 years of age although they are similar at about 5 years. In comparison with the NCHS growth references, the Hmar boys are far below the 50^{th} percentile from 2 to 10 years of age, but they are above the 3^{rd} percentile across these ages. However, the Hmar boys are above the 50^{th} percentile of the ICMR growth references. In comparison with their counterparts reported from some populations of Northeast India, the Hmar boys are comparable to the War Khasi boys (Khongsdier, 1996) from 3 to 5 years of age and to the Khynriam Khasi boys (Mukherjee, 2002) from 4 to 5 years of age. However, the War Khasi boys are heavier than the Hmar boys from 5 to 10 years of age. The Hmar boys are heavier than the Khynriam Khasi boys from 5 years onwards, although the Khynriam are heavier at 9 years of age. In comparison with the Assamese boys, the Hmar boys are heavier than the Kalita boys (Choudhury and Bhuyan, 1994) across ages. They are also heavier than the Assamese Muslim boys (Begum and Choudhury, 1999) from 3 to 6 and 8 to 9 years, although the latter are heavier from 9 to 10 years of age. In general, it reveals that the Hmar boys are above the 50^{th} percentile of the ICMR growth references and heavier than the Kalita boys, although they are lighter than the War Khasi boys from 5 to 10 years of age. They are comparable to the Assamese Muslim boys.

As for girls, it is observed that they are above the 50^{th} percentile of the ICMR and 3^{rd} percentile of the NCHS growth references from 2 to 10 years of age. However, they are far below the 50^{th} percentile of the NCHS growth references. In comparison with some populations in Northeast India, the Hmar girls are heavier than the Kalita girls across ages. They are similar to the Khynriam and Assamese Muslim girls from about 3 to 5 years, and thereafter they are lighter up to about 8 years of age. They are similar to the Assamese Muslim girls from 8 to 10 years, although they are lighter than the Khynriam and War Khasi girls in this age group. They are also heavier than the War khasi girls from about 3.5 to 5 years, and thereafter the latter surpassed the former up to about 8 years. On average, like their male counterparts, the Hmar girls are above the 50^{th} percentile of the ICMR growth references and heavier than the Kalita girls of Assam. They are comparable to the War Khasi and Assamese Muslim girls, irrespective of certain fluctuations.

Height

It is observed that the Hmar boys are below the 50^{th} percentile of the ICMR growth references across ages although they are more or less comparable from 2 to about 3.5 years of age. The Hmar boys are also far below the 50^{th} percentile of the NCHS growth references, but they are more or less comparable to the 3^{rd} percentile of the international growth references across ages. The Hmar boys are found to be taller than the Khynriam boys across ages, but shorter than the War Khasi, Kalita and Assamese Muslim boys. They are similar to the Assamese Muslim boys only from 3 to 4 years of age. Thus, in view of these comparisons, the Hmar boys seem to be better in growth status of height when compared with the Khynriam Khasi and ICMR growth references. However, they are shorter than War Khasi, Kalita and Assamese Muslim boys.

As for girls, they are, on average, below the 50^{th} percentile of the ICMR growth references with respect to growth in height, and they are far below the 50^{th} percentile of the NCHS growth references. They are taller than the Kalita and Khynriam Khasi children . They are similar to the war Khasi girls from 7 to 10 years of age and to the

Assamese Muslim girls from 3 to 5 years of age. However, they are shorter than the War Khasi and Assamese Muslim girls from 3 to 7 years and 5-10 years of age, respectively.

Nutritional Status

Nutritional status is defined as the physical expression of the relationship between the nutrient intakes, or bio-availability of nutrients, and the physiological requirements of an individual (Brown, 1984). This physical expression of the relationship between nutrient intakes and physiological requirements of a person can be measured by a number of methods. Of different methods, anthropometry is one that is generally used for measuring the magnitude of undernutrition at both individual and population levels. In the present study, we have taken into consideration three anthropometric indices, i.e., weight-for-age (indicator of underweight), height-for-age (indicator of stunting) and weight-for-height (indicator of wasting or thinness) for assessing the nutritional status of children. The cut-off point of – 2 Z-score was used for screening undernourished groups of children (WHO, 1983) for all the three indices.

Prevalence of Underweight and Its Risk Factors

The risk factors of underweight in terms of odds ratios derived from logistic regression models after adjusting certain variables . Four logistic regression models were used for presenting the risk factors of underweight. In the first model, age was taken into consideration by dividing the children into two age groups, viz., 2-5 and 6-10 years, for computing the odds ratio with 95% confidence interval (CI) from the regression models after adjusting for sex, income and mother's education. It is found that older children aged 6-10 years had about 1.15 times greater in risk of being underweight as compared to younger children aged 2-5 years of age. However, this risk is not statistically significant ($p = 0.508$). The second model is concerned with the sex difference after adjusting for age, income level and mother's education. It is seen from the table that boys had about 1.48 (95% CI: 1.01-2.30, $p < 0.05$) greater risk of underweight as compared with girls. This is somewhat in contrast to the general observation that underweight in Southeast Asia is higher in girls than in boys.

In the third model of logistic regression, we have taken into consideration the three income groups after adjusting for age, sex and mother's education. It is found that children in the low and middle income groups had greater risk of underweight when compared to those in the high income group. Children in the low income group had about 2.58 (95% CI: 1.32-5.05, $p < 0.006$) times greater in risks of being underweight as compared to those in the high income group. Similarly, children in the middle income group had about 2.41 (95% CI: 1.11-5.24, $p < 0.027$) times greater in risks of being underweight as compared to those in the high income group. This is clear that household income is very important factor for regulating body weight of children.

The effect of maternal education is not statistically significant in the present population. However, children of the mothers without any education had about 0.96 times the risk of underweight when compared to those with secondary level of education.

Prevalence of Stunting and Its Risk Factors

The risk factors of stunting in terms of odds ratios like in the case of underweight were analyzed . Adjusting for sex, household income, and maternal education, children aged 6-10 years had about 1.26 (95% CI: 0.86-1.80) greater risk of being short stature or stunting. However, this odds ratio is not statistically significant. In the next model, the odds ratio for the sex difference in the prevalence of stunting was worked out after adjusting for age, household income and maternal education. It is observed from the table that boys had about 1.64 (1.09-2.23) times greater in risks of stunting as compared to girls. Thus, like in the case of underweight, stunting is likely to be more prevalent in boys than in girls.

With respect to economic condition, it is found that children in the low and middle income groups had greater risk of stunting when compared to those in the high income group, i.e., the prevalence of stunting is similar to that of underweight with respect to economic condition. Children in the low income group had about 2.64 (95% CI: 1.52-4.56, $p < 0.001$) times greater in risks of stunting as compared to those in the high income group. In comparison with those in the high income group, children in the middle income group had also about 2.18 (95% CI: 1.13-4.19, $p < 0.022$) times greater in risks of stunting after adjusting for age, sex, and mother's education. Thus, household income is likely to be an important in determining stunting in the present population. Like in the case of underweight, the effects of maternal education are not clearly perceptible in the present population.

Prevalence of Wasting and Its Risk Factors

The risk factors of wasting in terms of odds ratios are derived from logistic regression models. Unlike in the case of underweight and stunting, the effects of demographic and socio-economic factors on wasting are not statistically significant in the present population. However, it is likely that children in the low and middle income groups had greater risk of wasting when compared to those in the high income group. Thus, it cannot be totally ruled out the role of household income in regulating wasting in the present population.

ADULT NUTRITIONAL AND HEALTH STATUS

Adult Body Dimensions

In observing the means and standard deviations of anthropometric traits for adult males by age groups, with the exception of bi-iliac diameter, the mean anthropometric traits are higher significantly in the lower age groups. The same is observed for adult females. Perhaps, this may be due to secular trend other than chance factors such as sampling variation are not involved. By secular trend, we mean an increase in anthropometric measurements from one generation to another due to improvement in economic condition of a given population. With respect to bi-iliac diameter, different explanations may be given, but it is likely to be associated with the increase in fat accumulation at the bi-iliac portion of the body with the increasing age. Nevertheless, it is evident from the results presented in the Tables that individual age should be taken into consideration when carrying out statistical analyzes on the effects of socio-economic conditions on anthropometric traits, or assessing the nutritional status of the study population in relation to socio-economic conditions.

Prevalence of Under- and Over-nutrition

The individuals with BMIs of < 16.0, 16.0-16.9, 17.0-18.4, 15.5-23.0 and > 23.0 kg/m^2 were considered to be in the severe, mild, moderate, normal and overweight grades of nutritional status, respectively (James *et al.*, 1988; WHO, 2000c). It is found that about 1.01%, 3.24% and 10.53% of adult males suffer from severe, mild and moderate under-nutrition, respectively. Among adult females, these frequencies are 0.83, 4.55% and 10.74%, respectively. Considering the cut-off point of 18.5 for screening the individuals into normal and undernourished or chronic energy deficiency (CED) groups (Ferro-Luzzi *et al.*, 1992, WHO, 1995), the overall prevalence of under-nutrition is 14.78% in males and 16.12% in females. This sex difference in the prevalence of under-nutrition is not statistically significant ($\chi^2 = 0.34$, $p > 0.05$). These prevalent rates of CED are also lower than those reported for several populations of Northeast India, including caste groups like Brahmins, Kalitas, Jogis, Kaibartas and Hinduised groups like Ahoms, Kochs and Rajbhanjis (Khongsdier, 2001).

With respect to overweight, it has been suggested recently that the BMI of 23.0-25.0 and > 25.0 should be considered the cut-off points for screening overweight and obesity, respectively (WHO, 2000c). Using the cut-off point of 23.0 for screening overweight individuals, about 12.96% of males and 16.12% of females are overweight in the present population. It indicates that the prevalence of overweight is higher in females than in males, although it is not statistically significant ($\chi^2 = 1.97$, $p > 0.05$).

Risks of Under-nutrition

In order to have a better understanding of how under-nutrition is related to age, sex, cormic index and socio-economic conditions in the study population, an attempt was made to carry out the logistic regression analysis. The odds ratios (with 95% confidence interval (CI) relative to the prevalence of under-nutrition or CED) are derived from logistic regression models after adjusting for other variables under consideration. With respect to age, it is found that older individuals had greater risks of being undernourished after adjusting for cormic index, sex, education and income. The individuals aged 60 + years had about 5.06 (95% CI: 2.98-8.61) times greater in risk of being undernourished as compared with those aged < 40 years. On the other hand, the subjects who are aged 40-59 years had about 2.08 (95% CI: 1.37-3.17) greater in the prevalence of under-nutrition as compared with those aged < 40 years. Thus, it is evident from the present analysis that age is significantly associated with the nutritional status of the individuals in the present population.

As for cormic index, it is observed that the individuals with low cormic index seem to have a higher risk of being undernourished. Adjusting for age, sex, education and household income, the prevalence of under-nutrition was about 1.61 (95% CI: 1.12-2.33) times greater than those with cormic index of > 0.53. This indicates that cormic index is significantly associated with the prevalence of CED in the present population. It is also found that the odds ratio for the prevalence of CED according to sex. Adjusting for age, cormic index, education and household income, females had about 1.38 (95% CI: 0.95-2.00) times greater in the prevalence of CED as compared males. This difference is, however, not statistically significant ($P > 0.05$).

In comparison with the high income group, the low income group had about 1.78 (95% CI: 1.04-3.05) times greater in risk of being undernourished after allowing for age, sex, cormic index and education. However, the middle income group is not significantly deviated from the high income group with respect to the risk of CED (OR= 1.04; CI: 0.55-1.97). Nevertheless, income seems to have a great influence on the nutritional status of the adult individuals in the Hmar population. Like in the case of mean BMI, the effect of education on the nutritional status of the adult males and females is not clearly perceptible.

Morbidity by Age and Sex

The prevalence of morbidity, that is, those individuals who had suffered from any illness and were at least one day in bed during the last one month before the survey. The overall prevalence of morbidity is 11.45%, and it is higher in males (13.36%) than in females (9.50%), and it is statistically significant ($\chi^2 = 9.18$, D.F. = 1, $p < 0.002$). The prevalence of morbidity increases with the increasing age groups in both males and females. In males, the prevalence of morbidity increases from about 12% in the age group < 40 years to 20% in the age group 60 + years. On the other hand, the prevalence of morbidity in females is higher in the age group 40-59 years (12.23%) as compared to the age groups < 40 years (7.92%). However, these age differences are not statistically significant for both males ($\chi^2 = 3.11$, D.F. = 2, $p > 0.05$) and females ($\chi^2 = 2.37$, D.F. = 2, $p > 0.05$). Thus, according to data presented in Table 5.10, it can be argued that sex is more important than age for influencing morbidity, although older individuals are likely to have a greater risk of morbidity.

The self-reported symptoms of morbidity were classified into three broad categories as generally suggested (Sadana, 2000). **Cold and Respiratory and Intestinal Disorders** include those symptoms such as cough + runny nose + headache + fever, fever + cough, cough alone, swollen glands, + cold, ear problem, breathing problem, chest pain, sore throat, TB. On the other hand, **Intestinal Disorders** include diarrhoea, dysentery, worms, vomiting, vomiting + fever, and other self-reported problems of stomach pain. Self-reported symptoms of morbidity other than the two categories above were included in the category of **Other Problems**.

It can be observed that the prevalence of cold and respiratory disorders is more common than that of intestinal ones for both the sexes. It is slightly higher in males (5.67%) than in females (3.93%). The prevalence of intestinal disorders is more or less similar in both males (1.82%) and females (1.86%).

Risks factors of Morbidity

It is found that older individuals are likely to get sick when compared with the younger ones, although the odds ratios are not statistically significant. It is also found that adult males had about 1.62 (95% CI: 1.07-2.46) times greater in risk of morbidity when compared with females, i.e., after adjusting for age, nutritional status, education and household income. The undernourished individuals also have greater risks of morbidity. Adjusting for age, sex, education and household income, the prevalence of morbidity was more than 2 times (95% CI: 1.32-3.60) greater in undernourished individuals than those with normal grade of nutrition. This indicates that morbidity is significantly associated with the prevalence of CED.

Household income does not seem to have influenced morbidity pattern in the present population. However, education seems to be important factor influencing morbidity in the present population even after adjusting for age, sex, nutritional status and household income. The subjects without education had about 1.89 (95% CI: 1.13-3.16) times greater in risks of having morbidity problems when compared to those with secondary level of education.

Hemoglobin Content by Sex and Age

As theoretically expected, the mean hemoglobin content is significantly higher in males than in females for all of the age groups. It is also observed that the hemoglobin content tends to decrease with the increasing age groups for both males and females. The analysis of variance (ANOVA) shows that the differences in hemoglobin level between age groups are statistically significant for both males ($F = 4.99$, d.f. = 2, 287; $p < 0.007$) and females ($F = 3.64$, d.f. = 2, 258; $p < 0.02$). This indicates that age should be taken into consideration while analyzing the relationship between hemoglobin content and other factors.

Prevalence of Anemia by Sex and Age

It is found that the prevalence of anemia is higher in males (38.97%) than in females (37.55%), and the differences between the sexes are statistically significant ($\chi^2 = 9.95$, d.f. = 2, $p < 0.002$). The prevalence of anemia increases with the increasing age groups for both males and females. However, the chi-square test indicates that the differences between age groups are statistically significant only in males ($\chi^2 = 12.31$, d.f. = 2, $p < 0.007$), but not in females ($\chi^2 = 3.55$, d.f. = 2, $p > 0.05$). Nevertheless, the present findings indicate that both sex and age are associated with the prevalence of anemia in the present population.

Risk Factors of Anemia

It is observed that the older individuals are likely to become anemic when compared with the younger ones, especially those who are aged 60 years and above. The subjects aged 60 + years had about 2.60 (95% CI: 1.36-4.95) times greater in risks of anemia when compared with those who are aged < 40 years. Although there is no significant difference between the age groups < 40 and 40-59 years, it is clear that individuals aged 60 years and above are likely to have higher prevalence of anemia. Further, the odds ratios of anemia for the sex and nutritional differences are not statistically significant, although the prevalence of anemia is higher in males as compared to females as well as in undernourished as compared to the individuals with normal grade of the nutritional status. The effect of socio-economic condition, on the other hand, on the prevalence of anemia seems to be significant in the present population. As for economic condition, the low income group had about 1.84 (95% CI: 1.10-3.07) times greater in risks of anemia when compared with those in the high income group. Also, the middle income group had 1.46 (95% CI: 0.80-2.67) times greater in risks of having anemia when compared with those in the high income group, despite the absence of statistical significance. Similarly, the subjects with no formal education were about 1.56 (95% CI: 1.01-2.41) times greater in risk of having anemia as compared to those with secondary level of education. In short, income and education seem to be very important risk factors of anemia in the present population.

CONCLUDING REMARKS

In the present study, we have taken demographic parameters, growth of children, adult body dimensions, morbidity and anemia as indicators of the health and nutritional status of the Hmar population. Our findings indicate that the Hmar population is highly progressive due to high fertility and lower mortality rates. The growth status of children aged 2-10 years of age is far below the 50^{th} percentile of the WHO/NCHS growth references, although it is above the 50^{th} percentile of the ICMR references. As for nutritional status of children, the Hmar population is characterized by a high prevalence of underweight (28.40% for both sexes) and a very high prevalence of stunting (48.72% for both sexes) but with low prevalence of wasting (3.16%), according to the classificatory criteria proposed by Gorstein *et al.*, (1994), which takes into consideration all the three anthropometric indices. With respect to the nutritional status of adults, the Hmar population seems to be better than those reported for many populations in Northeast India. There is also an indication of overweight perhaps due to improved standards of living as generally suggested in developing countries (Nube, 1998; Khongsdier, 2002). The better nutritional status in the adults of the present population is also consistent with the results on lower morbidity and anemia. The present findings have many implications which may be summarized briefly as follows:

1. The present findings seem to have certain implications for the application of the demographic transition theory. It is well known that the second stage of demographic transition theory predicts that improvement in standard of living and health facilities results in population growth due to high fertility and low mortality. The poor performance of family planning welfare programmes and/or low practice of family planning methods of contraception enhances the fertility rate or population growth. It is observed that only about 5 % of the Hmars married women adopted family planning methods. Therefore, fertility rate is still high in the population, thereby suggesting a need for greater political will to implement family planning programmes.
2. It is observed that the fertility rate in the present population is negatively associated with the maternal age, age at marriage and income levels of households. The effect of age at marriage on fertility is by and large universal

since the reproductive period is shorter in the case of those with higher age at marriage. On the other hand, the significant effect of the household income on fertility rate in this population is likely to be related to the fact that people belonging to the higher economic groups are more conscious of the socio-economic welfare of their children. It is likely that they have higher aspiration for better education and higher economic status, thereby reducing the birth rate in order to provide their children with the best facilities (Mukherjee, 2002). What is interesting in the present study is that the effect of maternal education disappeared after adjusting for maternal and household income. This insignificant effect of education on fertility rate in the Hmars of the present study is inconsistent with the general observation in other populations (Caldwell *et al.*, 1999), and it is difficult to give any clear-cut explanation. It, however, suggests that maternal education is not the only factor that can regulate fertility rates in the Hmar population. For example, our analysis indicates that most educated mothers are in the lower age groups, whereas the proportion of illiterate mothers or mothers without educational background is higher in the older age groups, thereby resulting in sampling variation. In addition, it is likely that other social and cultural factors also might have played a significant role in either directly regulating fertility rate or indirectly controlling the effect of education on fertility rate. This, however, does not mean to say that education is not important in the Hmar population. It is observed that maternal age and maternal education are very important factors in controlling infant mortality. Further studies are needed to have a better understanding of this problem in the Hmar population.

3. The high prevalence of underweight and stunting in Hmar children is contradicted by the low prevalence of wasting. This has an implication for the relevance of the international growth references/standards to the study population. It has been suggested that the use of international growth references is relevant only to the children below 5 years of age in South Asian populations (Khongsdier and Mukherjee, 2003). In the present study, we also observed the higher prevalence of underweight and stunting in the higher age group (6-10 years) than in the lower age group (below 6 years) for both boys and girls. The low prevalence of wasting

as indicated by weight-for-height is consistent with the observation made by Seckler (1982) in Indian and Nepali populations. This is due to the fact that weight-for-height is independent of age, whereas indices of underweight and stunting are dependent of age. In short, the role of genetic factors and errors in the estimation of age cannot be totally ruled out in the present study. Weight-for-height is, therefore, a better indicator of nutritional status.

4. The present findings also indicate the co-existence of under- and over-nutrition (as indicated by BMI) in the Hmar population. Recent reviews has revealed that although under-nutrition remains a major health problem in many developing countries, over-nutrition is also emerging with the improvement in socio-economic condition and/or increasing urbanization (Popkin, 2002, Khongsdier, 2005c). Consequently, the double burden of under- and over-nutrition exerts considerable impact on the economy and health system in many developing countries. In general, many countries in Asia are in this situation due to "changing dietary pattern towards energy-dense and high fat diets, together with a more sedentary lifestyle arising from increasing urbanization" (Florentino, 2002). The increasing urbanization, changes in standards of living, dietary patterns and occupational work patterns are the key factors to risks of the epidemic of obesity and associated morbidity and mortality. Therefore, the spread of overweight and obesity in the Hmar population needs to be monitored and prevented, but it should not be done at the expense of the efforts to alleviate under-nutrition.
5. On average, the present findings indicate that the health and nutritional status is better in females than in males for both children and adults. This is contrary to the general observation in South Asian populations, which reveal that the health and nutritional status of females is worst as compared with males. There are two major implications with respect to these findings. The first implication is concerned with the hypothesis of the "biological fragility" of males as compared to females (Kraemer, 2000). Our study may have certain implications with respect to the observation that boys are more vulnerable than girls to adverse conditions, such as infections and/or nutritional deprivation (Tanner, 1962; Stinson, 1985; Worthman, 1996). The second implication is related to the role of

cultural diversity in regulating health and nutritional inequalities. It is often argued that discrimination against females is very high in South Asian populations because of the patrilineal system of societies. However, our recent analysis on the nutritional status of the adolescents in both patrilineal and matrilineal societies did not confirm such an observation (Khongsdier *et al.*, 2005). It is observed that the nutritional status is better in females than in males in both matrilineal and patrilineal societies. It is, therefore, suggested that the regional variation in biological and cultural characteristics should be taken into consideration to understand this problem. For example, discrimination against females may not exist everywhere in India, but varies from one society to another depending upon different socio-cultural conditions. As for the present study, we failed to observe such sex discrimination, although sex preference may arise in the case of the question on lineage continuity and old age security.

6. Another important implication of the present findings is that of socio-economic inequality in health and nutritional status. On average, our findings confirm the general observation that the health and nutritional status is better in the higher socio-economic classes than in the lower socio-economic ones. From the anthropological point of view, the question arises whether or not being in a poor socio-economic condition is also indicative of being the victims of natural selection? Natural selection is a blind natural force that preserves the beneficial variations and eliminates the injurious ones. The process of preserving the beneficial variations is also known as the *survival of the fittest* in the *struggle for existence*. According to Malthusian and Darwinian points of view, the struggle for existence, or competition for survival, is due to the increase in population beyond the means of subsistence. The short supply of resources, therefore, increases competition in different forms including social stratification in which "members of the privileged class may own even up to or over 10,000% of what a poor person owns" (Cohen, 1998). The high prevalence of malnutrition and infections is a clear evidence of poor access to adequate nutrition and health amenities among the lower socio-economic classes. From this point of view, one may argue that social stratification mediates natural selection in human populations in the

form of malnutrition and infections, which ultimately lead to higher morbidity and mortality in the lower strata of social stratification. However, this argument is based simply on differential survival or *survival of the fittest* due to limited resources mediated by social stratification. There is no evidence that the operation of natural selection in the lower socio-economic strata of the society is genetic in nature (Khongsdier, 2006). Therefore, equality of economic opportunity in a society, for example, enables a man to choose any occupation, which is most suited for him by his abilities and willingness to strive for his survival and well-being.

'ATUS OF THE H
, MIZORAM

By
L. ROBERT VARTE
DEPARTMENT OF ANTHROPOLOGY

THESIS SUBMITTED
TO
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PHILOSOPHY
IN
ANTHROPOLOGY

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SHILLONG- 793022
MAY, 2006

DECLARATION

I, **L. Robert Varte**, hereby declare that the subject matter of this thesis entitled "Health and Nutritional Status of the Hmars of Aizawl District, Mizoram" is the record of work done by me, that the contents of this thesis did not form basis of the award of any previous degree to me or to the best of my knowledge to anybody else, and that the thesis has not been submitted by me for any research degree in any other University/Institute.

This is being submitted to the North Eastern Hill University for the degree of Doctor of Philosophy in Anthropology.

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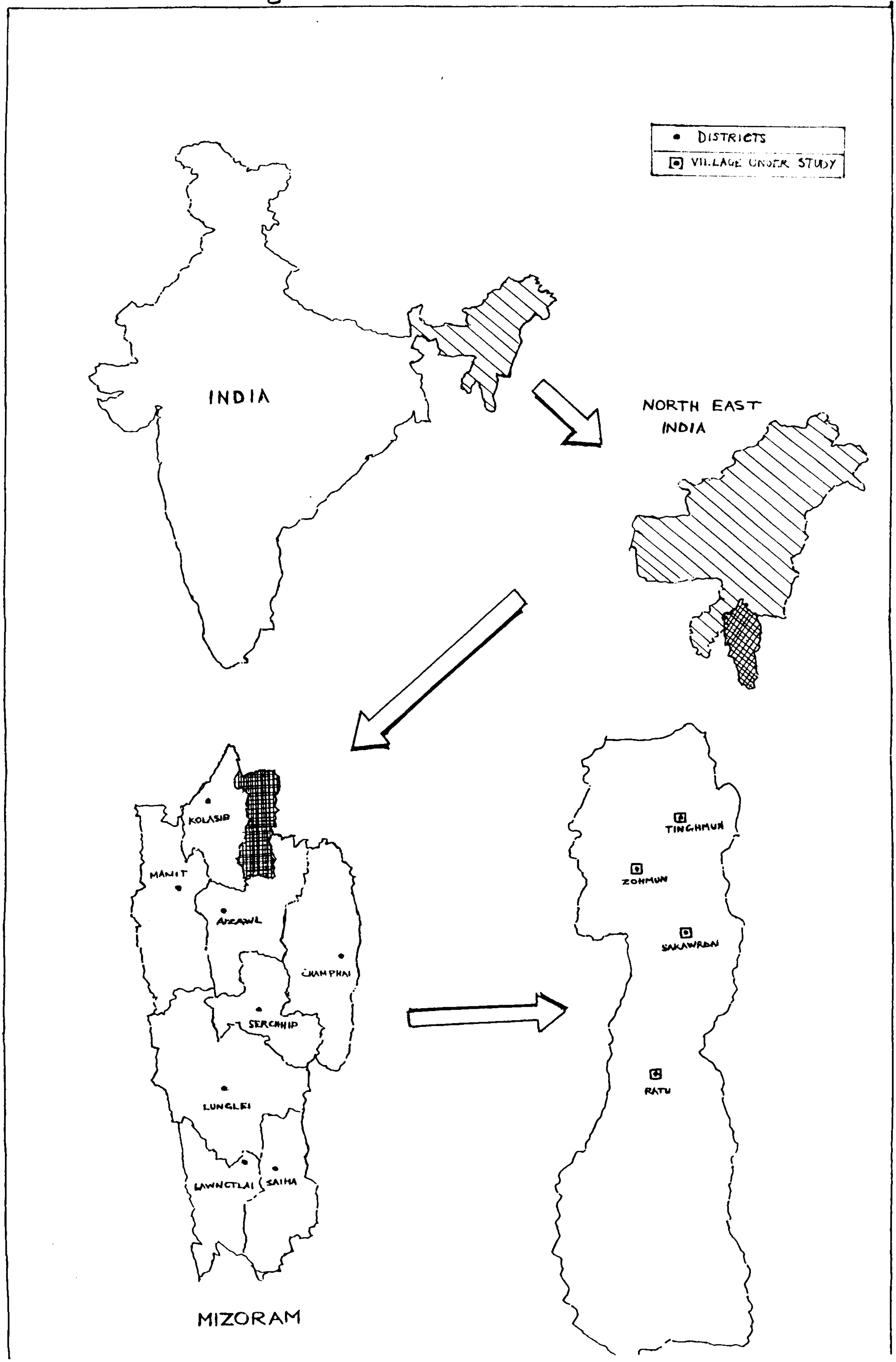
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CHAPTER I
INTRODUCTION

INTRODUCTION

One of the central themes of physical anthropology is the study of human biological variations with a view to understanding the processes of human evolution. In the early part of the 20^{th} century, physical anthropology was primarily concerned with the taxonomic classification of human population with a view to understanding the human evolutionary history. It is under this theme of study that the sub-discipline has undergone different stages of changes and development. The advent of the science of genetics, in particular, has brought about a considerable impact on the anthropological perspective of human evolution. One of the major breakthroughs during the1950s is the recognition that the changes in the genetic composition of population from generation to generation are but an evolution. The population as such is the "unit of evolution". As a unit of evolution, a population has a heredity, which consists of an array of genes of the different genotypes, or individuals of such a population. "It occupies a definite position in space and time. It derives what it needs for energy, growth, body repair, reproduction, protection against the elements of enemies, from its physical environment, and so affects it and is affected by it. If the population is successful in meeting its needs it survives or expands; if not, it diminishes and become extinct" (Roberts, 1991). Thus, there is always a "delicate balance" between a population and its environment. For its survival, the population must maintain such a balance through time. This realization has now dominated the views of many modern physical anthropologists, or biological anthropologists. Besides, the impact of other disciplines such as demography, zoology, molecular genetics, physiology, auxology, nutrition, ecology, etc. has considerably expanded the horizons of physical anthropology as a holistic discipline of human biology. The areas of interest are nowadays manifold ranging from functional aspects of anthropometry to mapping of human DNA. The concepts and approaches that have emerged in the fields of modern physical anthropology are more holistic in nature with more emphasis on biological and social problems of the world today – overpopulation, environmental destruction, poverty, nutritional and health problems.

Many physical anthropologists today are interested to understand the relationship between human biology, especially to those aspects relating to health and nutrition, and various socio-cultural factors (Strickland and Tuffrey, 1997). In fact, it is now believed that the human biological processes are largely influenced by various social, economic and cultural aspects of the society. Thus, it is crucial on the part of physical anthropologists to undertake such studies with a view to having a better understanding of not only the processes of human evolution, but also the health and nutritional aspect of human populations. This thesis is a small attempt to deal with the health and nutritional status of the Hmar population in Mizoram with a view to understanding how certain selected socioeconomic variables interact or associated with demographic and biological measures of health and nutrition.

Health is an important input for the development of human resources and the quality of life, necessary for the overall development of a community or country as a whole. According to the World Health Organization, "health is a state of complete mental and social well being and not merely the absence of diseases or infirmity" (WHO, 1971). Although it may not be possible to attain all such types of well-being as referred to in this definition, the WHO's constitution says, "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political, economic and social condition." As such, health is a holistic concept, and one may define health in any manner relating to either one or all physical, mental and well-being of an individual, or a population, according to one's expediency of study. From the anthropological point of view, one may consider health as a state of well-being due to the interplay between socio-cultural and biological factors - environmental and genetic factors (Kar, 2000).

In order to measure the health status of a population, one needs to take into consideration certain health parameters, which are generally considered as health indicators, although the method of measuring may vary from one study to another (Gwatkin, 2000). Park (1995) has listed a number of health indicators under different categories, viz., *mortality rates, morbidity rates, disability or illness and injury rates, nutritional status, health care and delivery indicators, family planning and epidemiological policies, social and mental health indicators* (e.g., include suicide, homicide, acts of violence and crimes, road traffic accidents, juvenile delinquency, alcohol and drug abuse, smoking, and the like), *environmental indicators* (e.g., physical and biological environmental conditions in which diseases occur such as air and water pollution, radiation, solid wastes, noise, exposure to solid substances in food and drinks, etc.), *socio-economic indicators* (e.g., population growth, per capita income, per capita expenditure, per capita gross national product, level of unemployment, literacy rates, family size, number of persons per room, per capita calorie availability, social security and welfare services), and *health policy indicators* (e.g., GNP spent on health services, water supply, sanitation, housing, community development, and so on).

It is, therefore, obvious that there are a large number of health variables, and for that reason, it is also suggested that health status is a function of many biological and socio-environmental factors. Accordingly, it is not simple to assess the health status of the population, especially in the case of individual research as it requires a technical knowledge from different fields or disciplines. "This is because health, like happiness, cannot be defined in exact measurable terms. Its presence or absence is so largely a matter of subjective judgment" (Park, 1995). Nevertheless, selection of few sensitive, specific and reliable variables is also meaningful especially for screening or identifying the health problems of a specific population at a given point of time, which are required for immediate intervention. From the biological anthropological point of view, demographic variables (e.g., fertility, mortality and reproductive wastage), self-reported morbidity, nutritional anthropometry of adults, growth and nutritional status of children, and haematological traits including blood pressure and hemoglobin contents are commonly used as health indicators of population (Khongsdier, 1996). These health variables/traits are in turn influenced by numerous biosocial factors. An attempt to understand the relationship of these health traits with various socio-economic factors like educational level, occupation, income, etc., may be very helpful in understanding the health status of a population.

In the present thesis, we shall deal with the health status of the Hmar population of Aizawl District, Mizoram, with respect to certain selected health parameters such as demographic variables, anthropometric variables, growth and nutritional status, morbidity and hemoglobin level. An attempt will be made to look into the interrelationship between these health parameters and their association with age, sex, economic condition and educational level. In the following sections, we shall make a brief review of literature to have a general idea of the current status of research in this area and to derive the specific objectives of this study.

REVIEW OF RELATED LITERATURE

The review of related literature given below is far from being exhaustive. Instead, an attempt has been made to point out the needs of further researches in Northeast India in general, and to derive the objectives of the present study in particular. The review may be briefly presented as follows:

DEMOGRAPHY

Demographic variables such as fertility and mortality are very important to understand the genetic and social structure of human population (Basu, 1969; Khongsdier, 2005c). Thus, demographic study of population is an integral part of anthropological research. On one hand, demographic variables are largely influenced by various socioeconomic factors. On the other hand, they can affect the genetic composition of human population. Demographic parameters are, therefore, very vital for understanding not only the genetic structure, but also the socio-economic condition of a population. In the present study, we are not concerned with the genetic structure of the population, but we shall look into certain socio-economic factors that may influence fertility and mortality of the population.

It is widely accepted that fertility and mortality are influenced by a large number of biosocial factors like maternal age, parity, education, religion, economic conditions and so on (Caldwell, 1979, 1982; Nag, 1981; Cochrane, 1983; Kost and Amin, 1992; Bicego and Boerma, 1993; Freeny and Feng, 1993; and others). For example, demographic transition from high to low levels of fertility and mortality is considered to be associated with the economic development of a population, or rising in the income of a household. However, recent studies have also suggested that the effect of economic condition is rather slow in comparison with other social variables like education, particularly female education (Murthi *et al.*, 1995). For example, Kerala recorded the lowest fertility rate in India during the 1980s, though the per capita income in the state was lower than that in many other states. Likewise, according to the National Family Health Survey in 1998-99 (IIPS, 2000), Mizoram had the lowest the per capita income in Northeast India, but the state had recorded the lowest fertility rates. The studies in Bangladesh by the World Bank (Cleland *et al.*, 1994) have also indicated that the lower fertility in that country with low per capita income is mainly because of the efficient implementation of family planning programmes. Similarly, the effect of education on fertility rate varies from one population to another depending upon other socio-cultural factors.

Age at marriage

The negative effect of age at marriage on fertility has been reported in many studies (Mandelbaum, 1974; Mahadevan, 1979; Patnaik, 1981; Choudhury, 1984; Bharati and Dastidar, 1990; Sengupta and Gogoi, 1995; Verma *et al.*, 1999; Khongsdier, 2005c). Cohen (1998) identified later marriage and greater use of modern contraception as being the driving forces behind the African fertility declines. Letamo (1996) suggests that in Botswana, rising age at marriage contributed to the fertility decline by increasing the proportion of never married women who have lower fertility compared to those married or living with a partner. As summarised by Lesthaeghe and Jolly (1995), the increase in the proportions of single women in the age-group 15–19 contributes to a lowering of overall fertility, in as much as it is only partially offset by an increase in premarital teenage fertility. A similar observation has also been made by Freeney and Feng (1993). Zathar (1988) has observed that the "Initial rises in mean age at marriage of women to around 18 in Pakistan may lead to higher marital fertility owing to higher fecundity and other factors which seem to lead to very spacing between consecutive births."

Many studies conducted in India have also revealed that fertility rate declines with the increasing mean age at marriage (Agarwala, 1962; Driver, 1963; Gulati, 1969;

Raman, 1973; Patnaik, 1981, Bharati and Dastidar, 1990; Verma *et al.*, 1999; Khongsdier, 2005c; and others). In Northeast India also, Khongsdier (2005c) has shown that the mean number of live births per mother decreases with the rise in age at marriage of the mothers. It may however be noted that age at marriage is also associated with different socio-economic factors. Husain (1970) has suggested that age at marriage has an inverse effect on fertility, but educational status of the mother exerts in turn a great influence on age at marriage. Some studies also show that age at marriage is associated with socio-economic conditions thereby it is difficult to assess its direct impact on fertility (Gulati, 1969, 1988). Nevertheless, it is obvious from the findings on other populations that age at marriage has significant inverse association with fertility rate. In northeast India, especially Meghalaya, there has been hardly any study on age at marriage and its effect on fertility rate (IIPS, 2000; Khongsdier, 2005c). Thus, it is imperative on the part of not only demographers but also the anthropologists to look into this problem in order to have a better understanding of the fertility trend in a population.

Education

Education, especially maternal education, is generally considered a key factor to development. It is closely related to demographic variables and other indicators of health and socioeconomic conditions of a population, or a nation as a whole. Female education is believed to have a great influence on the maternal and child health as it enhances the knowledge and skills of the mother concerning age at marriage, contraception, nutrition, prevention and treatment of diseases (Mosley and Chen, 1984). This also means that the higher infant and child mortality rates among the poorly educated mothers are due to their poor hygienic practices and lack of connection with the modern medical facilities. Moreover, maternal education is related to child health because it reduces the cost of public health programmes relating to information on health technology, increases household income and productivity of health inputs (McIntosh and Finkle, 1995). Thus it is suggested that the best health development agenda for the developing countries is to increase investment in formal education, particularly female education (Caldwell, 1979, 1982; Cochrane, 1983; Bicego and Boerma, 1993). In fact, the 1994 International Conference on Population and Development (ICPD) in Cairo has strongly recommended that all countries should take immediate steps to achieve the goal of universal primary education before the year 2015, and to ensure that girls and women should get the widest and earliest possible access to secondary and higher levels of education (McIntosh and Finkle, 1995; Knodel and Jones, 1996). It is argued that about 75 per cent of 960 million illiterate persons in the world are women. India is one of the best examples of such a country with sex disparity in literacy rate till the last census, despite research evidences of the important role of female education in regulating demographic transition and other socio-economic parameters.

Besides, several studies have revealed that female education is more important than paternal education in exerting a negative effect on fertility, though the influence of the latter is also significant in certain studies (Murthi *et al.*, 1995). Khongsdier (2003) has summarised the following reasons why female education is expected to reduce birth rates: First, educated women are likely to have more voice with regard to lightening the burden of repeated pregnancies because they have more control over household resources and personal behaviour. Second, educated women are likely to be less dependent on their children as a source of social status and old age security, thereby leading to a reduction in a desired family size. Third, educated women have higher aspirations for the better achievements of their children, which is conducive to a reduction in a desired family size. Fourth, educated women often have a higher age at first marriage, which is in turn affecting fertility rate. Fifth, educated women often have higher rate of adoption of family planning method, despite certain contradictory results.

Economic Condition

The effect of economic condition on fertility has been revealed in many studies (Choudhury, 1988; Lloyd, 1991; Adamchak and Mbizvo, 1994; Verma *et al.*, 1999; Strulik, H. and Sikandar, S. 2002). Many studies revealed that there is an inverse relationship between fertility and occupation and/or economic condition (Stoeckel and Choudhury, 1969; Chang *et al.*, 1979). In United States, during the period of urban growth and industrial development, higher economic status was typically associated with lower level of fertility Freedman (Thompson and Lewis, 1980). The World Bank (1974) has reported that the average fertility rate as well as the average gross reproduction rate in the low income countries is about two times higher then those in the high income countries. Rao (1977) has observed that some countries in South Asia like China, Sri

Lanka, Philippines, and Thailand have experienced a rapid decline in birth rate with the increase in national income. Recently, it has been reported that the high fertility rate in Sub-Saharan Africa is the most acute symptom of poverty (Dasgupta, 2000). Becker (1981) has suggested that the increase in household income owing to an increase in labour productivity would lead to a decline in fertility if the substitution effect were to dominate the income effect.

The United Nations' (UN, 1985) study outlines several conceptual frame works on the relationship between women's employment and fertility. The major finding of the study was that the relationship between women's occupation and fertility appears to be strong in countries at higher levels of socioeconomic development, particularly in countries with strong family planning programs, and where women's status is relatively higher as measured by age at marriage and educational attainment. A similar observation was also made by Lloyd (1991) and Adamchak and Mbizvo (1999). Recently, the decline in fertility rate in China and Taiwan has also been attributed to higher level of social and economic development (Poston, 2000). In fact, many studies have made an attempt to correlate between low fertility and economic development. However, there is also considerable literature suggesting that standards of living as reflected in basic measures of social welfare like level of education and health care can be more relevant to fertility than the degree of economic prosperity and modernization (Freedman, 1982; Malhotra *et al.*, 1995). This suggests that there has been controversy among the scholars regarding the relationship between fertility and economic condition (Dasgupta, 2000).

In India also, many studies have revealed that fertility rate is higher among the lower income groups than that among the higher ones (Agarwala, 1972; Mukhopadhyay, 1981; Choudhury, 1988). Verma *et al.* (1977) observed that settled agricultural Santals were economically better off and had relatively higher fertility than the economically depressed hunting gathering nomadic Birhors. But Driver (1963) observed that economic status had only some indirect effects on fertility in Central India. Jain (1975) has also suggested that the effect of income particularly that of occupation on fertility is "fragmentary and inclusive." Thus, it is necessary to carry out further studies on the relationship between fertility and economic condition of the populations, especially in Northeast India where there has been a lack of such studies (NFHS, 1999).

With respect to mortality, several studies have revealed the effects of biosocial factors such as household income, education, religion, maternal age, sex, and birth order (Ayeni and Oduntan, 1978; Basu *et al.*, 1980; Martorell and Ho, 1984; Rutstein, 1984; Rao and Sastry, 1977; Amin, 1990; Redaiah and Kapoor, 1992; Kost and Amin, 1992; Nath *et al.*, 1994; Arnold *et al.*, 1998; Wagstaff, 2000; and many others).

Improvement in socioeconomic status is generally considered to be essential for improvement in children's health condition, thereby reducing infant and child mortality. In other words, improvement of the health of the poor can lead to reducing the health inequality between the poor and non-poor, and this is the central goal of many internal organizations, including the World Health Organization (Wagstaff, 2000). It is reported that infant and child mortality has been declining in many developing countries from the mid 1980s and throughout the 1990s. Rutstein (2000) has suggested that such a trend in infant and child mortality is no doubt associated with improvement in socio-economic status along with the improvement in a number of factors like nutritional status, environmental health conditions, breastfeeding and the use of health services. In this connection, it may also be mentioned that the World Bank (1974) has reported that mortality rate is independent of economic development. It has suggested that the decline in mortality rate in many developing countries is mainly due to important in the fields of public health and disease control methods.

In India, Murthi *et al.* (1995) have suggested that the relationship between mortality and poverty may deserve careful examination. They have observed that the association between poverty and child mortality is rather weak in India. "The question remains whether poverty has a strong effect or mortality or fertility after controlling for other explanatory variables." The general opinion is that infant and child mortality is lower in the higher economic groups as they are able to afford better health care facilities, and they have higher educational standard, thereby becoming more conscious of the health of their children. Thus, although different factors are associated with mortality, the effect of household income has been revealed in many studies (Miller, 1981; Chen, 1982; Mosley and Chen, 1984). The above suggestion given by Murthi *et al.* (1995) may be taken into consideration with a view to having a better understanding of the effect of family income on infant and child mortality. Such type of further study is likely to be more important especially in Northeast where there has been lack of information, except those given by the NFHS (1999) and few researchers (Saikia *et al.*, 2001).

PHYSICAL GROWTH

The study of human growth has been an essential part of anthropological research since the birth of the discipline itself. Early anthropologists, especially Franz Boas are well known for their contribution to growth studies. **Growth** is defined as a regular process of quantitative increase in size or mass of different tissues and organs of the body especially from conception to adulthood. For example, the growth in height and weight can be measured from one age group to another or the number, weight and size of cells can be used to measure the growth of body organs like liver and kidney from one stage to another. On the other hand, **development** consists in the "progression of changes" in form and function, thus, it can be defined not only as a change in functional capacity due to increase in size or mass, but also as a unified network of the differentiation and modification that translates a single fertilized egg into a complex-multicellular individual of mature state (Bogin, 1999). For example, the development of skills and functional capacity to stand up and walk on two feet due to increase in size of locomotion parts of the body, or the development of an embryo into fetus, or the development of reproductive organs plus their functions, and so on. Thus, according to Bogin (1999), development refers to the "progression of changes, either quantitative or qualitative, that leads from an undifferentiated or immature state to a highly organized, specialized, and mature state."

The study of human growth is also essential to understand not only the health and nutritional status of a population, but also the interaction between biology and culture. For example, the pattern of human growth is indirectly influenced by several socio-economic factors through their direct influence on nutrition and infection. Several studies have revealed that children belonging to different socio economic groups have shown differences in their growth pattern (Tanner, 1962, 1966; Garn, 1966, 1980; Eveleth and Tanner, 1976; Frisancho, 1978; Musaiger *et al.*, 1989; Hazzaa, 1990; Terrell and Mascie-Taylor, 1991; Hauspie *et al.*, 1992; Misuraca *et al.*, 1995; Edward *et al.*, 1996; Russo and Toselli, 1997; Das Gupta *et al.*, 1997; Milani *et al.*, 1999; Reddy and Rao, 2000; and many others).

Nutrition

Eveleth and Tanner (1990) have shown that populations living under chronic low dietary intakes have a pattern of growth characterized by (1) slow growth during childhood and adolescence, (2) late adolescence growth spurt and (3) a prolonged period of growth. Adequate nutritional intakes are generally considered to be necessary for normal growth and development as well as for prevention of deficiency diseases (Mitchell *et al.*, 1976; WHO, 1986). Inadequate intake of protein and other nutrients during the preschool age period had an adverse effect on the child, leading to retardation in both physical growth and mental development (Jelliffe, 1966; Galler *et al.*, 1990; Stinson, 1998). In Kenya, Ongeri (1975) has suggested that malnutrition, particularly protein calories, is a common cause of poor growth in preschool children. Hertzig *et al.* (1972) have observed through a controlled study of children in Jamaica that malnourished children were shorter, and had lower intelligence and smaller head circumference than controlled children in the same school or their sibs. In fact, small body size of children in developing countries is largely due to effects of poor diet and frequent infection (Martorell and Ho, 1984).

Greulich's (1957) study on Physical growth and development of the American born and the native Japanese children has revealed that those children brought up in the United States were taller and heavier than their counterparts in Japan because of improved standard of nutrition and physical environment. Data from Malaysia (Chong *et al.*, 1984) have also shown a positive effect of protein energy malnutrition on growth pattern of the pre-school and primary school children. In Nigeria (Antinmo and Hart, 1980; Nnanyelugo, 1983) have indicated that malnutrition in primary school children could be attributed to low nutrient intake, low socio economic conditions and unfavourable environmental factors. Lampl *et al.* (1978) have reported that among the New Guinean school children, protein supplement has contributed largely to a faster growth and malnutrition. Similar observation has been made by Addo *et al.* (1988) while studying the school children of Nigeria.

Turning to Indian situation also, Rao (1961) pointed out that the pattern of growth was strongly influenced by dietary intakes. Easwaran *et al.* (1972, 1974), observed that boys and girls in the 'better fed' groups were heavier and taller than those in 'poorly fed' ones. A study conducted by Satyanarayana *et al.* (1980) has indicated that the main cause of growth retardation among the pre-school boys in rural Hyderabad is nutritional deficiencies. However, it is suggested that in a vast and multiethnic country like India, the extent and type of malnutrition among children varies from region to region, depending upon the geography, socio economic factors, food habits, level of literacy, climate, and religious cultural practices (ICMR, 1972; Gopalan, 1988; WHO, 1989).

Economic condition

Socioeconomic status plays a dominant role in determining growth and physical development of children as it has a positive relationship with nutritional intakes. Many studies have revealed the association between physical growth and socio economic condition of a population (Garn *et al.*, 1984; Johnston, 1986; Lasker and Mascie-Taylor, 1989; Rao *et al.*, 1990; Terrell and Mascie-Taylor, 1991, Hauspie *et al.* 1992; Khongsdier, 1993; Misuraca *et al.*, 1995; Mockus *et al.*, 1995; Post *et al.*, 1997; Milani *et al.*, 1999; Bogin 1999; and many others).

Bransby *et al.* (1956) observed that children from homes defined as 'poor' were consistently smaller and lighter than those from 'good' homes. Some studies suggest that within a given country children from economically advanced areas are taller and heavier than children belonging to the economically underprivileged areas (Ferro-Luzzi, 1967; Ferro-Luzzi *et al.*, 1979). In American children, height and weight were found to increase with increasing annual income or educational level (Hamill *et al.*, 1972).

According to Tanner (1986), growth may be described as "mirror of the conditions of the society" and height as a proxy for health. It is observed that growth retardation, or delay in growth appropriate for an individual or a population, takes place even in some sections of the populations in developed countries due to deprivation, illness, psycho-social stress and increased family size (Norgan, 2000). Growth retardation due to inadequate nutrition and infection is reported to be common in developing countries especially in the early stages of growth and development. It is generally agreed, on the basis of data from different continents, that variation in growth pattern of children in developed countries of Europe and North America on one hand and in the developing countries of Asia, Africa and Latin America on the other are mostly due to differences in their socio-economic status, and not because of genetic differences (Habicht *et al.*, 1974, Stephenson *et al.*, 1983; Eveleth and Tanner, 1990; Gopalan, 1992).

Abraham *et al.* (1975) also observed that in the United States, the boys and girls aged 1-17 years of above poverty level were taller, heavier and greater in skinfold thickness than those belonging to the below poverty level group. Rona *et al.*(1978) reported that children of unemployed fathers were shorter on average than those of employed ones. In England, it has been reported that children, belonging to the middle and upper classes are taller than those belonging to the unskilled working class (Goldstein, 1971). Amirhakimi (1974) conducted a study among the Iranian school children and found that the children of better economic condition are heavier and taller than those with low economic status. A similar observation has also been made by Lampl *et al.* (1978) while studying the New Guinean school children. Groenewold and Tilahun (1990) have observed the effect of income and father's occupation on weight for age and weight for height of Ethiopian children. A study conducted on Malaysian children by McKay (1969) has also revealed that the mid upper arm circumferences of the higher income group children are greater than those of children with lower socio economic status. In developing countries such as Bolivia, low socioeconomic status of the family, poor nutrition and vigorous physical activity are seen as major factors affecting children growth (Beall *et al.*, 1977; Stinson, 1980, 1982; Yip *et al.*, 1988). Post *et al.* (1997) carried out a study among the high altitude Bolivian children and suggested that nutritional intake was influenced by socioeconomic status, but not by altitude.

Although many studies have suggested the positive effect of socio-economic status on growth pattern of children, there are also certain controversies which need to be better understood through further studies. For example, Rona and Chin (1982) have suggested that father's social class and mother's education are not related to the variation in triceps skinfold thickness and weight for height of the children. Similarly Sukkar *et al.* (1979) have also observed that weight and height of the children have hardly changed owing to improvement in economic condition. The rural Zapotec children living in the valley of Oaxaca (Mexico) have similar height and weight to the well nourished U.S. children (Malina and Himes, 1978). Lindgren (1976) have also found that, in Swedish urban area, the girls from the lowest socio-economic status have more weight for height than the higher strata. Mockus *et al.* (1995) have reported that there is no correlation between socioeconomic status and height or weight. The negligible prevalence rates of wasting and low hemoglobin levels suggests that acute undernourishment in preschool children of Libya is not related to economic deficiency but to nutritional habits on the part of the caretaker (Bredan *et al.*, 1984). Therefore some studies have also revealed that there are less difference between socio-economic groups in respect of growth rate.

In India, some studies have shown that within the same community children from the well-to-do sections had higher values of height and weight than their counterparts in poor economic groups (Mitra, 1939; Mukherjee, 1951; Dutta Banik *et al.*, 1970; Bharati and Basu, 1990). Rajyalakshmi (1981) has also observed that the children of higher income groups are heavier and taller than those of lower income groups. The Indian Council of Medical Research (ICMR, 1972) has also reported that height, weight, subcutaneous tissue and other anthropometric variables are positively associated with socio-economic status. Similarly Vijayaraghavan *et al.*, (1974) and Rao (1980) reported that the arm circumference and fat fold at triceps of Indian children belonging to low socio-economic groups were considerably smaller than those of well to do children of corresponding ages. The effect of socio-economic condition on growth pattern of Indian children also been revealed in other studies (Rao and Sastry, 1977; Satyanarayana *et al.*, 1980; National Nutrition Monitoring Bureau, 1980; Bharati and Basu, 1990).

In north-east India, many growth studies have been published for the populations of Assam (Das, 1969-71, 1972; Hazarika, 1974; Das 1973, 1974; Choudhury *et al.*, 1992; Das and Choudhury, 1992; Begum and Choudhury, 1999; see reviews Khongsdier and Ghosh, 1998; Choudhury and Begum, 2003). Some studies have been published for other populations of Northeast India (Gaur and Singh, 1995; Talwar and Singh, 1995; Khongsdier, 1996, 1999; Singh and Singh, 2000; Khongsdier and Mukherjee, 2003a, 2003b; Khongsdier *et al.*, 2005). Most of the growth studies in Northeast India are concerned with the physiological changes and variation between populations. Only some studies used growth as an indicator of the nutritional status, and very few studies deal with the relationship between growth and socioeconomic conditions of the populations. Recently, it has been shown that growth and nutritional status of the Khasi children was greatly influenced by economic condition and by the intermixture with other populations (Khongsdier and Mukherjee, 2003a, 2003b). In another study, an attempt has also been made to assess the sex differences with respect to the nutritional status in the context of patrilineal and matrilineal systems of society (Khongsdier *et al.*, 2005). It is suggested that sex discrimination in Northeast India is not as strong as in other parts of India, although sex preference may exist in terms of lineage continuity. More growth studies are needed to carry out in populations of Northeast with a view to understanding the nutritional status of children in relation to socioeconomic condition and morbidity patterns.

ADULT BODY DIMENSIONS

Several studies have revealed the association between adult anthropometry or adult body dimensions and socio-economic conditions (Shapiro, 1939; Eveleth and Tanner, 1990; Naidu and Rao, 1994; Visweswara Rao *et al.*, 1990, 1995; Nube *et al.*, 1998; Reddy, 1998). For example, Rothammer and Spielman (1972) have suggested that socio-economic condition has a great influence on variation in adult body dimensions which are in turn a reflection of health and nutritional status of an individual, or a population. In India, Bharati (1989) has observed that almost all anthropometric measurements and indices considered under the study are higher in the higher income groups among the Mahishyas of West Bengal. Similarly, Rao *et al.* (1990) have found that both male and female adults belonging to the upper middle income group are taller and heavier than those belonging to the lower income groups. Recently, similar observation has been made among the south Indian population (Reddy, 1998). In Northeast India, there are hardly any studies on the relationship between adult anthropometry and socioeconomic conditions (Khongsdier, 1997, 2002, 2005c). Thus, it is quite imperative on the part of physical anthropologists to carry out such a study with a view to understanding the nutritional and socioeconomic status of the different populations of this part of the country.

ADULT NUTRITIONAL STATUS AND MORBIDITY

One of the major health problems in many developing countries is the widespread prevalence of under-nutrition and infectious diseases (WHO, 1990). Inadequacies in nutritional intake, or under-nutrition, can be considered a major scourge of many adverse effects on growth and health of individuals (Gordon *et al.*, 1968; Chandra and Newberne, 1977; Chen *et al.*, 1981; Chandra, 1981, 1983; Martorell and Ho, 1984; Mitra, 1985;

Mascie-Taylor, 1991; Edmundson *et al.*, 1992). It is generally reported that the basic causes of under-nutrition and infections in developing countries are poverty, poor hygienic conditions and little access to preventive and health care (Mitra, 1985; WHO, 1990). Hence, assessment of the nutritional status of population has attracted the attention of not only the nutritionists and other biological scientists, but also the economists and other social scientists with a view to understanding the health and socioeconomic status of the population (Osmani, 1992). Nutritional status is defined as the physical expression of the relationship between the nutrient intakes, or bio-availability of nutrients, and the physiological requirements of an individual (Brown, 1984).

Of different methods, anthropometry is one that is generally used for measuring the magnitude of under-nutrition at both individual and population levels. Anthropometric measurements and indices like weight, height, mid upper arm circumference, skinfold thickness, weight for age, height for age, weight for height, indices of upper arm circumference, etc., (Jelliffe, 1966; Frisancho, 1990) are commonly used for assessing the nutritional status of children. In the case of adult individuals, Quetelet or body mass index (BMI = weight in kg/height in m^2) and upper arm muscle area are widely accepted as one of the best indicators of the nutritional status of adult individuals and/or populations (James *et al.*, 1988, Ferro-Luzzi *et al.*, 1992; Shetty and James, 1994). It is suggested that the BMI may be more nutritionally than genetically related (Rolland-Cachera, 1993), despite the fact that there is a wide variation between human populations in weight and height (Eveleth and Tanner, 1990; Majumder *et al.*, 1990). Thus the use of BMI as an anthropometric indicator of nutritional status may be more appropriate in a country with diverse ethnic groups like India. It is also reported that BMI is closely associated with morbidity and mortality (Garrow, 1981, 1988; Garrow and Webster, 1985; WHO, 1990; Shetty and James, 1994; Henry, 1994). However, literature on BMI of adult Indians is concerned mostly with populations in south India (Shetty, 1984; Ferro-Luzzi *et al.*, 1992; Shetty and James, 1994; Naidu and Rao, 1994; Visweswara Rao *et al.*, 1990, 1995; Reddy, 1998), but it was very limited in the Northeast region of the country (Bharati 1989; Khongsdier, 1997). Khongsdier (2001) used the anthropometric data published by the Anthropological Survey of India for 12 populations of Northeast India. The results indicated that the majority of adult males in Northeast India were lean or thin in body composition as indicated by body mass index. Almost all of the 12 populations are characterized by a high prevalence of chronic energy deficiency. It was also observed that the prevalence of CED was lower in the tribal populations than in the Hinduized and Caste groups. It is suggested that further researches are needed to know about the morbidity and health status of the populations in Northeast India.

As for the relationship between morbidity and nutritional status, several studies in developed countries have revealed the relationship between obesity and morbidity/mortality (WHO/FAO, 2003). It is also well documented that mortality risk increases with the increase in BMI values (Garrow, 1981, 1988; Garrow and Webster, 1985; WHO, 1990). With regard to the lower value of BMI, a number of studies have suggested the higher mortality rate in individuals with low BMI (Waaler, 1984, Harris *et al.*, 1993). Henry (1994) has suggested that BMI below 13.0 kg/m^2 in adult males and 11.0 kg/m^2 in adult females may be considered the lowest thresholds of mortality risk. Of course, it has been reported that the relationship between BMI and mortality is U-shaped (Troiano et al., 1996). However, it is not yet clear whether the BMI<18.5 kg/m^2, which is suggested as the cut-off point for screening CED individuals (James *et al.*, 1988; Ferro-Luzzi *et al.*, 1992; Shetty & James, 1994; WHO, 1995), is also associated with morbidity, especially in developing countries. In Bangladesh, it has been suggested that morbidity rates among adult males increases when the BMIs are below 17.0 kg/m^2 (James *et al.*, 1988). Using probit analysis of data collected by IFPRI and the World Bank from four developing countries, viz., Philippines, Kenya, Pakistan and Ghana, Garcia and Kennedy (1994) have observed that the increase in morbidity is not consistent with the CED grades of BMI, although it is perceptible in Pakistan. However, a report from Brazil has indicated that there is a marked increase in morbidity among adult individuals with BMI below 18.5 kg/m^2 (de Vanconcellos, 1994). Also, Strickland and Ulijaszek (1993) have observed that the symptoms of self-reported illness are negatively associated with BMI among the Iban tribe of rural Sawarak. In the Indian subcontinent, less is known about such a relationship, although data from a South Indian population have revealed that mortality rate tends to increase with the decrease in BMI (Shetty and James, 1994).

In Northeast India, one study was conducted on the relationship between BMI and self-reported morbidity among the War Khasis (Khongsdier, 2002, 2005c). The results indicated that there was no significant relationship between BMI and morbidity, but morbidity was significantly influenced by poor socioeconomic condition. However, when BMI was separated into two components - body fat mass index and fat free mass index - the results indicated the significant relationship between self-reported morbidity and fat mass index but not with BMI (Khongsdier, 2005a). More studies are needed to carry out among populations in Northeast India in order to understand the relationship between anthropometric indices especially BMI and morbidity.

NUTRITIONAL ANAEMIA

According to the WHO Scientific Group (WHO, 1968), nutritional anemia is a "condition in which the haemoglobin content is lower than normal as a result of a deficiency of one or more essential nutrients, regardless of the cause of such deficiency." Thus, it is suggested that data on haemoglobin content are very helpful in understanding the health and nutritional status of a population (Garn *et al.*, 1977). The WHO Scientific Group has recommended that the normal values of haemoglobin content should be 13g/dl and 12g/dl for adult males and female, respectively. In the case of pregnant women the normal value is 11 g/dl.

Iron deficiency is the main cause of anemia, especially in developing countries (Khusun et al., 1999). It has been reported in many studies that the differences in haemoglobin level are associated with nutrition, socioeconomic conditions, age, sex, etc. (Vijayalakshmi and Devaki, 1976; Garn *et al.*, 1977, Das and Mukherjee 1978; and others). Vijayalakshmi and Devaki (1976) have found higher level of haemoglobin content among those individuals who belong to the higher socioeconomic strata than those in the lower ones. Bharati (1983) has found a similar trend in the case of Mahishyas males of West Bengal but in case of females, the lower economic groups have higher haemaglobin level than those belonging to the higher economic group. Das and Mukherjee (1978) have reported that there is a gradual rise in haemoglobin level with the rise in age of males and females.

In Northeast India, little is known about such relationship between haemoglobin content and socio-economic conditions. One study among the War Khasi of Meghalaya has revealed that haemoglobin level is positively associated with the economic levels (Khongsdier, 1997).

As noted earlier, the review of related literature given above is far from being exhaustive, but it is obvious that there is an urgent need to carry out research relative to health and nutritional status of a population, especially in understanding the relationship between health and socio-economic factors. Such studies are very limited in Northeast India in general and in Mizoram in particular.

AREA OF STUDY

Mizoram, or the land of the Mizos (highlanders), was known as Lushai Hills District under the British Administration. It was made into a Union Territory in 1972, and it became a full-fledged state on 20th February 1987. It covers an area of about 21,087 sq. km with a total population of 891,058 as per census 2001 (Census of India, 2001). The density of population per sq. km is 42. It lies between 92° 11′ and 93°.29′ E. longitude and 21° 58′ and 23° 35′ N latitude. The state is bounded by Myanmar on the east, Tripura on the west, Assam and Manipur on the north, and Bangladesh on the south. Aizawl is the scenic capital of Mizoram, located at nearly 1220 meters above sea level.

Mizoram is divided into eight districts viz., Aizawl district, Aizawl North district, Aizawl East district, Aizawl West district, Aizawl South district, Lunglei district, Chhimtuipui West district and Chhimtuipui East district. Tribal groups like Lushais, Pawis, Paites, Raltes, Pang, Kukis and Hmars predominantly dominate the state. In the present study, we shall deal with the Hmars of Aizawl district.

The present study was carried out in four villages of Aizawl District, Mizoram. Figure 1 (see pp. viii) shows the location of the four villages namely, Tinghmun, Zohmun, Sakawrdai and Ratu. The sampling methods adopted for the selection of these villages will be described in the next chapter.

Topography

Mizoram is fully covered with ranges of hills, which run from the north to southern direction in parallel series, separated from one another by narrow valleys. The hills consist of sandstones and shale of tertiary age. The average height of the hills varies from 3000 ft in the west and slowly rises as one goes eastward where there are ranges over 6000 ft high. The highest peak is the Blue Mountain, locally called *Phawnpui* (7100ft) at Saikal Range. The sides of the hills are covered with dense forests and bamboo jungles. However, due to jhum cultivation and wanton destruction, many forest areas have become a barren land. The soil in the hills is generally loose, porous, sandy loam but clayey in the lower elevation, mixed with angular shales of varying sizes. As such, the water holding capacity is low. The soil in the valley is, however, rich alluvial, which are washed down from the hills as a result of the jhum cultivation and excessive monsoon rains.

Climate

Mizoram enjoys a fairly pleasant weather, where it is neither very hot nor too cold. The Tropic of Cancer runs through the middle of the District. There is a slight change of temperature during summer and winter. This is partly due to the arrival of monsoons during the hottest months of May, June and July. The coldest month is January, but by late April and May, the weather is usually hot, the temperature rising up to 30°C. The monsoon rain starts in early April and late October. Due to heavy rains, landslides are a common occurrence, causing loss of lives and property, and transport and communication are often disrupted during the monsoon.

From the month of October – December, the villages are full of damp fogs during morning and evening whereas the hill tops are comparatively free from the fogs. The Southern region gets a relatively heavy rainfall, and is also relatively open to destructive cyclonic winds from Bangladesh causing damages to crops and properties every year. The average annual rainfall in Mizoram was 2251.62 mm in the year 2003-2004 (DES. 2004).

Flora

The rainfall and temperature of the state being suitable, the forests are covered with dense evergreen trees bushes, creepers and grasses. Most of the flora of Mizoram resembles with that of the state of Manipur and Assam. *Rhododendron*, cotton, cane, *ikra*, bamboo, grass, cactus, ferns, *rhynchosstylis retusa* (foxtail) orchids, wild flowering plants are available in the state. Paddy, maize, millet, pulses, cabbage, cauliflower, sweet potato, tapioca, chillies, brinjals, ladies fingers, etc. grow in the state. Fibreless ginger is a common crop and widely marketed to other neighbouring states. Tejpat, Dachini, Golmarich, etc. grow in the southern part of the state. Mustard, sesame, super sized potato, bananas, papaya, pineapple are common crops. Besides, sugarcane, orange, mango, tea, coffee, cocoa, rubber, cardamon, and cashew nut are also grown.

Fauna

The vegetation and climate of Mizoram offers an ideal sanctuary to wild animals. There are several sanctuaries like the Dampa Wild Life Sanctuary (572 sq.km), Ngengpui (Wild Life Sanctuary (110 sq. km) and Blue Mountain Wild Life Sanctuary (60 sq.km). The fauna consists of mithun (Bos frontalis), which is a semi-domesticate animal. Wild elephants are found in the foothills. Tiger, bison, buffalo, rhinoceros, barking deer, sambar, leopard, Himalayan black bear, Malay bear, wild dog, wild cat, rat, wild pig, monkey, jackal, snakes (viper, python, cobra, grass snakes) lizards, toads, eagles, vultures, skylark, owl, crow, hornbill, jungle fowl, etc. are common in the state. These wild animals are being gradually lost due to deforestation, hunting and jhum cultivation. The tribals of Mizoram eat all kinds of animals. Dogs are used for food, and are said to be similar to those eaten by the Chinese. The famous great hornbill bird is hunted mainly for their decorative purposes. Some of the animals especially rats damage crops.

THE PEOPLE

Origin and Characteristics

The term "Hmar" is believed to have originated from the term "Hmarh" meaning "tying of one's hair in a knot on the nape of one's head". According to Hmar tradition, there were once two brothers, namely, Hrumsawm and Tukbemsawm. Hrumsawm, the elder one, used to tie his hair in a knot on his forehead because of a sore on the nape of his neck. After his death, all his descendents followed the same hair style and the Pawis, who live in South Mizoram, are believed to be the progeny of Hrumsawm. The younger brother, Tukbemsawm, however, tied his hair in a knot on the back of his head. The Hmars, who continued Tukbemsawm's hairstyle, are believed to be the descendants of Tukbemsawm (Songate, 1967). The Hmar's tradition maintains that the original home of the Hmar is called "Sinlung", though it is difficult to ascertain the exact location of "Sinlung" today.

Several theories have been put forward regarding the origin of the Hmars, but it appears historically evident that the Hmars originally came from Central China. A Hmar historian, H. Songate (1956), proposes that the original home of the Hmars might be the present Tailing or Silung in South East China bordering the Shan state of Myanmar. According to Songate (1956), "The Hmars left Sinlung because of the waves of Chinese immigrants and political pressure drove them away to the south. The exact time of departure from Sinlung and the original route they followed is not known to this day. However, traces have been found in poems and legends that they came to the Himalayas, and the great mountains made it impossible for them to continue their southward journey. So, they turned eastward of India from there."

The Hmars are mainly distributed in Churachandpur, Tipaimukh and Jiribam divisions of Manipur State. A good number of Hmars are also found in North Cachar hills (Assam), Meghalaya, Mizoram and Tripura. The present study deals with the Hmars of Aizawl district in Mizoram.

Physically, the Hmars are a strong and sturdy race and belong to the Mongoloid stock, with a flat broad nose and short stature, and well developed legs. The skin is usually yellow brownish in colour. The face is broad and flat and body is fairly well built with scanty body hairs. The men seldom have hair upon their faces. (Allen *et al.* 1979).

The Hmars have their own dialect, which has a close affinity to the Lushais and invariably resemble Paites and Kukis. Linguistically, they belong to the Kuki-Chin family. It was the Christian missionaries who introduced the Roman script to the Hmar language in the 19th Century.

The Hmars are divided into 24 clans and each of these clans is again divided into 180 sub clans/families. Clanship does not regulate marriage rules and an individual can select his mate from any clan including his own. Widow re-marriage is not uncommon. Being a patriarchal society, the father heads the family and lineage is traced through the male line. The general rule of inheritance is that the youngest son inherits all parental property. Women are not allowed to inherit any property.

Occupation

Agriculture is the mainstay occupation of the Hmar. Most of them are engaged in jhum cultivation. Although they mainly cultivate rice in the jhums, they also cultivate other crops and vegetables like maize, castor, cucumber, watermelon, sweet gourd, watermelon, beans, etc. in the jhums. Thus, they raise mixed crop in the jhums. If the rain comes in time they can reap a good harvest. In case of failure of the rain the crops also fail and the people remain half-starved. The Hmars are also good horticulturists. They cultivate fruit plants like pineapple, orange, lemon, etc. by terracing the gentle hill slopes. They sell their produce in the weekly market, but the price they get for their agricultural products is not reasonable at all.

Weaving is an important household industry in every Hmar family. Every Hmar women is an expert weaver and most of the domestic requirements for clothes are met from the family looms. They weave attractively and design clothes (PUON). Formerly, they grew cotton from which yarns were spun. But, nowadays, in most cases yarns are purchased from the market.

Besides weaving, manufacturing of cane and bamboo goods required for domestic use is also another important cottage industry of the Hmars. Carpentry and black smithy are the two other trades followed by the Hmars. Some Hmars are also engaged in services and business.

Food habits

In the last 20 years, there have been no significant changes in patterns of dietary intake. Cereals remain the staple food among the Hmars, providing most of the energy intakes. However, wheat, maize and millets are the substantial cereals, which are prepared for consumption in various ways. Large quantities of cooked rice, meat, and vegetables are consumed with various kinds of chutney, ginger, garlic, chilies, and spices. Two heavy meals of almost identical preparation a day is consumed and all else are comestibles of little significance. Since jhum cultivation cannot supply all the vegetables and meat, they constantly go to the forest seeking for vegetables, and hunting for deer, fowls, trap small games like squirrels, birds, etc. In preparation, nothing is discarded; teeth, brain, claws, innards are all included. The Hmars eat lots of hot chilli (pepper) but with very little spice. Some of the famous dishes are CHARTANG (mixture of meat, vegetable and hot pepper0, HMEPAWK (stew), and CHANGALHME (vegetable or meat cooked with hot pepper and soda from the ashes, Pudaite, 1963). With a meal, occasionally, he sips the HMETUI (the liquid in which the curry is boiled). Beer of rice or ZU was openly served before they became Christians, especially during successful hunting expeditions, harvest festivals, and return of a good friend from a long journey. Among the Christians, tea is served in place of rice beer. They smoke indigenous "meiziel" or Mizo cigarette and other non-local cigarettes. They also use indigenous pipe for smoking indigenous tobacco. They sip nicotine water or "tuibur" frequently and chew betel leaves and areca nut.

CHAPTER II
MATERIALS AND METHODS

In this chapter, we shall describe the materials and methods adopted in the present study. These materials and methods are related to those adopted for collecting, analyzing and interpreting the data in the present study.

SAMPLING METHOD

The present study was carried out in Aizawl District of Mizoram during the months of September to December 2001. The state of Mizoram is predominantly dominated by the tribal groups like Lushais, Pawis, Paites, Raltes, Pang, Kukis, Hmars, etc. In the present study, we deal with the Hmars of Aizawl district. Linguistically, the Hmars belong to the Kuki-Chin family. They have their own dialect, which has a close affinity to the Lushais and invariably resemble Paites and Kukis. It was the Christian missionaries who introduced the Roman script to the Hmar language in the 19^{th} Century.

The data for the present study were collected from four villages, namely, Tinghmun, Zohmun, Sakawrdai and Ratu in rural areas of Aizawl district, Mizoram during the months of September to December 2001. These four villages (20% of the listed villages) were selected according to simple random sampling by using random numbers given by Snedecor and Cochran (1967). According to this sampling method, the list of 20 villages and their population in Aizawl District was first prepared based on the information from the District Gazetteer (TRI, 1992). The random numbers given in Snedecor and Cochran (1967) was used for selecting the required number of sample villages. The table of random numbers given by Snedecor and Cochran (1967) was used for selecting the required number of sample villages. This table of random numbers consists of any digit from 0 to 9, which has an equal chance of being appeared in any position of the table. The random numbers can be used to select either a single digit, two or more digit numbers depending on the size of the population. For example, suppose the population consists of 372 members and that the required sample size is 5 members. According to the table of random numbers given by Cochran and Snedecor (1967), the random numbers in column 00-04 for rows 2, 3, 4, 5, 6, 7, 8, 9, 10 and 11 are 15389, 85941, 61149, 05219, 41417, 28357, 17783, 40950, 96754 and 34357, respectively. The required sample size of 5 members can be selected from these random numbers picking out the first ten three-digit numbers that do not exceed 372. These are 153, 052, 283, 177 and 343.

No random sampling was applied for selection of subjects/informants from each of the selected villages due to operational difficulties in the field. An attempt was made to cover 410 households, that is, about 45% of the total 914 households in all four selected villages. Also, an attempt was made to include in our sample all those adults (aged 20-70 years) who are willing to co-operate with the present work.

NATURE OF DEMOGRAPHIC DATA

The nature of demographic data collected for the present study was based on those parameters suggested by the World Health Organization Working Group (WHO, 1964, 1968; Mahadevan, 1986). These may be briefly described as follows:

Individual records: These include name of informant, age, sex, marital status, relationship to head of the household, date and place at which record was taken, clan, tribe, religion, community affiliation, total number of family members, place of birth, place of residence, etc.

Fertility records: They include pregnancy history of each married woman or mother, present age of mother, approximate age at each conception, total number of live-births, birth order; age, sex and marital status of each offspring.

Mortality records: These include total number of conception, number of dead children, sex, date of birth, age at death, causes of death, if any, number of reproductive wastage (abortions and still- births), etc.

Socioeconomic variables: These include occupation, education, monthly and annual income of the household, monthly expenditure of the household, age at marriage, and religion.

The entire demographic data were collected through pedigrees and schedules from all the four hundred households in the four villages, viz., Tinghmun, Zohmun, Sakawrdai and Ratu. Information on age, sex, marital status, tribe, religion, occupation, income, education, community affiliation, place of birth, place of residence, etc. was collected from the head of the household or elder member who was capable of furnishing all the relevant information as per household schedule.

The fertility schedule was completed by filling-in the information on the number of conceptions, number of live births, number of reproductive wastages (abortion and still births), sex, present age, age at death, birth order, etc. from all the ever married women. Pedigrees were also collected for cross-checking of data on reproductive history of the mothers. Sometimes, information given by the mothers was cross-checked from their respective husbands. It may be mentioned that great difficulties were experienced in the assessment of age, particularly that of the elderly women because many of them were not aware of their real age. Consequently in such cases, the age was estimated with the help of other persons in the household/village. So, there could be some mistakes, in some cases, in the estimation of age.

ANTHROPOMETRY (ADULTS)

Some selected anthropometric measurements from the basic list of measurements, recommended by the International Biological Programme (Weiner and Lourie, 1981) were taken into consideration for the purpose of the present study. Following are the anthropometric measurements taken on 978 adults aged 20 years and above of both sexes wearing light apparel.

Weight (Kg)
Height (cm)
Sitting Height (cm)
Biacromial Diameter (cm)
Bi-iliac Diameter (cm)
Mid Upper Arm Circumference (MUAC)
Chest girth (inhaled) (cm)
Chest girth (exhaled) (cm)

Besides the above measurements, following indices were computed for adult males and females in order to assess the nutritional status.

1. Body mass index = weight (kg)/height $(m)^2$
2. Cormic index or relative-sitting height = sitting height (cm)/ height (cm)

ANTHROPOMETRY (CHILDREN)

The present study of physical group was based on a cross sectional sample of Hmar boys and girls aged between 2-10 years. Following are the anthropometric measurements taken on 255 boys and 252 children:

1. Weight (Kg)
2. Height vertex (cm)
3. Sitting height vertex (cm)
4. Biacromial diameter (cm)
5. Bi-iliac diameter (cm)
6. Mid upper arm circumference (Left arm) (cm)

Besides the above measurements, following are the ratios/indices and/or estimates computed for the children of the present study.

1. Weight for height (%)
2. Weight for age (%)
3. Height for age (%)

An attempt was made to follow as far as possible the standard techniques of taking the measurements as described in Lourie and Weiner (1981). For assessing the nutritional status of children, we have adopted three anthropometric indices – weight-for-age, height-for-age and weight-for-height - which are considered as the indicators of nutritional status. These indices were derived as a standard deviation (SD) or Z-score of a child's measurement to the median weight of the international standard or reference, i.e., the growth reference of the WHO/U.S. National Centre for Health Statistics (WHO, 1983, 1995). The Z-score of - 2 is generally considered as the cut-off point for screening the individuals who are likely to be malnourished. The formula for SD or Z-score is as follows:

Z = (Child's measurement – Reference median) ÷ Reference SD

where

Child's measurement = height or weight of a given child at age X

Reference median = mean or 50th percentile of the reference population at age X

Reference SD = standard deviation of the reference population at age X

Quetelet or body mass index (BMI = weight in kg divided by height squared in metres) was used as a measure of the nutritional status of the adult individuals (WHO, 1995). On the basis of data from developed countries, BMI ranges of 25–30 and > 30 kg/m^2 are considered to be indicative of overweight and obesity, respectively (WHO, 1995). The BMI < 18.5 kg/m^2 was used for classifying the individuals with chronic energy deficiency (CED), i.e., a "steady" underweight in which an individual is in energy balance irrespective of a loss in body weight, or body energy stores (Khongsdier, 2005a). Such a "steady" underweight is likely to be associated with morbidity, or other physiological and functional impairments (Shetty & James, 1994; WHO, 1995), despite certain limitations of BMI as an indicator of body energy stores (Khongsdier, 2005a).

Also, the individuals with BMI of > 23.0 kg/m^2 were classified as overweight, i.e., as recommended by the WHO for the Asian populations (WHO, 2000c).

METHODS OF TAKING MEASUREMENTS

Standard techniques of measurements described by Hooton (1946) Weiner and Lourie (1981) and Sen (1994) were followed while taking the anthropometric measurements of children. These may be briefly described as follows:

Weight

The body weight was taken with a spring weighing machine, asking the subject to stand on it with an erect posture and light apparel. The weighing machine was checked from time to time with a known standard weight. No deduction was made for the weight of light apparel while taking the final reading.

Height

It measures the vertical distance from the floor to the vertex. The subject was made to stand as erect as possible with his/her arms hanging at the sides with thumbs forward, heels holding together and eyes directing towards the horizon (Hooton, 1946). The anthropometer was placed at the back and between the heels of the subject, taking care that it is kept absolutely vertical. The sliding sleeve of the anthropometer was then lowered down towards the middle of the head (Sagital line) so that it would touch the vertex lightly. Reading in centimeter and its fractions was recorded.

Sitting height

It measures the vertical distance from the vertex to the sitting surface of the subject. The subject was made to sit on the stool, or a flat wooden chair, or at the end of wooden bench. Then he/she was positioned in an erect sitting posture, with ankles crossed, knees spread about 20 cm apart and hands rested on the thighs. The anthropometer was placed at the back and between the two buttocks, taking care that the lumbar curve of the subject was not flattened, but concave from behind. The sliding sleeve was then lowered down to touch the vertex lightly.

Biacromial Diameter

This measurement is the maximum breadth of the bony shoulder girdle taken from acromion to acromion. The measurement was taken from the back of the subject with the rod compass (i.e., the first segment of anthropometer), while he/she was standing in an erect posture with his/her arms hanging at the sides. When the two acromion points were located by palpating along the outside edge of the scapular spine, the measuring points of the left and right hand bars were pressed against the left and right acromia, respectively. Reading was then recorded. This measurement was taken with moderate pressure to indent the deltoid muscle, but not to cause discomfort to the subject.

Bi-iliac diameter

It measures the straight distance between the two most lateral points of the iliac-crests. The measurement was taken from the back of the subject with a rod compass, holding the fixed sleeve of the compass on the left hand and the sliding sleeve on the right hand. As in the case of biacromial diameter, the most lateral points on the illiac crests were palpated with fore-fingers while holding the two sleeves of the rod compass.

Mid upper arm circumference

The measurement was taken with a steel tape at the middle (midway between acromion and elbow) part of the left upper arm on the naked skin (Sen, 1994), while the arms were hanging at the sides of the body.

Chest Girth (inhaled)

It measures circumference of the chest of the adult subject when he/she was breathing normally. This measurement was taken with a steel tape (Precision–1mm) at the level of the meso-sternale and at the right angle to the axis of the body when the subject inhaled deeply.

Chest Girth (exhaled)

It measures circumference of the chest of the adult subject when he/she was breathing normally. This measurement was taken with a steel tape (Precision–1mm) at the level of the meso-sternale and at the right angle to the axis of the body when the subject exhaled normally.

HAEMOGLOBIN ESTIMATION

Data on haemoglobin content of 551 adults were collected using Sahli's Haemometer by following standard techniques (WHO, 1980), which may be described as follows:

1. 3 to 4 ml or 3 g/dl of N/10 HCL was taken in the clean graduated tube or measuring tube.
2. The blood sample was taken directly from the subject after piercing his/her left middle finger tip. Sahli's pipette with rubber tubing and mouthpiece was used for drawing or sucking the capillary blood up to 0.02 ml of the pipette. After drawing the capillary blood up to the desired mark, the outside of the pipette was wiped with absorbent or filter paper, making sure that the blood was still on 0.02 ml mark.
3. The blood was then blown from the pipette into the graduated tube containing N/10 HCL. The mixture was shaken thoroughly and allowed to stand for five minutes or so in the Sahli's haemometer.
4. After 5 minutes or so, two or three drops of distilled water were added to the mixture with the help of dropping pipette. Special care was taken that the blood was thoroughly diluted bus tiring it with the glass rod.
5. Seeing that the mixture had changed its colour, care was taken by adding drop by drop of distilled water after stirring it thoroughly. Reading was recorded when the colour of the mixture matched with those of the two reference tubes in the haemometer.

Precautions

1. All apparatus were cleaned thoroughly.
2. The first drop of the capillary blood was avoided for taking the measurement.
3. Care was taken not to allow air bubbles to enter Sahli's pipette before sucking or drawing the blood from the middle finger tip of the subjects.

DATA ON MORBIDITY

Data on morbidity were based on "self-reported illness experience" of a subject as generally adopted in surveys, which did not involve a clinician (Strickland & Ulijaszek, 1993; Garcia & Kennedy, 1994; Strickland & Tuffrey, 1997). SRM is also more preferable from the point of view that a clinical diagnosis involves much time, cost and technical expertise, which are not always possible when carrying out community-based studies in developing countries including India. Despite its limitations (Sadana, 2000), SRM might be considered to be the second alternative proxy for assessing the morbidity status of populations in developing countries. Nevertheless, the term "morbidity" in this study was defined simply in terms of the number of 'days ill' and/or 'days unable to work' in the last four weeks before the survey. Each subject included in the study was asked whether or not he had been ill at any time in the last four weeks? If the answer was yes, he was asked how many days had he been in bed or unable to work due to illness? A subject who reported at least two days ill was classified as being "ill."

The study was symptom-based in which the symptoms were grouped into four categories as suggested in many studies (Strickland and Ulijaszek, 1994; Strickland and Tuffery, 1997; Sadana, 2000). These categories are: **(1) Intestinal disorders:** diarrhoea, dysentery, worms, vomiting, vomiting + fever, bleeding from stool, stomach pain. **(2) Cold/respiratory disorders:** cough + runny nose + headache + fever, fever + cough, cough alone, swollen glands, + cold, ear problem, breathing problem, chest pain, sore throat, TB. **(3) Other disorders** refer to problems other than mentioned in categories (1) and (2) such as sores/boils, fever alone, chicken pox, typhoid, scabies, jaundice, all body pain, headache alone, malnutrition, weakness, etc.

SOCIO-ECONOMIC CATEGORIES

In the present study, three important socio-economic variables were taken into consideration. These include religion, monthly income of the households and educational level. These socio-economic variables were classified arbitrarily into different groups and/or categories with a view to understanding their influence on demographic characteristics, growth, health and nutritional status of the study population. Our classification may be briefly described as follows:

Income groups: Data on household income were collected directly from the head of the household and they were cross-checked taking into consideration some aspects of socio-economic conditions like housing condition, types of occupation, land holding, and monthly expenditure. The interval estimation based on standard deviation of the per capita monthly income of household was adopted for classifying the three economic groups (Khongsdier, 1997), which is as follows:

Above ($\bar{X} + 4SD/\sqrt{N}$) = High income group (HIG)

($\bar{X} - 4SD/\sqrt{N}$) to (Mean + $4SD/\sqrt{N}$) = Middle income group (MIG)

Below ($\bar{X} - 4SD/\sqrt{N}$) = Low income group (LIG)

Where N stands for the number of households and $\bar{X}$ is the average monthly per capita income of the households. In the present study, the average per capita monthly income for 400 households was found to be Rs. 723.48/- with a standard deviation (SD) of Rs. 520.71/-. Thus, following the above interval method, the households with per capita monthly income of below Rs. 619.34/- were classified as LIG, while the range of Rs. 619.34 to Rs. 627.62/- were considered as MIG, and those households with per capita monthly income of above Rs. 827.62/- were classified as HIG.

Educational Level: The data on educational attainment of individuals in the present study were arbitrarily classified as follows: The category **No education** includes those individuals who were unable to read and write and those who had no education but could read or write their names. The individuals who attended school up to standard V were grouped into **Primary** level of education. The individuals with education of standard VI and above are included in the category of **Secondary level** of education due to inadequacy of data.

STATISTICAL METHODS

The data collected for the present study are quantified and analysed statistically, using SPSS Window software. The data are presented in terms of means, standard deviation, standard error and proportions or percentages. The differences between two means were tested, using t-student test, while the differences between more than two means were determined, using one-way analysis of variance (ANOVA). Analysis of covariance was also carried out for testing the differences among means, allowing for the effects of other covariates. The differences between proportions were tested, using chi-square test. Multiple regression analysis was also carried out for understanding the effects of socio-economic factors on demographic parameters and growth patterns of children. Logistic regression analysis was used for analyzing the effects of maternal age, education, income and religion on infant mortality. Some of these may be briefly described as follows:

Mean: The mean is also known as arithmetic average. It is defined as the value which can be obtained by dividing the total values of various items in a series by the total number of items. It is worked out as under:

Mean ($\bar{X}$) = $\Sigma X_i/N = (x_1 + x_1 + \ldots + x_n)/N$, where is the value of the i-th item $X_{I,}$ $i = 1, 2, \ldots, n$, and N stands for the total number of items.

In the case of frequency distribution, the mean is obtained as follows:

Mean ($\bar{X}$) = $\Sigma f_i x_i/f_i N = (f_1 x_1/f_1 + f_2 x_2/f_2 + \ldots + f_n x_n/f_n)/N$, where $f_i x_i$ is the product of the mid value (x_i) of i-th class-interval and the frequency (f_i) of the i-th item.

Standard Deviation (SD): Standard deviation is defined as the square root of the mean of the squares of the deviation of observations from their arithmetic mean. It is computed as follows:

$SD = \sqrt{\{(X_i - \bar{X})^2/N - 1\}}$

Where X_i is the value of the i-th item, $\bar{X}$ stands for the mean, and N is the total number of cases. In the case of frequency distribution, the SD is obtained as follows:

$SD = \sqrt{\{(\Sigma fd^2/N - 1) - (\Sigma fd/N - 1)^2\}} \times C$

Where fd is the product of the deviation from the assumed mean (d) and the frequency (f) of item in the i-th class-interval; while C stands for class interval.

The divisor was taken as (N – 1) but not as N because we did not know the true mean and standard deviation of the population. So the mean and standard deviation were estimated through samples collected for the present study, and in doing so we lost what is known as a degree of freedom (Parker, 1973).

Standard Error of Mean (SE): It is calculated as SD/√N-1.

Differences between two means: In the present study, the number of observations in two sample means are almost more than 50. Therefore, the statistical difference between two means is worked out according to standard t-test given as follows:

$$t = (\bar{X}_1 - \bar{X}_2) \div \sqrt{\{(SE_1)^2 + (SE_2)^2\}}$$

where $\bar{X}_1$ and SE_1 are the mean and standard error of a given variable for the first sample, while $\bar{X}_1$ and SE_2 are the mean and standard error of the same variable for the second sample of the same population or different populations.

Differences between proportions: In the present study, the differences between proportions were tested by using the chi-square (χ^2). It is obtained as follows:

$$\chi^2 = \Sigma(O_i - E_i)^2/E_i = (O_1 - E_1)^2/E_1 + (O_1 - E_1)^2/E_1 + \ldots + (O_n - E_n)^2/E_n$$

where O_i and E_i are the observed and expected frequencies of the i-th character in each class.

The value obtained is then compared with that given in the Table of Chi-square distribution with (N –1) degree of freedom (d.f.). In the case of 2 × C contingency Table, the number of d.f. is (Row –1)(Column – 1). The expected frequency is calculated as (Row Total)(Column Total)/(Grand Total) OR (Column Total)/(Grand Total) multiplied by Row Total.

Analysis of Variance (ANOVA): One way analysis of variance was used for testing the differences between the means of more than two samples (Snedecor and Cochran, 1967). The basic procedure consists in examining the amount of variance "Within Samples" in relation to the amount of variance "Between Samples". Following are the steps followed for computing this test:

1. Correction factor (C) = $(\Sigma X_i)^2/N$, where X_i is the total number of ith item in all the samples, and N is the total number of items in all the samples.
2. Total sum of squares (TSS) = ΣX_i^2 - C, where X_i^2 is the square of each ith item in all the samples.

3. Sum of squares for variance between samples (SSB) = $n_1(\bar{X}_1 - \bar{X}) + n_2(\bar{X}_2 - \bar{X}) + \ldots + n_k(\bar{X}_k - \bar{X})$,

where $\bar{X}$ = Overall mean for all items in all samples

$\bar{X}_1, \bar{X}_2, \ldots, \bar{X}_k$ = Sample means 1, 2, . . . , k

$n_1, n_2, \ldots, n_k$ = Number of items in samples 1, 2, . . . , k.

4. Sum of squares for variance within samples (SSW) = (TSS – SSB)
5. Mean squares for variance between samples (MSB) = SSB/(K- 1), where (K – 1) is the degree of freedom between samples, i.e., K = Number of samples compared.
6. Mean square for variance within samples (MSW) = SSW/(N- K), where (N – K) is the degree of freedom for all individual items for all samples, i.e., N = Number of individual items for all samples.
7. F- ratio = MSB/MSW

The value obtained is then compared with that in the Table of F-distribution with (K – 1) as larger variance and (N – K) as smaller variance, taking 95% confidence interval.

Regression Analysis: Regression analysis has many applications. The main purpose is the regression analysis is to know if Y (dependent variable) does depend on X (independent variable), or to make a prediction of Y from X. In the present study, we are also concerned with the error in Y-variable after adjustments were made for the effects of X-variable. The regression coefficient (b) of Y on X is worked out as follows:

$$b = \Sigma xy/\Sigma x^2$$

where $\Sigma xy = \Sigma XY - (\Sigma X)(\Sigma Y)/N$

$$\Sigma x^2 = \Sigma X^2 - (\Sigma X)^2/N$$

The regression of Y on X is expressed as

$Y = a + bX$, where $a = \bar{Y} - \bar{X}b$, and $\bar{Y}$ = Estimated value.

CHAPTER III
DEMOGRAPHIC CHARACTERISTICS

In the present chapter, we shall deal with the demographic characteristics of the Hmars based on data collected from four villages, namely, Tinghmun, Zohmun, Sakawrdai and Ratu of Aizawl District in Mizoram.

Age, Sex and Marital Status

Table 3.1 shows the total population of the Hmars by age, sex and the marital status. It is found that 42.85, 47.74% and 9.40% of the total population belong to the age groups 0-14, 15-19 and 50 + years, respectively. According to Sundbarg's classification of population in terms of these age groups, a population is said to be progressive when the number of persons in relation to total population are 40%, 50% and 10% in the age groups 0 - 14, 15-19 and 50 + years, respectively. The population is referred to as *stationary* if these frequencies are 33%, 50% and 17% respectively, whereas the frequencies of 20%, 50% and 30% respectively are the characteristics of *regressive* population (Khongsdier, 2005c). Thus, according to Sundbarg's classification of population, the Hmar population may be categorized as *progressive type*, which is characterized by high fertility rates. The population pyramid (Figure 3.1) also shows that the base is quite broad, indicating that the fertility rate is fairly high in the present population.

Table 3.1 also shows that 92.71% of the unmarried males and 95.81% of the unmarried females belong to the age group of 24 years and below. Of the married males, 94.08% of them are aged 25 years and above. On the other hand, about 82.17% of the married females belong to the age group 25 years and above. Thus, these findings reveal that marriage is more delayed in males than in females.

Table 3.1. Population by age, sex and marital status

Age group in years	Unmarried		Married		DSW		Total		Persons
	Male	Female	Male	Female	Male	Female	Male	Female	
0-4	193	203	0	0	0	0	193	203	396
%	7.38	7.76	0	0	0	0	7.38	7.76	15.14
5-9	200	197	0	0	0	0	200	197	397
%	7.65	7.53	0	0	0	0	7.65	7.53	15.16
10-14	157	171	0	0	0	0	157	171	328
%	6.00	6.54	0	0	0	0	6.00	6.54	12.54
0-14	550	571	0	0	0	0	550	571	1121
%	21.02	21.83	0	0	0	0	21.02	21.83	42.85
15-19	133	165	1	8	0	0	134	173	307
%	5.08	6.31	0.04	0.31	0	0	5.12	6.61	11.74
20-24	67	65	26	69	0	0	93	134	227
%	2.56	2.48	0.99	2.64	0	0	3.56	5.12	8.68
25-29	37	22	65	89	0	3	102	114	216
%	1.41	0.84	2.48	3.40	0	0.11	3.90	4.36	8.26
30-34	14	3	60	57	0	1	74	61	135
%	0.54	0.11	2.29	2.18	0	0.04	2.83	2.33	5.16
35-39	4	1	60	68	0	1	64	70	134
%	0.15	0.04	2.29	2.60	0	0.04	2.45	2.68	5.12
40-44	4	4	61	66	0	0	65	70	135
%	0.15	0.15	2.33	2.52	0	0	2.48	2.68	5.16
45-49	0	1	50	41	2	1	52	43	95
%	0	0.04	1.91	1.57	0.08	0.04	1.99	1.64	3.63
15-49	259	261	323	398	2	6	584	665	1249
%	9.90	9.98	12.35	15.21	0.08	0.23	22.32	25.42	47.74
50-54	0	0	47	34	1	0	48	34	82
%	0	0	1.80	1.30	0.04	0	1.83	1.30	3.13
55-59	0	2	29	20	0	2	29	24	53
%	0	0.08	1.11	0.76	0	0.08	1.11	0.92	2.03
≥ 60	0	2	57	36	8	8	65	46	111
%	0	0.08	2.18	1.38	0.31	0.31	2.48	1.76	4.24
50+	0	4	133	90	9	10	142	104	246
%	0	0.15	5.08	3.44	0.34	0.38	5.43	3.98	9.40
Total	809	836	456	488	11	16	1276	1340	2616
%	30.93	31.96	17.43	18.65	0.42	0.61	48.78	51.22	100

Sex ratio = 95.22 males per females.
In (0-14) years = 96.32 males per 100 females.
(15-49) years = 87.82 males per 100 females
(50+) years = 136.54 males per 100 females

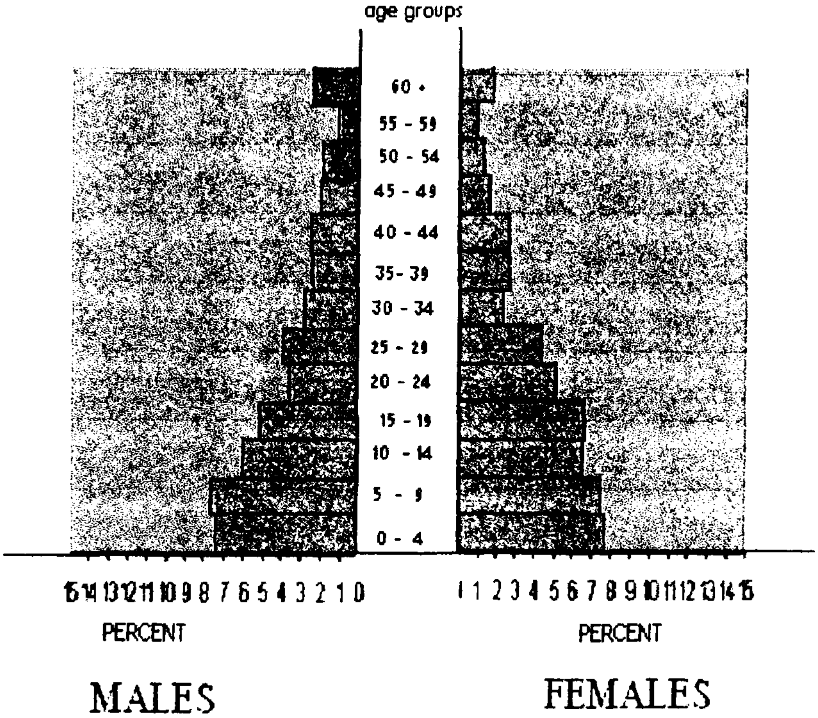

Figure 3.1. Population pyramid

Sex Ratio

In the present study, there are altogether 2616 individuals of which 1276 (48.78 %) are males and 1340 (51.22%) females. Thus, the overall sex ratio is 95.22 males per 100 females. This sex ratio is lower than the ideal sex ratio of 1:1, although the chi-square (χ^2) indicates that the sex difference is not statistically significant ($\chi^2 = 1.56$, d.f. = 1, $p > 0.05$).

In the age group 0-14 years, there are 550 males and 571 females, thereby giving a sex ratio of 96.32, which is low, although it is not statistically significant ($\chi^2 = 0.39$, d.f. = 1, $p > 0.53$). This suggests that in the present population infant and childhood mortality is higher in males than in females.

In the age group 15-49 years, there are 584 males and 665 females with a sex ratio of 87.82 males per 100 females. Like in the age group 0-14 years, the sex ratio in the age group 15-49 years is very low, and it is statistically significant ($\chi^2 = 5.24$, d.f. = 1, $p < 0.05$). Thus, it male mortality is significantly higher in this population, especially before 50 years of age.

In the age group 50 + years, there are 142 males and 104 females with a sex ratio of 136.54 males per 100 females. The sex ratio in this age group seems to be very high, and the χ^2 value shows that it is statistically significant ($\chi^2 = 5.86$, d. f. =1, $p < 0.05$). Thus, unlike in the younger age groups, the sex ratio in this age group is statistically high, thereby indicating that longevity is higher in males than in females. In other words, although mortality is higher in males than in females in the younger age groups, the longevity after 50 years of age is higher in males than in females. This can also be observed that the percentage distribution of males aged 60 years and above (2.48%) is slightly higher than that of females (1.76%).

In general, the present findings indicate that the Hmar population is progressive in nature that may be characterized by high fertility and low mortality rates. The population pyramid (Fig. 4.1) also depicts that the base is quite broad indicating a fairly high rate of fertility. The longevity after 50 years of age is likely to be higher in males than in females, although the situation is in reverse condition in the younger age groups.

Table 3.2. Mean age at marriage

Males			Females			t- value
Number	Mean	SE	Number	Mean	SE	
440	25.84	0.29	440	20.78	0.19	14.58*

*$p < 0.001$

Age at Marriage and First Child Birth

Table 3.2 shows the mean age at marriage for both males and females. The mean age at marriage is found to be 25.84 ± 0.29 years for males and 20.78 ± 0.19 years for females. Thus, the mean age at marriage is much higher in males than in females, and the difference is statistically significant ($t = 14.58$, $p < 0.001$). This indicates that females get married earlier than their male counterparts.

3.3 Mean age at first childbirth

Males			Females			t- value
Number	Mean	SE	Number	Mean	SE	
440	25.52	0.34	440	21.06	0.24	10.72*

*$p < 0.001$

The mean age at first childbirth is shown in Table 3.3. Like in the case of age at marriage, the mean age at first child birth is significantly higher in males (25.52 ± 0.34 years) have a higher mean age than that of females (21.06 ± 0.24 years). Thus, both age at marriage and first childbirth are much higher in males than in females. As shown in Table 3.1, the highest percentage of marriage is seen among males aged 35 years of age or above. Similarly, the lowest percentage of married males belonged to the age group 24 years of age or below.

Table 3.4. Live births by age groups of women

Age	Number of live births													Mothers	Mean ± SE
(yrs)	0	1	2	3	4	5	6	7	8	9	10	11	12		
≤ 24	9	15	22	4	4	0	0	0	0	0	0	0	0	54	1.61 ± 0.15
25-29	0	7	17	28	13	4	1	1	0	0	0	0	0	71	2.96 ± 0.14
30-34	0	2	8	14	16	9	2	0	0		0	0	0	51	3.55 ± 0.17
35-39	3	2	3	8	13	15	10	4	5	1	1	0	0	65	4.74 ± 0.27
40-44	2	1	3	3	10	10	9	9	6	5	1	1	0	60	5.67 ± 0.32
45-49	0	1	3	3	7	5	4	6	5	4	3	1	1	43	6.19 ± 0.43
50+	2	1	3	2	8	11	14	16	10	14	10	1	4	96	6.89 ± 0.27
Total	16	29	59	62	71	54	40	36	26	24	15	3	5	440	4.67± 0.13

F-ratio = 54.07, p = p < 0.000
Coefficient of correlation (r) = 0.65, p < 0.01

Fertility

Table 3.4 shows the live births by age groups of married women of all ages. The mean number of live births per married woman of all ages is found to be 4.67 ± 0.13. The mean number of live births per woman increases with the increasing age groups as generally observed in human populations. The Table shows that the mean numbers of live births per married woman are 1.16, 2.96, 3.55, 4.74, 5.67, 6.19, 6.89 in the age groups ≤ 24, 25-29, 30-34, 35-39, 40-44, 45-49 and ≥ 50 years, respectively. The one way analysis of variance (ANOVA) indicates that the differences between age groups are highly significant (F-ratio = 54.07, p = 0.000). Also, the coefficient of correlation is positively significant (r = 0.65, p < 0.01). Thus, it indicates that the mean number of live births per woman increases with the advance in age as normally expected.

It may be mentioned here that the adoption rate of modern family planning methods is very low (about 5% or 24 out of 464) in the present population. These women were excluded from the present analysis in order to have a better understanding of the relationship between fertility and socioeconomic conditions.

Table 3.5. Surviving children by age groups of women

Age (yrs)	Number of surviving children													No. of women	Mean ± SE
	0	1	2	3	4	5	6	7	8	9	10	11	12		
≤ 24	8	17	21	4	4	0	0	0	0	0	0	0	0	54	1.61 ± 0.16
25-29	0	8	19	25	14	13	1	1	0	0	0	0	0	71	2.89 ± 0.14
30-34	0	3	7	15	18	8	0	0	0	0	0	0	0	51	3.41 ± 0.15
35-39	3	2	4	7	17	14	10	3	3	1	1	0	0	65	4.54 ± 0.26
40-44	2	4	3	4	11	9	7	9	4	6	1	0	0	60	5.25 ± 0.34
45-49	0	1	4	4	7	5	8	4	5	2	2	1	0	43	5.56 ± 0.37
50+	2	2	4	9	7	16	21	7	14	10	2	1	1	96	5.89 ± 0.25
Total	15	38	64	71	82	70	53	31	34	28	16	13	13	440	4.27 ± 0.12

F-ratio = 39.45, $p < 0.001$
Coefficient of correlation (r) = 0.58, $p < 0.01$

Table 3.5 shows the mean number of surviving children per woman living in wedlock. The mean number of surviving children per mother living continuously in wedlock is 4.27 ± 0.12. Like in the case of live births, the mean number of surviving children per mother also increases with the rise in maternal age groups. It is found that the mean numbers of surviving children per woman living continuously in wedlock are 1.61, 2.89, 3.41, 4.54, 5.25, 5.56, 5.89 in the age groups below 24, 25-29, 30-34, 35-39, 40-44, 45-49 and 50 + respectively. It is found that the differences between age groups are highly significant (F-ratio = 39.45, $p < 0.001$). Also, the coefficient of correlation is positively significant ($r = 0.58$, $p < 0.01$). Thus, it indicates that the mean number of surviving children per woman living in wedlock increases with the advance in age as observed in the case of live births.

Table 3.6. Age-specific-fertility rate (ASRF)

Age groups (Years)	Number of married mother	No of live births	ASFR
15-19	427	211	0.50
20-24	424	554	1.31
25-29	378	522	1.38
30-34	310	416	1.34
35-39	259	230	0.89
40-44	194	95	0.49
≥ 45	134	25	0.19
Total fertility rate (TFR)	2126	2053	6.10

Age Specific Fertility Rate

Table 3.6 shows the age-specific fertility rates (ASFR) among the Hmar mothers. Figure 3.2 shows that ASFR reaches its peak (1.38) when the mothers are aged 25-29 years; then it starts decreasing with the rise in the age of the mothers. The total fertility rate (TFR), that is, the sum of the age-specific fertility rates, is 6.10, which is fairly high. In the following sections, we shall look into the factors responsible for high fertility rates in this population.

MORTALITY

The frequency of infant, childhood and juvenile mortality is given in the Table 3.7. It is seen that the over all infant, childhood and juvenile mortality rates are 2.83%, 1.56% and 1.90%, respectively. It indicates that infant mortality is higher than either childhood (i.e., deaths between 1 and 4 years of age) or juvenile mortality (i.e., deaths between 5 and 14 years of age).

With respect to sex differences, infant mortality rate (i.e., number of deaths before one year of life per 100 live births) is much higher in males (3.87%) than in females (1.82%). This difference between the sexes is statistically significant (χ^2 =7.82, d.f. =1, $p < 0.05$).

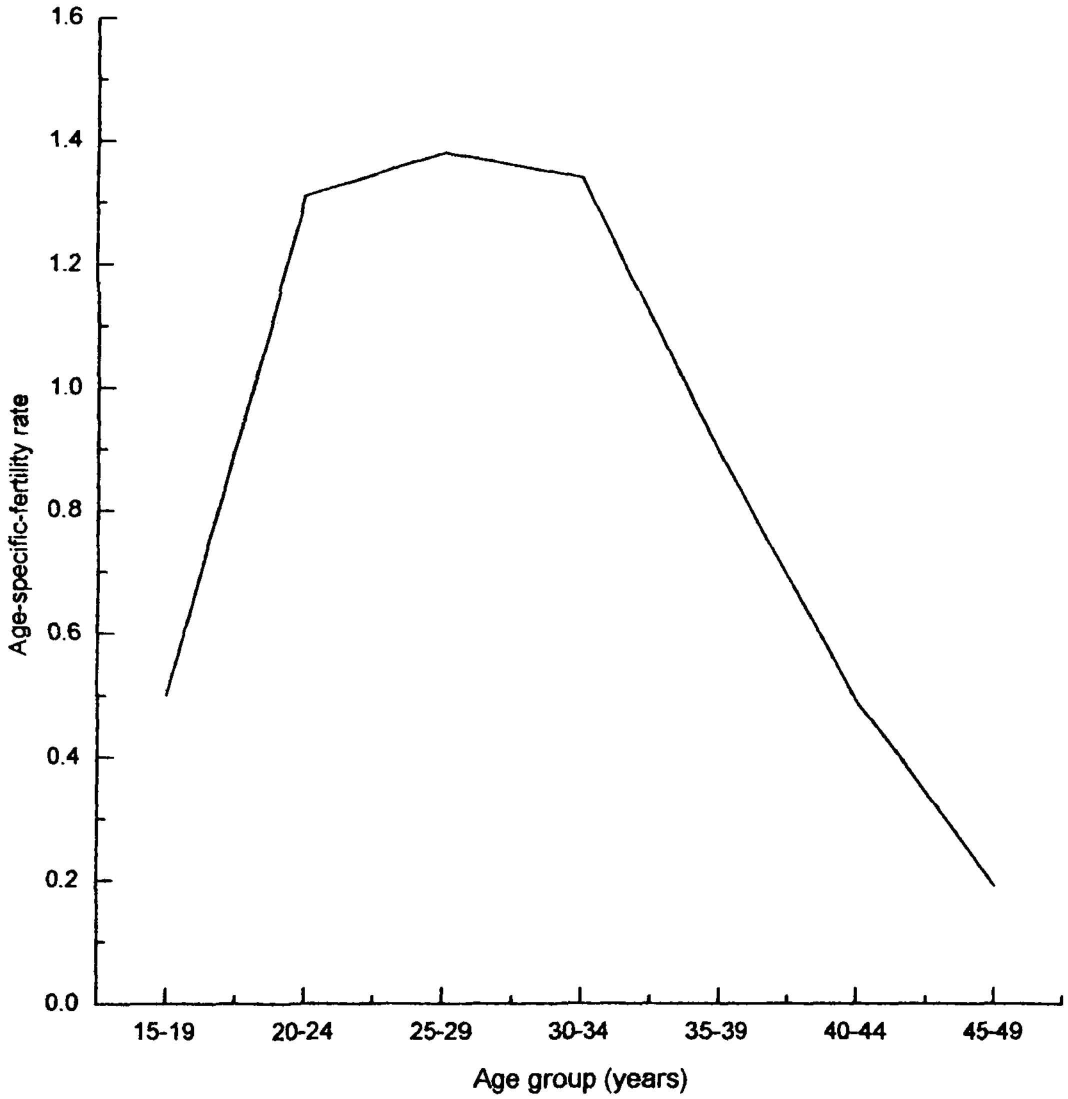

Figure 3.2. Age-specific-fertility rate

Table 3.7. Infant, childhood and juvenile mortality

Sex	No. of live births	Infant		Childhood		Juvenile	
		Number	%	Number	%	Number	%
Male (M)	1009	39	3.87	18	1.78	20	1.92
Female (F)	1044	19	1.82	14	1.34	19	1.82
Total (M + F)	2053	58	2.83	32	1.56	39	1.90

χ^2 values for the sex differences:
Infant: $\chi^2 = 7.82$, d.f. = 1, $p < 0.05$
Childhood: $\chi^2 = 0.66$, d.f. = 1, $p > 0.05$
Juvenile: $\chi^2 = 0.07$, d.f. = 1, $p > 0.05$

As for childhood mortality rate (i.e., number of deaths below 5 years of age per 100 live births), the frequency is slightly higher in males (1.78%) than in females (1.34%). However, the sex difference is not statistically significant (χ^2=0.66, d.f. = 1, $p > 0.05$). The juvenile mortality rate (i.e., number of deaths before 15 years of age per 100 live births) is also slightly higher in males (1.92%) than in females (1.82%), although it is statistically insignificant (χ^2=0.07, d.f. =1, $p > 0.05$).

Reproductive Wastage

The prevalence of reproductive wastage among the Hmars of the present study is given in Table 3.8. It is found that the still birth rate (i.e., number of still births per 100 pregnancies) is 1.26%, whereas the abortion rate (i.e., number of abortions per 100 pregnancies) is 2.86%. Thus, the rate of reproductive wastage (i.e., number of abortions and still births per 100 pregnancies) is 4.11%, which appears to be apparently high in modern population. It may be noted that all the reported abortion cases in the present study were spontaneous abortions but not induced abortions.

Table 3.8. Reproductive wastage

Parameters	Frequency
Total number of mothers	440
Total number of pregnancies	2140
Total number of abortions	61
Total number of still - births	27
Abortion rate (%)	2.86
Still birth (%)	1.26
Rate of reproductive wastage (%) i.e. abortions and still births	4.11

SOCIO-ECONOMIC CORRELATES

Age at marriage

The mean number of live births to married women by age at marriage is given in Table no. 3.9. The mean number of live births to women who married by the age of ≤ 19, 20-24 and ≥ 25 years is 4.85, 4.64 and 4.31, respectively. It is seen that the mean number of live births decreases with the increase in mean age at marriage. However, the differences between means are not statistically significant ($F= 0.914$, d.f =2,437, $p > 0.05$).

Table 3.9. Mean number of live births to married women by age at marriage

Age at marriage (Years)	No. of mothers	Mean number of live births per married woman	Standard error (SE)
< 19 years	145	4.85	0.24
20-24 years	227	4.66	0.18
> 25 years	68	4.31	0.28
Total	440	4.66	0.13
ANOVA-F-statistics = 0.914, d.f. = 2,437, p > 0.05			

Live Births and Maternal Education

The adjusted and unadjusted mean live births by educational level of mothers are given in Table 3.10. The mothers are divided into three educational groups, that is, those with no education, primary, secondary. The analysis of variance (ANOVA) and covariance (ANCOVA) were used for determining and adjusting the differences in mean live births. It is found that the unadjusted mean of live births decreases with the increasing educational level of the mothers. The differences between educational groups are also statistically significant ($F = 32.27$, d.f. = 2, 437, $p < 0.0001$). Adjusting for maternal age and household income, the differences in live births between educational groups of mother disappeared ($F = 0.93$, d.f. = 2, 437, $p > 0.05$). This indicates that the effects of education on live births are compounded by maternal age and household income. For example, it is likely that most educated mothers are in the lower age group, whereas illiterate mothers or mothers without educational background are more in the older age groups, thereby resulting in the fluctuation of sampling. From this point of view, the ANCOVA test is very helpful in determining how an independent variable (e.g., age in the present analysis) alone could influence the dependent factor (e.g., live birth in the present analysis).

Table 3.10. Adjusted and unadjusted number of live births by educational level of mothers

Educational level	Number of mothers	Mean number of live-births per married woman			
		Unadjusted		Adjusted*	
		Mean	SE	Mean	SE
No education	115	5.95	0.26	4.85	0.20
Primary	143	5.02	0.23	4.74	0.17
Secondary	182	3.58	0.16	4.49	0.16
F-statistics		32.27, p < 0.0001		0.93. p >0.05	

*Adjusted for maternal age and household income

Surviving Children and Maternal Education

The adjusted and unadjusted mean values of surviving children by educational level of mothers are given in Table 3.11. Like in the case of live births, the ANOVA test indicates that the unadjusted means are statistically significant ($F = 23.47$, d.f. = 2, 437, $p < 0.0001$). On the other hand, the ANCOVA test indicates that the differences between mean surviving children are not statistically significant after adjusting for maternal age and household income ($F = 0.45$, d.f. = 2, 437, $p > 0.05$). Thus, it may be concluded that the effect of education on live birth and surviving children are not significantly detected in the present population.

Table 3.11. Adjusted and unadjusted number of surviving children by educational level of mothers

Educational level	Number of mothers	Mean number of surviving children per married woman			
		Unadjusted		Adjusted*	
		Mean	SE	Mean	SE
No education	115	5.26	0.25	4.38	0.20
Primary	143	4.57	0.21	4.34	0.17
Secondary	182	3.42	0.15	4.16	0.16
F-statistics		23.47, p < 0.0001		0.45, p > 0.05	

*Adjusted for mother's age, and income level of households

Live Births and Household Income

Table 3.12 shows the adjusted and unadjusted number of live births by income group of mothers in the present population. Mothers are grouped into three income groups based on average monthly per capita income of the households. It is seen from the Table that the unadjusted mean live births are 5.10 ± 0.17, 4.22 ± 0.28 and 3.97 ± 0.28 in the low, middle and high income groups, respectively. The one way ANOVA test indicates that these differences are significant ($F = 7.57$, d.f. = 2, 437, $p < 0.001$). The higher mean live births in the lower income groups as compared to high income groups are statistically significant even after adjusting for maternal age and education ($F = 6.15$, d.f. = 2, 437, p

< 0.001). This indicates that household income is very important in regulating fertility rate in the present population.

Table 3.12. Adjusted and unadjusted number of live births by income group of mothers

Income level	Number of mothers	Mean number of live-births per married woman			
		Unadjusted		Adjusted*	
		Mean	SE	Mean	SE
Low	250	5.10	0.17	4.97	0.13
Middle	102	4.22	0.28	4.31	0.20
High	88	3.97	0.28	4.23	0.22
F- statistics		7.57, $p < 0.001$		6.15, $p < 0.002$	

*Adjusted for maternal age and educational level

Surviving Children and Household Income

The adjusted and unadjusted means of surviving children by income group of mothers are shown in Table 3.13. Like in the case of live births, the unadjusted mean of surviving children decreases with the rise in income levels. It is found to be 4.65 ± 0.15, 3.83 ± 0.25 and 3.70 ± 0.24 in the low, middle and high income groups, respectively. Using the one way ANOVA test, these differences between income groups are statistically significant ($F = 7.14$, d.f. = 2, 437, $p < 0.001$). Adjusting for maternal age and education, the mean surviving children are 4.55 ± 0.13, 3.91 ± 0.20 and 3.90 ± 0.22 in the low, middle and high income groups, respectively. And these differences between income groups with respect to surviving children are statistically significant ($F = 5.56$, d.f. = 2, 437, $p < 0.004$). In other words, the differences in mean surviving children between income groups are statistically significant even after adjusting for maternal age and education. This indicates the importance of household income in regulating live births and surviving children in the present population.

Table 3.13. Adjusted and unadjusted number of surviving children by income group of mothers

Income level	Number of mothers	Mean number of surviving children per married woman			
		Unadjusted		Adjusted*	
		Mean	SE	Mean	SE
Low	250	4.65	0.15	4.55	0.13
Middle	102	3.83	0.25	3.91	0.20
High	88	3.70	0.24	3.90	0.22
F statistics		7.14, $p < 0.001$		5.56, $p < 0.004$	

*Adjusted for maternal age and education

Table 3.14. Regression of live-births and surviving children on age and socioeconomic factors

Parameters	Coefficient of regression (b) and its standard error (SE)		t-value	P-level
	b	SE		
Live births				
Maternal age	0.129	0.008	16.42	0.0001
Age at marriage	-0.120	0.025	4.84	0.001
Household income	-0.365	0.122	2.99	0.003
Maternal education	-0.123	0.135	0.92	0.362
Constant	2.925	0.682	4.29	0.001
Surviving children				
Maternal age	0.104	0.008	13.45	0.0001
Age at marriage	-0.110	0.024	4.55	0.001
Household income	-0.327	0.120	2.74	0.006
Maternal education	-0.062	0.132	0.47	0.638
Constant	3.148	0.667	4.72	0.001

Regression of Live Births and Surviving Children on Age and Socioeconomic Variables

Table 3.14 shows the summary of regression analysis on the relationship between live births/surviving children and socioeconomic conditions. The Table shows that the coefficient of regression (b) and its standard error (SE) is highly significant with respect to maternal age, age at marriage and household income for both live births and surviving children. It is found that maternal age is positively associated with live births ($b = 0.129 \pm 0.008$, $t = 16.42$, $p < 0.0001$) and surviving children ($b = 0.104 \pm 0.008$, $t = 12.65$, $p < 0.0001$). The Table also shows that maternal age at marriage is negatively associated with live births ($b = -0.120 \pm 0.025$, $t = 4.84$, $p < 0.001$) and surviving children ($b = -0.110 \pm 0.024$, $t = 4.55$, $p < 0.001$). Further, household income is also negatively associated with live births ($b = -0.365 \pm 0.122$, $t = 2.99$, $p < 0.003$) and surviving children ($b = -0.327 \pm 0.120$, $t = 2.74$, $p < 0.006$). On the other hand, the present analysis failed to get a significant relationship between maternal education and live births as well as surviving children. Thus, it may be concluded that the role of maternal education is not clearly perceptible in the present analysis. Instead, maternal age, age at marriage and household income are very important factors for controlling live births and surviving children.

Table 3.15. Regression of infant and child mortality on age and socioeconomic factors

Parameters	Coefficient of regression (b) and its standard error (SE)		t-value	P-level
	b	SE		
Infant mortality				
Maternal age	0.029	0.011	2.62	0.009
Household income	0.001	0.026	0.052	0.959
Maternal education	-0.052	0.026	2.00	0.05
Constant	-0.121	0.097	1.25	0.211
Child mortality				
Maternal age	0.026	0.007	3.85	0.001
Household income	-0.029	0.016	1.82	0.07
Maternal education	-0.001	0.017	0.05	0.964
Constant	0.012	0.060	0.20	0.840

Regression of Infant and Child Mortality and on Age and Socioeconomic Variables

Table 3.15 shows the summary of regression analysis on the relationship between infant/child mortality and socioeconomic conditions. It can be observed that infant mortality is positively associated with maternal age ($b = 0.029 \pm 0.011$, $t = 2.62$, $p < 0.009$) and negatively associated with maternal education ($b = -0.052 \pm 0.026$, $t = 2.00$, $p < 0.05$). On the other hand, the effect of household income on infant mortality is not clearly perceptible in the present study. Table 3.15 further shows that child mortality is associated with maternal age only ($b = 0.026 \pm 0.007$, $t = 3.85$, $p < 0.001$). The effects of household income and maternal education are not statistically significant. Nevertheless, it is obvious from Table 3.15 that maternal age and maternal education are very important factors in controlling infant mortality in the present population.

CHAPTER – IV

GROWTH AND NUTRITIONAL STATUS

In this chapter we shall describe the growth pattern of the Hmar boys and girls taking into consideration the body weight, height, sitting height, bi-acromial diameter, bi-iliac diameter and mid upper arm circumference (MUAC). We shall also describe the nutritional status of these children using anthropometric indices such as weight-for-age, height-for-age and weight-for-height.

Sample Size

Table 4.1 shows the sample size for each sex and age group from 2 to 10 years of age. The sample size is equal for all the anthropometric measurements taken in the present study. Although the sample size is small for growth analysis, the findings of the present study are supposed to reflect to certain extent the growth and nutritional status of the Hmar population, which can be tested and/or refuted by future studies with large sample size.

Table 4.1. Sample size for all anthropometric measurements taken for the present study

Age (yrs)	Boys	Girls
2	15	16
3	28	26
4	29	27
5	31	23
6	29	42
7	31	42
8	25	24
9	41	24
10	26	28

Table 4.2. Statistical constants of weight (kg) for boys and girls

Age (yrs)	Boys			Girls			t-value
	Mean	SD	Increment	Mean	SD	Increment	
2	11.00	1.07	-	10.13	0.81	-	2.58*
3	12.89	1.93	1.89	11.62	1.42	1.49	2.75*
4	13.90	1.72	1.00	13.89	1.34	2.27	0.02
5	15.35	2.11	1.65	15.39	2.61	1.50	0.06
6	17.21	2.83	1.85	16.19	2.94	0.80	1.45
7	18.77	2.43	1.57	18.38	2.41	2.20	0.69
8	21.06	4.03	2.29	20.79	2.02	2.41	0.29
9	22.79	2.91	1.73	22.00	3.41	1.21	0.99
10	25.38	3.63	2.59	24.82	3.69	2.82	0.56

*$p < 0.05$

Weight

Table 4.2 shows the means and standard deviations of the body weight for both boys and girls by age groups. The mean values are plotted against age in Figure 4.1. The distance curve shows that there is a gradual increase in average weight for both boys and girls from 2 to 10 years of age. It can be observed that boys are heavier than girls at many age groups, and the differences are significant at 2 and 3 years of age (2 years: t-value = 2.58, $P < 0.05$; 3 years: t-value = 2.75, $P < 0.05$). It is further observed that both boys and girls are more or less same in body weight from 4 to 5 years of age.

The annual increment or growth rate in weight is plotted against age in Figure 4.2. There is no clear sex difference with respect to the velocity in body weight. It is seen that the velocity is higher in boys than in girls from 2 to 3, 4 to 5, 5 to 6 and 8 to 9 years of age. On the other hand, girls had higher velocities from 3 to 4, 6 to 7, 7 to 8 and 9 to 10 years of age. The maximum gain takes place at 8 years for both boys (4.03 kg) and girls (2.41 kg). It is also found that the total gain from 2 to 10 years of age is higher in girls (14.69 kg) than in boys (14.28 kg).

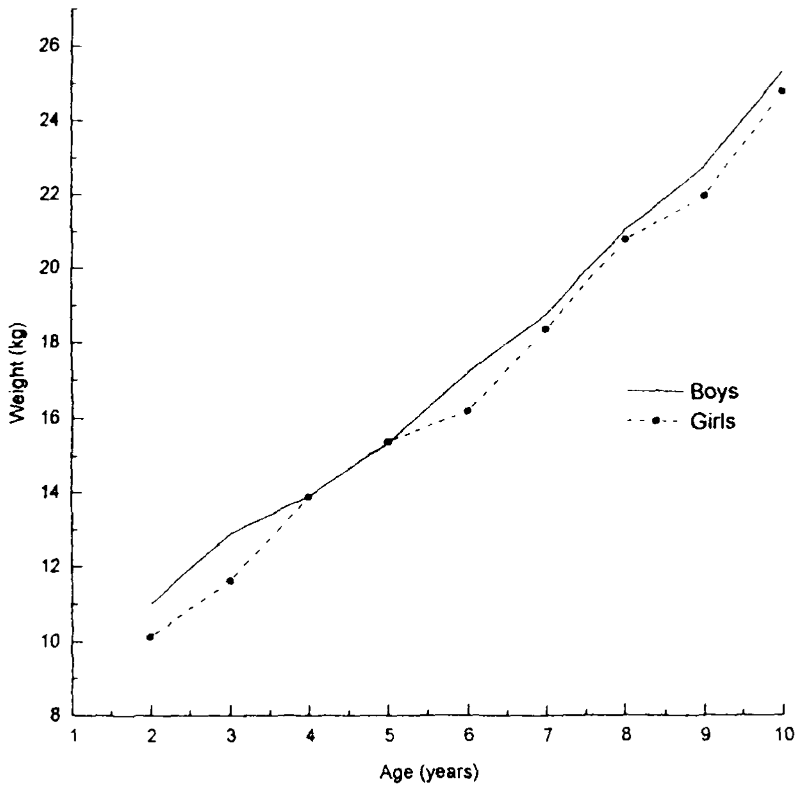

Figure 4.1 Distance curve for weight of boys and girls

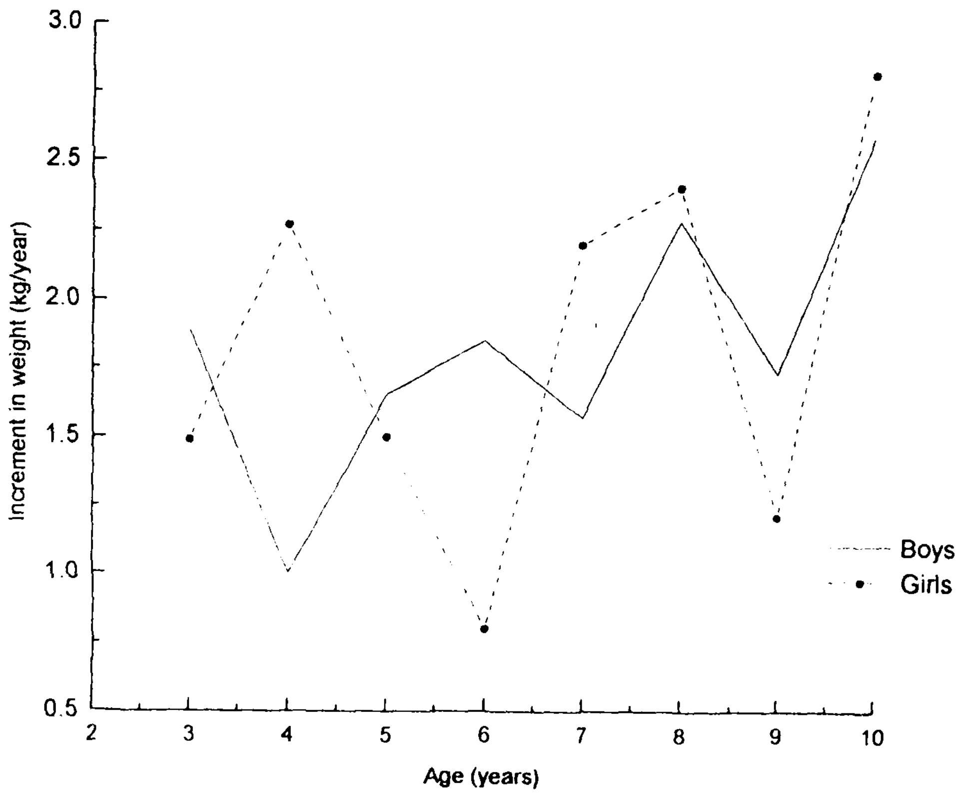

Table 4.3. Statistical constants of height (cm) for boys and girls

Age (yrs)	Boys			Girls			t-value
	Mean	SD	Increment	Mean	SD	Increment	
2	80.37	2.46	-	80.55	4.76	-	0.13
3	88.92	4.84	8.55	87.30	5.76	6.75	1.12
4	94.53	5.36	5.61	92.70	4.35	5.40	1.40
5	100.11	5.59	5.58	100.58	5.00	7.88	0.32
6	105.85	4.79	5.74	105.24	6.40	4.66	0.44
7	112.13	4.49	6.28	111.42	5.07	6.18	0.62
8	116.68	5.77	4.55	116.29	3.98	4.87	0.27
9	120.84	5.54	4.17	120.05	3.83	3.76	0.62
10	125.61	5.34	4.77	124.96	5.61	4.91	0.43

Height

Table 4.3 shows the means and standard deviations of height for both boys and girls from 2 to 10 years of age. As expected, height increases with the increase in age for both boys and girls. The distance curve (Figure 4.3) shows that boys are taller than girls at many age groups, except at ages 2 and 5 years when girls are slightly taller than boys. However, the differences between boys and girls in height are found to be statistically insignificant across age groups. Thus, according to the present findings, there are no statistical differences between boys and girls with respect to height, although it does look as boys were taller than girls at many age groups.

The velocity curve (Figure 4.4), which indicates the growth rate per year, shows that both the sexes gained their height from 3 to 10 years in a moderate and continuous manner. It is observed that the growth rate is higher in boys than in girls in many age groups, although it is higher in the latter than in the former at 5, 8 and 10 years of age. On the other hand, the growth rate is more or less similar for both boys and girls at 7 and 10 years of age. It is found that the maximum increase in height occurs between 2 and 3 years for boys (8.55 cm) and 4 and 5 years for girls (7.88 cm).

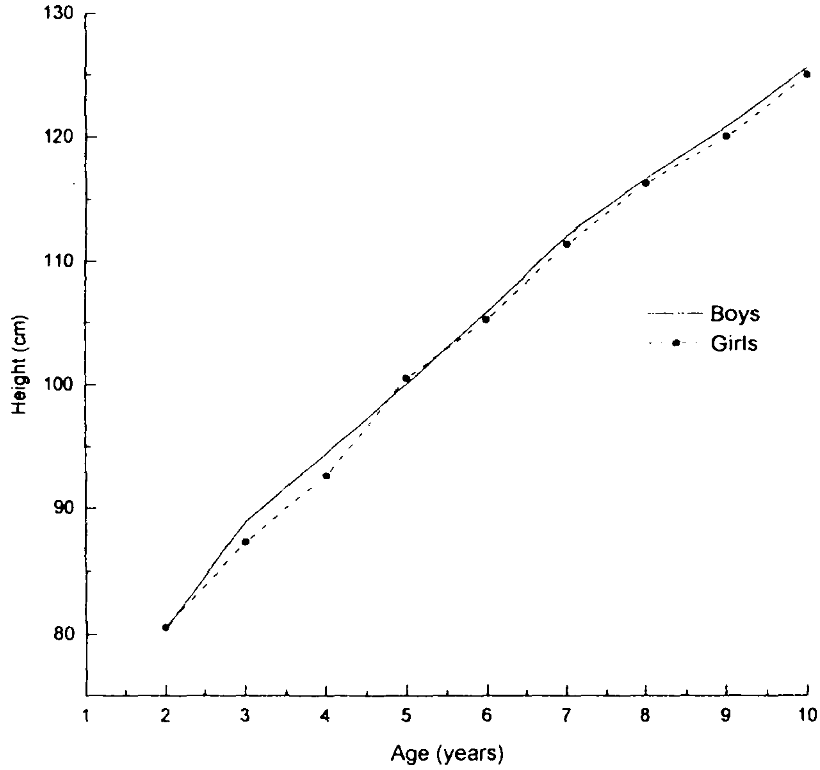

Figure 4.3. Distance curve for height of boys and girls

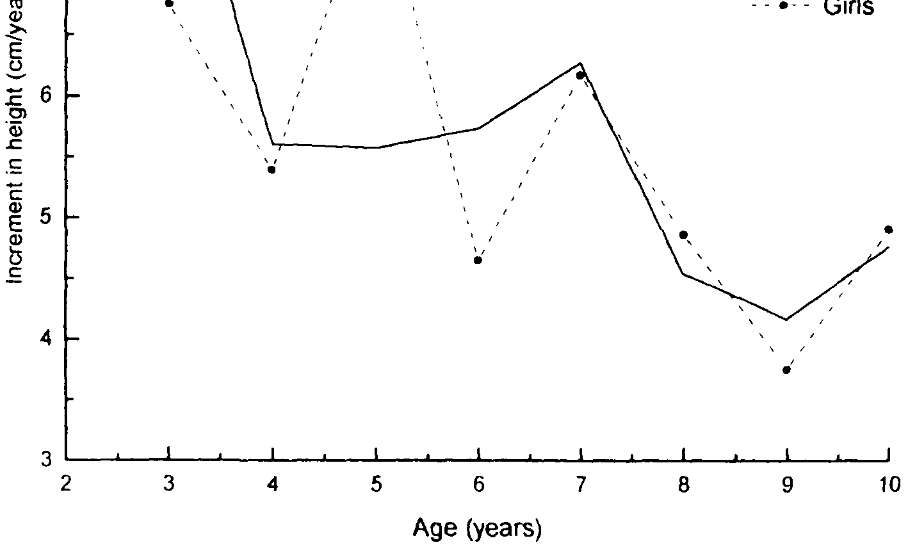

Fig. 4.4. Velocity curve for height of boys and girls

Table 4.4. Statistical constants of sitting height (cm) for boys and girls

Age (yrs)	Boys			Girls			t-value
	Mean	SD	Increment	Mean	SD	Increment	
2	48.21	3.23	-	48.41	2.60	-	0.19
3	51.40	2.79	3.20	51.10	2.80	2.70	0.39
4	54.66	2.91	3.25	53.36	2.55	2.26	1.77
5	56.16	2.85	1.51	56.60	3.17	3.24	0.52
6	58.97	3.46	2.32	58.37	3.45	2.76	0.72
7	61.56	3.07	2.60	61.13	2.74	2.76	0.63
8	63.16	3.50	1.60	62.80	2.66	1.66	0.41
9	65.15	3.98	1.99	64.98	3.18	2.19	0.18
10	67.58	3.23	2.42	67.03	3.12	2.04	0.64

Sitting height

Table 4.4 shows the means and standard deviations of sitting height for both boys and girls from 2 to 10 years of age. There is a gradual increase in sitting height with the increase in age. Boys are slightly higher in sitting height than girls at ages 3, 4, 6, 7, 8, 9 and 10 years, while girls surpassed boys at ages 2 and 5 years. However, these differences between boys and girls are not statistically significant (Table 4.3). The distance curve for sitting height (Figure 4.5) also shows that boys and girls have similar growth patterns.

The velocity curve (Figure 4.6) shows that both the sexes gained their sitting height continuously from 2 to 10 years. Table 4.3 shows that the velocity is higher in boys than in girls at ages 3, 4 and 10 years, although it is higher in the latter than in the former at 5, 6, and 9 years of age. The growth rate is more or less similar for both boys and girls at 7 and 8 years of age. It is found that the maximum increase in sitting height occurs between 3 to 4 years for boys (3.25 cm) and between 4 to 5 years for girls (3.24 cm).

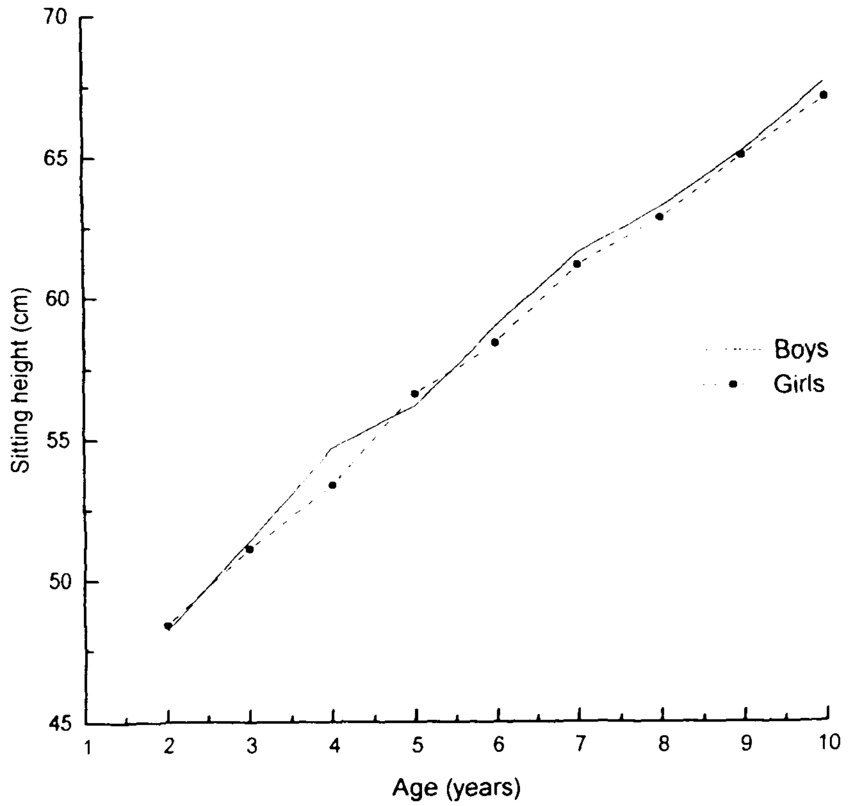

Figure 4.5. Distance curve for sitting height of boys and girls

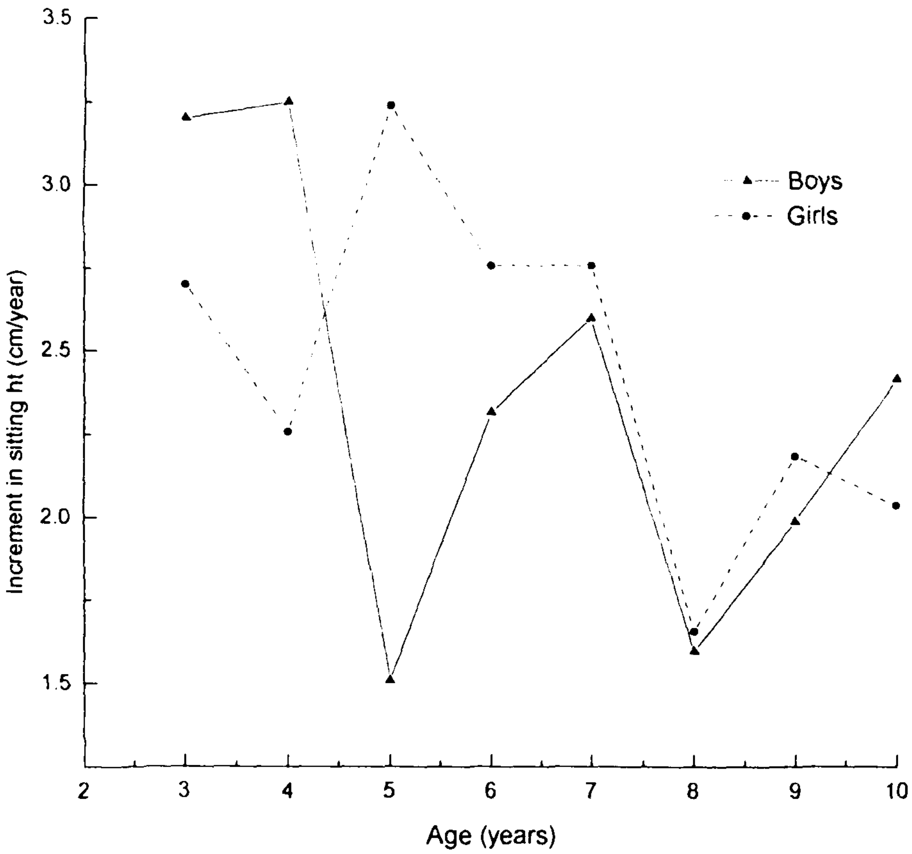

Figure 4.6. Velocity curve for sitting height of boys and girls

Table 4.5. Statistical constants of biacromial diameter (cm) for boys and girls

Age (yrs)	Boys			Girls			t-value
	Mean	SD	Increment	Mean	SD	Increment	
2	19.51	1.48	-	18.47	1.19	-	1.50
3	20.50	1.26	0.99	19.80	1.34	1.33	1.97*
4	21.95	1.63	1.45	21.43	1.88	1.63	1.10
5	22.08	1.60	0.13	22.28	1.44	0.85	0.48
6	23.39	1.59	1.86	23.04	1.71	0.76	0.88
7	24.62	1.27	1.22	24.53	1.71	1.49	0.25
8	25.46	1.71	0.85	25.11	1.77	0.58	0.71
9	26.04	1.99	0.58	25.85	1.80	0.74	0.38
10	27.48	1.68	1.44	27.19	1.69	1.34	0.64

*$p < 0.05$

Biacromial Diameter

Table 4.5 shows the means and standard deviations of biacromial diameter for both boys and girls. The mean values of biacromial diameter are plotted against age as shown in Figure 4.7. For both boys and girls there is a gradual increase in the biacromial diameter as age advances. It can be observed that boys have slightly broader shoulder than girls in all age groups, except at 5 years of age, when the latter have a higher mean value (22.28 cm) than the former (22.08 cm). But this difference is not statistically significant ($t = 0.476$, $p > 0.05$). Like in the case of height and sitting height, there are no statistical differences between boys and girls with respect to biacromial diameter, except at 3 years of age (Table 4.5).

Figure 4.8 shows the velocity curve for the biacromial diameter of both boys and girls. It is seen that the growth rate is higher in girls than in boys except at 6, 8 and 10 years of age when the velocity is higher in the latter than the former. In boys the maximum acceleration gain of 1.86 cm occurs from 5 to 6 years of age. On the other hand, the maximum acceleration rate of 1.63 cm in girls takes place from about 3 to 4 years of age.

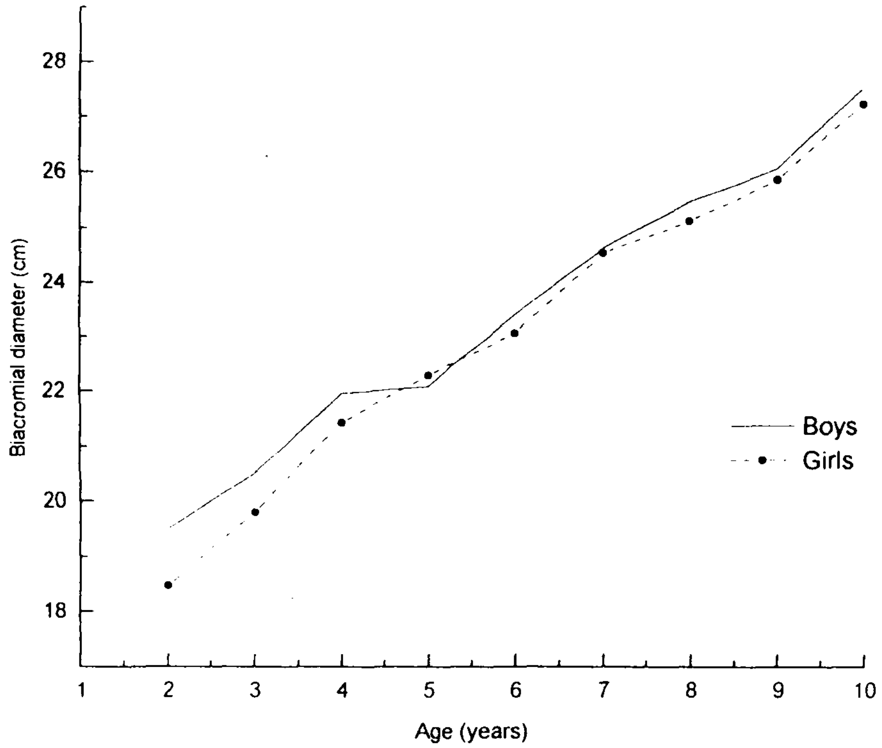

Figure 4.7. Distance curve for biacromial diameter of boys and girls

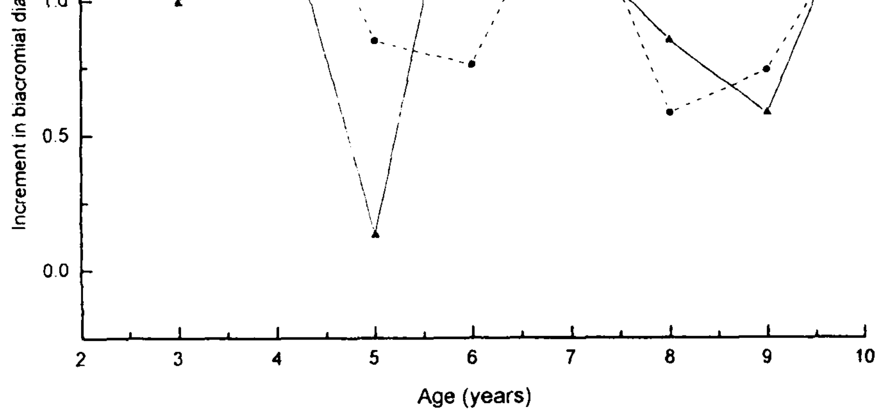

Figure 4.8. Velocity curve for biacromial diameter of boys and girls

Table 4.6. Statistical constants of bi-iliac diameter (cm) for boys and girls

Age (yrs)	Boys			Girls			t-value
	Mean	SD	Increment	Mean	SD	Increment	
2	15.21	1.24	-	14.61	0.97	-	1.50
3	15.84	1.14	0.64	15.26	0.88	0.65	2.09*
4	16.60	0.93	0.76	16.32	1.07	1.06	1.04
5	17.34	1.86	0.74	17.57	1.20	1.25	0.52
6	17.74	1.10	0.40	17.80	1.08	0.23	0.23
7	18.44	1.50	0.70	18.26	1.25	0.46	0.57
8	19.57	1.56	1.13	19.15	1.13	0.89	1.08
9	20.27	1.49	0.70	19.77	1.68	0.62	1.23
10	21.12	1.55	0.85	20.50	1.75	0.73	1.36

*$p < 0.05$

Bi-Iliac diameter

Table 4.6 shows the means and standard deviations of bi-iliac diameter for both boys and girls. The distance curve based on the means against age is shown in Figure 4.9. Excepting at 5 and 6 years of age, boys have a broader hip than girls in many age groups, and the difference is statistically significant at 3 years of age ($t = 2.09$, $p < 0.05$).

The growth rate per annum is plotted against age in Figure 4.10. It is seen that the velocity is somewhat higher in boys than in girls in many age groups, except at 4 and 5 years of age when the acceleration rate is higher in girls than in boys. The acceleration or velocity in boys is highest (1.13 cm) at about 8 years of age. On the other hand, girls have the highest velocity of 1.25 cm at 5 years of age. Overall, the total gain from 2 to 10 years of age is by and large similar in both boys (5.91 cm) and girls (5.89 cm).

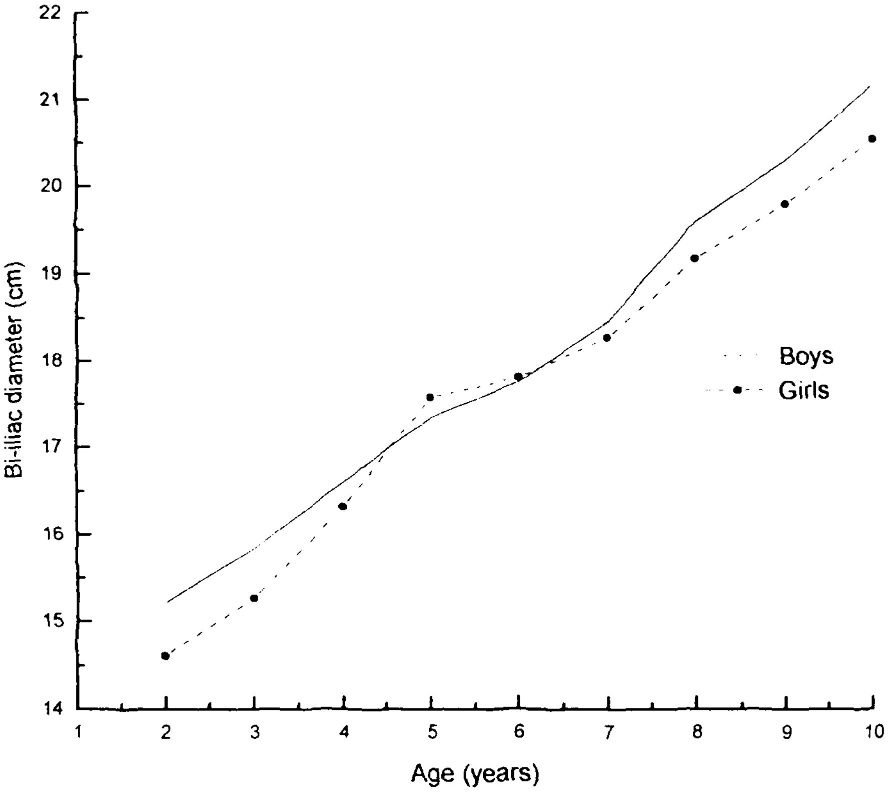

Figure 4.9. Distance curve for bi-iliac diameter of boys and girls

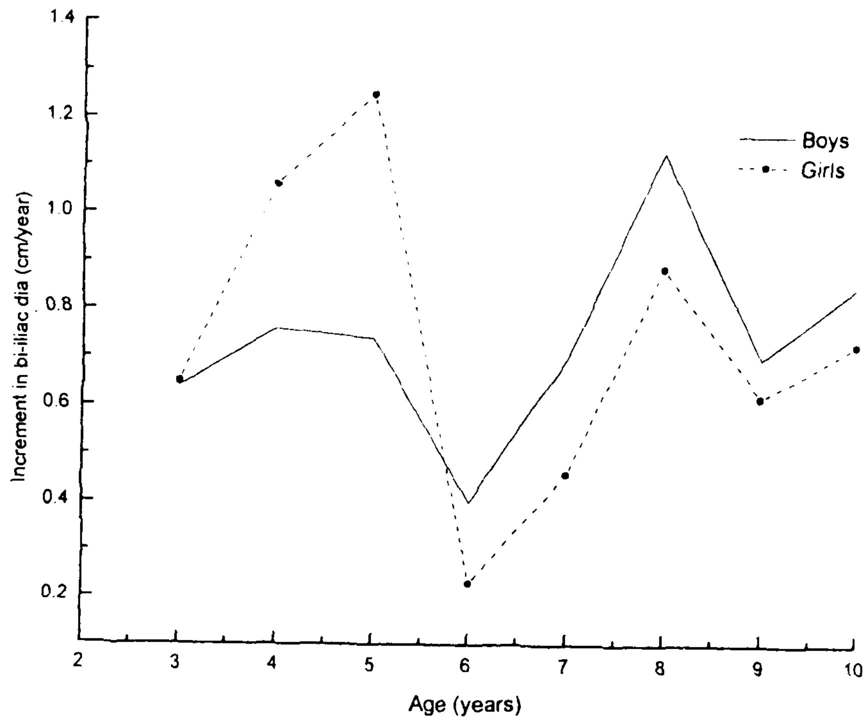

Figure 4.10. Velocity curve for bi-iliac diameter of boys and girls

Table 4.7. Statistical constants of upper arm circumference (cm) for boys and girls

Age (yrs)	Boys			Girls			t-value
	Mean	SD	Increment	Mean	SD	Increment	
2	13.49	0.80	-	12.93	0.46	-	2.42*
3	13.53	1.04	0.04	13.15	0.60	0.22	1.62
4	14.18	2.42	0.65	13.53	1.04	0.38	1.30
5	13.77	1.02	-0.41	13.67	0.67	0.14	0.41
6	14.21	1.22	0.44	13.97	0.87	0.30	0.98
7	14.91	1.30	0.70	14.37	1.00	0.40	2.00*
8	15.41	1.36	0.50	14.97	1.26	0.60	1.18
9	15.99	1.68	0.58	15.20	0.94	0.23	2.11*
10	16.69	1.98	0.70	16.09	1.10	0.89	1.39

*$p < 0.05$

Mid Upper Arm Circumference

Table 4.7 shows the mean and standard deviation of the mid upper arm circumference (MUAC) for both boys and girls. The distance curve (Figure 4.11) shows that boys have higher mean value of the arm circumference than girls in all age groups except at age 5 and 6 years. The differences between the sexes are found to be statistically significant at age 2, 7 and 9 years of age (Table 4.6). (2 years: t-value = 2.42, $p < 0.05$; 7 years: t-value = 2.00, $p < 0.05$; 9 years: t-value =.2.11, $p < 0.05$). Thus, the sex differences seem to be greater in mid upper arm circumference as compared with other measurements taken in the present study.

The annual growth rate or velocity in mid upper arm circumference is plotted against age in Figure 4.12. The velocity rate of the boys is higher than that of the girls at age 4, 6, 7 and 9 years of age, while the latter are higher in velocity rate at the age of 3, 8 and 10 years. The total gain in arm circumference is more in boys (3.19 cm) than in girls (3.16 cm). In both boys and girls, the maximum gain occurs at 10 years of age.

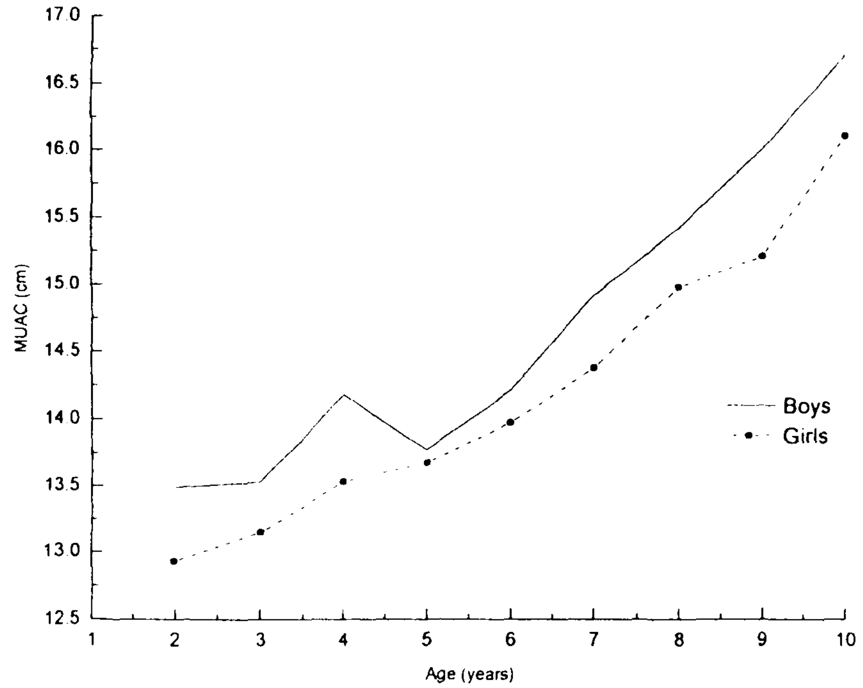

Figure 4.11. Distance curve for mid upper arm circumference (MUAC) of boys and girls

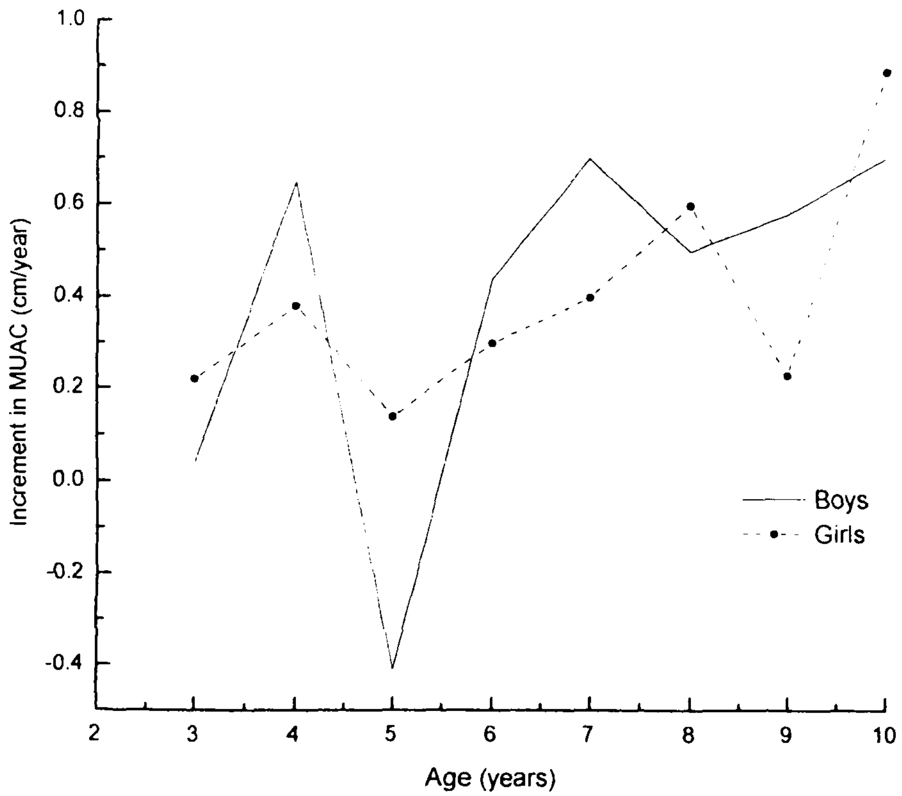

Figure 4.12. Velocity curve for mid upper arm circumference (MUAC) of boys and girls

NUTRITIONAL STATUS

One of the major health problems in many developing countries is the widespread prevalence of under nutrition and infectious diseases (WHO, 1990). It is generally reported that the basic causes of under nutrition and infections in developing countries are poverty, poor hygienic conditions and little access to preventive and health care (Mitra, 1985; WHO, 1990). Hence, assessment of the nutritional status of population has attracted the attention of not only the nutritionists and other biological scientists, but also the economists and other social scientists with a view to understanding the health and socioeconomic status of the population (Osmani, 1992). Nutritional status is defined as a physical expression of the relationship between the nutrient intakes, or bio-availability of nutrients, and the physiological requirements of an individual (Brown, 1984). This physical expression of the relationship between nutrient intakes and physiological requirements of a person can be measured by a number of methods. Of different methods, anthropometry is one that is generally used for measuring the magnitude of under nutrition at both individual and population levels. Anthropometric measurements and indices like weight, height, mid upper arm circumference, skinfold thickness, weight-for-age, height-for-age, weight-for-height, body mass index, indices of upper arm circumference, etc., (WHO, 1963; Jelliffe, 1966; Frisancho, 1990) are used for assessing the nutritional status of children.

In the present study, we have taken three important anthropometric indices, i.e., weight-for-age, height-for-age, and weight-for-height for assessing the nutritional status of the children. We have also made an attempt to correlate these indices with certain socioeconomic variables such as household income, maternal education and family size. The findings of the study may be presented briefly as follows:

Weight-for-age

Weight-for-age, expressed as percentage or Z-score of individual weight to the median or 50th percentile of the international population references (i.e., WHO/NCHS growth references) is generally considered as one of the indicators of underweight. The means and standard deviations of the z-score for weight-for-age are given in Table 4.8. It is seen that the mean weight-for-age is higher in girls than in boys across age groups, except at 3 years of age and from 9 to 10 years of age when boys had higher z-score for weight-for-age. The sex differences are not statistically significant except at 3 years of age ($t = 2.04$, $p < 0.05$).

Table 4.8. Mean z-scores for weight-for-age of both boys and girls

Age	Boys			Girls			
(yrs)	Number	Mean	SD	Number	Mean	SD	t-value
2	15	-1.19	0.95	16	-1.42	0.69	0.78
3	28	-1.08	1.21	26	-1.69	0.96	2.04*
4	29	-1.47	0.90	27	-1.22	0.79	1.10
5	31	-1.57	1.00	23	-1.18	1.35	1.22
6	29	-1.49	1.22	42	-1.48	1.30	0.03
7	31	-1.55	0.92	42	-1.26	0.88	1.37
8	25	-1.37	1.30	24	-1.17	0.58	0.69
9	41	-1.41	0.77	24	-1.48	0.78	0.35
10	26	-1.26	0.79	28	-1.41	0.70	0.74

*$p < 0.05$

Table 4.9 shows that about 67.84% of boys and 74.21% of girls for all age groups are in the normal category (-2 to + 2 of Z-scores) of nutritional status relative to weight-for-age. On the other hand, the prevalence of moderate (-2 to –3 of Z-scores) and severe (below –3 of Z-scores) forms of underweight among boys is 29.02% and 2.75%, respectively. In the case of girls, these frequencies are found to be 23.41% and 1.59%, respectively. These sex differences in the prevalence of underweight are, however, not statistically significant ($\chi^2 = 2.85$, D.F. = 1, $p > 0.05$). Considering the cut-off point of - 2 Z-score, the age-adjusted odds ratio (OR) of underweight in boys for all age groups is 1.40 times greater than in girls (95% CI = 0.95-2.07) (Table 4.9). Despite the absence of statistical difference, boys are likely to have a higher prevalence of underweight when compared with girls across age groups.

Table 4.9. Nutritional status according to weight-for-age (based on NCHS references)

Nutritional status	Boys (N =255)		Girls (N = 252)	
	Number	Percent	Number	Per cent
2- 5 years				
Above normal (≤ + 2 score)	0	0.00	1	1.09
Normal (≤ -2 to +2 Z-score)	71	68.93	70	76.09
Moderate (-2 to -3 Z-score)	27	26.21	20	21.74
Severe (< -3 Z-score)	5	4.85	1	1.09
Total	103	100.00	92	100.00
χ^2 = 1.67, D.F. = 1, p > 0.05, OR (95% CI) = 1.57(0.82-2.99)				
6 to 10 years				
Above normal (≤ + 2 score)	1	0.66	1	0.63
Normal (≤ -2 to +2 Z-score)	102	67.10	117	73.12
Moderate (-2 to -3 Z-score)	47	30.92	39	24.37
Severe (< -3 Z-score)	2	1.32	3	1.88
Total	152	100.00	160	100.00
χ^2 = 1.35, D.F. = 1, p > 0.05, OR (95% CI) = 1.47 (0.89-2.43)				
2 to 10 years				
Above normal (≤ + 2 score)	1	0.39	2	0.79
Normal (≤ -2 to +2 Z-score)	173	67.84	187	74.21
Moderate (-2 to -3 Z-score)	74	29.02	59	23.41
Severe (< -3 Z-score)	7	2.75	4	1.59
Total	255	100.00	252	100.00
χ^2 = 2.85, D.F. = 1, p > 0.05, OR (95% CI) = 1.40 (0.95-2.07)				

χ^2 test for sex differences in the prevalence of underweight
OR = Odds ratio, CI = 95% confidential interval

Table 4.9 also shows the percentage distribution of undernourished children according to two arbitrary age groups. In the age group 2-5 years, about 26.21% and 4.85% of boys, and 21.74% and 1.69% of girls are in the categories of moderate and severe forms of underweight, respectively. Thus, it indicates that the prevalence of underweight is higher in boys than in girls in this age group, despite the absence of statistical significance (χ^2 = 1.67, D.F. = 1, p > 0.05). Also, the OR is 1.57 (95% CI = 0.82-2.99), which indicates a marked difference in the prevalence of underweight in boys when compared with girls, although it is not statistically significant (p > 0.05). Also, the prevalence of moderate and severe forms of underweight is higher in boys than in girls in the age group 6-10 years, although the difference is not statistically significant (χ^2 = 1.35, D.F. = 1, p >0.05). It is found that boys are about 1.47 times likely to be underweight as compared to girls (OR = 1.47, 95% CI = 0.89-2.43).

Besides sex variation in the distribution of low weight for age mentioned above, Table 4.9 further shows that the frequencies of underweight (i.e., moderate plus severe forms) in boys for the age groups 2-5 and 6-10 years are 31.07% and 32.24%, respectively. While in the case of girls, these frequencies are 22.83% and 26.25%, respectively. Thus, it indicates that the prevalence of underweight is higher in the higher age groups especially for both boys and girls. In other words, the nutritional status with respect to weight-for-age seems to be better in the lower age groups as compared with the higher age groups. However, these differences in the distribution of undernourished individuals between age groups are not statistically significant in both boys (χ^2 =0.04, D.F. = 1, p > 0.05) and girls (χ^2 =0.36, D.F. = 1, P>0.05).

Therefore, the present findings indicate that there are differences between the sexes and age groups with respect to the percentage distribution of underweight children, despite the absence of statistical significance. Girls seem to fair better than boys. Also, children in the lower age groups are better in weight-for-age as compared with those in the higher age groups.

Table 4.10. Mean z-scores of height-for-age of both boys and girls

Age (yrs)	Boys			Girls			t-value
	Number	Mean	SD	Number	Mean	SD	
2	15	-1.64	0.77	16	-1.23	1.49	0.95
3	28	-1.58	1.27	26	-1.78	1.55	0.52
4	29	-1.97	1.26	27	-2.21	1.07	0.77
5	31	-2.14	1.22	23	-1.77	1.13	1.14
6	29	-2.11	0.99	42	-1.91	1.30	0.70
7	31	-1.88	0.88	42	-1.67	0.93	1.17
8	25	-1.92	1.08	24	-1.67	0.66	0.97
9	41	-2.00	0.98	24	-1.87	0.59	0.59
10	26	-1.89	0.88	28	-1.88	0.82	0.04

Height-for-age

Table 4.10 gives the means and standard deviations of Z-score for height-for-age. Height-for-age is considered as one of the best indicators of stunting or short stature of individuals due to under-nutrition. Like in the case of weight-for-age, it reveals that the mean Z-scores for height-for-age are higher in girls than in boys, except from 3 to 4 years when the mean values are higher in the latter than in the former. Although the sex differences are not statistically significant for all age groups (Table 4.10), it is obvious that girls are by and large better than boys in respect of height-for-age especially after 4 years of age.

Table 4.10 shows the nutritional status of both boys and girls according to height-for-age, following the cut-off levels proposed by Visweswara Roa (1996). It is seen that the proportions of boys with normal, moderate, and severe forms of growth retardation are 47.06%, 40.78% and 12.16%, respectively. In the case of girls, these frequencies are found to be 55.16%, 30.56% and 13.89%, respectively. Thus, it indicates that the overall prevalence of under-nutrition (moderate plus severe forms) for all age groups is higher in boys (52.94%) than in girls (44.44%), and it is statistically significant ($\chi^2 = 3.67$, D.F. = 1, $p < 0.05$). The estimated OR is found to be 1.45 (95% CI = 1.02-2.06), which is also significant at 5% level.

Table 4.11. Nutritional status according to height-for-age (based on NCHS references)

Nutritional status	Boys (N =255)		Girls (N = 252)	
	Number	Percent	Number	Per cent
2-5 years				
Above normal (≤ + 2 score)	0	0.00	0	0.00
Normal (≤ -2 to +2 Z-score)	53	51.46	53	57.61
Moderate (-2 to -3 Z-score)	36	34.95	21	22.83
Severe (< -3 Z-score)	14	13.59	18	19.56
Total	103	100.00	92	100.00
χ^2 = 0.74, D.F. = 1, p > 0.05, OR (95% CI) = 1.26 (0.71-2.22)				
6 to 10 years				
Above normal (≤ + 2 score)	0	0.00	1	0.63
Normal (≤ -2 to +2 Z-score)	66	44.08	86	53.75
Moderate (-2 to -3 Z-score)	69	44.74	56	35.00
Severe (< -3 Z-score)	17	11.18	17	10.63
Total	152	100.00	160	100.00
χ^2 = 3.74, D.F. = 1, p < 0.05; OR (95% CI) = 1.61(1.03-2.54)				
2 to 10 years				
Above normal (≤ + 2 score)	0	0.00	1	0.40
Normal (≤ -2 to +2 Z-score)	120	47.06	139	55.16
Moderate (-2 to -3 Z-score)	104	40.78	77	30.56
Severe (< -3 Z-score)	31	12.16	35	13.89
Total	255	100.00	252	100.00
χ^2 = 3.67, D.F. = 1, p < 0.05, OR (95% CI) = 1.45 (1.02-2.06)*				

χ^2 test for sex differences in the prevalence of stunting
OR = Odds ratio, CI = 95% confidential interval
*p < 0.05

Table 4.11 further shows the percentage distribution of growth retardation in boys and girls according to two age groups arbitrarily classified as in the case of weight-for-age. In the first age group (i.e., 2-5 years), the frequencies of moderate and severe forms of stunting/growth retardation in boys are about 34.95% and 13.59%, respectively, whereas in girls these frequencies are found to be about 22.83% and 19.56%, respectively. However, these sex differences in the prevalence of stunting in this age group is not statistically significant (χ^2 =.74, D.F. = 1, $p > 0.05$). The age-adjusted OR is found to be 1.26 with a confidence interval of 0.71and 2.22, which is also not significant.

In the second age group (i.e., 6-10 years), Table 4.11 shows that about 44.74% and 11.18% of boys suffered from moderate and severe forms of stunting, respectively. In the case of girls, the frequencies of moderate and severe forms of stunting are about 35% and 10.63%, respectively. Accordingly, like the case of the first age group, the frequency of low height-for-age is higher in boys than in girls, and it is statistically significant (χ^2 = 3.74, D.F. = 1, $p < 0.05$). The estimated OR shows that the prevalence of low height-for-age in boys are about 1.6 times higher than girls in this age group (95% CI = 1.03-2.54, $p < 0.05$). Thus, it indicates that the sex difference in height-for-age is more marked in the higher age groups. It is found that about 48.54% and 56.58% of boys are stunted in the age groups 2-5 and 6-10 years, respectively. As for girls, these frequencies are about 42.39% and 45.63%, respectively. However, the chi-square test indicates that there are no statistical differences for both boys (χ^2 = 0.48, D.F. = 1, $p > 0.05$) and girls (χ^2 = 0.10, D.F. = 1, $p > 0.05$).

Weight-for-height

Weight-for-height is generally considered as the best indicator of body fat mass, or wasting and thinness due to chronic energy deficiency. It is similar to body mass index. The z-score for this index is expressed as the difference between the subject's weight and the reference weight (WHO/NCHS reference) relative to height divided by standard deviation of the reference population. In the present study, Table 4.12 shows the means and standard deviations of Z-score for weight-for-height of both boys and girls. It indicates that there are no significant differences between boys and girls, except at 4 years of age when girls had higher mean values than boys ($t = 2.29$, $p < 0.05$).

Table 4.12. Mean z-scores of weight-for-height of both boys and girls

Age	Boys			Girls			t-value
(yrs)	Number	Mean	SD	Number	Mean	SD	
2	15	0.05	1.06	16	-0.56	1.24	1.47
3	28	-0.10	1.16	26	-0.56	0.95	1.59
4	29	-0.34	1.19	27	0.32	0.94	2.29*
5	31	-0.30	1.38	23	-0.07	1.81	0.53
6	29	-0.17	1.26	42	-0.49	1.08	1.15
7	31	-0.35	1.17	42	-0.22	1.03	0.50
8	25	-0.02	1.33	24	0.23	0.90	0.77
9	41	0.11	0.98	24	0.03	1.22	0.29
10	26	0.30	0.84	28	0.25	1.10	0.19

*$p < 0.05$

The nutritional status of both boys and girls according to weight-for-height z-score relative to the NCHS growth references is given in Table 4.13. Considering all age groups, the prevalence of wasting (below – 2 Z-score) is more or less similar in both boys (3.14%) and girls (3.17%). In the age group 2-5 years, the estimated OR adjusted for age shows that the prevalence of low weight-for-height in boys are about 1.55 times higher than girls (95% CI = 0.36-6.67, $p > 0.05$). It is found that the prevalence of wasting is slightly higher in boys (4.85%) than in girls (3.26%), despite the absence of statistical difference ($\chi^2 = 2.37$, D.F. = 1, $p > 0.05$). On the other hand, the prevalence of wasting is higher in girls (3.12%) than in boys (1.97%) in the age group 6-10 years, although it is not statistically significant ($\chi^2 = 0.40$, D.F. = 1, $p > 0.05$). Nevertheless, it indicates that there are not significant differences between boys and girls with respect to weight-for-height except at years of age when girls had higher values of Z-score for weight-for-height. There are also no sex differences with respect to the prevalence of wasting as measured by weight-for-height.

Table 4.13. Nutritional status according to weight-for-height (based on NCHS references)

Nutritional status	Boys (N =255)		Girls (N = 252)	
	Number	Percent	Number	Per cent
2 - 5 years				
Above normal (≤ + 2 score)	3	2.91	2	1.09
Normal (≤ -2 to +2 Z-score)	95	68.93	87	94.56
Moderate (-2 to -3 Z-score)	3	2.91	2	2.17
Severe (< -3 Z-score)	2	1.94	1	1.09
Total	103	100.00	92	100.00
$\chi^2 = 2.37$, D.F. = 1, $p > 0.05$, OR (95% CI) = 1.55 (0.36-6.67)				
6 to 10 years				
Above normal (≤ + 2 score)	7	4.61	6	3.75
Normal (≤ -2 to +2 Z-score)	142	93.42	152	95.00
Moderate (-2 to -3 Z-score)	3	1.97	5	3.12
Severe (< -3 Z-score)	0	0.00	0	0.00
Total	152	100.00	160	100.00
$\chi^2 = 0.40$, D.F. = 1, $p > 0.05$ OR (95% CI) = 0.72 (0.17-3.13)				
2 to 10 years				
Above normal (≤ + 2 score)	10	3.92	8	3.17
Normal (≤ -2 to +2 Z-score)	237	92.94	239	94.84
Moderate (-2 to -3 Z-score)	6	2.35	7	2.78
Severe (< -3 Z-score)	2	0.78	1	0.40
Total	255	100.00	252	100.00
$\chi^2 = 0.001$, D.F. = 2, $p > 0.05$, OR (95% CI) = 0.99 (0.37-2.70)				

χ^2 test for sex differences in the prevalence of wasting
OR = Odds ratio, CI = 95% confidential interval
*$p < 0.05$

Summary on nutritional status

Despite the absence of statistical differences, boys are likely to have a higher prevalence of underweight when compared with girls across age groups. Also, children in the lower age groups are better in weight-for-age as compared with those in the higher age groups. Like in the case of weight-for-age, it reveals that the mean Z-scores for height-for-age are higher in girls than in boys, especially after 4 years of age. The overall prevalence of stunting (moderate plus severe forms) for all age groups is higher in boys (52.94%) than in girls (44.44%), and it is statistically significant (χ^2 = 3.67, D.F. = 1, p < 0.05). The estimated OR is found to be 1.45 (95% CI = 1.02-2.06), which is also significant at 5% level. In addition, the sex difference in stunting according to height-for-age index is more marked in the higher age groups. It is found that about 48.54% and 56.58% of boys are stunted in the age groups 2-5 and 6-10 years, respectively. As for girls, these frequencies are about 42.39% and 45.63%, respectively, although it is not statistically significant. With respect to weight-for-height, there are no significant differences between boys and girls, except at 4 years of age when girls had higher mean values than boys (t = 2.29, P < 0.05). Overall, it seems that the present population is characterized by a high prevalence of underweight (28.40% for both sexes) and a very high prevalence of stunting (48.72% for both sexes) but with low prevalence of wasting (3.16%), according to the classificatory criteria proposed by Gorstein *et al.*, (1994), which are given in Table 4.14. We shall discuss this issue in Chapter VI.

Table 4.14. Criteria for assessing severity of under-nutrition in a population*

	Prevalence (%)			
Indicator	Low	Moderate	High	Very high
Underweight	< 10	10.0 – 19.9	20.0 - 29.9	≥ 30.0
Stunting	< 20	20.0 – 29.9	30.0 - 39.9	≥ 40.0
Wasting	< 5	5.0 – 9.9	10.0 – 14.9	≥ 15.0

* As proposed by Gorstein *et al.*, (1994)

Risk Factors of Underweight

Table 4.15 shows the risk factors of underweight in terms of odds ratios derived from logistic regression models after adjusting certain variables. Four logistic regression models were used for presenting the risk factors of underweight. In the first model, age was taken into consideration by dividing the children into two age groups, viz., 2-5 and 6-10 years, for computing the odds ratio with 95% confidence interval (CI) from the regression models after adjusting for sex, income and maternal education. It is found that older children aged 6-10 years had about 1.15 times greater in risk of being underweight as compared to younger children aged 2-5 years of age. However, this risk is not statistically significant ($p = 0.508$). The second model is concerned with the sex difference after adjusting for age, income level and maternal education. It is seen from the table that boys had about 1.48 (95% CI: 1.01-2.30, $p < 0.05$) greater risk of underweight as compared with girls. This is somewhat in contrast to the general observation that underweight in Southeast Asia is higher in girls than in boys. This issue will be discussed more in chapter VII.

Table 4.15. Risk factors for underweight adjusted by logistic regression analysis

Parameters	N	Prevalence %)	Odds ratio (95% CI)	P-level
Age groups (years)				
2-5	195	53 (27.18)	-	
6-10	312	91 (29.17)	1.15 (0.77-1.72)	0.508
Sex				
Girls	252	63 (25.00)	-	-
Boys	255	81 (31.76)	1.48 (1.01-2.30)	0.052
Income group				
High	78	12 (15.38)	-	-
Middle	87	26 (29.89)	2.41 (1.11-5.24)	0.027
Low	342	106 (30.99)	2.58 (1.32-5.05)	0.006
Maternal education				
Secondary	249	66 (26.51)	-	-
Primary	139	45 (32.37)	1.22 (0.76-1.97)	0.403
No education	119	33 (27.73)	0.96 (0.56-1.66)	0.893

In the third model of logistic regression, we have taken into consideration the three income groups after adjusting for age, sex and maternal education. It is found that children in the low and middle income groups had greater risk of underweight when compared to those in the high income group. Children in the low income group had about 2.58 (95% CI: 1.32-5.05, $p < 0.006$) times greater in risks of being underweight as compared to those in the high income group. Similarly, children in the middle income group had about 2.41 (95% CI: 1.41-5.24, $p < 0.027$) times greater in risks of being underweight as compared to those in the high income group. This is clear that household income is very important factor for regulating body weight of children.

The effect of maternal is not statistically significant in the present population. However, children of the mothers without any education had about 0.96 times in risks of being underweight when compared to those with secondary level of education.

Risk Factors of Stunting

Table 4.16 shows the risk factors of stunting in terms of odds ratios like in the case of underweight shown above. Adjusting for sex, household income and mother's education, children aged 6-10 years had about 1.26 (95% CI: 0.86-1.80) greater risk of being short stature or stunting. However, this odds ratio is not statistically significant. In the next model, the odds ratio for the sex difference in the prevalence of stunting was worked out after adjusting for age, household income, and mother's education. It can be observed from the table that boys had about 1.64 (1.09-2.23) times greater in risks of stunting as compared to girls. Thus, like in the case of underweight, stunting is likely to be more prevalent in boys than in girls.

With respect to economic condition, it is found that children in the low and middle income groups had greater risk of stunting when compared to those in the high income group, i.e., the prevalence of stunting is similar to that of underweight with respect to economic condition. Children in the low income group had about 2.64 (95% CI: 1.52-4.56, $p < 0.001$) times greater in risks of stunting as compared to those in the high income group. In comparison with those in the high income group, children in the middle income group had also about 2.18 (95% CI: 1.13-4.19, $p < 0.022$) times greater in risks of stunting after adjusting for age, sex, and mother's education. Thus, household income is likely to be an important in determining stunting in the present population. Like in the case of underweight, the effects of maternal education are not clearly perceptible in the present population.

Table 4.16. Risk factors for stunting adjusted by logistic regression analysis

Parameters	N	Prevalence %)	Odds ratio (95% CI)	P-level
Age groups (years)				
2-5	195	89 (45.64)	-	-
6-10	312	156 (50.00)	1.26 (0.86-1.80)	0.243
Sex				
Girls	252	110 (43.65)	-	-
Boys	255	135 (52.94)	1.64 (1.09-2.23)	0.015
Income group				
High	78	23 (29.49)	-	-
Middle	87	42 (48.27)	2.18 (1.13-4.19)	0.022
Low	342	180 (52.63)	2.64 (1.52-4.56)	0.001
Maternal education				
Secondary	249	108 (43.37)	-	-
Primary	139	72 (51.80)	1.30 (0.84-2.02)	0.240
No education	119	65 (54.62)	1.46 (0.89-2.38)	0.131

Table 4.17. Risk factors for wasting adjusted by logistic regression analysis

Parameters	N	Prevalence %)	Odds ratio (95% CI)	P-level
Age groups (years)				
2-5	195	8 (4.10)	-	-
6-10	312	8 (2.56)	0.62 (0.23-1.70)	0.352
Sex				
Girls	252	8 (3.14)	-	-
Boys	255	8 (3.17)	0.92 (0.34-2.52)	0.874
Income group				
High	78	2 (2.56)	-	-
Middle	87	4 (4.60)	2.11 (0.37-12.09)	0.404
Low	342	10 (2.92)	1.34 (0.28-6.41)	0.714
Maternal education				
Secondary	249	10 (4.02)	-	-
Primary	139	5 (3.60)	0.84 (0.27-2.67)	0.768
No education	119	1 (0.84)	0.18 (0.02-1.58)	0.122

Risk Factors of Wasting

The risk factors of wasting in terms of odds derived from logistic regression models are presented in Table 4.17. Unlike in the case of underweight and stunting, the effects of demographic and socioeconomic factors on wasting are not statistically significant in the present population. However, it is likely that children in the low and middle income groups had greater risk of wasting when compared to those in the high income group. Thus, it cannot be totally ruled out the role of household income in regulating wasting in the present population.

Chapter V

ADULT BODY DIMENSIONS AND HEALTH STATUS

In this chapter we shall describe the anthropometric characteristics and health status of the adult males and females. We shall assess the nutritional status of the population using body mass index derived from anthropometric measurements. The prevalence of morbidity and anemia will also be presented. An attempt will also be made to analyze the relationship between certain health indicators and socioeconomic conditions of the population.

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Adult Body Dimensions

Table 5.1 shows the means and standard deviations of anthropometric traits for adult males by age groups. With the exception of bi-iliac diameter, the mean anthropometric traits are higher significantly in the lower age groups. The same is true for adult females as shown in Table 5.2. Perhaps, this may be due to secular trend other than chance factors such as sampling variation are not involved. By secular trend, we mean an increase in anthropometric measurements from one generation to another due to improvement in economic condition of a given population. With respect to bi-iliac diameter, different explanations may be given, but it is likely to be associated with the increase in fat accumulation at the bi-iliac portion of the body with the increasing age. Nevertheless, the point to be noted here is that the main purpose of data presentation in Tables 6.1 and 6.2 is to understand whether or not age influences anthropometric measurements of adult males and females in the present population. It is evident from the results presented in the Tables that individual age should be taken into consideration when carrying out statistical analyzes on the effects of socioeconomic conditions on anthropometric traits, or assessing the nutritional status of the study population in relation to socioeconomic conditions.

Table 5.1. Means and standard deviations of anthropometric traits for adult males by age groups.

Anthropometric characters	20-39 yrs (n = 236)		40-59 yrs (n = 188)		60 + yrs (n = 70)		Total (n = 494)		F-ratio
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Weight (kg)	53.48	6.06	53.70	6.91	47.33	7.38	52.70	6.93	27.12***
Height (cm)	159.70	5.48	160.17	5.16	156.67	5.90	159.45	5.53	11.09***
Sitting height (cm)	84.80	4.25	84.52	4.61	81.95	4.04	84.29	4.45	12.05***
Bi-acromial diameter (cm)	37.34	5.35	36.75	2.74	35.21	2.65	36.81	4.24	7.00**
Bi-iliac diameter (cm)	27.03	1.73	27.68	1.62	27.99	1.73	27.42	1.73	12.41***
Chest girth (exhale) (cm)	82.90	4.86	83.89	5.07	81.37	4.72	83.06	4.98	6.91**
Chest girth (inhale) (cm)	87.20	5.30	87.44	5.22	84.30	5.16	86.88	5.34	9.92***
Mid-upper arm cir. (cm)	23.50	1.98	23.55	2.22	21.47	2.31	23.23	2.24	28.07***
Indices									
Body mass index	20.96	2.01	20.93	2.47	19.24	2.44	20.70	2.33	17.21***
Cormic index	0.53	0.02	0.53	0.03	0.52	0.02	0.530	0.02	3.27*

* $p < 0.04$, ** $p < 0.001$, *** $p < 0.0001$

Table 5.2. Means and standard deviations of anthropometric traits for adult females by Age groups.

Anthropometric characters	20-39 yrs (n = 236)		40-59 yrs (n = 188)		60 + yrs (n = 70)		Total (n = 484)		F-ratio
	Mean	SD	Mean	SD	Mean	SD	Mean	SD	
Weight (kg)	47.41	5.69	45.73	7.26	40.86	4.24	46.36	6.35	22.53***
Height (cm)	150.34	5.00	149.31	4.77	146.14	5.40	149.68	5.10	13.71***
Sitting height (cm)	80.22	3.26	79.42	3.27	77.41	4.57	79.74	3.48	13.43***
Bi-acromial diameter (cm)	33.58	2.97	33.28	3.87	32.16	1.88	33.37	3.20	3.79*
Bi-iliac diameter (cm)	27.62	3.70	27.79	2.09	27.91	1.75	27.69	3.16	0.25
Chest girth (exhale) (cm)	77.09	5.80	76.51	4.91	73.86	4.32	76.65	5.51	6.41**
Chest girth (inhale) (cm)	80.67	4.43	79.02	6.74	76.78	4.32	79.86	5.32	12.95***
Mid-upper arm cir. (cm)	21.69	2.05	21.86	2.81	20.01	2.19	21.59	2.35	10.99***
Indices									
Body mass index	20.96	2.15	20.49	2.89	19.14	1.87	20.67	2.42	11.50***
Cormic index	0.533	0.018	0.532	0.019	0.530	0.032	0.532	0.020	0.80

* $p < 0.04$, ** $p < 0.001$, *** $p < 0.0001$

Body Mass Index

Body mass index, calculated as weight in kg divided by height squared in meter, is presented in Table 5.3 according to cormic index or relative sitting height index (sitting height/height) and sex. The subjects are grouped into two groups: those who have a cormic index of < 0.53 and those who have a cormic index of > 0.53. The subjects are divided according to cormic index categories because it is generally reported that BMI is also influenced by cormic index (Norgan, 1994; Khongsdier, 2002). It is observed from the Table that the mean BMI is significantly higher in both males and females with higher cormic index when compared with those having lower cormic index. This is in contrast to the general observation that BMI is lower in those populations with higher cormic index (Norgan, 1994). Nevertheless, the present findings indicate that cormic index also influences BMI of both adult males and females in the present population.

Table 5.3. Mean BMI and standard deviation according to sex and cormic index level

	Cormic index of < 0.53			Cormic index of ≥ 0.53			t-value
	Number	Mean	SD	Number	Mean	SD	
Males	177	20.30	2.51	317	20.93	2.20	2.87**
Females	142	20.15	2.39	342	20.67	2.65	2.02*
t-value for sex differences	0.54, $p > 0.05$			1.35, $p > 0.05$			

*$p < 0.04$; **$p < 0.004$

Table 5.4. Percentage distribution of individuals by BMI categories

BMI categories	Males (n = 494)		Females (n = 484)	
	Frequency	%	Frequency	%
< 16.0	5	1.01	4	0.83
16.0-16.9	16	3.24	22	4.55
17.0-18.4	52	10.53	52	10.74
18.5-22.9	357	72.27	328	67.77
≥ 23.0	64	12.96	78	16.12

The percentage distribution of the subjects according to BMI categories is given in Table 5.4. The individuals with BMIs of < 16.0, 16.0-16.9, 17.0-18.4, 15.5-23.0 and > 23.0 kg/m^2 may be considered as having severe, mild, moderate, normal and overweight grades of nutritional status, respectively (James *et al.*, 1988, WHO, 2000). It is seen from Table 5.4 that about 1.01%, 3.24% and 10.53% of adult males suffer from severe, mild and moderate under-nutrition, respectively. Among adult females, these frequencies are 0.83, 4.55% and 10.74%, respectively. Considering the cut-off point of 18.5 for screening the individuals into normal and undernourished or chronic energy deficiency (CED) groups (Ferro-Luzzi *et al.*, 1992, WHO, 1995), the overall prevalence of under-nutrition is 14.78% in males and 16.12% in females. This sex difference in the prevalence of under-nutrition is not statistically significant ($\chi^2 = 0.34$, $p > 0.05$).

With respect to overweight, it has been suggested recently that the BMI of 23.0-25.0 and > 25.0 should be considered the cut-off points for screening overweight and obesity, respectively (WHO, 2000c). Therefore, using the cut-off point of 23.0 as a cut-off for screening overweight individuals, Table 5.4 shows that about 12.96% of males and 16.12% of females are overweight in the present population. It indicates that the prevalence of overweight is higher in females than in males, although it is not statistically significant ($\chi^2 = 1.97$, $p > 0.05$).

NUTRITIONAL STATUS BY SOCIOECONOMIC CONDITIONS

Nutritional Status and Household Income

The relationship between anthropometric traits and socioeconomic conditions may be better summarized in terms of anthropometric indices which are frequently used as indicators of nutritional status. As for the adults, BMI is widely used to as an indicator of the nutritional status. In the present study too, we use BMI in assessing the nutritional status of the adult individuals.

The relationship between mean BMI and economic condition is assessed using per capita income of the household. The results are presented in Table 5.5. It indicates that the unadjusted means of BMI are lower in the lower income groups when compared with the high income group. The same is true after adjusting for age, cormic index and education of the mothers. The differences are found to be statistically significant for both the sexes. Thus, it indicates that BMI is negatively associated with income level of the household. The Pearson coefficient of correlation is found to be 0.202 ($p < 0.01$) for males and 0.206 ($p < 0.01$) for females.

Table 5.5. BMI according to income groups adjusted for age, cormic index and education

Income groups	Unadjusted			Adjusted		
	N	Mean	SD	N	Mean	SD
Males						
Low Income Group	299	20.43	2.20	299	20.46	2.23
Middle Income Group	102	20.48	1.99	102	20.49	2.22
High Income Group	93	21.81	2.77	93	21.72	2.27
ANCOVA-F ratio	13.53, $p < 0.0001$			11.36, $p < 0.0001$		
Females						
Low Income Group	265	20.32	2.16	265	20.33	2.34
Middle Income Group	123	20.60	2.36	123	20.61	2.34
High Income Group	96	21.70	2.85	96	21.66	2.36
ANCOVA-F ratio	12.09, $p < 0.001$			11.08, $p < 0.001$		

Table 5.6. Prevalence of under nutrition by economic groups

Income groups	Nutritional status by BMI (kg/m^2)		
	Undernourished (< 18.5)	Normal	Overweight
Males			
Low Income Group (n =299)	55 (18.39 %)	214 (72.30 %)	30 (10.14 %)
Middle Income Group (n = 102)	10 (9.80 %)	85 (83.33 %)	7 (6.86 %)
High Income Group (n = 93)	8(8.60 %)	58 (60.42 %)	27 (28.13 %)
χ^2 - value	7.93 $p < 0.05$	12.96 $p< 0.001$	25.03 $p < 0.0001$
Females			
Low Income Group (n =265)	50(18.87%)	188 (71.21%)	27 (10.23 %)
Middle Income Group (n =123)	18 (14.63 %)	89 (72.95 %)	16 (13.11 %)
High Income Group (n =96)	11 (11.46%)	58 (59.18 %)	27 (27.55 %)
χ^2 - value	3.17 $p> 0.05$	4.89 $p > 0.05$	17.58 $p< 0.0001$

D.F. = degrees of freedom

With respect to the prevalence of under-nutrition, Table 5.6 shows that about 18.39%, 8.30% and 8.60% of males are undernourished in the low, middle and high income groups, respectively. These differences are statistically significant in males ($\chi^2 = 7.93$, $p < 0.05$). In the case of females, the frequencies of under-nutrition are 18.87%, 14.63% and 11.46%, respectively. Although the prevalence is higher in the lower income groups, the differences are not statistically significant ($\chi^2 = 3.17$, $p > 0.05$).

Nutritional Status and Educational Level

Table 5.7 shows the mean BMI according to educational level. It is observed that mean BMI tends to increase with the increasing educational level. The analysis of covariance (ANCOVA), however, indicates the absence of significant differences especially after adjusting for age, cormic index and income level. In short, the present findings indicate that education is not significantly associated with mean BMI.

Table 5.7. BMI according to educational groups adjusted for age, cormic index and household income

Educational groups	Unadjusted			Adjusted		
	N	Mean	SD	N	Mean	SD
Males						
No education	87	20.17	2.56	87	20.51	2.31
Primary	105	20.32	2.27	105	20.54	2.29
Secondary	302	20.99	2.25	302	20.82	2.31
ANCOVA-F ratio	6.06, $p < 0.05$			0.86, $p > 0.05$		
Females						
No education	130	20.48	2.62	130	20.90	2.53
Primary	116	20.68	2.69	116	20.81	2.36
Secondary	238	20.76	2.15	238	20.47	2.51
ANCOVA-F ratio	0.59, $p > 0.05$			1.25, $p > 0.05$		

Table 5.8. Prevalence of under nutrition by educational level

Income groups	Nutritional status by BMI (kg/m^2)		
	Undernourished (< 18.5)	Normal (18.5 – 23.0)	Overweight > 23.0
Males			
No education (n = 87)	19 (21.84 %)	60 (68.97 %)	8 (9.20 %)
Primary (n = 105)	18 (17.14 %)	74 (70.48 %)	13 (12.38 %)
Secondary & above (n = 302)	36 (11.92 %)	223 (73.84 %)	43 (14.24 %)
Total	73	357	64
χ^2 - value	1.01, p > 0.05	1.01, p > 0.05	1.56, p > 0.05
Females			
No education (n = 130)	29 (22.31 %)	83 (63.85 %)	18 (13.85 %)
Primary (n = 116)	19 (16.38 %)	82 (70.69 %)	15 (12.93 %)
Secondary (n = 238)	31 (13.03 %)	170 (71.43 %)	37 (15.55 %)
Total	79	335	70
χ^2 - value	5.31, p > 0.05	2.43, p > 0.05	0.48, p > 0.05

Table 5.8 shows the prevalence of under-nutrition according to educational level. In general, indicates that the prevalence of under-nutrition is much higher in those individuals with no educational background as compared to those with primary and secondary levels of education. This holds true for both males and females. It is also observed that the prevalence of overweight is much higher in those subjects with secondary and above secondary level of education. The prevalence of overweight is about 14.24% in males with secondary education as compared to 9.30% for those with no education. In females, these frequencies are 15.55% and 13.85%, respectively. This is according to the theoretical expectation that individuals with higher educational levels are mostly engaged in government and other services, which involve less physical activity, and thereby they are likely to be overweight and obese. However, the chi-square test indicates that the overweight differences between educational groups are not statistically significant (Males: χ^2 = 1.56, p > 0.05; Females: χ^2 = 0.48, p > 0.05). Thus, from the statistical point of view, it may be difficult to argue that nutritional status is associated with educational level of adult individuals of the present population.

Table 5. 9. Summary of logistic regression analysis for the risk factors of under-nutrition

Parameters	N	Prevalence %)	Odds ratio (95% CI)	P-level
Age groups (years)				
< 40	539	52 (9.65)	-	-
40 - 59	327	60 (18.35)	2.08 (1.37-3.17)	0.001
60 +	112	40 (35.71)	5.06 (2.98-8.61)	0.000
Cormic index				
High (> 0.53)	659	86 (13.05)	-	-
Low (< 0.53)	319	66 (20.69)	1.61 (1.12-2.33)	0.011
Sex				
Male	494	73 (14.78)	-	-
Female	484	79 (16.32)	1.38 (0.95-2.00)	0.089
Income group				
High	194	24 (12.37)	-	-
Middle	224	27 (12.05)	1.04 (0.55-1.97)	0.905
Low	560	101 (18.04)	1.78 (1.04-3.05)	0.037
Educational group				
Secondary	540	67 (12.41)	-	-
Primary	221	37 (16.74)	0.91 (0.57-1.45)	0.806
No education	217	48 (22.12)	1.06 (0.66-1.70)	0.693

In order to have a better understanding of how under-nutrition is related to age, sex, cormic index and socioeconomic conditions in the study population, an attempt has been made to carry out the logistic regression analysis as shown in Table 5.9. The odds ratios (with 95% confidence interval (CI) relative to the prevalence of under-nutrition or CED) are derived from logistic regression models after adjusting for other variables under consideration. With respect to age, it is found that older individuals had greater risks of being undernourished after adjusting for cormic index, sex, education and income. The individuals aged 60 + years had about 5.06 (95% CI: 2.98-8.61) times greater in risk of being undernourished as compared with those aged < 40 years. On the other hands, the subjects who are aged 60 + years had about 2.08 (95% CI: 1.37-3.17) greater in the prevalence of under-nutrition as compared with those aged < 40 years. Thus, it is evident from the present analysis that age is significantly associated with the nutritional status of the individuals in the present population.

As for cormic index, Table 5.9 shows that the individuals with low cormic index seem to have a higher risk of being undernourished. Adjusting for age, sex, education and household income, the prevalence of under-nutrition was about 1.61 (95% CI: 1.12-2.33) times greater than those with cormic index of > 0.53. This indicates that cormic index is significantly associated with the prevalence of CED in the present population. Table 5.9 further shows the odds ratio for the prevalence of CED according to sex. Adjusting for age, cormic index, education and household income, females had about 1.38 (95% CI: 0.95-2.00) times greater in the prevalence of CED as compared males. This difference is however not statistically significant ($p > 0.05$).

Table 5.9 further shows the odds ratio for the prevalence of CED according to income groups after allowing for age, sex, cormic index and education. In comparison with the high income group, the low income group had about 1.78 (95% CI: 1.04-3.05) times greater in risk of being undernourished. However, the middle income group is not significantly deviated from the high income group with respect to the risk of CED (OR= 1.04; CI: 0.55-1.97). Nevertheless, income seems to have a great influence on the nutritional status of the adult individuals in the Hmar population. Like in the case of mean BMI, the effect of education on the nutritional status of the adult males and females is not clearly perceptible in the present population.

Morbidity by Age and Sex

Table 5.10 shows the prevalence of morbidity, that is, those individuals who had suffered from any condition and were at least one day in bed during the last one month before the survey. The overall prevalence of morbidity is 11.45%, and it is higher in males (13.36%) than in females (9.50%), and it is statistically significant ($\chi^2 = 9.18$, D.F. = 1, $p < 0.002$). The Table also shows that the prevalence of morbidity increases with the increasing age groups of both males and females. In males, the prevalence of morbidity increases from about 12% in the age groups < 40, and 40-59 years to 20% in the age group 60 + years.

On the other hand, the prevalence of morbidity in females is higher in the age group 40-59 years (12.23%) as compared to the age groups < 40 (7.92%) and 60 + (11.90%) years. However, the chi-square test indicates that these age differences in the prevalence of morbidity are not statistically significant for both males ($\chi^2 = 3.11$, D.F. = 2, $p > 0.05$) and females ($\chi^2 = 2.37$, D.F. = 2, $p > 0.05$). Thus, according to data presented in Table 5.10, it can be argued that sex is more important than age for influencing morbidity in the present population, although it also indicates that older individuals are likely to have a greater risk of morbidity.

Table 5.11 shows the prevalence of self-reported symptoms of morbidity by sex. The self-reported symptoms of morbidity were classified into three broad categories as generally suggested (Sadana, 2000). **Cold and Respiratory and Intestinal Disorders** include those symptoms such as cough + runny nose + headache + fever, fever + cough, cough alone, swollen glands, + cold, ear problem, breathing problem, chest pain, sore throat, TB. On the other hand, **Intestinal Disorders** include diarrhoea, dysentery, worms, vomiting, vomiting + fever, and other self-reported problems of stomach pain. Self-reported symptoms of morbidity other than the two categories above were included in the category of **Other Problems**.

It can be observed from the Table that the prevalence of cold and respiratory disorders is more common than that of intestinal ones for both the sexes. It is slightly higher in males (5.67%) than in females (3.93%). The prevalence of intestinal disorders is more or less similar in both males (1.82%) and females (1.86%).

Table 5.10. Prevalence of morbidity by age group

Age group (years)	Males (n = 494)		Females (n = 484)	
	Number	Prevalence (%)	Number	Prevalence (%)
< 40	236	29(12.29)	303	24(7.92)
40-59	188	23 (12.23)	139	17(12.23)
60 +	70	14 (20.00)	42	5 (11.90)
All ages	494	66 (13.36)	484	46 (9.50)
Chi-square	3.11 $p > 0.05$		2.37 $p > 0.05$	

Table 5.11. Prevalence of respiratory and intestinal disorders by sex

Symptoms	Males (n = 494)		Females (n = 484)	
	Number	(%)	Number	(%)
Cold and respiratory disorders	28	5.67	19	3.93
Intestinal disorders	9	1.82	9	1.86
Other problems	29	5.87	18	3.72

Morbidity by Nutritional Status

The prevalence of morbidity by nutritional status is given in Table 5.12. As theoretically expected, the prevalence of morbidity is higher in undernourished and overweight individuals as compared to those in the normal category of the nutritional status. Among males, the prevalence of morbidity is about 20.55% in the undernourished and 15.63% in the overweight as compared to 11.48% in the normal category of the nutritional status. However, these differences are not statistically significant ($\chi^2 = 4.63$, D.F. = 2, $p > 0.05$). As for females, about 17.72%, 6.87% and 12.86% of them reported morbidity, and these differences are statistically significant ($\chi^2 = 9.83$, D.F. = 2, $p < 0.05$). The present findings, therefore, indicate that the association between morbidity and nutritional status cannot be ruled out in the Hmar population.

Table 5.12. Prevalence of morbidity by nutritional status

Nutritional status	Males (n = 494)		Females (n = 484)	
	Number	Prevalence (%)	Number	Prevalence (%)
Undernourished (< 18.5 kg/m^2)	73	15 (20.55)	79	14 (17.72)
Normal (18.5 – 23.0 kg/m^2)	357	41 (11.48)	335	23 (6.87)
Overweight (> 23 kg/m^2)	64	10 (15.63)	70	9 (12.86)
Chi-square	4.63 P > 0.05		9.83 p < 0.05	

Morbidity by Scio-economic Conditions

Table 5.13 shows the prevalence of morbidity by income level of the household. It is observed from the table that the prevalence of morbidity is about 13.85%, 13.73% and 11.46% in adult males belonging to the low, middle and high income groups, respectively. Among females, these frequencies are 7.58%, 11.48% and 12.24%, respectively. Although the prevalence of morbidity is higher in the lower income groups, the chi-square test indicates that the differences between income groups are not statistically significant for both males (χ^2 = 0.037, D.F. = 2, p > 0.05) and females (χ^2 = 2.55, D.F.= 2, p > 0.05). Thus, it may be concluded that the relationship between morbidity and economic condition is not clearly perceptible in the present study.

Table 5.13. Prevalence of morbidity by income level

Nutritional status	Males (n = 494)		Females (n = 484)	
	Number	Prevalence (%)	Number	Prevalence (%)
Low	296	41(13.85)	264	20 (7.58)
Middle	102	14(13.73)	122	14 (11.48)
High	96	11(11.46)	98	12 (12.24)
Chi-square	0.037 P > 0.05		2.55 p > 0.05	

Table 5.14 shows the prevalence of morbidity by educational level. It can be observed that the prevalence of morbidity is higher in those individuals with no education as compared with those in the higher level of education. The differences in the prevalence of morbidity between educational groups are statistically significant in females (χ^2 = 12.40, D.F. = 2, p < 0.001), although there were absence of such significant differences in males (χ^2 = 4.92, D.F. = 2, p > 0.05). Nevertheless, the role of education in regulating morbidity cannot be ruled out in the present population.

Table 5.14. Prevalence of morbidity by educational level

Nutritional status	Males (n = 494)		Females (n = 484)	
	Number	Prevalence (%)	Number	Prevalence (%)
No education	87	18 (20.69)	130	17 (13.08)
Primary	105	12 (11.43)	116	14 (12.07)
Secondary	302	36 (11.92)	238	15 (6.30)
Chi-square	4.92 P > 0.05		12.40 p > 0.001	

Like in the case of the prevalence of under-nutrition, an attempt has been made to carry out the logistic regression analysis in order to have a better understanding of the relationship between morbidity and other factors. Such an analysis will also help us summarize our findings with respect to morbidity pattern in the present population. The results are presented in Table 5.15. It is seen that although older individuals are likely to get sick when compared with the younger ones, the odds ratios are not statistically significant. However, men are likely to have higher morbidity than are the women. Table 5.14 shows that adult males had about 1.62 (95% CI: 1.07-2.46) times greater in risk of morbidity when compared with females, i.e., after adjusting for age, nutritional status, education and household income. This significantly greater risk of morbidity for men is inconsistent to the results of the chi-square test presented in Table 5.12. The reason is that chi-square test applied to data in Table 5.12 is a crude one which does not take into account other compounding factors such as age, nutritional status, education and household income.

Table 5. 15. Summary of logistic regression analysis for the risk factors of morbidity

Parameters	N	Prevalence %)	Odds ratio (95% CI)	P-level
Age groups (years)				
< 40	539	53 (9.83)	-	-
40 - 59	327	40 (12.23)	1.06 (0.68-1.68)	0.788
60 +	112	19 (16.96)	1.29 (0.69-2.40)	0.421
Sex				
Female	484	46 (9.50)	-	-
Male	494	66 (13.36)	1.62 (1.07-2.46)	0.024
Nutritional status				
Normal	692	64 (9.25)	-	-
Undernourished	152	29 (19.08)	2.18 (1.32-3.60)	0.002
Overweight	134	19 (14.18)	1.63 (0.93-2.87)	0.087
Income group				
High	194	20 (10.58)	-	-
Middle	224	29 (12.89)	1.23 (0.66-2.28)	0.521
Low	560	63 (11.17)	0.88 (0.51-1.53)	0.647
Educational group				
Secondary	540	51 (9.44)	-	-
Primary	221	26 (11.76)	1.29 (0.76-2.19)	0.338
No education	217	35 (16.13)	1.89 (1.13-3.16)	0.015

As for nutritional status, Table 5.15 shows that undernourished individuals have greater risks of morbidity. Adjusting for age, sex, education and household income, the prevalence of morbidity was more than 2 times (95% CI: 1.32-3.60) greater in undernourished individuals than those with normal grade of nutrition. This indicates that morbidity is significantly associated with the prevalence of CED in the present population.

Table 5.15 further shows the odds ratio for the prevalence of morbidity according to income groups after allowing for age, sex, nutritional status and education. Like in the case of chi-square test (Table 5.12), household income does not seem to have influenced morbidity pattern in the present population. However, education seems to be important factor influencing morbidity in the present population. Adjusting for age, sex, nutritional status and household income; Table 5.15 shows that the subjects without education had about 1.89 (95% CI: 1.13-3.16) times greater in risks of having morbidity problems when compared to those with secondary level of education. Thus, education seems to have a great influence on the prevalence of morbidity among the adult individuals in the present population.

HAEMOGLOBIN

Hemoglobin Content by Sex and Age

Table 5.16 shows the means and standard deviation of hemoglobin level by sex and age groups. As theoretically expected, the mean hemoglobin content is significantly higher in males than in females for all of the age groups. It may be mentioned here that the World Health Organization (WHO, 1968) has recommended a different cut-off point for adult males (13.0 g/dl) and females (12.0 g/dl) to screen anemia in a population. The present study confirms the importance of such a separate cut-off point for males and females. It may also be noted that we carried out hemoglobin test only among the non-pregnant women of the present study. Table 5.16 further shows that the hemoglobin content tends to decrease with the increasing age groups for both males and females. The analysis of variance (ANOVA) shows that the differences in hemoglobin level between age groups are statistically significant for both males ($F= 4.99$, D.F. = 2, 258; $p < 0.007$) and females ($F= 3.64$, D.F. = 2, 287; $p < 0.02$). This indicates that age should be taken into consideration while analyzing the relationship between hemoglobin content and other factors.

Table 5.16. Mean hemoglobin level by sex and age groups

Age group	Males (n = 290)			Females (n = 261)			t-value
	N	Mean	SD	N	Mean	SD	
< 40	133	13.25	1.61	156	12.32	1.62	4.88, p < 0.001
40-59	122	13.05	1.52	88	12.31	1.89	3.14, p < 0.002
60 +	35	12.32	1.34	17	11.52	1.29	3.04, p < 0.05
Total	290	13.05	1.57	261	12.27	1.19	6.52, p < 0.001
ANOVA-F statistics	4.99, D.F. = 2, 287; p < 0.007			3.64, D.F. = 2, 258; p < 0.02			

Hemoglobin Content by Nutritional Status

The means and standard deviations of hemoglobin content by nutritional status are given in Table 5.17. It shows that both unadjusted and adjusted means of hemoglobin level among males increase from undernourished to overweight groups of the individuals. The unadjusted mean increases from 12.31 g/dl for the undernourished to 13.77 g/dl for the overweight, whereas the adjusted mean for age, education and income increases from 12.53 g/dl for the undernourished to 13.64 g/dl for the overweight. Both unadjusted and adjusted means are statistically significant. In the case of females, the situation is different. Table 5.17 shows that there are no differences between undernourished and normal grades of nutritional status with respect to both unadjusted and adjusted means of hemoglobin content in females. However, overweight women had lower mean value of hemoglobin content as compared to those with undernourished and normal grades of nutritional status. The analysis of variance indicates that the differences are statistically significant even after adjusted for age, education and household income.

Table 5.17. Mean hemoglobin level by nutritional status adjusted for age, education and income

	Unadjusted			Adjusted		
Income groups	N	Mean	SD	N	Mean	SD
Males						
Undernourished	40	12.31	1.59	40	12.53	1.49
Normal	211	13.06	1.54	211	13.04	1.47
Overweight	39	13.77	1.32	39	13.64	1.49
F-statistics	4.99, $p < 0.007$			5.45, $p < 0.005$		
Females						
Undernourished	186	12.33	1.16	186	12.33	1.22
Normal	88	12.31	1.19	88	12.31	1.22
Overweight	17	11.52	1.29	17	11.51	1.24
F-statistics	3.64, $p < 0.03$			3.38, $p < 0.05$		

Hemoglobin Content by Economic Condition

Table 5.18 shows the means and standard deviations of hemoglobin content by income groups unadjusted and adjusted for age, education and nutritional status. The mean hemoglobin in males increases from low to high income groups. It is highly significant even after adjusting for age, education and nutritional status. This effect of household income is, however, not clearly perceptible in females. Table 5.18 shows that there are hardly any differences between income groups with respect to mean hemoglobin content in females. Nevertheless, the role of household income in patterning hemoglobin content cannot be totally ruled out in the present population, especially among males. Adult males in the lower income groups are likely to have lower hemoglobin content as compared with their counterparts in the high income group.

Table 5.18. Mean hemoglobin level by income groups adjusted for age, education and nutritional status

Income groups	Unadjusted			Adjusted		
	N	Mean	SD	N	Mean	SD
Males						
Low Income Group	182	12.77	1.53	182	12.82	1.47
Middle Income Group	54	13.02	1.51	54	13.02	1.45
High Income Group	54	14.02	1.37	54	13.88	1.49
F -statistics	14.44, $p < 0.0001$			10.55, $p < 0.0001$		
Females						
Low Income Group	156	12.26	1.22	156	12.26	1.21
Middle Income Group	58	12.32	1.11	58	12.32	1.20
High Income Group	47	12.25	1.21	47	12.24	1.22
F -statistics	0.07, $p > 0.05$			0.06, $p > 0.05$		

Hemoglobin Content by Educational Level

Table 5.19 shows the unadjusted and adjusted mean values of hemoglobin content by educational groups adjusted for age, income and nutritional status. It is observed that the mean hemoglobin content is lower in adult males with no education as compared to those with primary and secondary levels of education. However, the differences are not statistically significant. Similarly, the differences between educational groups are not clearly perceptible in females, or not statistically significant. Thus, we may conclude that hemoglobin content does not seem to be associated with education in both males and females of the present study.

Table 5.19. Mean hemoglobin level by educational groups adjusted for age, income and nutritional status

Educational groups	Unadjusted			Adjusted		
	N	Mean	SD	N	Mean	SD
Males						
No education	48	12.67	1.55	48	12.94	1.49
Primary	59	13.03	1.55	59	13.21	1.49
Secondary	183	13.16	1.57	183	13.03	1.50
ANCOVA-F ratio	1.91, p > 0.05			0.51, p > 0.05		
Females						
No education	82	12.12	1.31	82	12.15	1.26
Primary	67	12.34	1.10	67	12.34	1.20
Secondary	112	12.31	1.11	112	12.31	1.27
ANCOVA-F ratio	0.82, p > 0.05			0.54, p > 0.05		

Prevalence of Anemia by Sex and Age

The prevalence of anemia by age groups is presented in Table 5.20 for both males and females. It is found that the prevalence of anemia is higher in males (38.98%) than in females (37.55%), and the differences between the sexes are statistically significant (χ^2 = 9.95, D.F. = 2, p < 0.002). Table 5.20 further shows that the prevalence of anemia increases with the increasing age groups for both males and females. However, the chi-square test indicates that the differences between age groups are statistically significant only in males ($\chi^2 = 12.31$, D.F. = 2, $p < 0.007$), but not in females ($\chi^2 = 3.55$, D.F. = 2, $p > 0.05$). Nevertheless, the present findings indicate that both sex and age are associated with the prevalence of anemia in the present population.

Table 5.20. Prevalence of anemia by age groups

Age groups	Males (n = 290)		Females (n = 261)	
	Number	Frequency (%)	Number	Frequency (%)
< 40	133	41 (30.83)	156	57 (36.54)
40-59	122	50 (40.98)	88	31 (35.23)
60 +	35	22 (62.86)	17	10 (58.82)
Total	290	113 (38.97)	261	98 (37.55)
Chi-square	12.31 p < 0.002		3.55 p > 0.05	

Prevalence of Anemia by Nutritional Status

The prevalence of anemia by nutritional status is given in Table 5.21. According to this table, undernourished males and females are also more likely to have greater risks of anemia as compared with those in the normal category of nutritional status. However, the prevalence of anemia among the overweight individuals varies according to sex. The prevalence of anemia in overweight males (20.51%) is less than that among the overweight females (44.12 %). In other words, overweight males have less prevalence of anemia when compared with those who are normal (39.81%) and undernourished (52.50%). On the other hand, overweight females have higher prevalence of anemia than those with undernourished (38.78%) and normal (35.96%) grades of the nutritional status. However, the chi-square test indicates that the differences in the prevalence of anemia between nutritional groups are significant only in males ($\chi^2 = 8.73$, D.F. = 2, $p < 0.01$), but not in females ($\chi^2 = 0.85$, D.F. = 2, $p > 0.05$).

Table 5.21. Prevalence of anemia by nutritional status

Nutritional status by BMI categories	Males (n = 290)		Females (n = 261)	
	Number	Frequency (%)	Number	Frequency (%)
Undernourished (< 18.5 kg/m^2)	40	21 (52.50)	49	19 (38.78)
Normal (18.5 – 23.0 kg/m^2)	211	84 (39.81)	178	64 (35.96)
Overweight (> 23.0 kg/m^2)	39	8 (20.51)	34	15 (44.12)
Chi-square	8.73 $p < 0.01$		0.85 $p > 0.05$	

Prevalence of Anemia by Economic Condition

The prevalence of anemia by income level is given in Table 5.22. It is found that about 45.60%, 33.33% and 22.22% of males are anemic in the low, middle and high income groups, respectively. In females, these frequencies are 39.10%, 37.93% and 31.91%, respectively. However, the chi-square test indicates that the differences between income groups with respect to the prevalence of anemia is significant only in males ($\chi^2 = 10.46$, D.F. = 2, $p < 0.005$), but not in females ($\chi^2 = 0.80$, D.F. = 2, $p > 0.05$). Thus, like in the case of mean hemoglobin content, the differences between income groups are statistically significant only in males.

Table 5.22. Prevalence of anemia by income level

Income groups	Males (n = 290)		Females (n = 484)	
	Number	Frequency (%)	Number	Frequency (%)
Low	182	83 (45.60)	156	61 (39.10)
Middle	54	18 (33.33)	58	22 (37.93)
High	54	12 (22.22)	47	15 (31.91)
Chi-square	10.46 $p < 0.005$		0.80 $p > 0.05$	

Prevalence of Anemia by Educational Level

Table 5.23 shows the prevalence of anemia by educational level. Although the mean hemoglobin levels presented in Table 5.21 are not statistically significant, the prevalence of anemia seems to be associated with educational level especially in males. It is found that about 56.25%, 38.98% and 34.34% of males were having anemia in the categories of no education, primary and secondary level, respectively. In females, these frequencies are 45.12%, 34.33% and 33.93%, respectively. However, the chi-square test indicates that the differences between educational groups are statistically significant in males ($\chi^2 = 7.62$, D.F. = 2, $p < 0.02$), but not in females ($\chi^2 = 2.93$, D.F. = 2, $p > 0.05$). Nevertheless, it may be concluded that the role of education in patterning anemia cannot be ruled out in the present population.

Table 5.23. Prevalence of anemia by educational level

Educational level	Males (n = 290)		Females (n = 484)	
	Number	Frequency (%)	Number	Frequency (%)
No education	48	27 (56.25)	82	37 (45.12)
Primary	59	23 (38.98)	67	23 (34.33)
Secondary	183	63 (34.43)	112	38 (33.93)
Chi-square	7.62 p < 0.02		2.93 p > 0.05	

Table 5. 24. Summary of logistic regression analysis for the risk factors of anemia

Parameters	N	Prevalence %)	Odds ratio (95% CI)	P-level
Age groups (years)				
< 40	289	98 (33.91)	-	-
40 - 59	210	81 (38.57)	1.04 (0.70-1.54)	0.838
60 +	52	32 (61.54)	2.60 (1.36-4.95)	0.004
Sex				
Female	290	113 (38.97)	-	-
Male	261	98 (37.55)	1.07 (0.74-1.55)	0.724
Nutritional status				
Normal	389	148 (38.05)	-	-
Undernourished	89	40 (44.94)	1.09 (0.67-1.78)	0.720
Overweight	73	23 (31.51)	0.83 (0.48-1.43)	0.494
Income group				
High	99	26 (26.26)	-	-
Middle	112	40 (35.71)	1.46 (0.80-2.67)	0.213
Low	340	145 (42.65)	1.84 (1.10-3.07)	0.017
Educational group				
Secondary	295	101 (34.24)	-	-
Primary	126	46 (36.51)	0.93 (0.59-1.48)	0.770
No education	130	64 (49.23)	1.56 (1.01-2.41)	0.050

Risk Factors of Anemia

The summary of the logistic regression analysis on the risk factors of anemia is given in Table 5.24. It is seen that older individuals are likely to become anemic when compared with the younger ones, especially those who are aged 60 years and above. The subjects aged 60 + years had about 2.60 (95% CI: 1.36-4.95) times greater in risks of anemia when compared with those who are aged < 40 years. Although there is no significant difference between the age groups < 40 and 40-59 years, it is clear that individuals aged 60 years and above are likely to have higher prevalence of anemia. Table 5.24 further shows that the odds ratios of anemia for the sex and nutritional differences are not statistically significant, although the prevalence of anemia is higher in males as compared to females as well as in undernourished as compared to the individuals with normal grade of the nutritional status. The effects of socioeconomic condition, on the other hand, on the prevalence of anemia seem to be significant in the present population. As for economic condition, the low income group had about 1.84 (95% CI: 1.11-3.07) times greater in risks of anemia when compared with those in the high income group. Also, the middle income group had 1.46 (95% CI: 0.80-2.67) times greater in risks of having anemia when compared with those in the high income group, despite the absence of statistical significance. Similarly, the subjects with no formal education were about 1.56 (95% CI: 1.01-2.41) times greater in risk of having anemia as compared to those with secondary level of education. In short, income and education seem to be very important risk factors of anemia in the present population.

CHAPTER VI
DISCUSSION

In the present Chapter, we shall briefly discuss our findings in the context of other findings on other populations especially in Northeast India. We shall also look into the implications of the present findings.

DEMOGRAPHY

From an evolutionary point of view, human species- *Homo sapiens* – is more successful in adapting and thereby in maintaining and increasing its numbers. It is generally believed that one of the main reasons for the successful adaptation of human species is its ability to change the environments through culture. For example, technological development has aided human being to reduce the intensity of natural selection, i.e., by manipulating fertility rates and controlling mortality rates. Notwithstanding there are still many problems that we are confronting today through which natural selection is operating to shape the composition and diversity of human species. According to Molnar (1992), "The dimensions and scope of these ongoing processes require careful consideration, especially the increase in numbers of people and the burden these expanded populations place on the environment. Demographic factors of this expansion exert a major influence on gene frequencies. Epidemiology, the types and distribution of disease, is also altered each generation as new diseases gain in population influence while other ones decline as treats to human health."

Demographic variables are very important to understand the genetic structure of a given population, and thereby the evolutionary processes of human populations. It is theoretically believed that natural selection, one of the major evolutionary forces, is operating in human population through differential fertility and mortality (Crow, 1958; Johnston, 1973). Also, other demographic variables like population size, mating patterns admixture rate, migration, etc., are very helpful in understanding the biological characteristics of human populations (Basu, 1969; Khongsdier, 2005c). In the meantime, demographic variables are largely influenced by various socio-economic factors like religion, education, income, occupation, age at marriage, adoption of family planning, etc. (Mosley and Chen, 1984; Mahadevan, 1986; World Bank, 1999; Caldwell *et al.*, 1999; and others). So, it is quite important for the physical anthropologists to undertake studies on the effect of socio-economic factors on demographic traits, particularly on fertility and mortality.

Fertility

In the present study, we have observed that the Hmar population is highly *progressive*, thereby indicating a high fertility rate. It is found that the mean age at marriage among the Hmar women (20.78 years) is higher than those reported for many populations of Assam (Sengupta and Gogoi, 1995; Gogoi, 2002). Also, the mean number of live births to married women of all ages is higher than those reported for different sub-groups of the Kochs in Garo hills (Kotal, 2002) and Pnars (3.35) of Jatinga (Khongsdier *et al.*, 2001). It is, however, lower than those reported for the Mukhloms (5.20) of Arunachal Pradesh (Sarkar, 2002), Khasis (5.18) of Shillong (Mukherjee, 2002) and War Khasis (Khongsdier, 2005). It is observed that the total fertility rate in the Hmars is much higher than that reported for the state of Mizoram (2.30) by the National Family Survey (IIPS, 2000) and the Kochs of Garo hills (Kotal, 2002). The age specific fertility rate reached its peak point in the age group 25- 29 years, and the total fertility rates are more or less similar to those reported for the different religious groups of the Khasis of Shillong (Mukherjee, 2002). In comparison with the recent findings on some populations in Northeast India, the fertility rate among the Hmars of the present study seems to be fairly high.

It is observed that the fertility rate in the Hmar population is negatively associated with the maternal age, age at marriage and household income. The effect of age at marriage on fertility is by and large universal since the reproductive period is shorter in the case of those women with higher age at marriage (as briefly reviewed in Chapter I). On the other hand, the significant effect of household income on fertility rate in this population seems to be related to the fact that people belonging to the higher economic groups are more conscious of the socio-economic welfare of their children. It is likely that such people have higher aspiration for better education and higher economic status, thereby reducing the birth rate in order to provide their children with the best facilities (Mukherjee, 2002).

What is interesting in the present study is that the effect of maternal education is not clearly perceptible after adjusting for maternal age and household income. This insignificant effect of education on fertility rate in the Hmars of the present study is inconsistent with the general observation in other populations (Caldwell *et al.*, 1999), and it is difficult to give any clear-cut explanation. It is, however, clear that maternal education is not the only factor that can regulate fertility rates in the Hmar population. For example, it is possible that most educated mothers are in the lower age groups, whereas illiterate mothers or mothers without educational background are more in the older age groups, thereby resulting in sampling variation. In addition, it is likely that other social and cultural factors might have played a significant role in either directly regulating fertility rate or indirectly controlling the effect of education on fertility rate.

As pointed out in Chapter I, maternal education is expected to reduce birth rates for the following reasons (Murthi *et al.*, 1995): First, educated women are likely to have more voice with regard to lightening the burden of repeated pregnancies because they have more control over household resources and personal behaviour. Second, educated women are likely to be less dependent on their children as a source of social status and old age security, thereby leading to a reduction in a desired family size. Third, educated women have higher aspirations for the better achievements of their children, which is conducive to a reduction in a desired family size. Fourth, educated women often have a higher age at first marriage, which is in turn affecting fertility rate. Fifth, educated women often have higher rate of adoption of family planning methods.

Unquestionably education is critical for disseminating safe and effective birth control methods to slow down population growth. However, it is evident from the present findings that that education alone may not be sufficient to bring about changes in fertility behavior without taking into consideration other social and cultural situations. According to Jennings (1970), "If it is difficult to inform people in the Western cultures where education is valued and the need for birth control is appreciated, it is infinitely more difficult to instill necessary ideas in people who link many children with cultural ideals. Education will be effective only to the degree that cultural values and customs are understood and the principles of acculturation are applied." For example, it is well known that Islam does not expressly forbid the voluntary restriction of birth, but children are regarded as the richest blessing that Allah bestows and therefore any attempt to prevent fertility is against the wishes of God (Choudhury, 1982). Indeed, it generally reported that Muslims have higher fertility rate followed by the Hindus and Christians (Irudaya Rajan and Rao, 1991). Likewise, the Bible does not specifically prohibit birth control, but certain Christian denominations like the Catholic Church are against the use of artificial means of birth control (Irudaya Rajan and Rao, 1991). Thus, it is likely that even education of the mothers may not become so important in such a situation. In the present study, all of the subjects were Christians hence it is difficult to suggest the role of religion. However, cultural practices and values have not been totally abandoned by the Hmars, although they have accepted Christianity. The possible role of son preference in enhancing fertility among the educated women cannot be completely ruled out if one talks about the importance of lineage system among the Hmars. We hope that future studies will throw much more light on what we have pointed out here.

Infant Mortality

The infant mortality rate in the Hmars (2.83%) of the present study is lower than many populations in Northeast India. Recent studies show that the infant mortality rates among the Christian and Non-Christian Khasis of Shillong are 6.82% and 8.60%, respectively (Mukherjee, 2002). Gogoi (2002) also reported that the infant mortality rate among the Christian and Non-Christian Mundas of Assam were 5.93% and 7.44%, respectively. Thus, it indicates that the infant mortality rate is much lower in the Hmars than in these populations of Assam and Meghalaya. It is also lower than that reported for the Pnars (4.20%) of Jatinga (Khongsdier *et al.*, 2001) and Christian and Non-Christian War Khasis (Khongsdier, 2005). Thus, in comparison with some populations reported recently from Northeast India, the infant mortality rate in the Hmars is moderately low. Similarly, the rate of reproductive wastage (abortion and still-birth) is moderately in the Hmars when compared with the Mundas of Assam (Gogoi, 2002), Khasis (Mukherjee, 2002) and Pnars of Jatinga (Khongsdier *et al.*, 2001). It is similar to those reported for the Mukloms of Arunachal Pradesh (Sarkar, 2002). Kotal (2002) reported that the child mortality (deaths between 1 and 4 years of life) rates among the Koch sub-groups, namely, Chapras, Sangas, Satparis, Tintikiyas and Wanangs of Garo Hills were 13.72%, 8.37%, 7.55%, 8.58% and 13.81%, respectively. In comparison with these Koch subgroups of Garo Hills, the child mortality among the Hmars is moderately low.

It is observed that the infant mortality rate increases with the increasing age of mothers. It is found that infant mortality is positively associated with maternal age ($b = -0.029 \pm 0.011$, $t = 2.62$, $p < 0.009$) and negatively associated with maternal education ($b = -0.052 \pm 0.026$, $t = 2.00$, $p < 0.05$). However, the effect of household income on infant mortality is not statistically significant. Thus, it indicates that maternal age and education are very important factors in influencing infant mortality in the present population. This may be due to the fact that mothers of higher age groups have higher fertility rate, which is theoretically correlated with higher infant mortality rate. The inverse relationship between infant mortality and education is according to the general observation in other populations (Rustein, 2000; Wagstaff, 2000), which indicate that mothers belonging to the higher educational levels are more conscious of the health of their children, and they have more access to modern medical aids, etc. On the other hand, the insignificant effect on infant mortality rate indicates that economic condition alone is not sufficient to bring down mortality rate, unless the mothers are also educated or well conscious of the health care of their children.

GROWTH PATTERN

Besides demographic aspects, physical growth and development of children is another important field of anthropological research. The pattern of human growth serves as a type of mirror that reflects the bio-cultural evolution of human population. According to Tanner (1988), "The study of growth is important in elucidating the mechanism of evolution, for the evolution of morphological characters necessarily comes about through alteration in the inherited pattern of growth and development. Growth also occupies an important place in the study of individual differences in form and function of man, for many of these also arise through differential rates of growth of particular parts of the body relative to others." Further, Eveleth and Tanner (1990) have also observed, "A child's growth rate reflects, perhaps better than any other single index, his state of health and nutrition; and often indeed his psychological situation also. Similarly the average values of children's height and weight reflect accurately the state of a nation's public health and the average nutritional status of its citizens, when appropriate allowance is made for differences, if any, in genetic potential. This is especially so in developing and disintegrating countries." Since human growth and development is also largely influenced by socio-environmental factors such as nutrition, infection, occupation, income and religion, it is very vital for understanding the bio-cultural variation and evolution of human populations (Tanner 1988, Eveleth and Tanner, 1990; Bogin, 1999).

In the present study, we have considered the growth of children aged 2 to 10 years of age. The main purpose is to assess the nutritional status of children in relation to other demographic and socio-economic conditions of the study population. However, an attempt will be also made in this section to assess the growth status of Hmar children. By "growth status" we mean the growth pattern of children in relation to their coevals at a given age in other populations, or in relation to the recommended growth references and/or standards. Thus, in this section of the present Chapter, we shall look into the growth status of the Hmar children to understand the population variation, which may reflect the socio-economic conditions of the study population. In this regard, we shall take into consideration only some important anthropometric variables like weight and height, which are also reported for few populations in Northeast India, such as War Khasis (Khongsdier, 1996), Khynriam Khasis (Mukherjee, 2002), Assamese Muslims (Begum and Choudhury, 1999) and Kalitas (Choudhury and Bhuyan, 1994).

It may be noted here that in India we do not have the recommended growth references and/or standards. Although the growth data collected by the Indian Council of Medical Research (ICMR, 1972) are old and unrepresentative of all sections of the Indian population, its use in the present study is but to understand the growth status of the Hmar children, but not as a target or standard of growth that one should assess the children's growth in the present study. As a matter of fact, we have used the NCHS/WHO growth references (WHO, 1983) for the assessment of the nutritional status of the children in the present study as internationally recommended.

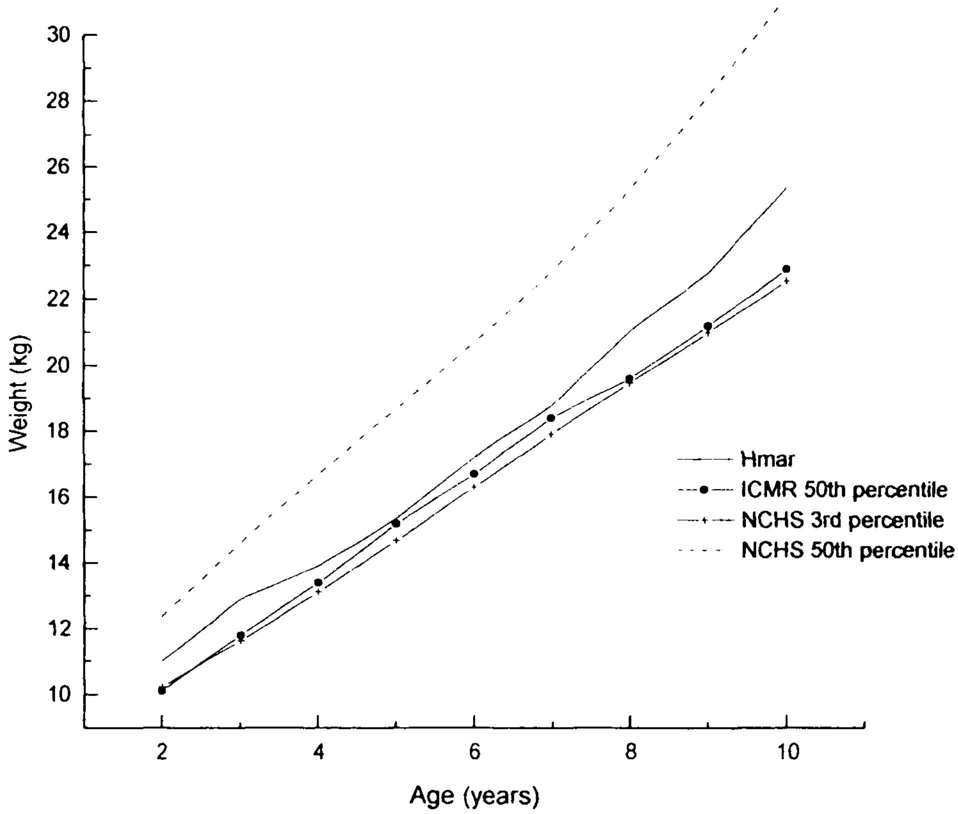

Fig. 6.1 Mean weight (kg) of Hmar boys in comparison with ICMR and NCHS growth references

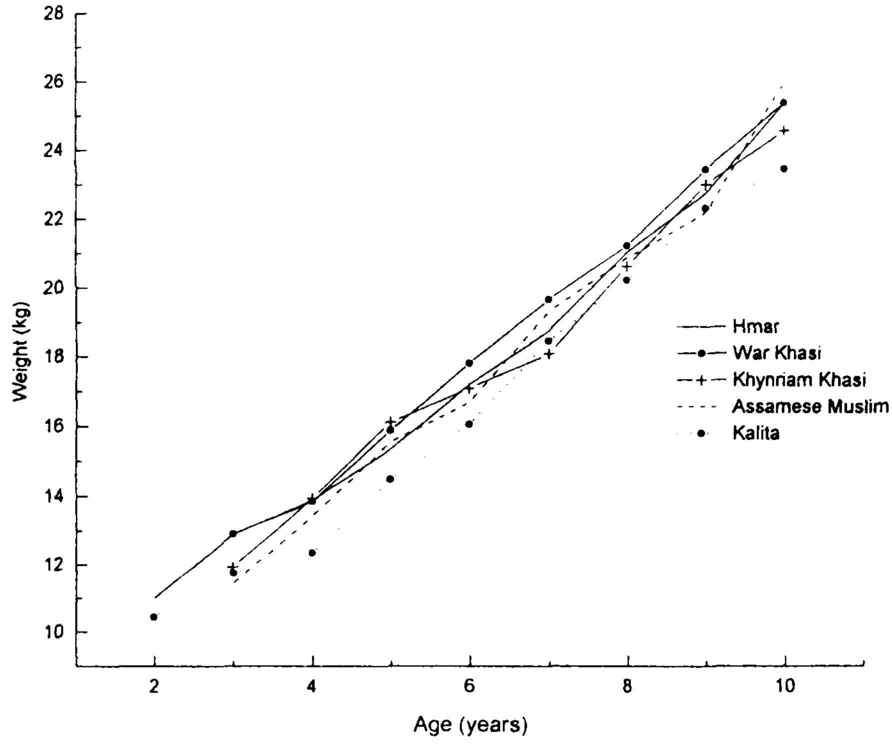

Fig. 6.2 Mean body weight of Hmar boys in comparison with other populations in Northeast India

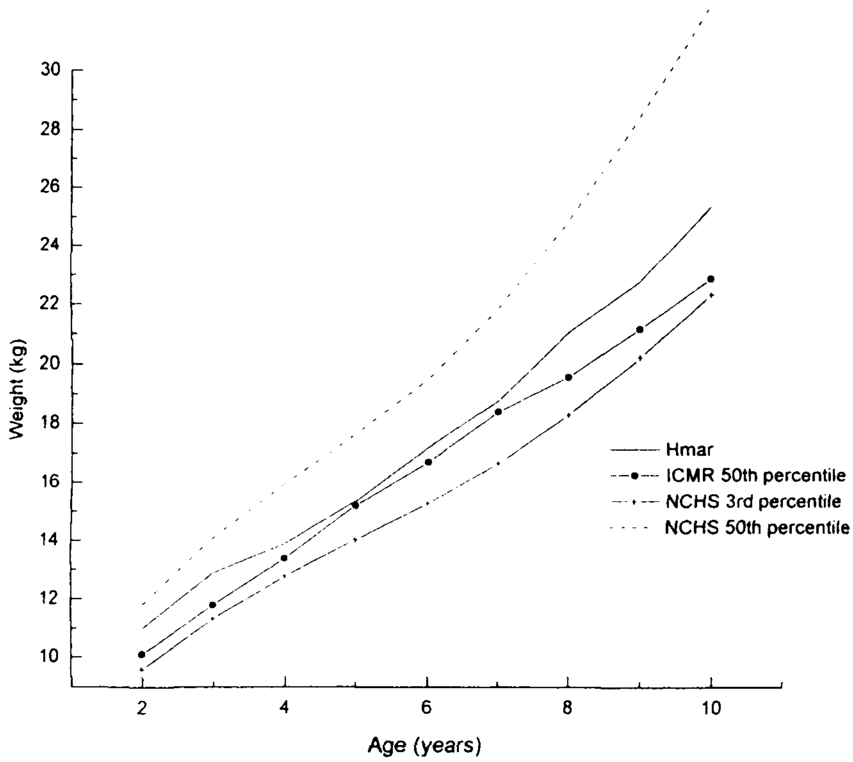

Fig. 6.3. Mean weight of Hmar girls in comparison with ICMR and NCHS growth references

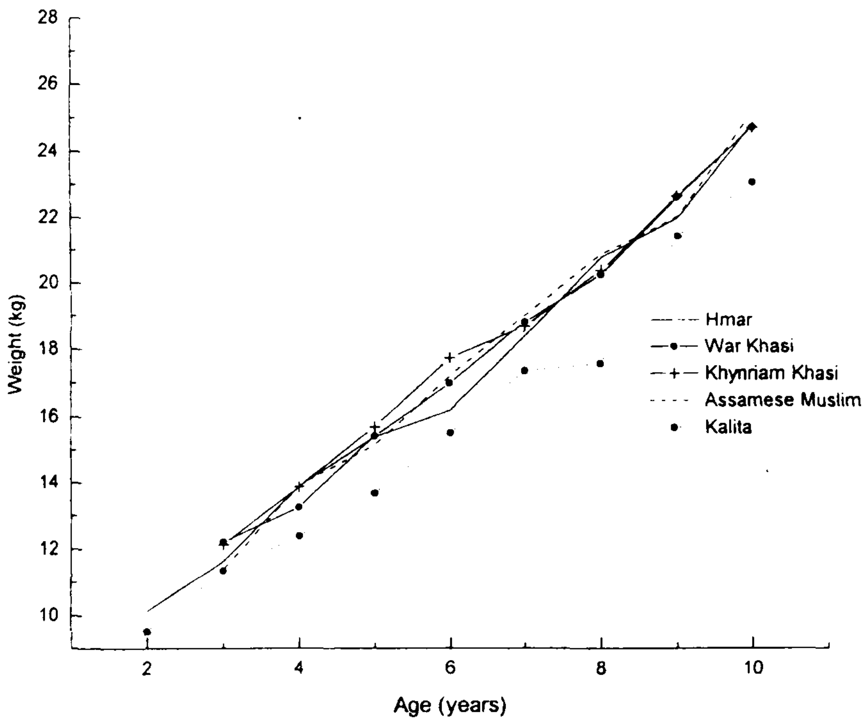

Fig. 6.4. Mean body weight of Hmar girls in comparison with their counterparts in Northeast India

Weight

Figure 6.1 shows the mean weight of Hmar boys in comparison with the ICMR and NCHS/WHO growth references. It is observed that the Hmar boys are above the 50th percentile of the ICMR growth references from 2 to 10 years of age, although they are similar at about 5 years. In comparison with the NCHS growth references, the Hmar boys are far below the 50th percentile from 2 to 10 years of age, but they are above the 3rd percentile across these ages. Nevertheless, it is evident that the Hmar boys of the present study are above the 50th percentile of the ICMR growth references. In comparison with their counterparts reported from some populations of Northeast India, the Hmar boys are comparable to the War Khasi boys (Khongsdier, 1996) from 3 to 5 years of age and to the Khynriam Khasi boys (Mukherjee, 2002) from 4 to 5 years of age (Figure 6.2). However, the War Khasi boys are heavier than the Hmar boys from 5 to 10 years of age. The Hmar boys are heavier than the Khynriam Khasi boys from 5 years onwards, although the latter are heavier at 9 years of age. In comparison with the Assamese boys, the Hmar boys are heavier than the Kalita boys (Choudhury and Bhuyan, 1994) across ages. They are also heavier than the Assamese Muslim boys (Begum and Choudhury, 1999) from 3 to 6 and 8 to 9 years, although the latter are heavier from 9 to 10 years of age. In general, it reveals that the Hmar boys are above the 50th percentile of the ICMR growth references and heavier than the Kalita boys, although they are lighter than the War Khasi boys from 5 to 10 years of age. They are comparable to the Assamese Muslim boys.

As for girls, Figure 6.3 shows the mean weight of Hmar girls in comparison with the ICMR and NCHS growth references. The Hmar girls are above the 50th percentile of the ICMR and 3rd percentile of the NCHS growth references from 2 to 10 years of age. They are, however, far below the 50th percentile of the NCHS growth references. In comparison with some populations in Northeast India, the Hmar girls are heavier than the Kalita girls across ages (Figure 6.4). They are similar to the Khynriam and Assamese Muslim girls from about 3 to 5 years, and thereafter they are lighter up to about 8 years of age. The Hmar girls are similar to the Assamese Muslim girls from 8 to 10 years, although they are lighter than the Khynriam and War Khasi girls in this age group. They are also heavier than the War Khasi girls from about 3.5 to 5 years, and thereafter the latter surpassed the former up to about 8 years. On average, like their male counterparts, the Hmar girls are above the 50th percentile of the ICMR growth references and heavier than the Kalita girls of Assam. They are comparable to the War Khasi and Assamese Muslim girls, irrespective of certain fluctuations.

Figure 6.5 shows the mean height of Hmar boys in comparison with the ICMR and NCHS growth references. It can be observed that the Hmar boys are below the 50th percentile of the ICMR growth references across ages although they are more or less comparable from 2 to about 3.5 years of age. The Hmar boys are also far below the 50th percentile of the NCHS growth references, but they are more or less comparable to the 3rd percentile of the international growth references across ages. In comparison with their counterparts reported from some populations of Northeast India, the Hmar boys are taller than the Khynriam boys across ages, but shorter than the War Khasi, Kalita and Assamese Muslim boys (Figure 6.6). They are similar to the Assamese Muslim girls only from 3 to 4 years of age. Thus, on average, the Hmar boys seem to be better in growth status of height when compared with the Khynriam Khasi and ICMR growth references. However, they are shorter than War Khasi, Kalita and Assamese Muslim boys.

Figure 6.7 shows the mean height of Hmar girls in comparison with the ICMR and NCHS growth references. It is seen that the Hmar girls are above the 50th percentile of the ICMR growth references, although they are similar at about 5 years of age. The Hmar girls are also above the 3rd percentile but far below the 50th percentile of the NCHS growth references. In comparison with the 4 selected populations in Northeast India, the Hmar girls are taller than the Khynriam Khasi and Kalita girls across ages, except from 4 to 5 years of age when they are similar to the Kalita girls (Figure 6.8). They are also similar to the War Khasi girls from 7 to 10 years of age, and to the Assamese Muslim girls from 3 to 5 years of age. However, they are shorter than the war Khasi girls from 3 to 7 years of age, although the latter are taller before 7 years of age. The Assamese Muslim girls are also taller than the Hmar girls from 5 years onwards. On average, the Hmar girls are above the 50th percentile of the ICMR growth references with respect to growth in height, although they are far below the 50th percentile of the NCHS growth references. They are taller than the Kalita and Khynriam Khasi children. They are similar to the war Khasi girls from 7 to 10 years of age and to the Assamese Muslim girls from 3 to 5 years of age. They are, however, shorter than the War Khasi and Assamese Muslim girls from 3 to 7 years and 5-10 years of age, respectively.

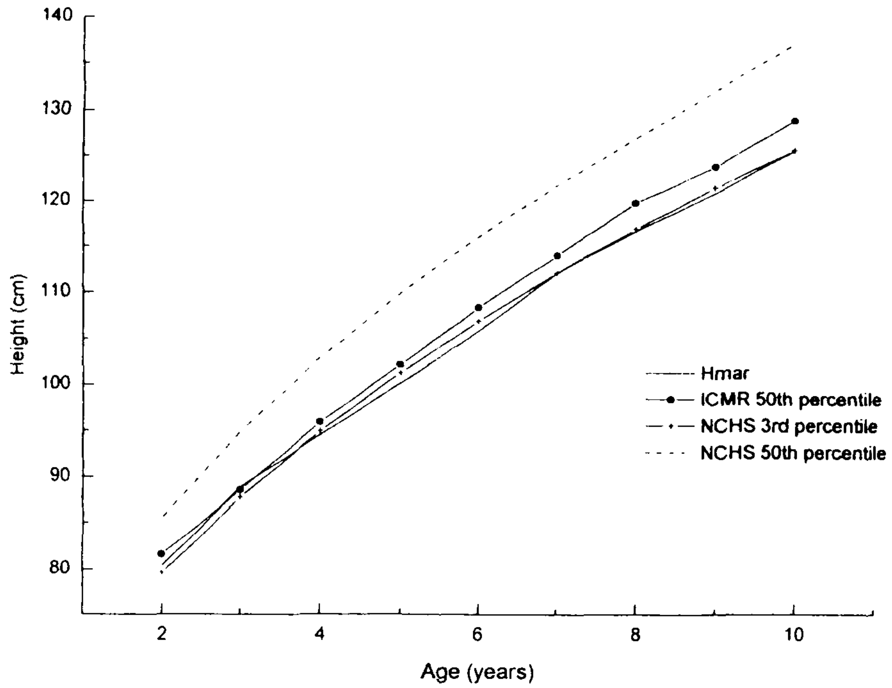

Fig. 6.5. Mean height of Hmar boys in comparison with ICMR and NCHS growth references

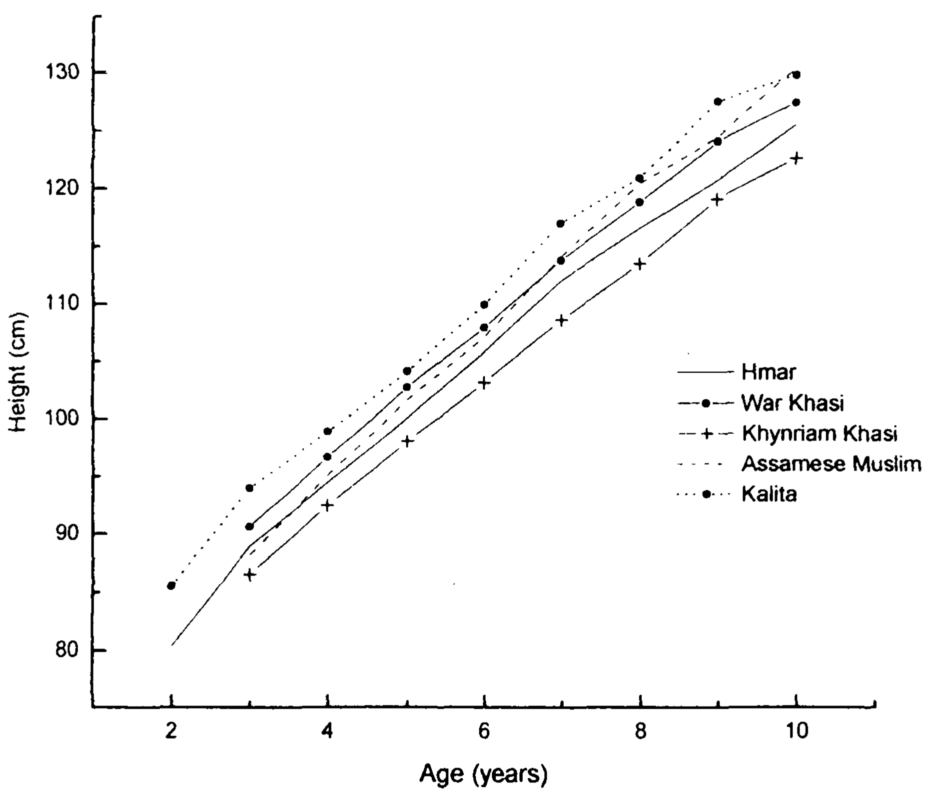

Fig. 6.6. Mean height of Hmar boys in comparison with their counterparts in Northeast India

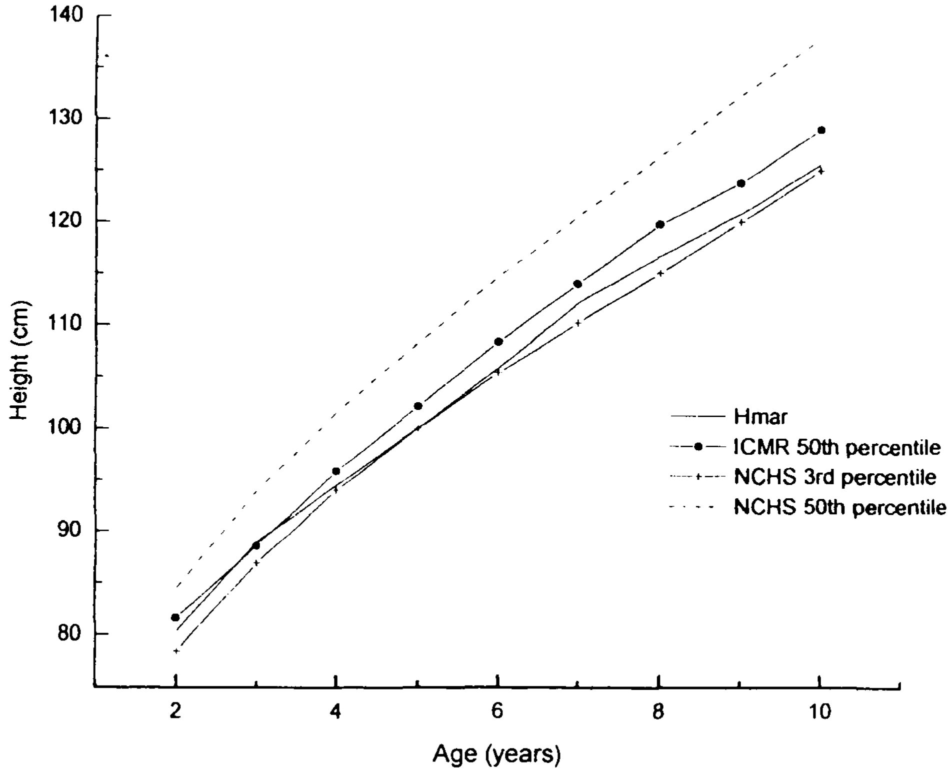

Fig. 6.7. Mean height of Hmar girls in comparison with ICMR and NCHS growth references

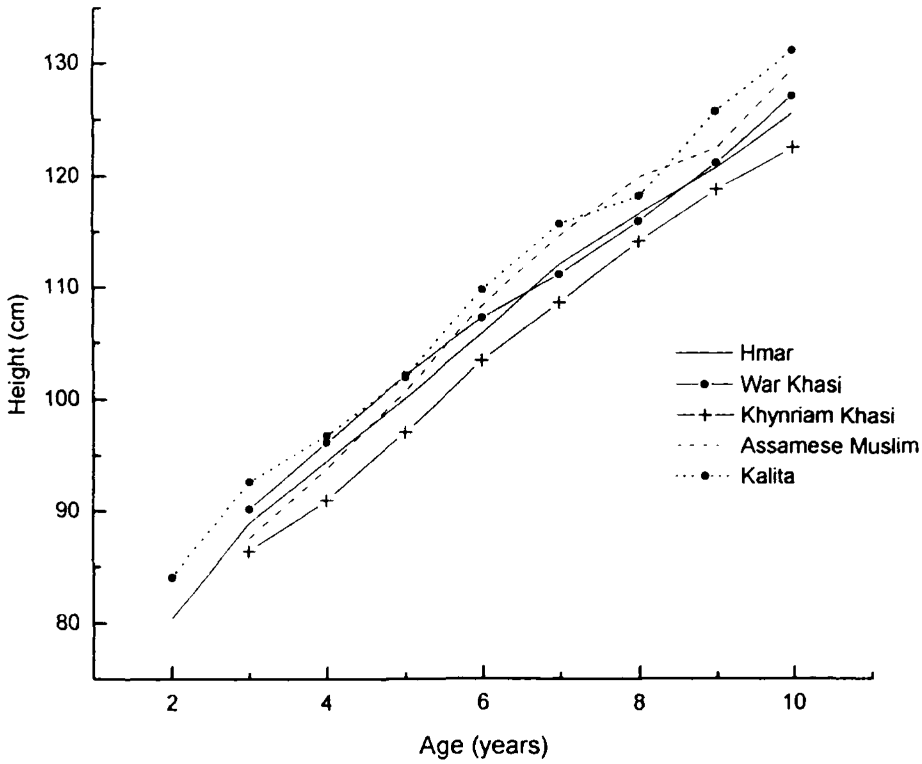

Fig.6.8. Mean height of Hmar girls in comparison with their counterparts in Northeast India

NUTRITIONAL STATUS

The present findings indicate that boys have a higher prevalence of underweight when compared with girls across age groups. Also, children in the lower age groups are better in weight-for-age compared with those in the higher age groups. Similarly, the mean Z-scores for height-for-age are higher in girls than in boys, especially after 4 years of age. The overall prevalence of stunting (moderate plus severe forms) for all age groups is significantly higher in boys (52.94%) than in girls (44.44%) with the estimated OR of 1.45 (95% CI = 1.02-2.06). In addition, the sex difference in the prevalence of stunting according to height-for-age index is more marked in the higher age groups. It is found that about 48.54% and 56.58% of boys are stunted in the age groups 2-5 and 6-10 years, respectively. As for girls, these frequencies are about 42.39% and 45.63%, respectively, although it is not statistically significant. With respect to weight-for-height, there are no significant differences between boys and girls, except at 4 years of age when girls had higher mean values than boys. Overall, according to the classificatory criteria proposed by Gorstein *et al.* (1994), the present population is characterized by a high prevalence of underweight (28.40% for both sexes) and a very high prevalence of stunting (48.72% for both sexes).

There are two major implications with respect to above summary of the present findings on the nutritional status of children. These implications may be described as follows:

Sex differences

The present study clearly indicates the higher prevalence of under-nutrition in boys than in girls. There are again two major implications with respect to this sex difference in nutritional status: the first implication is concerned with the hypothesis of the "biological fragility" of males as compared to females (Kraemer, 2000), while the second implication is related to the role of cultural diversity in regulating health and nutritional inequalities.

Role of biological factors

As for the role of biological factors, our findings are consistent those revealed by various nutrition surveys for under-five children in many developing countries (Marcoux, 2002). Nutrition surveys at the national level in many developing countries have revealed that nutritional status, as indicated by anthropometric indicators, is better among girls than among boys aged below 5 years (Marcoux, 2002; Garenne, 2003). According to Marcoux (2002), "boys usually fare worse than girls by anthropometric indicators" and "it appears that the issue of sex biases in food distribution has been overstated in advocacy of work." On the basis of evidence from 41 Demographic Health Surveys, Sommerfelt and Arnold (1998) also drew a similar conclusion on sex differences in anthropometric indicators of nutritional status. Our findings also corroborate those reported for adolescents in Jamaica (Jackson *et al.*, 2002), Brazil (Wang *et al.*, 2002), China (Hesketh *et al.*, 2002; Wang *et al.*, 2002) and Bolivia (Pérez-Cueto *et al.*, 2005) in general, and to the adolescents of the present population (Khongsdier *et al.*., 2005) in particular. Thus, our study may have certain implications with respect to the observation that boys are more vulnerable than girls to adverse conditions, such as infections and/or nutritional deprivation (Tanner, 1962; Stinson, 1985; Worthman, 1996), notwithstanding other risks of different obstetric complications (Mizuno, 2000).

It is well known that boys are, on average, larger than girls until the beginning of the adolescent growth spurt in girls. However, the adolescent growth spurt begins earlier in average girls than in average boys, when the former are larger and more sexually mature than do the latter. During their adolescent growth spurt, boys again surpass girls until adulthood with a larger body size and more physically powerful sex. Compared to females, males generally expend more energy per unit body mass especially during adolescence (Spurr and Reina, 1989; van Mil *et al.*, 2001). Considering their greater physiological requirement of energy due to changes in body size and physical strength, boys are perhaps more vulnerable than girls to poor environmental conditions during the pre-adolescent and adolescent stages of growth and development. It is often hypothesised that growth before adolescence is more sensitive to environmental factors (Bogin, 1999), whereas growth during adolescence is a result of the complex interaction between biological and environmental factors. The greater vulnerability to poor environmental quality in boys is, perhaps, due to the greater changes in body size and composition as compared to girls. Such a greater vulnerability in boys may be more pronounced during the pre-adolescent stages when growth is more sensitive to poor environmental quality, especially inadequate nutrition and its synergistic relation to infections (Scrimshaw *et al.*, 1968). The present findings indicated that pre-adolescent girls in the study populations also fared better than their male counterparts with respect to the prevalence of under-nutrition.

The synergistic relation between under-nutrition and infectious diseases is well documented, especially among young children (Scrimshaw *et al.*, 1968; Rice *et al.*, 2000). As for sex differences, it is unclear whether certain Y-linked genes and/or recessive genes located on the sex chromosomes are responsible for lower resistance to infections? It is suggested that a higher level of testosterone in males could have an immunosuppressive effect, thereby making males more susceptible to infectious diseases (Folstad and Karter, 1992). There are, however, inconsistent results on sex differences in the prevalence of certain infectious diseases. For example, malaria vulnerability does not appear to be associated with sex except in pregnant women (Bates *et al.*, 2004). A study in Thailand revealed that the prevalence of malaria in males and females is inconsistent and varies according to sources of data drawn from communities or health care centers (Vlassoff and Bonilla, 1994). As for tuberculosis, several studies have revealed the absence of sex differences in the prevalence of tuberculosis before 16 years of age, thereafter it is more prevalent in males (Holmes *et al.*, 1998; Martinez *et al.*, 2000; Salim *et al.*, 2004). However, the difficulty in excluding social and cultural factors relative to sex differences in access to treatment, social stigmas, presentation of symptoms and responses to tuberculin testing has complicated the issue of sex differences in tuberculosis susceptibility (Hudelson, 1996; Diwan and Thorson, 1999; Thorson and Diwan, 2001). In addition, the HIV/AIDS epidemic, which affects males and females differently according to geographical locations, has made the tuberculosis issue further complicated (Diwan and Thorson, 1999; de la Hera *et al.*, 2004).

Although there is conflicting evidence of sex differences in susceptibility to certain infections, it is often reported that males are likely to have higher mortality than females throughout life (Waldron, 1983; Kraemer, 2000; Ashorn *et al.*, 2002; Kruger and Nesse, 2004). The higher ratio of male to female at birth may be one of the selective forces to compensate for such excess male mortality (Stevenson *et al.*, 2000). According to Darwin (1871), excess male mortality could be attributed to natural selection, including sexual selection, although he expressed his difficulty in giving a proper explanation of excess male to female ratio at birth. Indeed, mortality is due to different factors including nutrition and/or infections, thereby it is more difficult to apportion the biological factors concerning excess male mortality as compared to specific infections or diseases. Nonetheless, sex biological factors including genetic and endocrine factors (Daly and Wilson, 1983) should be also taken into consideration in order to have a better understanding of gender differences in nutritional status and/or health inequalities.

Role of cultural diversity

Although there is conflicting evidence of sex differences in nutritional outcomes in South Asia, it is often reported that child mortality is higher in females than in males due to anti-female discriminations in access to nutrition, education and health care (Das Gupta, 1987; Muhuri and Preston, 1991; Arnold *et al.*, 1998). In South Asia, sons are preferred over daughters due to different economic, social and cultural factors (Mayer, 1999; Arnold *et al.*, 2002; Mishra *et al.*, 2004), which are operating differently in different population groups or culture areas. For example, it was suggested that excess female child mortality was lower in South than in North India due to variation in kinship systems and female autonomy, i.e., the "capacity to manipulate one's personal environment" (Dyson and Moore, 1983). Females in South India enjoy more autonomy relative to males than do females in the North, and the magnitude of anti-female discrimination among children in access to food distribution and medical care is less in the South. On the basis of the first and second Indian National Family Health Surveys data, Mishra *et al.* (2004) also found that boys were more likely than girls to be fully immunized in North than in South India. On the contrary, girls aged below 3 years were more likely than boys to be underweight and stunted in the South than in the North. In addition, it has been suggested that economic and political factors, including political will, are more important than kinship structures in patterning gender differences between North and South India (Rahman and Rao, 2004).

Although our study is inconsistent with those reported for under-five children in South Asia (Miller, 1997; Choudhury *et al.*, 2000; Nubé and van den Boom, 2003; Shaikh *et al.*, 2003), it may have certain implications for the role of cultural diversity in health and nutritional disparity in India. The excess under-nutrition among boys in the present study does seem to be indicative of the absence of female discrimination in the Hmar society. However, it does not mean for us to generalise that there was an absence of excess female under-nutrition in other Indian patrilineal societies. Considering our study and other studies, it is likely that anti-female bias in India varies from one population to another, or from one culture area to another, which might not be detected statistically at the national level (Marcoux, 2002).

Nutritional and health discriminations against girls in India may vary from one region to another depending upon a number of cultural factors relating to beliefs, ideas and behaviours that are socially transmitted from one generation to another in a specific population or culture area (Jejeebhoy and Sathar, 2001). Subject to further studies, such cultural factors may in turn act as constraints of the so-called universal factors (socio-economic factors) of social and economic change, such as employment, educational and income levels. Hence, the impact of these socio-economic factors on gender discrimination and/or sex differences in nutritional and health status may also vary from region to region (Sen, 2003). Recently, it is also reported that adolescent boys in the Khasi matrilineal society had higher prevalence of under-nutrition than their female counterparts (Khongsdier *et al.*, 2005). The authors have, however, cautioned that little is known about anti-male bias in the Khasi society (Gurdon, 1981; Pakyntein, 1999), which can be considered as comparable to anti-female bias as in other parts of South Asia including India (Jejeebhoy and Sathar, 2001; Fikree and Pasha, 2004). It is, therefore, crucial to understand the role of cultural diversity in patterning health and nutritional disparity in India. It is obvious, in this context, that there is a need for a holistic, community-based approach to understanding the health and nutritional inequalities in India.

Relevance of NCHS/WHO growth references

There are considerable differences between and within populations in the rate of physical growth and attainment of body size at any given age (Eveleth and Tanner, 1990). Such differences are often attributed to both genetic and environmental factors. However, growth retardation especially in developing countries is mainly due to environmental factors, including inadequate nutrition, infections and poor socio-economic conditions. Empirical evidence shows that under-five children belonging to the higher socio-economic strata in developing countries have shown similar growth patterns to their coevals in developed or high-income countries (Habitch *et al.*, 1974). Accordingly, growth retardation is generally considered an indicator of poor nutritional status, or failure in the expression of the "genetic potential" for growth (Gopalan, 1992). Accordingly, the growth curves of well-nourished children in high-income countries are widely used to assess or monitor the growth and nutritional status of children all over the world. It is argued that since children in high-income countries are unhindered by nutritional deprivation, thereby enjoying the maximal growth permitted by their genetic potential, they constitute a reference group against which to assess the nutritional status of all other groups of children. For this purpose, international standards, or growth references, such as the U.S. National Center for health Statistics (NCHS) growth reference population endorsed by the World health Organization (WHO, 1983, 1995) are widely used for assessing the nutritional status of children all over the world. The children who are below – 2 SD or – 2 Z score of these standards/references are classified as undernourished relative to their sex and age groups.

However, there has been a limited consensus over the use of these growth references especially in populations of Southeast Asia like India (Seckler, 1982). Ulijaszek (1995) has pointed out that "any use of growth references internationally should acknowledge that they can act, at best, as imperfect yardsticks, since human populations may show similar growth characteristics, but are unlikely to ever become so homogeneous that they show the same genetic potential for growth" because these growth references do not represent the greatest possible human potential for growth. Of course, there is considerable evidence of the population differences in growth and development.

On the basis of his observation on the populations of India and Nepal, Seckler (1982) suggested that the children treated as mild and moderate undernourished, according to height for age with reference to international standards, should be regarded as "small but healthy." According to Seckler (1982), "about 90% of all the malnutrition found in these countries are those people with low height-for-age but *with proper weight-for- height ratio*. Now, if one thinks of malnutrition in the conventional imaginary of thin, wasted bodies, rather than in terms merely of short people, the incidence of malnutrition must be considerably reduced. Of course, since short people with proper weight to height ratio will also be light people, their consumption requirements will also be less than conventionally estimated" (Author's italics). This may have certain implication if we also take into consideration our present findings. It is found that the overall prevalence of wasting for both boys and girls was only 3.16% as compared to the prevalent rates of underweight and stunting, which are 28.40% and 48.72% as measured by weight-for-age and height-for-age, respectively. These results in the Hmar population of the present study clearly indicate that the prevalence of under-nutrition according to weight-for-height is not as high as that indicated by weight-for-age and height-for-age.

Seckler was of the opinion that there were no functional impairments in the range of mild to moderate malnutrition as defined by growth standards, "because this range represents an adaptive response of body size to adverse conditions *in order to avoid these impairments*"(Author's italics). Accordingly, he suggested that appropriate reference standard for the assessment of undernutrition should be lower than the recommended reference value predicted under the concept of genetic potential for growth. Payne (1992), though in a different way, also supported that the scientific concept of nutrition should be concerned not with the failure of meeting some normative targets, but with the failure of maintaining the functional capabilities relative to nutritional intake. On the contrary, most of the individuals below the standards as proposed under the concept of genetic potential for growth do not show such functional impairment. Payne (1992) criticized the genetic potential theory for supporting the armpit of obesity and associated risks of NCDs.

The "small but health" hypothesis has been severely criticized by many scholars (Gopalan, 1992; Bogin, 1999), but its significance lies with the concept of small body size. It may be noted that Tanner (1978) warned against assuming that being small is necessarily bad. "Though rate of growth remains one of the most useful of all indices of public health and economic well-being in developing and heterogeneously developed countries, it must not be thought that bigger, or faster, is necessarily better" (Tanner, 1978). The advantage of small body size is that it enables a person to survive and sustain his level of activity in a given habitat of nutritional constraint, because a smaller body requires less energy. However, if the level of productivity in such small people is low, it proves to be disadvantageous (Ulijaszek, 1995, Strickland and Tuffrey, 1997). In the present study, we are not dealing with the physical activity of the children, and thereby we are not in a position to either refute or support the above contention. However, it is clear that the present findings seem to be consistent with the observation made by Seckler (1982). It may also be mentioned that the WHO has now proposed to set up new growth references for international use with the aim of developing a new reference for assessing the growth and nutritional status of infants and young children. (de Onis, M. *et al.* 1997).

Socio-economic Condition and Under-nutrition

Under-nutrition affects all sexes and ages. What makes the situation more serious is that children under 5 years of age are the most vulnerable victims. Under-nutrition predisposes an individual to infection and *vice versa*. It is one of the major risk factors for infections and diseases (WHO, 2000a). About 50% of the total annual deaths in children under 5 years of age are associated with under-nutrition in developing countries (Rice *et al.*, 2000; WHO, 2000b). Under-nutrition is attributable not only to poor access to food but also to other poor environmental conditions, such as poor housing and hygienic conditions, unsafe drinking water, heavy workloads, lack of preventive and control measures of locally endemic diseases and infections (Khongsdier, 2002). These poor environmental conditions are the common characteristics of population groups belonging to the lower socio-economic strata of the society, especially in developing countries (de Onis *et al.*, 2000). In other words, the major cause of under-nutrition is poverty compounded by other poor environmental conditions that predispose an individual to morbidity and mortality. There is considerable evidence that children in the lower socio-economic groups especially in developing countries are often the victims of malnutrition and its associated morbidity and mortality (WHO, 2000a). In the present study, we have also observed that the prevalence of underweight and stunting is significantly higher in children with low economic condition. The important implication of the present study is that nutritional status is an indicator of not only the health inequality but also the social inequality in Hmar population and perhaps in many populations in developing countries. We shall discuss more on this issue when we discuss the health and nutritional status of adults in the present population.

ADULT NUTRITIONAL AND HEALTH STATUS

In the present study, we have taken nutritional status, morbidity and hemoglobin as indicators of the health and nutritional status of Hmar adults (see Chapter V). The nutritional status was assessed using body mass index (BMI), which is derived from anthropometric measurements of body weight and height, as internationally recommended (WHO Working Group, 1986; WHO, 1995). Data on morbidity were based on "self-reported illness experience" of a subject as generally adopted in surveys, which did not involve a clinician (Strickland & Ulijaszek, 1993; Garcia & Kennedy, 1994; Strickland & Tuffrey, 1997). Hemoglobin level was measured following Sahli's method (WHO, 1983). These indicators of the health and nutritional status were also correlated with socio-economic variables such as household income and education with a view to understanding the interaction between biological and cultural traits- the subject matter of anthropology as a discipline. In the present section, we shall restrict to discuss our findings on these health and nutritional traits.

Body Mass Index

In Chapter V, we have shown that the mean BMI is 20.70 kg/m^2 and 20.67 kg/m^2 in adult males and females, respectively. These mean values of BMI among the Hmars are higher than those reported for 12 populations in Northeast India (Khongsdier, 2001). It is also higher than those reported for the War Khasi males (Khongsdier, 2002, 2005c). The prevalence of chronic energy deficiency (CED) (< 18.5 kg/m^2) was about 14.78% in males and 16.12% in females. These prevalent rates of CED are also lower than those reported for several populations of Northeast India, including caste groups like Brahmins, Kalitas, Jogis, Kaibartas and Hinduised groups like Ahoms, Kochs and Rajbhanjis (Khongsdier, 2001). They are also lower than the tribal groups like Lalungs, Miris (Khongsdier, 2001) and War Khasis (Khongsdier, 2002). Thus, it may be concluded that the nutritional status in the present populations is better than many populations in Northeast India. It is also found that the prevalence of overweight is 12.96% in males and 16.12% in females (Chapter V). This indicates that overweight is an emerging problem in the Hmar population. Considering BMI as an indicator of standards of living in developing countries (Nube, 1998; Khongsdier, 2002), it may be suggested that the Hmar population is also better in economic condition, as indicated by BMI index, than many other populations in Northeast India. The other possible explanation is that BMI is lower in those populations with higher sitting height (Norgan, 1994; Khongsdier, 2001). However, Hmar adults do not seem to deviate significantly from many populations in Northeast India (Khongsdier, 2001) with respect to cormic index. Thus, the higher BMI in Hmar population does not seem to be associated with cormic index, despite the presence of significant correlation between BMI and cormic index in the present analysis. In other words, although BMI is associated with cormic index, the Hmars are not much different from other populations in Northeast India with respect to cormic index.

The point that we would like to make here is that, although under-nutrition remains a major health problem in many developing countries, over-nutrition is also emerging with the improvement in socio-economic condition and increasing urbanization (Khongsdier, 2005c). Consequently, the double burden of under- and over-nutrition exerts considerable impact on the economy and health system in many developing countries (Popkin, 1998, 2002). In general, many countries in Asia are in this situation due to "changing dietary pattern towards energy-dense and high fat diets, together with a more sedentary lifestyle arising from increasing urbanization" (Florentino, 2002). The increasing urbanization, changes in standards of living, dietary patterns, and occupational work patterns are the key factors to risks of the epidemic of obesity and associated morbidity and mortality.

A recent review has revealed that India is also characterized by the development and nutrition transition that may contribute to the risk of overweight and obesity, especially in urban areas (Shetty, 2002). Visweswara Rao *et al.* (1995) reported that the prevalence of overweight among adults in urban colonies of Hyderabad was 21.8% in males and 27.4% in females, while the prevalence of obesity was 2.1% and 8.9%, respectively. It was also observed that the prevalence of overweight and obesity was higher in the higher income groups for both males and females. A study conducted in urban Delhi by the Nutrition Foundation of India also revealed that the prevalence of overweight (defined as $\geq$ 25 of BMI) among the "middle class" increased from low- to high-income groups, showing that about 32.2% of males and 50.0% of females in the high-income group suffered from overweight (Gopalan, 1998). Both of these studies indicated that the prevalence of overweight and obesity was higher in females than in males. In the present study, we have also observed that the prevalence of overweight in higher in females (16%) than in males (13 %).

Thus the spread of overweight and obesity needs to be monitored and prevented, but it should not be done at the expense of the efforts to alleviate under-nutrition. Most nutrition programmes in developing countries pay more attention to alleviating under-nutrition, especially in providing food complements, without much attention to monitor and prevent the epidemic of overweight and obesity that may create more harm in the future generations (Uauy and Kain, 2002).

Another point of significance with respect to the findings of the present study is the relationship between BMI and socio-economic conditions. It is observed that mean BMI is positively associated with household income of the household, whereas the prevalence of CED is negatively associated with income. Thus, the suggestion that BMI is an indicator of standards of living seems to have implication for the Hmar population as mentioned above. However, the present study failed to get any significant relationship between BMI and educational level. This indicates that the important factor for BMI is economic condition of the household, rather than social factors like education.

Morbidity

The present analysis given in Chapter V reveals that the overall prevalence of morbidity is 11.45%, which is lower than that reported for the War Khasis (Khongsdier, 2002). The prevalence of morbidity is significantly higher in males (13.36%) than in females (7.44%). It is found that the prevalence of morbidity increases with the increasing age groups of both and females. It is also higher in the undernourished and overweight individuals as compared to those in the normal category of nutritional status. The effect of household income on morbidity is not clearly perceptible in the present study. However, education of the individuals seems to be important in regulating morbidity pattern.

In view of the above, one may argue that the results of the present study are as generally expected. However, the sex differences and the absence of significant relationship between morbidity and household income may need further explanation. With respect top sex differences, our argument is the same as in the case of the sex differences in the nutritional status of the children given earlier in the present chapter.

Therefore, we shall summarize it later in the end of this chapter. The absence of significant relationship between morbidity and household income is difficult to give explanation because our findings show that the individuals in the higher economic groups are better in nutritional status. Our expectation is that families with higher income are better in health status because of not only their better nutritional status but also due to their greater access to health facilities than those in the lower income group. Thus, it may be speculated, on the basis of the present findings, that household income is not enough to bring about good health if the individuals lack awareness of hygienic conditions, nutrition and health facilities or services which prevent from morbidity and mortality. Education seems to play a very important role in creating this sort of awareness among the members of the present population. Therefore, morbidity in the present population is more related to education than to household income.

Hemoglobin Content

It is found that the mean hemoglobin among the Hmars of the current study is 13.05 g/dl for males and 12.27 g/dl for females. These mean hemoglobin levels among the Hmars are higher than those reported for some populations in Northeast India, but lower than the Christian and Non-Christian War Khasis (Khongsdier, 1997). It is found that the mean Hb content decreases with the increasing age groups of both males and females. It is also associated with nutritional status and household income. The prevalence of anemia is significantly higher in males (38.98%) than in females (37.55%). It is observed that the prevalence of anemia increases with the increasing age groups of both males and females. It is also associated with household income and individual education (see Chapter IV). The findings on hemoglobin and anemia in the present populations seem to be consistent with the general observation that hemoglobin level is higher in males than in females, and also decreases with age (WHO, 1968). Also, it clearly indicates that hemoglobin level and the prevalence of anemia is to a great extent influenced by socio-economic conditions as generally observed in developing countries.

OVERALL HEALTH STATUS

In view of the present findings, the question may arise as to what is the overall health development in the present population? The answer to this question may be difficult because it depends on the nature and types of health indicators taken under a given study. It is well known that human development index (HDI) is measured by taking the average of (1) life expectancy, (2) weighted average of functional literacy and combined elementary and secondary net enrolment rate, and (3) real per capita income. Considering the concept of HDI, we have also measured the population or overall health index in the present study by taking into consideration the average of infant mortality, proportions of children with underweight, stunting and wasting, and proportions of adults with self-reported morbidity, chronic energy deficiency (CED) and anemia. Assuming that the ideal population health index as 1 and the least population health as 0, we calculated the overall health index (OHI) as follows:

$OHI = \sum H/N$

where

N = Number of health indicators

$\sum H = H_1 + H_2 + H_3 + \ldots + H_n$

H_1 = Health index due to infant mortality (i.e., $H_1 = 1 - P_1$)
H_2 = Health index due to underweight (i.e., $H_2 = 1 - P_2$)
H_3 = Health index due to stunting (i.e., $H_3 = 1 - P_3$)
H_4 = Health index due to wasting (i.e., $H_4 = 1 - P_4$)
H_5 = Health index due to CED (i.e., $H_5 = 1 - P_5$)
H_6 = Health index due to morbidity (i.e., $H_6 = 1 - P_6$)
H_7 = Health index due to anemia (i.e., $H_7 = 1 - P_7$)
P_1 = Infant mortality rate (per live birth)
P_2 = Proportion of underweight children
P_3 = Proportion of stunted children
P_4 = Proportion of wasted children
P_5 = Proportion of adults with CED
P_6 = Proportion of adults with self-reported morbidity
P_7 = Proportion of adults with anemia

Table 6.1. Distribution of health indicators by income groups

Health Indicators	Proportions			
	LIG	MIG	HIG	Total
Infant mortality (P_1)	0.0283	0.0256	0.0315	0.0283
Underweight (P_2)	0.3099	0.2989	0.1538	0.2840
Stunting (P_3)	0.5263	0.4827	0.2949	0.4832
Wasting (P_4)	0.0292	0.0460	0.0256	0.0316
Chronic energy deficiency (P_5)	0.1804	0.1205	0.1237	0.1554
Self-reported morbidity (P_6)	0.1117	0.1289	0.1058	0.1145
Anemia (P_7)	0.4265	0.3571	0.2626	0.2051

Table 6.2. Overall Health Index (OHI) by income groups

Indices	LIG	MIG	HIG	Total
Health index due to mortality (H_1)	0.9717	0.9744	0.9685	0.9717
Health index due to underweight (H_2)	0.6901	0.7011	0.8462	0.7160
Health index due to stunting(H_3)	0.4737	0.5173	0.7051	0.5168
Health index due to stunting (H_4)	0.9708	0.9540	0.9744	0.9684
Health index due to CED (H_5)	0.8196	0.8795	0.8763	0.8446
Health index due to morbidity (H_6)	0.8883	0.8711	0.8942	0.8855
Health index due to anemia (H_7)	0.5735	0.6429	0.7374	0.7949
Overall Health Index (OHI)	0.7997	0.7915	0.8574	0.8140

Table 6.3. Overall Health Index (OHI) by educational groups

Indicators	No education	Primary	Secondary
Health index due to mortality (H_1)*	0.9561	0.9819	0.9770
Health index due to underweight (H_2)*	0.7227	0.6763	0.7349
Health index due to stunting(H_3)*	0.4538	0.4820	0.5663
Health index due to stunting (H_4)*	0.9916	0.9640	0.9598
Health index due to CED (H_5)	0.7788	0.8326	0.8759
Health index due to morbidity (H_6)	0.8387	0.8824	0.9056
Health index due to anemia (H_7)	0.5077	0.6349	0.6576
Overall Health Index (OHI)	0.7499	0.7792	0.8110

*Based on maternal education

Table 6.1 shows the distribution of the individuals according to different health indicators for the low income group (LIG), middle income group (MIG) and high income group (HIG). The OHI (0.8140 or 81.40%) and its components are given in Table 6.2. The OHI in the high income group (0.8574 or 85.74%) is much higher than in the middle (0.7915 or 79.15%) and low (0.7997 or 79.97%) income groups. Similarly, Table 6.3 shows that the OHI is higher in the individuals with secondary level of education (0.8110 or 81.10%) than in those with no education (0.7499 or 74.99%) and primary level of education (0.7792 or 77.92%). This clearly reveals that the health status in the higher socio-economic group is better than that in the lower ones.

On the basis of these findings, the moot anthropological question is that whether being in poor socio-economic condition is also indicative of being victims of natural selection? Natural selection acts primarily at the individual level. The simple definition of natural selection given by Darwin (1859) is the "preservation of favourable individual differences and variations, and the destruction of those which are injurious." He further clarified that "under the term of "variations," it must never be forgotten that mere individual differences are included." Thus, natural selection operates primarily at the individual level through differential survival and reproduction. The aggregate or average differential survival and reproduction of a given number of individuals may be considered its action at a group or population level.

Like the present study, there is considerable evidence that the health and nutritional status of the poor is worse than is the rich. Mortality rates due to malnutrition, infections and other causes of deaths are much higher in the lower socio-economic classes (Khongsdier, 2006). The significance of these inequalities also influenced the writings of Malthus (1803) and Darwin (1871, 1859). According to Malthus (1803), the "constant tendency in all animated life to increase" would prevent any permanent amelioration of poverty in the lower classes. In Central and South Asia, the positive checks including epidemics and consequences of "indigence and bad nourishment" would fall heavily on those in the lowest socio-economic strata "before any considerable degree of want had reached the middle classes of the society" (Malthus, 1803). Acknowledging this important observation of Malthus, Darwin (1871) wrote, "As all animals tend to multiply beyond their means of subsistence, so it must have been with the progenitors of man; and this would inevitably lead to a struggle for existence and to natural selection." Although Darwin did not say that natural selection is stronger among the poor, he also observed the "greater death-rate of infants in the poorest classes ... as well as the greater mortality, from various diseases, of the inhabitants of crowded and miserable houses, at all ages" (Darwin, 1871). It was Franz Boas (Boas, F. 1938) who argued that natural selection in humans operates primarily through social stratification. In addition, malnutrition, associated with poor environmental conditions in the lower socio-economic strata, is suggested to be a strong force of natural selection especially among children and reproductively-active women (Segraves, 1977). Thus, the view that socio-economic inequality mediates the process of natural selection in human populations seems to have originated with Darwin himself (Strickland & Tuffrey, 1997).

Natural selection is a blind natural force that preserves the beneficial variations and eliminates the injurious ones. The process of preserving the beneficial variations is also known as the *survival of the fittest* in the *struggle for existence*. According to Malthusian and Darwinian points of view, the struggle for existence, or competition for survival, is due to the increase in population beyond the means of subsistence. The short supply of resources, therefore, increases competition in different forms including social stratification in which "members of the privileged class may own even up to or over 10,000% of what a poor person owns" (Cohen, 1998). The high prevalence of malnutrition and infections is a clear evidence of poor access to adequate nutrition and health amenities among the lower socio-economic classes. From this point of view, one may argue that social stratification mediates natural selection in human populations in the form of malnutrition and infections, which ultimately lead to higher morbidity and mortality in the lower strata of social stratification. However, this argument is based simply on differential survival or *survival of the fittest* due to limited resources mediated by social stratification.

Natural selection or *survival of the fittest* also occurs whenever two or more individuals of distinct genotypes transmit their genes to the succeeding generations at different rates, despite the absence of limited resources (Birch, 1957). Any population is capable of increasing in number only when the progeny are able to survive and reproduce from generation to generation. Considering the findings on differential fertility and mortality in the present study, one may argue that reproductive success is lower in the higher socio-economic groups than in the lower socio-economic groups because fertility and mortality rates are lower in the former than in the latter. Indeed, there might not be a large difference between low and high socio-economic classes in differential reproduction because a higher mortality rate among the low socio-economic class is compensated for by a higher fertility rate. There is considerable evidence that fertility rates are higher in the lower socio-economic groups than in the higher ones. "This situation is undesirable, irrespective of any genetic considerations. People who should be able to provide the best environment for the physical and mental development of their children produce fewest progeny" (Dozhansky, 1962).

According to the adaptive systems theory, parents living in risky and uncertain environment maximize the current reproduction in terms of the *quantity* of offspring to minimize the risk of lineage extinction because of high mortality; while parents living in good environmental conditions maximize the *quality* of their offspring by reducing the quantity of the current reproduction (Chisholm and Burbank, 2001). Consequently, the future reproductive success of the parents under good environmental conditions is higher than that of the parents under poor environmental conditions because the high quality offspring are more likely to survive and reproduce from generation to generation.

In the present study, although we observed higher fertility and mortality in the lower socio-economic groups, we were not concerned with the case study or longitudinal study of the quality of offspring in the lower and high socio-economic groups of the Hmar population. More studies are needed to know whether or not the higher fertility and mortality rates in the lower classes are a form of plasticity to minimize the lineage extinction at the cost of high mortality? There is also a possibility of minimizing the lineage extinction at the expense of individual physical disadvantages (Strickland and Tuffrey, 1997). However, such a form of plasticity, if any, is because of necessity rather than for long-term benefits of populations (Khongsdier, 2006). Natural selection that operates in the lower strata of social stratification does not result in a long-term beneficial adaptation. As for the upper class, Harrison (1998) points out, "any physiological ability facilitating access to better environments will be strongly favoured through the greater success, reproduction and offspring survival which the better environments are likely to promote . . . . Darwinian fitness will tend to be highest in the upper class, especially in the absence of contraception, and physiological ability can influence the probability of being in those classes" through its effects on health and functional capability. Despite improvement in agricultural productivity in the 20th century, millions of people in developing countries still remain poor and undernourished because food is "neither produced nor distributed equitably" (WHO, 2000a). This problem remains a major setback to the "recognized fundamental human right to adequate food and nutrition, and freedom from hunger and malnutrition, particularly in a world that has both the resources and knowledge to end this catastrophe" (WHO, 2000b).

CONCLUDING REMARKS

In the present study, we have taken demographic parameters, growth of children, adult body dimensions, morbidity and anemia as indicators of the health and nutritional status of the Hmar population. Our findings indicate that the Hmar population is highly progressive due to high fertility and lower mortality rates. The growth status of children aged 2-10 years of age is far below the 50th percentile of the WHO/NCHS growth references, although it is above the 50th percentile of the ICMR references. As for nutritional status of children, the Hmar population is characterized by a high prevalence of underweight (28.40% for both sexes) and a very high prevalence of stunting (48.72% for both sexes) but with low prevalence of wasting (3.16%), according to the classificatory criteria proposed by Gorstein *et al.*, (1994), which takes into consideration all the three anthropometric indices (Table 4.14). With respect to the nutritional status of adults, the Hmar population seems to be better than those reported for many populations in Northeast India. There is also an indication of overweight perhaps due to improved standards of living as generally suggested in developing countries (Nube, 1998; Khongsdier, 2002). The better nutritional status in the adults of the present population is also consistent with the results on lower morbidity and anemia. The present findings have many implications which may be summarized briefly as follows:

1. The present findings seem to have certain implications for the application of the demographic transition theory. It is well known that the second stage of demographic transition theory predicts that improvement in standard of living and

health facilities results in population growth due to high fertility and low mortality. The poor performance of family planning welfare programmes and/or low practice of family planning methods of contraception enhances the fertility rate or population growth. It is observed that only about 5% of the Hmars married women adopted family planning methods. Therefore, fertility rate is still high in the population, thereby suggesting a need for greater political will to implement family planning programmes.

2. It is observed that the fertility rate in the present population is negatively associated with the maternal age, age at marriage and income levels of households. The effect of age at marriage on fertility is by and large universal since the reproductive period is shorter in the case of those with higher age at marriage. On the other hand, the significant effect of the household income on fertility rate in this population is likely to be related to the fact that people belonging to the higher economic groups are more conscious of the socio-economic welfare of their children. It is likely that they have higher aspiration for better education and higher economic status, thereby reducing the birth rate in order to provide their children with the best facilities (Mukherjee, 2002). What is interesting in the present study is that the effect of maternal education disappeared after adjusting for maternal and household income. This insignificant effect of education on fertility rate in the Hmars of the present study is inconsistent with the general observation in other populations (Caldwell *et al.*, 1999), and it is difficult to give any clear-cut explanation. It, however, suggests that maternal education is not the only factor that can regulate fertility rates in the Hmar population. For example, our analysis indicates that most educated mothers are in the lower age groups, whereas the proportion of illiterate mothers or mothers without educational background is higher in the older age groups, thereby resulting in sampling variation. In addition, it is likely that other social and cultural factors also might have played a significant role in either directly regulating fertility rate or indirectly controlling the effect of education on fertility rate. This, however, does not mean to say that education is not important in the Hmar population. It is observed that maternal age and maternal education are

very important factors in controlling infant mortality. Further studies are needed to have a better understanding of this problem in the Hmar population.

3. The high prevalence of underweight and stunting in Hmar children is contradicted by the low prevalence of wasting. This has an implication for the relevance of the international growth references/standards to the study population. It has been suggested that the use of international growth references is relevant only to the children below 5 years of age in South Asian populations (Khongsdier and Mukherjee, 2003). In the present study, we also observed the higher prevalence of underweight and stunting in the higher age group (6-10 years) than in the lower age group (below 6 years) for both boys and girls. The low prevalence of wasting as indicated by weight-for-height is consistent with the observation made by Seckler (1982) in Indian and Nepali populations. This is due to the fact that weight-for-height is independent of age, whereas indices of underweight and stunting are dependent of age. In short, the role of genetic factors and errors in the estimation of age cannot be totally ruled out in the present study. Weight-for-height is, therefore, a better indicator of nutritional status.
4. The present findings also indicate the co-existence of under- and over-nutrition (as indicated by BMI) in the Hmar population. Recent reviews has revealed that although under-nutrition remains a major health problem in many developing countries, over-nutrition is also emerging with the improvement in socio-economic condition and/or increasing urbanization (Popkin, 2002, Khongsdier, 2005c). Consequently, the double burden of under- and over-nutrition exerts considerable impact on the economy and health system in many developing countries. In general, many countries in Asia are in this situation due to "changing dietary pattern towards energy-dense and high fat diets, together with a more sedentary lifestyle arising from increasing urbanization" (Florentino, 2002). The increasing urbanization, changes in standards of living, dietary patterns and occupational work patterns are the key factors to risks of the epidemic of obesity and associated morbidity and mortality. Therefore, the spread of overweight and obesity in the Hmar population needs to be monitored and prevented, but it should not be done at the expense of the efforts to alleviate under-nutrition.

5. On average, the present findings indicate that the health and nutritional status is better in females than in males for both children and adults. This is contrary to the general observation in South Asian populations, which reveal that the health and nutritional status of females is worst as compared with males. There are two major implications with respect to these findings. The first implication is concerned with the hypothesis of the "biological fragility" of males as compared to females (Kraemer, 2000). Our study may have certain implications with respect to the observation that boys are more vulnerable than girls to adverse conditions, such as infections and/or nutritional deprivation (Tanner, 1962; Stinson, 1985; Worthman, 1996). The second implication is related to the role of cultural diversity in regulating health and nutritional inequalities. It is often argued that discrimination against females is very high in South Asian populations because of the patrilineal system of societies. However, our recent analysis on the nutritional status of the adolescents in both patrilineal and matrilineal societies did not confirm such an observation (Khongsdier *et al.*, 2005). It is observed that the nutritional status is better in females than in males in both matrilineal and patrilineal societies. It is, therefore, suggested that the regional variation in biological and cultural characteristics should be taken into consideration to understand this problem. For example, discrimination against females may not exist everywhere in India, but varies from one society to another depending upon different socio-cultural conditions. As for the present study, we failed to observe such sex discrimination, although sex preference may arise in the case of the question on lineage continuity and old age security.
6. Another important implication of the present findings is that socio-economic inequality in health and nutritional status. On average, our findings confirm the general observation that the health and nutritional status is better in the higher socio-economic classes than in the lower socio-economic ones (Tables 6.2 and 6.3). From the anthropological point of view, the question arises whether or not being in a poor socio-economic condition is also indicative of being the victims of natural selection? Natural selection is a blind natural force that preserves the beneficial variations and eliminates the injurious ones. The process of preserving

the beneficial variations is also known as the *survival of the fittest* in the *struggle for existence*. According to Malthusian and Darwinian points of view, the struggle for existence, or competition for survival, is due to the increase in population beyond the means of subsistence. The short supply of resources, therefore, increases competition in different forms including social stratification in which "members of the privileged class may own even up to or over 10,000% of what a poor person owns" (Cohen, 1998). The high prevalence of malnutrition and infections is a clear evidence of poor access to adequate nutrition and health amenities among the lower socio-economic classes. From this point of view, one may argue that social stratification mediates natural selection in human populations in the form of malnutrition and infections, which ultimately lead to higher morbidity and mortality in the lower strata of social stratification. However, this argument is based simply on differential survival or *survival of the fittest* due to limited resources mediated by social stratification. There is no evidence that the operation of natural selection in the lower socio-economic strata of the society is genetic in nature (Khongsdier, 2006). Therefore, equality of economic opportunity in a society, for example, enables a man to choose any occupation, which is most suited for him by his abilities and willingness to strive for his survival and well-being.

CHAPTER VII

SUMMARY

Health is an important input for the development of human resources and the quality of life necessary for the overall development of the community or country as a whole. In this connection, the World Health Organization has defined health as "a state of complete mental and social well being and not merely the absence of diseases or infirmity" (WHO, 1971). Although it may not be possible to attain all such types of well-being as referred to in this definition, the WHO's constitution says, "The enjoyment of the highest attainable standard of health is one of the fundamental rights of every human being without distinction of race, religion, political, economic and social condition." As such, health is a holistic concept, and one may define health in any manner relating to either one or all physical, mental and well-being of an individual, or a population, according to one's expediency of study. From an anthropological point of view, one may look into health as a state of well-being due to the interplay between socio-cultural and biological factors - environmental and genetic factors (Kar, 2000).

In order to measure the health status of a population, one needs to take into consideration certain health parameters, which are generally considered as health indicators, although the method of measuring may vary from one study to another (Gwatkin, 2000). Park (1995) has listed a number of health indicators under different categories, viz., *mortality rates, morbidity rates, disability or illness and injury rates, nutritional status, health care and delivery indicators, family planning and epidemiological policies, social and mental health indicators* (e.g., include suicide, homicide, acts of violence and crimes, road traffic accidents, juvenile delinquency, alcohol and drug abuse, smoking, and the like), *environmental indicators* (e.g., physical and biological environmental conditions in which diseases occur like air and water pollution, radiation, solid wastes, noise, exposure to solid substances in food and drinks, etc.), *socio-economic indicators* (e.g., population growth, per capita income, per capita expenditure, per capita gross national product, level of unemployment, literacy rates, family size, number of persons per room, per capita calorie availability, social security and welfare services), and *health policy indicators* (e.g., GNP spent on health services, water supply, sanitation, housing, community development, and so on).

It is, therefore, obvious that there are a large number of health parameters, and for that reason, it is often argued that health status is a function of many biological and socio-environmental factors. Accordingly, it is not simple to assess the health status of the population, especially in the case of individual research as it requires a technical knowledge from different fields or disciplines. "This is because health, like happiness, cannot be defined in exact measurable terms. Its presence or absence is so largely a matter of subjective judgment" (Park, 1995). Nevertheless, selection of few sensitive, specific and reliable parameters is also meaningful especially for screening or identifying the health problems of a specific population at a given point of time, which are required for immediate intervention. From the biological anthropological point of view, demographic variables (e.g., fertility, mortality and reproductive wastage), self-reported morbidity, nutritional anthropometry of adults, growth and nutritional status of children, and haematological traits including blood pressure and hemoglobin content are commonly used as health indicators of population (Khongsdier, 1996). These health parameters are in turn influenced by numerous biosocial factors. An attempt to understand the relationship of these health parameters with various socio-economic factors like educational level, occupation, income and expenditure of the household, etc., may be very helpful in understanding the health status of a population.

In the present thesis, we shall deal with the health status of the Hmar population of Aizawl District, Mizoram, with respect to certain selected health parameters such as demographic variables, anthropometric variables, growth and nutritional status, morbidity and hemoglobin level. An attempt will be made to look into the interrelationship between these health parameters and their association with age, sex, economic condition and educational level. With this end in view, we propose to undertake a study on the health and nutritional status of the Hmars of Aizawl **district in** Mizoram, taking into consideration the following objectives:

1. To describe the demographic structure of the Hmar population of Aizawl district of Mizoram.
2. To understand the growth and nutritional status of children aged 2 to 10 years, using selected anthropometric measurements and indices in relation to socio-economic conditions.
3. To understand the health and nutritional status of adults in terms of anthropometric variables, hemoglobin level and morbidity pattern, and to find out the possible relationship between these health variables and certain socio-economic factors.

MATERIALS AND METHODS

Study Area and Population

The present study was carried out in Aizawl District of Mizoram during the months of September to December 2001. The state is predominantly dominated by tribal groups like Lushais, Pawis, Paites, Raltes, Pang, Kukis, Hmars, etc. In the present study, we shall deal with the Hmars of Aizawl district. The Hmars have their own dialect, which has a close affinity to the Lushais and invariably resemble Paites and Kukis. Linguistically, they belong to the Kuki-Chin family. It was the Christian missionaries who introduced the Roman script to the Hmar language in the 19^{th} Century.

The Hmars are divided into 24 clans and each of these clans is again divided into about 180 sub clans/families. Clanship does not regulate marriage rules and an individual can select his mate from any clan including his own. Widow re-marriage is not uncommon. Being a patriarchal society, the father heads the family and lineage is traced through the male line. The general rule of inheritance is that the youngest son gets the lion share of parental property. Women are not allowed to inherit any property. Agriculture is the main occupation of the Hmars. Some are also engaged in weaving, handicraft, business and services.

The data for the present study were collected from four villages, namely, Tinghmun, Zohmun, Sakawrdai and Ratu, Darlawn Block in rural areas of Aizawl district, Mizoram by means of simple random sampling (Census 2001). According to this sampling method, the list of 20 villages and their population in Aizawl District was first prepared based on the information from Indian Census 1991 and T.R.I. 1992.The random numbers given in Snedecor and Cochran (1967) was used for selecting the required number of sample villages. No random sampling was applied for selection of subjects/informants from each of the selected villages due to operational difficulties in the field. An attempt was made to cover 410 households, that is, about 45% of the total 914 households in all four selected villages.

Demographic Data

The nature of demographic data collected for the present study was based on those parameters suggested by the World Health Organization Working Group (WHO, 1964, 1968; Mahadevan, 1986). The entire demographic data were collected through pedigrees and schedules from all the four hundred households in the four villages, namely, Tinghmun, Zohmun, Sakawrdai and Ratu. Information on age, sex, marital status, tribe, religion, occupation, income, education, community affiliation, place of birth, place of residence, etc. was collected from the head of the household or elder member who was capable of furnishing all the relevant information as per household schedule.

The fertility schedule was completed by filling-in the information on the number of conceptions, number of live births, number of reproductive wastages (abortion and still births), sex, present age, age at death, birth order, etc. from all the ever married women. Pedigrees were also collected from cross-checking of data on reproductive history of the mothers. Sometimes, information given by the mothers was cross-checked from their respective husbands. It may be mentioned that great difficulties were experienced in the assessment of age particularly that of the elderly women, since many of them were not aware of their real age. Consequently in such cases, the age was estimated with the help of other persons in the household/village. So, there could be some mistakes, in some cases, in the estimation of age.

Data on Adult Body dimensions

Some selected anthropometric measurements from the basic list of measurements, recommended by the International Biological Programme (Weiner and Lourie, 1981) were taken into consideration for the purpose of the present study. Following are the anthropometric measurements taken on 978 adults aged 20 years and above of both sexes wearing light apparel.

Weight (Kg)

Height (cm)

Sitting Height (cm)

Biacromial Diameter (cm)

Bi-iliac Diameter (cm)

Mid Upper Arm Circumference (MUAC)

Chest girth (inhaled) (cm)

Chest girth (exhaled) (cm)

Besides the above measurements, following indices were computed for adult males and females in order to assess the nutritional status.

1. Body mass index = weight (kg)/height $(m)^2$
2. Cormic index or relative-sitting height = sitting height (cm)/ height (cm)

Data on Growth and Nutritional Status of Children

The present study of physical group was based on a cross sectional sample of Hmar boys and girls aged between 2-10 years. Following are the anthropometric measurements taken on 255 boys and 252 girls:

1. Weight (Kg)
2. Height vertex (cm)
3. Sitting height vertex (cm)
4. Bi acromial Diameter (cm)
5. Bi iliac Diameter (cm)
6. Mid upper arm circumference (Left arm) (cm)

An attempt was made to follow as far as possible the standard techniques of taking the measurements as described in Weiner and Lourie (1981). For assessing the nutritional status of children, we had taken three anthropometric indices – weight-for-age, height-for-age and weight-for-height - which are considered as the indicators of nutritional status. These indices were derived as z-scores of the international standard or reference, i.e., the growth reference of the WHO/U.S. National Centre for Health Statistics (WHO, 1983, 1995). Body mass index (BMI = weight in kg/height in meter squared) was used for assessing the nutritional status of adult males and females (WHO, 1995).

Data on Morbidity and Hemoglobin Level

Data on haemoglobin content of 551 adults were collected using Sahli's Haemometer by following standard techniques (WHO, 1980). The cut-off points of 13.0 g/dl and 12.0 g/dl were taken for screening the adult men and non-pregnant women, respectively (WHO, 1968). Data on morbidity were based on "self-reported illness experience" of a subject as generally adopted in surveys, which did not involve a clinician (Strickland & Ulijaszek, 1993; Garcia & Kennedy, 1994; Strickland & Tuffrey, 1997). SRM is also more preferable from the point of view that a clinical diagnosis involves much time, cost and technical expertise, which are not always possible when carrying out community-based studies in developing countries including India.

Socio-economic Categories

In the present study, three important socio-economic variables were taken into consideration. These include religion, monthly income of the households and educational level. These socio-economic variables were classified arbitrarily into different groups and/or categories with a view to understanding their influence on the health traits of the study population. Our classification may be briefly described as follows:

Income groups: Data on household income were collected directly from the head of the household and they were cross-checked taking into consideration some aspects of socio-economic conditions like housing condition, types of occupation, land holding, and monthly expenditure. The interval estimation based on standard deviation of the per capita monthly income of household was adopted for classifying the three economic groups (Khongsdier, 1997), which is as follows:

Above ($\bar{X} + 4SD/\sqrt{N}$) = High income group (HIG)

($\bar{X} - 4SD/\sqrt{N}$) to (Mean + $4SD/\sqrt{N}$) = Middle income group (MIG)

Below ($\bar{X} - 4SD/\sqrt{N}$) = Low income group (LIG)

Educational Level: The data on educational attainment of individuals in the present study were arbitrarily classified as follows: The category **No education** includes those individuals who were unable to read and write and those who had no education but could read or write their names. The individuals who attended school up to standard V were grouped into **Primary** level of education. The individuals with education of standard VI and above are included in the category of **Secondary level** of education due to inadequacy of data.

Statistical Analyses

The data collected for the present study are quantified and analysed statistically, using SPSS Window software. The data are presented in terms of means, standard deviation, standard error and proportions or percentages. The differences between two means were tested, using t-student test, while the differences between more than two means were determined, using one-way analysis of variance (ANOVA). Analysis of covariance was also carried out for testing the differences among means, allowing for the effects of other covariates. The differences between proportions were tested, using chi-square test. Multiple regression analysis was also carried out for understanding the effects of socio-economic factors on demographic parameters and growth patterns of children. Logistic regression analysis was used for analyzing the effects of maternal age, education, income and religion on infant mortality.

FINDINGS OF THE PRESENT STUDY

The findings of the present study were presented in three chapters. In chapter III, we deal with the demographic characteristics of the three religious groups. The growth and nutritional status of children are presented in Chapters IV, whereas adult body dimensions and health status was given in Chapter V.

DEMOGRAPHIC CHARACTERISTICS

The findings on important demographic characteristics of the study population are as follows:

1. According to Sundbarg's classification of population, a population is said to be *progressive* when the number of persons in relation to the total population

are 40.0%, 50.00% and 10.00% in the age groups 0-14, 15-49 and 50 + years, respectively. The population is referred to as *stationary* if these frequencies are 33.00%, 50.00% and 17.00%, respectively; while the frequencies of 20.00%, 50.00% and 30.00%, respectively, are the characteristics of *regressive* population (Khongsdier, 2005). Following these classifications of population, the Hmar population is categorized as *progressive type*.

2. The over all sex ratio, i.e., the number of males per 100 females, is found to be 95.22 which is lower than the ideal sex ratio of 1:1, despite the absence of statistical significance ($\chi^2 = 1.56$, d.f. = 1, $p > 0.05$).
3. The mean age at marriage is significantly higher in males (25.84 ± 0.29 years) than in females (20.78 ± 0.19 years) as generally observed in other populations (Khongsdier, 2005). The mean age at marriage among the Hmar married women of the present study is higher than those reported for many populations of Assam (Sengupta and Gogoi, 1995), but it is more less similar to that reported for the War Khasi and Khynriam Khasis (Khongsdier, 2001; Mukherjee, 2002).

Fertility and Mortality

1. The mean live birth per mother of all ages was 4.67 ± 0.13. In comparison with the recent reports on some populations in Northeast India, the fertility rate among the Hmars of the present study seems to be fairly high.
2. The age specific fertility rate seemed to reach its peak point in the age group 25-29 years. The total fertility rate (6.10) was much higher than that reported recently for some populations in Northeast India. It is similar to those reported for the Khasi sub-groups which had the highest fertility rate in Northeast India (Mukherjee, 2002; Khongsdier, 2005c). It may be mentioned that the adoption rate of modern family planning methods is very low (about 6%) in the present population.
3. The infant mortality rate (i.e., number of deaths before 1 year of life per 100 live births) was found to be 2.83%, which was the lowest in comparison with some populations in Northeast India.

4. The prevalence of reproductive wastage (4.12%) appears to be moderate in the present population (spontaneous abortion rate = 2.86% and still-birth rate = 1.26%). In comparison with most recent data for populations from Northeast India, the prevalence of reproductive wastage among the Hmars was higher than that among the Mukloms of Arunachal Pradesh (Sarkar, 2002), similar to the Sanga and Wanang Kochs of Garo hills (Murali, 2002), but lower than many other populations (Sengupta and Kalita, 2001; Mukherjee, 2002; Khongsdier, 2005c).
5. The mean number of live births to women who married by the age of ≤ 19, 20-24 and ≥ 25 years is 4.85, 4.66 and 4.31, respectively. It is seen that the mean number of live births decreases with the increase in the mean age at marriage, despite the absence of statistical difference ($F= 0.914$, d.f.=2,437, $p > 0.05$).
6. It is found that the unadjusted mean of live births decreases significantly with the increasing educational level of the mothers ($F = 32.27$, d.f. = 2, 437, $p < 0.0001$). Adjusting for maternal age and household income, these differences in live births between educational groups of mother disappeared ($F = 0.93$, d.f. = 2, 437, $p > 0.05$). This indicates that the effects of education on live births are compounded by maternal age and household income. For example, it is likely that most educated mothers are in the lower age group, whereas illiterate mothers or mothers without educational background are more in the older age groups, thereby resulting in sampling variation. From this point of view, the ANCOVA test is very helpful in determining how an independent variable (e.g., maternal age in the present analysis) alone could influence the dependent factor (e.g., live birth in the present analysis).
7. It is observed that the unadjusted mean live births are 5.10 ± 0.17, 4.22 ± 0.28 and 3.97 ± 0.28 in the low, middle and high income groups, respectively, and these differences are statistically significant ($F = 7.57$, d.f. = 2, 437, $p < 0.001$). The higher mean live births in the lower income groups as compared to high income groups are statistically significant even after adjusting for maternal age and education ($F = 6.15$, d.f. = 2, 437, $p < 0.001$). This indicates that household income is very important in regulating fertility rate in the present population.

8. Results of multiple regression analysis was also carried out to have a better understanding of the relationship between live births/surviving children and socio-economic conditions. It was observed that maternal age was positively associated with live births ($b = 0.129 \pm 0.008$, $t = 16.42$, $p < 0.0001$) and surviving children ($b = 0.104 \pm 0.008$, $t = 13.45$, $p < 0.0001$). It was also found that maternal age at marriage was negatively associated with live births ($b = -0.120 \pm 0.025$, $t = 4.84$, $p < 0.001$) and surviving children ($b = -0.110 \pm 0.024$, $t = 4.55$, $p < 0.001$). In addition, household income was also negatively associated with live births ($b = -0.365 \pm 0.122$, $t = 2.99$, $p < 0.003$) and surviving children ($b = -0.327 \pm 0.120$, $t = 2.74$, $p < 0.006$). On the other hand, we failed to get a significant relationship between maternal education and live births as well as surviving children. Thus, it may be concluded that the role of maternal education is not clearly perceptible in the present analysis. Instead, maternal age, age at marriage and household income are very important factors for controlling live births and surviving children.
9. With respect to infant mortality, it was observed that infant mortality is negatively associated with maternal age ($b = -0.029 \pm 0.011$, $t = 2.62$, $p < 0.009$) and negatively associated with maternal education ($b = -0.052 \pm 0.026$, $t = 2.00$, $p < 0.05$). On the other hand, the effect of household income on infant mortality is not clearly perceptible in the present study. Thus, maternal age and maternal education seem to be very important factors in controlling infant mortality in the present population. It also indicates that household income alone may not be sufficient to bring down death rates, if maternal education is not taken into account.

GROWTH AND NUTRITIONAL STATUS OF CHILDREN

In the present study, we have considered the growth of children aged 2 to 10 years of age. The main purpose is to assess the nutritional status of children in relation to other demographic and socio-economic conditions of the study population. However, an attempt was also made to assess the growth status of these Hmar children in relation to their coevals at a given age in other populations including the recommended growth references and/or standards. In this regard, we have taken into consideration only some important anthropometric variables like weight and height, which are also reported for few populations in Northeast India, such as War Khasis (Khongsdier, 1996), Khynriam Khasis (Mukherjee, 2002), Assamese Muslims (Begum and Choudhury, 1999) and Kalitas (Choudhury and Bhuyan, 1994).

It may be noted here that in India we do not have the recommended growth references and/or standards. Although the data collected by the Indian Council of Medical Research (ICMR, 1972) are old and unrepresentative of all sections of the Indian population, we used in the present study simply to understand the growth status of the Hmar children, but not as a target or standard of growth that one should assess the children's growth in the present study. As a matter of fact, we used the NCHS/WHO growth references (WHO, 1983) for assessing the nutritional status of children as internationally recommended.

Weight

It is observed that the Hmar boys are above the 50^{th} percentile of the ICMR growth references from 2 to 10 years of age although they are similar at about 5 years. In comparison with the NCHS growth references, the Hmar boys are far below the 50^{th} percentile from 2 to 10 years of age, but they are above the 3^{rd} percentile across these ages. However, the Hmar boys are above the 50^{th} percentile of the ICMR growth references. In comparison with their counterparts reported from some populations of Northeast India, the Hmar boys are comparable to the War Khasi boys (Khongsdier, 1996) from 3 to 5 years of age and to the Khynriam Khasi boys (Mukherjee, 2002) from 4 to 5 years of age. However, the War Khasi boys are heavier than the Hmar boys from 5 to 10 years of age. The Hmar boys are heavier than the Khynriam Khasi boys from 5 years onwards, although the Khynriam are heavier at 9 years of age. In comparison with the Assamese boys, the Hmar boys are heavier than the Kalita boys (Choudhury and Bhuyan, 1994) across ages. They are also heavier than the Assamese Muslim boys (Begum and Choudhury, 1999) from 3 to 6 and 8 to 9 years, although the latter are heavier from 9 to 10 years of age. In general, it reveals that the Hmar boys are above the 50^{th} percentile of the ICMR growth references and heavier than the Kalita boys, although they are lighter than the War Khasi boys from 5 to 10 years of age. They are comparable to the Assamese Muslim boys.

As for girls, it is observed that they are above the 50th percentile of the ICMR and 3rd percentile of the NCHS growth references from 2 to 10 years of age. However, they are far below the 50th percentile of the NCHS growth references. In comparison with some populations in Northeast India, the Hmar girls are heavier than the Kalita girls across ages. They are similar to the Khynriam and Assamese Muslim girls from about 3 to 5 years, and thereafter they are lighter up to about 8 years of age. They are similar to the Assamese Muslim girls from 8 to 10 years, although they are lighter than the Khynriam and War Khasi girls in this age group. They are also heavier than the War khasi girls from about 3.5 to 5 years, and thereafter the latter surpassed the former up to about 8 years. On average, like their male counterparts, the Hmar girls are above the 50th percentile of the ICMR growth references and heavier than the Kalita girls of Assam. They are comparable to the War Khasi and Assamese Muslim girls, irrespective of certain fluctuations.

Height

It is observed that the Hmar boys are below the 50th percentile of the ICMR growth references across ages although they are more or less comparable from 2 to about 3.5 years of age. The Hmar boys are also far below the 50th percentile of the NCHS growth references, but they are more or less comparable to the 3rd percentile of the international growth references across ages. The Hmar boys are found to be taller than the Khynriam boys across ages, but shorter than the War Khasi, Kalita and Assamese Muslim boys. They are similar to the Assamese Muslim boys only from 3 to 4 years of age. Thus, in view of these comparisons, the Hmar boys seem to be better in growth status of height when compared with the Khynriam Khasi and ICMR growth references. However, they are shorter than War Khasi, Kalita and Assamese Muslim boys.

As for girls, they are, on average, below the 50th percentile of the ICMR growth references with respect to growth in height, and they are far below the 50th percentile of the NCHS growth references. They are taller than the Kalita and Khynriam Khasi children . They are similar to the war Khasi girls from 7 to 10 years of age and to the

Assamese Muslim girls from 3 to 5 years of age. However, they are shorter than the War Khasi and Assamese Muslim girls from 3 to 7 years and 5-10 years of age, respectively.

Nutritional Status

Nutritional status is defined as the physical expression of the relationship between the nutrient intakes, or bio-availability of nutrients, and the physiological requirements of an individual (Brown, 1984). This physical expression of the relationship between nutrient intakes and physiological requirements of a person can be measured by a number of methods. Of different methods, anthropometry is one that is generally used for measuring the magnitude of undernutrition at both individual and population levels. In the present study, we have taken into consideration three anthropometric indices, i.e., weight-for-age (indicator of underweight), height-for-age (indicator of stunting) and weight-for-height (indicator of wasting or thinness) for assessing the nutritional status of children. The cut-off point of – 2 Z-score was used for screening undernourished groups of children (WHO, 1983) for all the three indices.

Prevalence of Underweight and Its Risk Factors

The risk factors of underweight in terms of odds ratios derived from logistic regression models after adjusting certain variables . Four logistic regression models were used for presenting the risk factors of underweight. In the first model, age was taken into consideration by dividing the children into two age groups, viz., 2-5 and 6-10 years, for computing the odds ratio with 95% confidence interval (CI) from the regression models after adjusting for sex, income and mother's education. It is found that older children aged 6-10 years had about 1.15 times greater in risk of being underweight as compared to younger children aged 2-5 years of age. However, this risk is not statistically significant ($p = 0.508$). The second model is concerned with the sex difference after adjusting for age, income level and mother's education. It is seen from the table that boys had about 1.48 (95% CI: 1.01-2.30, $p < 0.05$) greater risk of underweight as compared with girls. This is somewhat in contrast to the general observation that underweight in Southeast Asia is higher in girls than in boys.

In the third model of logistic regression, we have taken into consideration the three income groups after adjusting for age, sex and mother's education. It is found that children in the low and middle income groups had greater risk of underweight when compared to those in the high income group. Children in the low income group had about 2.58 (95% CI: 1.32-5.05, $p < 0.006$) times greater in risks of being underweight as compared to those in the high income group. Similarly, children in the middle income group had about 2.41 (95% CI: 1.11-5.24, $p < 0.027$) times greater in risks of being underweight as compared to those in the high income group. This is clear that household income is very important factor for regulating body weight of children.

The effect of maternal education is not statistically significant in the present population. However, children of the mothers without any education had about 0.96 times the risk of underweight when compared to those with secondary level of education.

Prevalence of Stunting and Its Risk Factors

The risk factors of stunting in terms of odds ratios like in the case of underweight were analyzed . Adjusting for sex, household income, and maternal education, children aged 6-10 years had about 1.26 (95% CI: 0.86-1.80) greater risk of being short stature or stunting. However, this odds ratio is not statistically significant. In the next model, the odds ratio for the sex difference in the prevalence of stunting was worked out after adjusting for age, household income and maternal education. It is observed from the table that boys had about 1.64 (1.09-2.23) times greater in risks of stunting as compared to girls. Thus, like in the case of underweight, stunting is likely to be more prevalent in boys than in girls.

With respect to economic condition, it is found that children in the low and middle income groups had greater risk of stunting when compared to those in the high income group, i.e., the prevalence of stunting is similar to that of underweight with respect to economic condition. Children in the low income group had about 2.64 (95% CI: 1.52-4.56, $p < 0.001$) times greater in risks of stunting as compared to those in the high income group. In comparison with those in the high income group, children in the middle income group had also about 2.18 (95% CI: 1.13-4.19, $p < 0.022$) times greater in risks of stunting after adjusting for age, sex, and mother's education. Thus, household income is likely to be an important in determining stunting in the present population. Like in the case of underweight, the effects of maternal education are not clearly perceptible in the present population.

Prevalence of Wasting and Its Risk Factors

The risk factors of wasting in terms of odds ratios are derived from logistic regression models. Unlike in the case of underweight and stunting, the effects of demographic and socio-economic factors on wasting are not statistically significant in the present population. However, it is likely that children in the low and middle income groups had greater risk of wasting when compared to those in the high income group. Thus, it cannot be totally ruled out the role of household income in regulating wasting in the present population.

ADULT NUTRITIONAL AND HEALTH STATUS

Adult Body Dimensions

In observing the means and standard deviations of anthropometric traits for adult males by age groups, with the exception of bi-iliac diameter, the mean anthropometric traits are higher significantly in the lower age groups. The same is observed for adult females. Perhaps, this may be due to secular trend other than chance factors such as sampling variation are not involved. By secular trend, we mean an increase in anthropometric measurements from one generation to another due to improvement in economic condition of a given population. With respect to bi-iliac diameter, different explanations may be given, but it is likely to be associated with the increase in fat accumulation at the bi-iliac portion of the body with the increasing age. Nevertheless, it is evident from the results presented in the Tables that individual age should be taken into consideration when carrying out statistical analyzes on the effects of socio-economic conditions on anthropometric traits, or assessing the nutritional status of the study population in relation to socio-economic conditions.

Prevalence of Under- and Over-nutrition

The individuals with BMIs of < 16.0, 16.0-16.9, 17.0-18.4, 15.5-23.0 and > 23.0 kg/m^2 were considered to be in the severe, mild, moderate, normal and overweight grades of nutritional status, respectively (James *et al.*, 1988; WHO, 2000c). It is found that about 1.01%, 3.24% and 10.53% of adult males suffer from severe, mild and moderate under-nutrition, respectively. Among adult females, these frequencies are 0.83, 4.55% and 10.74%, respectively. Considering the cut-off point of 18.5 for screening the individuals into normal and undernourished or chronic energy deficiency (CED) groups (Ferro-Luzzi *et al.*, 1992, WHO, 1995), the overall prevalence of under-nutrition is 14.78% in males and 16.12% in females. This sex difference in the prevalence of under-nutrition is not statistically significant ($\chi^2 = 0.34$, $p > 0.05$). These prevalent rates of CED are also lower than those reported for several populations of Northeast India, including caste groups like Brahmins, Kalitas, Jogis, Kaibartas and Hinduised groups like Ahoms, Kochs and Rajbhanjis (Khongsdier, 2001).

With respect to overweight, it has been suggested recently that the BMI of 23.0-25.0 and > 25.0 should be considered the cut-off points for screening overweight and obesity, respectively (WHO, 2000c). Using the cut-off point of 23.0 for screening overweight individuals, about 12.96% of males and 16.12% of females are overweight in the present population. It indicates that the prevalence of overweight is higher in females than in males, although it is not statistically significant ($\chi^2 = 1.97$, $p > 0.05$).

Risks of Under-nutrition

In order to have a better understanding of how under-nutrition is related to age, sex, cormic index and socio-economic conditions in the study population, an attempt was made to carry out the logistic regression analysis. The odds ratios (with 95% confidence interval (CI) relative to the prevalence of under-nutrition or CED) are derived from logistic regression models after adjusting for other variables under consideration. With respect to age, it is found that older individuals had greater risks of being undernourished after adjusting for cormic index, sex, education and income. The individuals aged 60 + years had about 5.06 (95% CI: 2.98-8.61) times greater in risk of being undernourished as compared with those aged < 40 years. On the other hand, the subjects who are aged 40-59 years had about 2.08 (95% CI: 1.37-3.17) greater in the prevalence of under-nutrition as compared with those aged < 40 years. Thus, it is evident from the present analysis that age is significantly associated with the nutritional status of the individuals in the present population.

As for cormic index, it is observed that the individuals with low cormic index seem to have a higher risk of being undernourished. Adjusting for age, sex, education and household income, the prevalence of under-nutrition was about 1.61 (95% CI: 1.12-2.33) times greater than those with cormic index of > 0.53. This indicates that cormic index is significantly associated with the prevalence of CED in the present population. It is also found that the odds ratio for the prevalence of CED according to sex. Adjusting for age, cormic index, education and household income, females had about 1.38 (95% CI: 0.95-2.00) times greater in the prevalence of CED as compared males. This difference is, however, not statistically significant ($P > 0.05$).

In comparison with the high income group, the low income group had about 1.78 (95% CI: 1.04-3.05) times greater in risk of being undernourished after allowing for age, sex, cormic index and education. However, the middle income group is not significantly deviated from the high income group with respect to the risk of CED (OR= 1.04; CI: 0.55-1.97). Nevertheless, income seems to have a great influence on the nutritional status of the adult individuals in the Hmar population. Like in the case of mean BMI, the effect of education on the nutritional status of the adult males and females is not clearly perceptible.

Morbidity by Age and Sex

The prevalence of morbidity, that is, those individuals who had suffered from any illness and were at least one day in bed during the last one month before the survey. The overall prevalence of morbidity is 11.45%, and it is higher in males (13.36%) than in females (9.50%), and it is statistically significant ($\chi^2 = 9.18$, D.F. = 1, $p < 0.002$). The prevalence of morbidity increases with the increasing age groups in both males and females. In males, the prevalence of morbidity increases from about 12% in the age group < 40 years to 20% in the age group 60 + years. On the other hand, the prevalence of morbidity in females is higher in the age group 40-59 years (12.23%) as compared to the age groups < 40 years (7.92%). However, these age differences are not statistically significant for both males ($\chi^2 = 3.11$, D.F. = 2, $p > 0.05$) and females ($\chi^2 = 2.37$, D.F. = 2, $p > 0.05$). Thus, according to data presented in Table 5.10, it can be argued that sex is more important than age for influencing morbidity, although older individuals are likely to have a greater risk of morbidity.

The self-reported symptoms of morbidity were classified into three broad categories as generally suggested (Sadana, 2000). **Cold and Respiratory and Intestinal Disorders** include those symptoms such as cough + runny nose + headache + fever, fever + cough, cough alone, swollen glands, + cold, ear problem, breathing problem, chest pain, sore throat, TB. On the other hand, **Intestinal Disorders** include diarrhoea, dysentery, worms, vomiting, vomiting + fever, and other self-reported problems of stomach pain. Self-reported symptoms of morbidity other than the two categories above were included in the category of **Other Problems**.

It can be observed that the prevalence of cold and respiratory disorders is more common than that of intestinal ones for both the sexes. It is slightly higher in males (5.67%) than in females (3.93%). The prevalence of intestinal disorders is more or less similar in both males (1.82%) and females (1.86%).

Risks factors of Morbidity

It is found that older individuals are likely to get sick when compared with the younger ones, although the odds ratios are not statistically significant. It is also found that adult males had about 1.62 (95% CI: 1.07-2.46) times greater in risk of morbidity when compared with females, i.e., after adjusting for age, nutritional status, education and household income. The undernourished individuals also have greater risks of morbidity. Adjusting for age, sex, education and household income, the prevalence of morbidity was more than 2 times (95% CI: 1.32-3.60) greater in undernourished individuals than those with normal grade of nutrition. This indicates that morbidity is significantly associated with the prevalence of CED.

Household income does not seem to have influenced morbidity pattern in the present population. However, education seems to be important factor influencing morbidity in the present population even after adjusting for age, sex, nutritional status and household income. The subjects without education had about 1.89 (95% CI: 1.13-3.16) times greater in risks of having morbidity problems when compared to those with secondary level of education.

Hemoglobin Content by Sex and Age

As theoretically expected, the mean hemoglobin content is significantly higher in males than in females for all of the age groups. It is also observed that the hemoglobin content tends to decrease with the increasing age groups for both males and females. The analysis of variance (ANOVA) shows that the differences in hemoglobin level between age groups are statistically significant for both males ($F = 4.99$, d.f. = 2, 287; $p < 0.007$) and females ($F = 3.64$, d.f. = 2, 258; $p < 0.02$). This indicates that age should be taken into consideration while analyzing the relationship between hemoglobin content and other factors.

Prevalence of Anemia by Sex and Age

It is found that the prevalence of anemia is higher in males (38.97%) than in females (37.55%), and the differences between the sexes are statistically significant ($\chi^2 = 9.95$, d.f. = 2, $p < 0.002$). The prevalence of anemia increases with the increasing age groups for both males and females. However, the chi-square test indicates that the differences between age groups are statistically significant only in males ($\chi^2 = 12.31$, d.f. = 2, $p < 0.007$), but not in females ($\chi^2 = 3.55$, d.f. = 2, $p > 0.05$). Nevertheless, the present findings indicate that both sex and age are associated with the prevalence of anemia in the present population.

Risk Factors of Anemia

It is observed that the older individuals are likely to become anemic when compared with the younger ones, especially those who are aged 60 years and above. The subjects aged 60 + years had about 2.60 (95% CI: 1.36-4.95) times greater in risks of anemia when compared with those who are aged < 40 years. Although there is no significant difference between the age groups < 40 and 40-59 years, it is clear that individuals aged 60 years and above are likely to have higher prevalence of anemia. Further, the odds ratios of anemia for the sex and nutritional differences are not statistically significant, although the prevalence of anemia is higher in males as compared to females as well as in undernourished as compared to the individuals with normal grade of the nutritional status. The effect of socio-economic condition, on the other hand, on the prevalence of anemia seems to be significant in the present population. As for economic condition, the low income group had about 1.84 (95% CI: 1.10-3.07) times greater in risks of anemia when compared with those in the high income group. Also, the middle income group had 1.46 (95% CI: 0.80-2.67) times greater in risks of having anemia when compared with those in the high income group, despite the absence of statistical significance. Similarly, the subjects with no formal education were about 1.56 (95% CI: 1.01-2.41) times greater in risk of having anemia as compared to those with secondary level of education. In short, income and education seem to be very important risk factors of anemia in the present population.

CONCLUDING REMARKS

In the present study, we have taken demographic parameters, growth of children, adult body dimensions, morbidity and anemia as indicators of the health and nutritional status of the Hmar population. Our findings indicate that the Hmar population is highly progressive due to high fertility and lower mortality rates. The growth status of children aged 2-10 years of age is far below the 50th percentile of the WHO/NCHS growth references, although it is above the 50th percentile of the ICMR references. As for nutritional status of children, the Hmar population is characterized by a high prevalence of underweight (28.40% for both sexes) and a very high prevalence of stunting (48.72% for both sexes) but with low prevalence of wasting (3.16%), according to the classificatory criteria proposed by Gorstein *et al.*, (1994), which takes into consideration all the three anthropometric indices. With respect to the nutritional status of adults, the Hmar population seems to be better than those reported for many populations in Northeast India. There is also an indication of overweight perhaps due to improved standards of living as generally suggested in developing countries (Nube, 1998; Khongsdier, 2002). The better nutritional status in the adults of the present population is also consistent with the results on lower morbidity and anemia. The present findings have many implications which may be summarized briefly as follows:

1. The present findings seem to have certain implications for the application of the demographic transition theory. It is well known that the second stage of demographic transition theory predicts that improvement in standard of living and health facilities results in population growth due to high fertility and low mortality. The poor performance of family planning welfare programmes and/or low practice of family planning methods of contraception enhances the fertility rate or population growth. It is observed that only about 5 % of the Hmars married women adopted family planning methods. Therefore, fertility rate is still high in the population, thereby suggesting a need for greater political will to implement family planning programmes.
2. It is observed that the fertility rate in the present population is negatively associated with the maternal age, age at marriage and income levels of households. The effect of age at marriage on fertility is by and large universal

since the reproductive period is shorter in the case of those with higher age at marriage. On the other hand, the significant effect of the household income on fertility rate in this population is likely to be related to the fact that people belonging to the higher economic groups are more conscious of the socio-economic welfare of their children. It is likely that they have higher aspiration for better education and higher economic status, thereby reducing the birth rate in order to provide their children with the best facilities (Mukherjee, 2002). What is interesting in the present study is that the effect of maternal education disappeared after adjusting for maternal and household income. This insignificant effect of education on fertility rate in the Hmars of the present study is inconsistent with the general observation in other populations (Caldwell *et al.*, 1999), and it is difficult to give any clear-cut explanation. It, however, suggests that maternal education is not the only factor that can regulate fertility rates in the Hmar population. For example, our analysis indicates that most educated mothers are in the lower age groups, whereas the proportion of illiterate mothers or mothers without educational background is higher in the older age groups, thereby resulting in sampling variation. In addition, it is likely that other social and cultural factors also might have played a significant role in either directly regulating fertility rate or indirectly controlling the effect of education on fertility rate. This, however, does not mean to say that education is not important in the Hmar population. It is observed that maternal age and maternal education are very important factors in controlling infant mortality. Further studies are needed to have a better understanding of this problem in the Hmar population.

3. The high prevalence of underweight and stunting in Hmar children is contradicted by the low prevalence of wasting. This has an implication for the relevance of the international growth references/standards to the study population. It has been suggested that the use of international growth references is relevant only to the children below 5 years of age in South Asian populations (Khongsdier and Mukherjee, 2003). In the present study, we also observed the higher prevalence of underweight and stunting in the higher age group (6-10 years) than in the lower age group (below 6 years) for both boys and girls. The low prevalence of wasting

as indicated by weight-for-height is consistent with the observation made by Seckler (1982) in Indian and Nepali populations. This is due to the fact that weight-for-height is independent of age, whereas indices of underweight and stunting are dependent of age. In short, the role of genetic factors and errors in the estimation of age cannot be totally ruled out in the present study. Weight-for-height is, therefore, a better indicator of nutritional status.

4. The present findings also indicate the co-existence of under- and over-nutrition (as indicated by BMI) in the Hmar population. Recent reviews has revealed that although under-nutrition remains a major health problem in many developing countries, over-nutrition is also emerging with the improvement in socio-economic condition and/or increasing urbanization (Popkin, 2002, Khongsdier, 2005c). Consequently, the double burden of under- and over-nutrition exerts considerable impact on the economy and health system in many developing countries. In general, many countries in Asia are in this situation due to "changing dietary pattern towards energy-dense and high fat diets, together with a more sedentary lifestyle arising from increasing urbanization" (Florentino, 2002). The increasing urbanization, changes in standards of living, dietary patterns and occupational work patterns are the key factors to risks of the epidemic of obesity and associated morbidity and mortality. Therefore, the spread of overweight and obesity in the Hmar population needs to be monitored and prevented, but it should not be done at the expense of the efforts to alleviate under-nutrition.
5. On average, the present findings indicate that the health and nutritional status is better in females than in males for both children and adults. This is contrary to the general observation in South Asian populations, which reveal that the health and nutritional status of females is worst as compared with males. There are two major implications with respect to these findings. The first implication is concerned with the hypothesis of the "biological fragility" of males as compared to females (Kraemer, 2000). Our study may have certain implications with respect to the observation that boys are more vulnerable than girls to adverse conditions, such as infections and/or nutritional deprivation (Tanner, 1962; Stinson, 1985; Worthman, 1996). The second implication is related to the role of

cultural diversity in regulating health and nutritional inequalities. It is often argued that discrimination against females is very high in South Asian populations because of the patrilineal system of societies. However, our recent analysis on the nutritional status of the adolescents in both patrilineal and matrilineal societies did not confirm such an observation (Khongsdier *et al.*, 2005). It is observed that the nutritional status is better in females than in males in both matrilineal and patrilineal societies. It is, therefore, suggested that the regional variation in biological and cultural characteristics should be taken into consideration to understand this problem. For example, discrimination against females may not exist everywhere in India, but varies from one society to another depending upon different socio-cultural conditions. As for the present study, we failed to observe such sex discrimination, although sex preference may arise in the case of the question on lineage continuity and old age security.

6. Another important implication of the present findings is that of socio-economic inequality in health and nutritional status. On average, our findings confirm the general observation that the health and nutritional status is better in the higher socio-economic classes than in the lower socio-economic ones. From the anthropological point of view, the question arises whether or not being in a poor socio-economic condition is also indicative of being the victims of natural selection? Natural selection is a blind natural force that preserves the beneficial variations and eliminates the injurious ones. The process of preserving the beneficial variations is also known as the *survival of the fittest* in the *struggle for existence*. According to Malthusian and Darwinian points of view, the struggle for existence, or competition for survival, is due to the increase in population beyond the means of subsistence. The short supply of resources, therefore, increases competition in different forms including social stratification in which "members of the privileged class may own even up to or over 10,000% of what a poor person owns" (Cohen, 1998). The high prevalence of malnutrition and infections is a clear evidence of poor access to adequate nutrition and health amenities among the lower socio-economic classes. From this point of view, one may argue that social stratification mediates natural selection in human populations in the

form of malnutrition and infections, which ultimately lead to higher morbidity and mortality in the lower strata of social stratification. However, this argument is based simply on differential survival or *survival of the fittest* due to limited resources mediated by social stratification. There is no evidence that the operation of natural selection in the lower socio-economic strata of the society is genetic in nature (Khongsdier, 2006). Therefore, equality of economic opportunity in a society, for example, enables a man to choose any occupation, which is most suited for him by his abilities and willingness to strive for his survival and well-being.

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