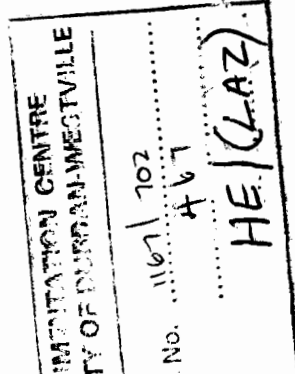


AN INVESTIGATION INTO THE RELATIONSHIP
BETWEEN SEVERE AND MODERATE MALNUTRITION
IN INFANCY AND CHILDHOOD AND CERTAIN
PSYCHOLOGICAL VARIABLES



by

THEOPHILUS LAZARUS

*Submitted in part fulfilment of
the requirements for the degree
of,*

MASTER OF SCIENCE

*in the Department of Psychology,
in the Faculty of Science at the
University of Durban-Westville.*

SUPERVISOR : PROF K BHANA

DATE SUBMITTED : JANUARY, 1984

ACKNOWLEDGEMENTS

I wish to thank the following individuals and institutions for their valued support in making this project possible:

My supervisor, Prof K Bhana, Head of the Department of Psychology, University of Durban-Westville, for her keen interest, invaluable support, constructive criticism, and endless patience;

Drs C.C. Jinabhai and H.M. Coovadia of the Faculty of Medicine, University of Natal, for their helpful suggestions;

The Tongaat Child and Family Welfare Society (Buffelsdale) for supplying useful information, and for their kind permission to use the preschool for testing purposes;

The Human Sciences Research Council for their generous grant that assisted in the financing of this project;

Mr K Haripersad of the Library section, for his assistance in locating relevant literature;

And finally, I wish to thank my parents, Pastor and Mrs I.P.Lazarus for their unending encouragement throughout my academic career.

T. LAZARUS

1984

FOR MY WIFE, RANI AND MY SONS

GERSHOM AND JOASH THEOPHILUS

CONTENTS

PAGE

CHAPTER ONE INTRODUCTION

1.1	INTRODUCTION	1
1.2	MOTIVATION	2
1.3	AIMS OF THE INVESTIGATION	4
1.4	HYPOTHESES	4
1.5	CONCLUSION	5

CHAPTER TWO DEFINITIONAL CONCEPTS

2.1	NOMENCLATURE IN THE LITERATURE ON MALNUTRITION ..	7
2.2	DEFINITIONAL CONCEPTS OF MALNUTRITION	7
2.2.1	Introduction	7
2.2.2	Categories of malnutrition	11
2.3	CRITERIA EMPLOYED IN THE DIAGNOSIS OF MALNUTRITION	16
2.3.1	Clinical signs	16
2.3.2	Biochemical measures	16
2.3.3	Tissue tests	19
2.3.4	Anthropometric measures	19
2.3.5	Summary and conclusions	25
2.4	CRITERION SYSTEMS USED IN ANTHROPOMETRY FOR THE DIAGNOSIS AND CLASSIFICATION OF MALNUTRITION	
2.4.1	Introduction	26

<u>CHAPTER THREE</u>	REVIEW OF LITERATURE-INCIDENCE AND/OR PREVALENCE STUDIES	
3.1	LITERATURE REVIEW	39
3.2	STUDIES ON THE INCIDENCE AND/OR PREVALENCE OF MALNUTRITION	40
3.3	PREVALENCE AND/OR INCIDENCE STUDIES DONE IN SOUTH AFRICA	60
3.4	PROTEIN-ENERGY MALNUTRITION (PEM) AS REFLECTED IN MORTALITY FIGURES	72
3.5	SUMMARY AND CONCLUSIONS	76
<u>CHAPTER FOUR</u>	REVIEW OF ANIMAL STUDIES	
4.1	INTRODUCTION TO ANIMAL STUDIES ON MALNUTRITION AND MENTAL DEVELOPMENT	79
4.2	FACTORS MOTIVATING THE USE OF ANIMAL MODELS IN STUDIES ON MALNUTRITION	80
4.3	REVIEW OF STUDIES PUBLISHED FROM 1963 TO 1977	82
4.4	REVIEW OF ANIMAL STUDIES REPORTED FROM 1980 TO 1982 .	100
4.5	CRITICAL ANALYSIS OF ANIMAL STUDIES ON MALNUTRITION AND MENTAL DEVELOPMENT	105
4.6	CONCLUSIONS	109

CHAPTER FIVE
LITERATURE REVIEW OF
HUMAN STUDIES

5.1	INTRODUCTION	111
5.2	MALNUTRITION AND PSYCHOLOGICAL DEVELOPMENT	112
5.3	SUMMARY AND CONCLUSIONS	134

CHAPTER SIX DESIGN OF THE STUDY

6.1	THE INVESTIGATION	148
6.2	A BRIEF DESCRIPTION OF THE SETTING	149
6.2.1	Housing and accommodation	149
6.3	INVESTIGATIVE PROCEDURES USED IN STUDY	151
6.3.1	Anthropometric measures	151
6.3.2	The biographical inventories	151
6.3.3	The Minnesota Preschool Scale (MPS)	152
6.4	PART ONE OF STUDY: THE INCIDENCE OF MALNUTRITION. 155	
6.4.1	Selection of households	155
6.4.2	Contact with study sample	156
6.4.3	Subject selection	157
6.4.4	Study visit	159
6.5	PART TWO OF STUDY: RELATIONSHIP BETWEEN MALNUTRITION AND PSYCHOLOGICAL TEST PERFORMANCE . 161	
6.5.1	Administration of psychological test	165

CHAPTER SEVEN

RESULTS

7.1	RESULTS	167
7.2	PART ONE: INCIDENCE OF MALNUTRITION	168
7.2.1	Incidence of severe and moderate malnutrition ...	168
7.2.2	Relationships between nutritional status and sex	171
7.2.3	Relationships between nutritional status and family birth position	174
7.2.4	Family size relationships	177
7.2.5	<i>Per capita</i> family income relationships	180
7.2.6	Relationships between nutritional status and maternal educational levels	183
7.3	PART TWO: ANALYSIS OF DEVELOPMENTAL, HEALTH AND NUTRITIONAL HISTORIES	186
7.3.1	Analysis of developmental histories	187
7.3.2	Health histories	192
7.3.3	Conclusions on developmental and health histories	221
7.3.4	Nutritional histories	222
7.3.5	Conclusions	262
7.4	PART THREE: NUTRITIONAL STATUS AND IQ	264
7.4.1	Total IQ analysis	264
7.4.2	Verbal and non-verbal IQ analyses	265

CHAPTER EIGHT

DISCUSSION

8.1	DISCUSSION OF RESULTS	269
8.2	SOCIAL, ECONOMIC AND POLITICAL IMPLICATIONS OF THE FINDINGS OF THE STUDY	298

CHAPTER NINE

SUMMARY

LIST OF TABLES

PAGE

TABLE

DESCRIPTION

1 Clinical findings of nutritional significance 43

in rural Punjabi children up to 40 months of age

2 Percentage of Punjabi children severely malnourished with anthropometric values falling below the third percentile on the Harvard standards 45

3 Percentage of Punjabi children classified as normal, mild-to-moderate, and severe cases of PEM on the basis of weight measures 46

4 Classification of nutritional status using the 50th percentile weight value of ALL-INDIA standards as reference data 47

5 Percentage of malnourished Bangladesh children classified on weight, height for age, weight for height, mid-upper arm circumference and triceps skinfold thickness measures 51

6 Prevalence of "significant malnutrition" as defined by Garrow(1966) on the basis of weight for age measures, among Malay preschool children under five years of age 56

7 Percentage of Black preschool children classified as malnourished according to varying anthropometric indices and reference standards 61

9 Prevalence of malnutrition among Coloured subjects one to sixteen years of age, diagnosis based on various anthropometric indices and expressed in percentages 63

10 Prevalence of malnutrition, stunting, and wasting among Black children under seventeen years of age, living in the Diepkloof area, South Africa 65

LIST OF TABLES CONTINUED.....

	PAGE
11 Percentages of Indian, White, Coloured, and Black preschool children classified as malnourished on the basis of weight measures with reference to the Harvard growth charts	68
12 Incidence of malnutrition among Indian children, classification based on weight and height for age measures using the Harvard standards as reference data	69
13 Incidence of malnutrition among Cape Coloured children, using the indices of weight, height and weight for height with reference to the NCHS standards	70
14 Mortality rates among one-to-four year olds in several countries, as an indication of PEM during that developmental period	73
15 Summary of animal studies on malnutrition from 1963 to 1977	83
16 Summary of animal studies on malnutrition published from 1980 to 1982	104
17 Summary of human studies on malnutrition and mental development	136
18 Distribution of 36-, 18-, 12-, and six-flat blocks in Buffelsdale, Flamingo Heights and Chelmsford Heights	150
19 Distribution of types of blocks, and the number of flats randomly selected for the nutritional survey	156
20 Sex and age distribution of the survey sample, according to seven age groups	158
21 Composition of male experimental and control groups in terms of the relevant variables, age (in months), and SES	163

LIST OF TABLES CONTINUED.....

	PAGE
22 Composition of female experimental and control groups in terms of the relevant variables, age (in months), and SES	164
23 Classification of nutritional status of preschoolers in the Tongaat South community, showing the incidence of malnutrition	169
24 Nutritional status x sex contingency table based on weight for age measures	171
25 Nutritional status x sex contingency table based on height for measures	172
26 Nutritional status x sex contingency table based on weight for height measures	173
27 Nutritional status x family birth position contingency table for weight for age classification	174
28 Nutritional status x birth position contingency table for height for age classification	175
29 Nutritional status x birth position contingency table for weight for height classification	176
30 Nutritional status x family size contingency table for weight for age classification	177
31 Nutritional status x family size contingency table for height for age classification	178
32 Nutritional status x family size contingency table for weight for height classification	179
33 Summary table of nutritional status x <i>per capita</i> family income of severely, moderately and adequately nourished subjects, classified on weight for age	180

34	Summary table of nutritional status x <i>per capita</i> family income of severely, moderately and adequately nourished subjects, classified on height for age	181
35	Summary table of nutritional status x <i>per capita</i> family income of severely, moderately and adequately nourished subjects, classified on weight for height ratios	182
36	Nutritional status x maternal educational level contingency table for weight for age classification	183
37	Nutritional status x maternal educational level contingency table for height for age classification	184
38	Nutritional status x maternal educational level contingency table for weight for height classification	184
39	Nutritional status x sitting age contingency table for severely, moderately and adequately nourished subjects	187
40	Nutritional status x crawling age contingency table for severely, moderately and adequately nourished subjects	188
41	Nutritional status x walking age contingency table for severely, moderately and adequately nourished subjects	189
42	Nutritional status x talking age contingency table for severely, moderately and adequately nourished subjects	190
43	Nutritional status x general family planning contingency table for responses of mothers of subjects	193

LIST OF TABLES CONTINUED...

(ix)

PAGE

44	Nutritional status x maternal reactions to pregnancy contingency table for mothers of severely, moderately and adequately nourished subjects	194
45	Nutritional status x paternal reactions to pregnancy contingency table for fathers of severely, moderately and adequately nourished subjects	195
46	Nutritional status x ante-natal care attendance contingency table of mothers in the different nutritional groups	196
47	Nutritional status x ante-natal care service contingency table for mothers of severely, moderately and adequately nourished subjects	197
48	Frequency of ante-natal care visits at a professional centre	198
49	Nutritional status x frequency of ante-natal care visits contingency table of mothers of severely, moderately and adequately nourished subjects	199
50	Nutritional status x physical trauma contingency table for mothers of severely, moderately and adequately nourished subjects	200
51	Nutritional status x maternal smoking habits contingency table of mothers of severely, moderately, and adequately nourished subjects	201
52	Nutritional status x maternal prenatal psychological trauma contingency table for mothers of severely, moderately and adequately nourished subjects	203

LIST OF TABLES CONTINUED....

	PAGE
53 Nutritional status x type of birth delivery contingency table for severely, moderately and adequately nourished subjects	207
54 Nutritional status x birth weight contingency table of severely, moderately and adequately nourished subjects	208
55 Duration of labour during childbirth of mothers of severely, moderately and adequately nourished subjects	210
56 Nutritional status x duration of labour contingency table for mothers of severely, moderately and adequately nourished subjects	211
57 Nutritional status x place of birth delivery contingency table of severely, moderately and adequately nourished subjects	212
58 Officers in charge of delivery at the births of severely, moderately and adequately nourished subjects	213
59 Nutritional status x birth delivery officer contingency table of severely, moderately and adequately nourished subjects	214
60 Nutritional status x neonatal problems contingency table of severely, moderately and adequately nourished subjects	215
61 Nutritional status x daily caretaker contingency table for caretakers of severely, moderately and adequately nourished subjects	218

LIST OF TABLES CONTINUED...

PAGE

62	Nutritional status x time spent by father with child contingency table for severely, moderately and adequately nourished subjects	219
63	Summary table of the various developmental and health relationships examined by means of the χ^2 analysis	221
64	Foods eaten by mothers during their pregnancies with severely, moderately and adequately nourished subjects, respectively	223
65	Nutritional status x mother's rating of child's appetite contingency table	224
66	Duration of breast feed among the severely, moderately and adequately nourished subjects	226
67	Nutritional status x duration of breast feed contingency table of severely, moderately and adequately nourished subjects	227
68	Weaning ages of severely, moderately and adequately nourished subjects	228
69	Nutritional status x weaning ages contingency table for severely, moderately and adequately nourished subjects	229
70	Nutritional status x type of weaning foods contingency table for severely, moderately and adequately nourished subjects	230
71	Nutritional status x eating regularity contingency table for severely, moderately and adequately nourished subjects	231
72	Foods eaten by severely, moderately and adequately nourished subjects for breakfast over three days	234

LIST OF TABLES CONTINUED.....

PAGE

73	Nutritional status x foods contingency table for foods eaten for breakfast over three days	235
74	Summary of χ^2 s for nutritional status x foods eaten for breakfast over three days	236
75	Foods eaten by severely, moderately and adequately nourished subjects for lunch over three days	239
76	Nutritional status x food contingency table for foods eaten at lunch over three days	241
77	Summary of χ^2 s for nutritional status x foods eaten for lunch over three days	242
78	Foods eaten by severely, moderately and adequately nourished subjects for supper over three days	245
79	Nutritional status x foods eaten contingency table for types of foods eaten for supper by severely, moderately and adequately nourished subjects over three days	246
80	Summary of χ^2 analyses for nutritional status x foods eaten for supper over three days	247
81	Monthly food expenditure of families of severely malnourished subjects	249
82	Monthly food expenditure of families of moderately malnourished subjects	250
83	Monthly food expenditure of families of adequately nourished subjects	250
84	Food-purchasing agents of families of severely, moderately and adequately nourished subjects	252

LIST OF TABLES CONTINUED.....

PAGE

85	Nutritional status x food-purchasing agent contingency table for families of severely, moderately and adequately nourished subjects	252
86	Loaves of bread bought daily by families of severely malnourished subjects	253
87	Loaves of bread bought daily by families of moderately malnourished subjects	253
88	Loaves of bread bought daily by families of adequately nourished subjects	254
89	Types of milk purchased by the families of severely, moderately and adequately nourished subjects	255
90	Nutritional status x type of milk contingency table for milk bought by families of severely, moderately and adequately nourished subjects	255
91	Litres of milk bought by the families of severely malnourished subjects	256
92	Litres of milk bought daily by families of moderately malnourished subjects	257
93	Litres of milk bought by families of adequately nourished subjects	257
94	Summary table of various relationships examined by means of the χ^2 analysis	259
95	Summary table of a total IQ x nutritional status ANOVA, of 82 subjects on the Minnesota Preschool Scale	264
96	Summary table of verbal and non-verbal IQ x nutritional status ANOVA of 82 subjects on the Minnesota Preschool Scale	266

LIST OF FIGURES

FIGURE	DESCRIPTION	PAGE
1	Graphical representation of nutritional status, classified on three anthropometric indices	170
2	Ecological - family factors influencing nutritional status	292

APPENDICES

PAGE

A	Biographical inventory for nutritional survey	306
B	Biographical inventory for study of malnutrition and psychological test performance	310
C	Letter sent to households randomly selected for nutritional survey	317
D	Letter sent to parents of those children selected for psychological testing	319
E	Classification of occupations according to the Institute for Social Research, University of Natal	321
F	Illustration of statistical computations using selected data from the study	323

REFERENCES

330

INDEX TO CHAPTER ONE

1.1 Introduction

1.2 Motivation

1.3 Aims of the investigation

1.4 Hypotheses

1.5 Conclusion

CHAPTER ONE

1.1. INTRODUCTION

Human communities have been subjected to periodic famines at least since the development of agriculture initiated by Neolithic man. Paleolithic man, who came earlier and was primarily a hunter, must also have suffered periods of severe hunger and subsequent malnutrition. However, the recognition of malnutrition as a health hazard has emerged at a later point in time.

According to Aykroyd (1970) a key factor in the high infant mortality rates during the early 1900's was malnutrition. The accompanying concern stimulated much research in the field, resulting in a curbing of mortality rates associated with malnutrition.

Subsequently, concern has shifted to those children who survive an episode of malnutrition. Attempts have been made to establish the proportion of such individuals. The difficulties in reaching these goals have been only too apparent. While it is easy to obtain the percentage of malnourished children from hospital records, a large portion of unhospitalized cases go unnoticed. There is considerable evidence to suggest that hospitalized cases reflect only "the tip of the iceberg" of this problem. (Jelliffe and Jelliffe, 1966; 1969).

There have been proposals that assessing the growth status using anthropometric measures may enable the identification of subclinical cases of malnutrition. Though successful, such measurements are subject to careful employment.

The effects of malnutrition early in life on later behaviours have been difficult to assess in view of the several confounding variables. However, there appears to

be a large body of literature implicating infantile malnutrition in poor intellectual development (Klein, Lester, Yarbrough and Habicht, 1975). Despite the number of studies, the evidence remains inconclusive.

Therefore, it seems important to ascertain the prevalence of malnutrition, and whether the condition affects behaviour, in particular mental development.

1.2. MOTIVATION

The following factors motivated this study:

- (i) Although there are worldwide figures for malnutrition (Keppel, 1968; Bengoa, 1974), such information in South Africa is lacking. This is particularly the case for Indian South Africans, specifically the preschool age group. There appears to be the implication that malnutrition does not constitute a health problem among Indian preschoolers. Consequently, much of the research in the field has been concentrated on the Black population. An investigation into the incidence of malnutrition among Indian preschoolers in an urban community would provide factual information on the nutritional patterns of such individuals.

- (ii) There appears to be strong evidence suggesting that malnutrition may be associated with lowered IQ scores and mental abilities (Stoch and Smythe, 1963, 1967, 1982; Richardson, 1976). The evidence is not conclusive in the light of the several inherent problems in such research designs. Therefore, a study comparing the IQ scores of severely, moderately, and adequately nourished children may contribute to the literature in the field.

(iii) The physiologic mechanisms of brain growth have been a strong motivating factor. In the earliest periods of life, the brain grows much faster than any other part of the body. By the age of four years, 90 per cent of the adult brain weight is reached (Stoch and Smythe, 1963; 1967). Studies with animals demonstrate that malnutrition reduces subsequent learning ability and memory and adversely affects behaviour (Guthrie, 1968) when instituted during the period of rapid brain growth.

(iv) There have been reports that more than half the children under the age of six in the entire world have suffered from malnutrition of varying degrees (Keppel, 1968). The major proportion of these individuals are moderately malnourished, and have not been identified. Consequently, the literature on the effects of malnutrition in such populations is severely lacking.

A study identifying and studying the IQ scores of moderately malnourished individuals will provide information on this area.

Furthermore, the incidence of malnutrition and the IQs of malnourished preschool populations will serve to inform on the state of child health among Indian South Africans in general.

From the above it can be seen that information on the nutrition patterns of Indian South Africans is lacking. The effects of malnutrition *per se* on mental development is far from clear. This investigation may, therefore, provide such information, and thereby enhance the literature in this field.

1.3. AIMS OF THE INVESTIGATION

The specific aims of this study are:

- (i) To establish the incidence of severe and moderate malnutrition among Indian preschoolers (two to five years of age, inclusive) in an urban community, using anthropometric indices, and to investigate relevant variables;
- (ii) To compare the IQ scores of a severely malnourished group with those of a matched group of controls;
- (iii) To compare the IQ scores of a moderately malnourished group with those of a matched group of controls;
- (iv) To compare the IQ scores of a severely malnourished group with those of a matched group of moderately malnourished subjects.

1.4. HYPOTHESES

In order to fulfil the aims listed above, the following hypotheses will be tested:

- (i) The incidence of malnutrition among Indian preschoolers is high.
- (ii) The severely malnourished group has lower IQ scores than the moderately malnourished group.
- (iii) The severely malnourished group has lower IQ scores than the control group.
- (iv) The moderately malnourished group has lower IQ scores than the control group, but higher than the severely malnourished group.

1.5. CONCLUSION

In this chapter, an attempt was made to delineate the problems to be investigated, and to formulate the aims and hypotheses of the present study. The definitional concepts, relevant empirical research and the design of the investigation are further discussed in the subsequent chapters.

INDEX TO CHAPTER TWO

- 2.1 Nomenclature in the literature on malnutrition.
- 2.2 Definitional concepts of malnutrition
 - 2.2.1 Introduction
 - 2.2.2 Categories of malnutrition
- 2.3 Criteria employed in the diagnosis of malnutrition
 - 2.3.1 Clinical signs
 - 2.3.2 Biochemical measures
 - 2.3.3 Tissue tests
 - 2.3.4 Anthropometric measures
- 2.4 Criterion systems used in anthropometry for the diagnosis and classification of malnutrition
 - 2.4.1 Introduction
 - 2.4.2 Anthropometric growth charts
 - 2.4.3 Classification systems using anthropometric growth charts
 - 2.4.4 Summary

CHAPTER TWO

2.1 NOMENCLATURE IN THE LITERATURE ON MALNUTRITION

The terminology in the field of malnutrition is varied. To achieve an effective management and employment of the terms, they need to be clarified and defined. There are, however, three related concepts pertaining to nutrition that have been arisen repeatedly but have failed to receive clarification in the literature. These terms are nutrition, nutriture and nutritional status.

(i) Nutrition is the process by which the organism uses food, or anything normally ingested through digestion, absorption, transport, storage, metabolism and elimination for purposes of maintenance of life, growth, normal functioning of organs and the production of energy" (McLaren, 1976).

(ii) Nutriture is described by McLaren (1976) as "the state resulting from the balance between supply of nutrition on the one hand, and the expenditure of the organism on the other". This definition is tantamount to defining nutriture as the physiological state which arises from the availability of nutrients to the cells.

(iii) Nutritional status is the expression of nutriture in a specific variable (Habicht, Yarbrough and Martorell, 1979). Therefore, one must always specify the variable or variables when referring to nutritional status, e.g., nutritional status as reflected in height measures. Accordingly, growth in height becomes an indicator of nutritional status. The difference between nutritional status and its indicators is that the indicators also reflect the non-nutritional influences on nutritional status.

(iv) Indicators of Nutritional status An indicator of nutritional status is a variable which allows for the

the expression of nutriture. The sensitivity of an indicator of nutritional status is a function of the extent to which it "reflects or predicts changes" in nutriture (Habicht, Yarbrough and Martorell, 1979). Two types of indicators have been defined, reflective and predictive indicators.

Reflective indicators are those variables which reflect events of present and past nutriture. For example, small height for age is indicative of chronic malnutrition, reflecting past nutriture. Predictive indicators are those variables that predict future outcomes, such as improved performance, or death due to malnutrition.

Some indicators may be both reflective and predictive at the same time. For example, weight for age reflects acute malnutrition and predicts mortality (Gomez, Galvan, Frenk, Cravioto-Munoz, Chavez and Vasquez, 1956). The accuracy of reflective and predictive indicators is based on how accurately the change in nutritional status reflects what the change in nutriture is. For example, weight for height is considered to be a sensitive indicator of severe protein - energy malnutrition (PEM) in preschool children. Similarly, it has been shown that growth in head circumference (HC) seems to be a sensitive indicator of PEM during the first two years of life, but growth in head circumference may have no relationship to nutritional status thereafter (Habicht *et al* , 1979).

Furthermore, the quantification of the relationships between nutritional status indicators and nutriture improves the accuracy of indicators. This feature enables the specification of the magnitude of change in the indicator that is expected at various levels of nutriture, thereby enhancing the identification of malnourished cases.



Habict *et al* (1979) proposed that the relationships between nutriture and nutritional status are physiological in nature, and will be similar from population to population over similar ranges of nutriture.

SUMMARY

There are three related concepts pertaining to nutrition that need some clarification. Nutrition may be considered to refer to those processes whereby the organism utilizes any material that has been ingested for its normal physical functioning. The term nutriture refers to the homeostasis that exists between the supply and the utilization of nutrients for this physical functioning. Nutritional status is defined as an expression of nutriture in a specific variable, e.g., height for age. Height for age is considered a reflective indicator which reflects past nutriture. A predictive indicator predicts future outcomes, e.g., weight for age. Indicators are considered accurate if they are able to reflect (or predict) what the change in nutriture was (or will be) on the basis of changes in the nutritional status.

For the current study, the terms nutrition, nutriture, and nutritional status will be employed in the context of the definitions presented. Next, the definitions used in malnutrition will be discussed.

2.2 DEFINITIONAL CONCEPTS OF MALNUTRITION

2.2.1 INTRODUCTION

According to Klein, Irwin, Engle and Yarbrough (1977), malnutrition is a difficult concept to operationalize because, while it refers in part to input, that is, the food eaten, the only measures usually available are output measures. that is, growth or health status. Thus, the

criteria for the classification of malnutrition are all inferential, with past malnutrition inferred from present physical state. Several attempts at providing a uniform definition of malnutrition have been made, of which some of the more prominent efforts will be discussed.

McLaren and Read (1972) broadly defined the malnourished condition as disordered nutrition of any kind which includes both undernutrition and overnutrition. They emphasized that the term protein-calorie malnutrition (PCM) is generally accepted, which enables the classification of the various manifestations of the forms of malnutrition that are widespread in childhood.

Read (1973) maintains that malnutrition is the "state of impaired functional ability or development caused by an inadequate intake of essential nutrients or calories to provide for long-term needs". There is an inherent implication that the functioning and development of the organism suffering from inadequate nutrition are not operating at optimal levels. Furthermore, this definition provides two criteria for the diagnosis of malnutrition, (a) a state of impaired functional ability, and, (b) an inadequate intake of essential nutrients or calories.

The term PCM has subsequently been adjusted to protein-energy malnutrition, or PEM, by the World Health Organisation (WHO). They contend that energy is the property at issue, whereas calories and joules are merely units used to measure energy. The WHO and the Food and Agriculture Organisation (FAO) (1973) subsequently defined PEM as a "range of pathological conditions arising from coincident lack, in varying proportions, of protein and calories, occurring most frequently in infants and young children, and commonly associated with infections".

Implicit in this definition is the acknowledgement that

PEM is a continuum of diseases varying in relation to extent of deficiency of either protein or calories.

On the basis of extent and duration, PEM may be subdivided into "severe", "moderate", and "mild" categories of malnutrition. These categories will be discussed next.

2.2.2 CATEGORIES OF MALNUTRITION

2.2.2.1 SEVERE MALNUTRITION

According to Read (1973) the severely malnourished condition results from prolonged protein and/or calorie restriction in early childhood. Gurney (1979) added that severe PEM is made up of a spectrum of conditions. He quotes Waterlow (1948) as proposing that the two extremes of this spectrum are represented by two separate clinical syndromes - *starvation (or nutritional) marasmus* and *kwashiorkor*. Between these two syndromes fall the intermediate categories, including *marasmic kwashiorkor*.

(1) Starvation Marasmus

According to Read (1973) *marasmus* is caused by inadequate food intake, particularly of calories, from birth or shortly thereafter. Furthermore, this deficiency in total dietary energy, according to Gurney (1979) is derived from carbohydrates, fats, or protein.

(i) Age-of-onset:

According to Gopalan (1967; 1968) *starvation marasmus* has its maximal incidence during the period of six to 18 months of age in the individual's life-span when the quantity of the mother's breast milk is not sufficient to provide adequate protein and calories for the growing child and when supplementary feeding is inadequate.

(ii) Clinical Picture:

According to Read (1973), the marasmus condition is manifested in tissue wasting and severe growth retardation. Gopalan (1968) maintains, however, that there is no oedema (inflammation or accumulation of interstitial fluids in excessively high amounts which impedes nutrition of cells (Ganong, 1975; Guyton, 1974)).

(2) Kwashiorkor:

According to Williams (1963) who introduced this term, kwashiorkor refers to the "disease of the deposed baby". Read (1973) reports that kwashiorkor results from inadequate protein intake and occurs when the child changes from breast or bottle milk to foods high in starch content, but low in protein. Gurney (1979) proposes that the kwashiorkor route to severe malnutrition implies a diet deficient in protein with a relative sufficiency of total energy, that is, calories.

(i) Age of onset:

According to Gopalan (1967), the condition is generally seen in children one to three years of age. This is usually due to inappropriate weaning foods being introduced into the diet of the child.

(ii) Clinical picture:

Gopalan (1967) states that there is a typical growth failure and in addition hypo-proteinanaemia (decreased serum protein) and oedema, which together form the diagnostic criteria for the disease. There is often a loss of appetite, increasing apathy, and the child may develop discolouration of the hair and skin and a characteristic fullness of the face (moon-faced).

(3) Marasmus-kwashiorkor:

Since there exists a continuum between marasmus and kwashiorkor, the marasmus-kwashiorkor condition prevails when weight drops below 60 per cent of accepted reference standards, and oedema is present (Wellcome, 1970).

(i) Age-of-onset:

According to Gopalan (1967) such a condition can exist between six months and three years of age.

(ii) Clinical picture:

Suskind (1977) notes that this patient has a reduction in statural growth and weight, a marked diminution of subcutaneous fat, a much greater degree of muscular wasting than do children with kwashiorkor, and a liver that has evidence of mild to moderate fatty infiltration. Next, a category of malnutrition of less severity, moderate malnutrition, will be discussed.

2.2.2.2 MODERATE MALNUTRITION

According to Read (1973) a restriction in both the quantity and quality of food intake results in moderate or chronic malnutrition. Gurney (1979) contends that because of the reduced dietary calorie and protein intakes, a reduction in the rate of increase of the cells operates as an adaptive mechanism of growth. When the deprivation is slight, the growth failure may be minimal and difficult or impossible to measure. If it is small and balanced, according to Gurney (1979), the child may be somewhat stunted and appear well-proportioned and normal to the average observer. However, as the deficit becomes more severe and more unbalanced, so does the growth failure.

Read (1973) emphasizes further that a child confronted with this condition is more susceptible to such childhood

diseases as measles, diarrhoea or pneumonia. Furthermore, dietary energy deficiencies diminish energy output as activity. However, a low activity level is hard to define and measure, and even harder to show that its derivation is a direct result of dietary restrictions (Gurney, 1979). Consequently, activity levels, despite their importance, are not objective indicators of moderate malnutrition. It seems though that the law of conservation of energy (which states that energy is neither created nor destroyed, but transformed from one form to another) supports the clinical finding that children whose diets are inadequate in energy, are less active than those children who are well fed (Gurney, 1979). The category of moderately malnourished subjects has become increasingly important with the realization that the syndromes of kwashiorkor, marasmus, and marasmic kwashiorkor constitute only a small part of the overall problem of malnutrition (Bengoa, 1970). Incidence figures for moderate malnutrition are lacking in view of the tedious investigative techniques involved in identifying these cases.

A less severe category of malnourished cases are those suffering from mild malnutrition, which is presented next.

2.2.2.3. Mild Malnutrition

McLaren and Read (1972) defined cases of mild malnutrition as those evidencing 85 to 90 per cent of reference standards on weight for length measures. Gurney (1979) noted that despite the well-proportioned and balanced picture presented by the child, reduced activity levels become obvious.

The term 'subclinical malnutrition' is sometimes used to refer to moderate and mild cases of malnutrition. No

clinical signs or obvious illnesses are presented by these cases. Another category of malnourished cases sometimes identified is nutritional dwarfism, which is discussed next.

2.2.2.4. Nutritional Dwarfism

The category nutritional dwarfism was described by Monckeberg (1968) in Chile. These are subjects who, presumably through underfeeding have never grown normally from birth and at 12 months have hardly exceeded their birth weight. McLaren *et al* (1972) have called these cases as the "late effects of PCM who have a normal weight for height ratio".

2.2.2.5. Summary

Malnutrition is difficult to define since it is measured in terms of inferential data. McLaren *et al* (1976) included both under- and overnutrition in their definition of malnutrition. The WHO and FAO (1973) proposed that protein-energy malnutrition (PEM) includes all malnourished states which result from protein and calorie deficiencies. Severe, moderate and mild categories of malnutrition are defined according to the extent and duration of these deficiencies. Severely malnourished syndromes consist of marasmus, kwashiorkor and marasmic kwashiorkor as its clinical manifestations. Moderately and mildly malnourished cases are usually identifiable by anthropometric measurement techniques. Monckeberg (1968) advanced the 'nutritional dwarfism' category of malnutrition from observations on the Chilean population to include children whose weights after a year are markedly similar to their birth weights.

Several criteria are employed in diagnosing malnutrition.

These criteria will be presented next, with an emphasis on anthropometric measures.

2.3 CRITERIA EMPLOYED IN THE DIAGNOSIS OF MALNUTRITION

Scientists in the field of malnutrition have already recognised the need for criterion measures and systems for the diagnosis and classification of malnourished cases. According to Roche and Falkner (1974) there are four main categories of criterion systems which are generally used.

2.3.1 Clinical Signs

Clinical signs have formed the most popular category for diagnosis. Suskind (1977) notes that marasmic children evidence growth retardation, weight loss, muscular atrophy and a severe decrease of subcutaneous tissue. Children with kwashiorkor have a picture characterized by oedema, skin lesions, hair changes, apathy, anorexia, and an enlarged, fatty liver. These children have abundant subcutaneous fat (Behar, Viteri, Bressani, Arroyave, Squibb and Scrimshaw, 1958). However, despite the general consensus among scientists on these clinical signs, Roche *et al* (1974) cautions that it is being increasingly appreciated that clinical signs are very variable and highly subjective and depend greatly on the experience of the clinician. These factors may impose limitations on the use of clinical signs in field studies of malnutrition.

2.3.2. Biochemical Measures

McLaren and Read (1972) noted that when biochemical measures are used for diagnosing malnutrition, they should be regarded and interpreted in the light of an overall evaluation which includes other diagnostic techniques. Lloyd-Still (1976) emphasized that attempts to provide a satisfactory biochemical test for malnutrition suitable for use in

all parts of the world have not been successful.

Lloyd-Still (1976) and Roche *et al* (1974) have subsequently proposed the following tests as forming the biochemical assessment technique.

2.3.2.1. Total Serum Protein and Albumin

Children suffering from kwashiorkor usually evidence reduced levels of blood serum protein and albumin. On the other hand children suffering from marasmus can present with normal total protein and albumin concentrations. Although these tests are easily dispensed with in a clinical setting, McLaren *et al* (1972) caution that results cannot be treated in isolation but in the general milieu of other biochemical measures.

2.3.2.2. Fasting Urinary Urea-Creatinine Ratio

In children on a low-protein diet, low ratios of fasting urinary urea-to-creatinine (a protein) are found (Lloyd-Still, 1976). Even in this test, caution must be exercised in interpreting results which must be done in conjunction with other biochemical tests (Roche *et al*, 1974).

2.3.2.3. Blood Serum Amino Acid (a.a.) Ratio

When compared to the pattern of normal individuals, kwashiorkor patients have been found to show a disturbed serum amino acid pattern. Thus, the test is a good reflection of primary protein deficiency. However, the test is of no positive help in marasmus where there is a total lack of calories (Lloyd-Still, 1976).

Another disadvantage of this test is that it must be ensured that the sample of blood serum used in the analysis

be taken when fasting. It has been widely documented (Lloyd-Still, 1976; McLaren *et al* 1972; Roche *et al* 1974) that under more variable conditions, erroneous results may be obtained.

In the light of this argument, one can appreciate the reluctance with which field workers have used this technique of assessment.

2.3.2.4. Urinary hydroxyproline index

This test is based on the fact that the excretion of the amino acid hydroxyproline peptides is very low in nutritionally dwarfed children. Although useful in identifying these cases, the requirements of a 24-hour sample impedes the employment of this test under field conditions. In addition, intercurrent infections such as hookworm or malaria result in high excretions of hydroxyproline thereby confounding results (Lloyd-Still, 1976).

2.3.2.5. Urinary creatinine-to-height index

According to Lloyd-Still (1976) the urinary creatinine-to-height ratio depends on the fact that a loss of muscle in malnutrition results in a reduction of the creatinine excreted per 24 hours. However, McLaren *et al* (1972) warn that this index has not given a consistent indication of recovery from severe PEM of the marasmic type. This is largely due to the variable 24-hour excretion figures for creatinine. Thus, Fomon (1974) advocated a minimum period of 72 hours collection. However, this test is confounded by the gross lack of comprehensive standard values of creatinine excretion for healthy, pre-school-aged children (McLaren *et al* 1972).

In assessing the status of biochemical measures as a criterion system for diagnosing malnutrition, Lloyd-Still (1976) argues that few of these tests are easy or practical. Jelliffe (1966) also emphasized the need for accurate interpretation when employing biochemical tests. The wide variation of the malnutrition syndromes plus the superimposed factors of infection and parasitic infestation preclude the development of a single biochemical test for malnutrition. There has consequently been an increasing tendency to use biochemical tests selectively, and sometimes only on subsamples because of their cost (Roche, *et al*, 1974).

Another criterion system proposed for the diagnosis of malnutrition comprises tissue tests.

2.3.3. Tissue tests

According to Roche *et al*, (1974) an examination of hair root morphology in an example of a tissue test. Hair, as a sensitive protein tissue, indicates the early effects of protein malnutrition by changes in its bulb root diameter when serum albumin levels are still within normal limits. Although age-independent, the results need to be combined with anthropometric measures to prove useful in diagnosing malnutrition (Roche *et al*, 1974).

Anthropometric measures have become an increasingly important tool in the identification of malnourished cases. This criterion system will be discussed next.

2.3.4. Anthropometric Measures

Anthropometric measurements have received increasing acknowledgement for their role in diagnosing subclinical malnutrition. In fact, several authorities emphasize

that such measures can more meaningfully reveal the extent of the problem of malnutrition in a community.

2.3.4.1. Definition of Anthropometric Measures

Anthropometric measurements involve the measuring of body size and shape (Roche, *et al*, 1974). The object of these measures is to provide a practical basis for the evaluation of nutritional status. The evaluation rests on a comparison of the body measurements of groups of comparable age and of the growth patterns of infants and children (Prinsloo, 1964). Some anthropometric measures are weight and height for age, weight for height, head and mid-upper arm circumferences, and fatfold thicknesses.

These measures will be discussed next.

(i) Weight for age

According to Greene (1977), Gomez, Galavan, Cravioto, and Frenk (1955) were among the first to define malnutrition in terms of deficits in weight for age. Perseverance in using weight for age in the assessment of nutritional status is due to its accuracy of measurement and the fact that the results are readily reproducible (McLaren, 1972). Seoane and Latham (1971) note that although weight is the commonest indicator currently used for establishing nutritional status in most countries, this parameter alone does not shed light on the acuteness or chronicity of the malnutrition. The weight measured does not enable one to determine whether the child is currently on a deficient diet, or alternately, whether he has evidence of past malnutrition but is now on a satisfactory diet. For this reason, other anthropometric measures are useful. One such measure is height for age.

(ii) Height for age

Seoane and Latham (1971) emphasized that height is a more stable growth parameter than is weight. The reasons advanced for this position are that once height levels are attained, they cannot be lost and, a reasonably long period on a deficient diet is necessary before height growth is significantly retarded. In contrast, weight is commonly lost as a result of dietary deficiencies or disease, and it can be lost over a reasonably short period of time. Thus, according to Suskind (1977) the child who has a decreased height for age value is stunted or chronically malnourished.

Although weight and height for age values are relatively easy to assess, the precise chronological ages of subjects are often difficult to determine, particularly in illiterate populations. In view of this finding, an age-independent parameter was suggested by Seoane and Latham (1971).

(iii) Weight for height

Seoane and Latham (1971) note that this parameter is a determination of the degree of thinness of the child in relation to his height. This measure provides an index of the current nutritional status of the subject. A child with a low percentage of weight in relation to height suggests that the child currently is, or in the period immediately prior to the examination, has been on a deficient diet and a diet that is probably deficient in calories and/or protein. Therefore, it is obvious that this parameter when observed in isolation, does not separate the children who have had past malnutrition or chronic malnutrition and those subjects who may have retarded growth both in length and weight. Beside weight and height measures, optimal circumferences

form another important anthropometric measure.

(iv) Optimal circumferences

According to Garn (1979) a number of circumferences may be used in nutritional surveys and chemical assessments. Depending on the age group, sample, purpose, and opportunities, all of these circumferences may be employed, or none of them. The types of circumferences generally used in nutritional surveillances are the following.

(1) Head circumference

According to Garn (1979), this measure has at least two purposes and uses. Firstly, it enables the identification of developmentally retarded and neurologically impaired individuals, especially in the younger ages. Secondly, it is possible to identify nutritional growth failures, where the chest or arms fail to increase relative to the head, as where early PEM is common. Furthermore, Winick and Rosso (1969) point out that this measurement is most commonly used to monitor brain growth since head circumference correlates significantly in the first year of life with brain cell number. Extending this observation, Habicht, Yarbrough and Martorell (1979) caution that although growth in head circumference seems to be a sensitive indicator of protein-energy nutritional status during the first two years of life, growth in head circumference may have no relationship to nutritional status thereafter. Assuming a constant relationship between growth in this measure and protein-calorie nutritional status at different ages is therefore inaccurate. This measure has subsequently been employed for individuals below the age of two years.

(2) Mid-upper arm circumference (MUAC)

Garn (1979) proposes that arms or legs are of immediate diagnostic importance in those geographic areas where PEM is common. Jelliffe and Jelliffe (1969) note that the MUAC is a simple and rapid measurement of PEM and is being increasingly used as a public health index of PEM. Neumann (1979), in further justifying the use of MUAC stated that decreased MUAC may represent a diminution of muscle mass and/or subcutaneous tissue and an increase may represent increased fat and/or muscle mass. Secane and Latham (1971) caution, however, that in proposing the use of MUAC, the assumption is made that the diameter of the humerus (upper arm) is relatively constant, so that it is included with muscle mass. They continue that although upper arm and muscle circumference are both reduced in severe malnutrition, the usefulness of this measure as a diagnostic tool in milder cases of malnutrition remains questionable.

Commenting on the usefulness of MUAC as a ratio to height, Waterlow (1972) claims that this value conveys the same information as weight for height, since a thin person tends to have thin arms. However, this ratio is less sensitive and less accurate than weight for height. Waterlow (1972) posits this view because arm circumference is a linear measurement and weight is a cubic one, and furthermore the percentage error in the former is likely to be greater.

Gurney and Jelliffe (1973) have proposed the following formula for the computation of estimated arm muscle circumference (Cm):

$$Cm = Ca - \pi S$$

where Ca = arm circumference

S = triceps fat fold

π = phi, or $\frac{22}{7}$

To alleviate the problem of calculations, the authors have developed a nomogram for the simple assessment of arm muscle circumference.

Despite the advancement in this measure, Brozek (1974) emphasizes the reserve with which this index is employed. The prime reason for this situation is the gross variation in results that are obtained with this measure. Another anthropometric measure suggested for use in malnutrition surveys is fatfold thickness which is presented next.

(v) Fatfold thicknesses

Garn (1979) stated that fatfolds "tell us how fat a person is, both in absolute terms, and relative to peers and various standards". Four or five fatfold sites in the body may be considered, among these the triceps, subcapular, abdominal, and iliac or lowest-rib site. These values measure the compressed double fold of fat plus skin, when standardized calipers are used. In addition, a defined pressure in grams per square millimeter, a defined jaw area, and hence a defined force must be employed for consistent results. Moreover, there are situations in which fatfolds should not be taken, for example, oedema and situations where fatfolds are affected by physiologic status, for example, pregnancy (Garn, 1979).

Thus, even more than length and weight, fatfold measurements demand careful instruction and regular replication so as to optimize its value. By virtue of modesty and the limits of the calipers themselves, the measurement of fatfold thicknesses is not usually practicable in field surveys.

The use of anthropometry in the assessment of nutritional

status is accompanied by a substantial degree of flexibility in technique. However, Zervas (1979) maintains that with consistent and rigorous techniques, anthropometry has become increasingly informative of the nutritional status of individuals and thereby of a population.

2.3.5. Summary and Conclusions of Criterion Systems

From the foregoing review, it becomes apparent that the use of clinical, biochemical and tissue tests are optimally convenient, beneficial and precise when executed in an environment conducive to such measures. One such environment is the hospital setting where samples of blood and the recording of clinical signs can be done under the rigorous conditions of control that are prerequisites for such tools. In the survey of a community where subjects are not hospitalized, the clinical, tissue and biochemical criterion system are usually impracticable.

Thus, in the current survey of the community, the anthropometric criterion system has been utilized with ease and precision, as will be demonstrated in the later chapters. However, not all of the anthropometric indices have been utilized. Those indices requiring strict controls of measurement, i.e., optimal circumferences and fatfold thicknesses, have been excluded from the classification system to be utilized. Therefore, the criterion classification system employed consisted of weight for age, height for age and weight for height. The former two measures were actively recorded, while the latter was derived from the former two measurements.

To facilitate the use of anthropometry in diagnosing and classifying the different categories of malnutrition, several criterion systems have been proposed based on

growth charts. These systems will be presented next.

2.4. Criterion Systems Used in Anthropometry for the Diagnosis and Classification of Malnutrition

2.4.1. Introduction

Anthropometry involves the measurement of body shape and size (Roche, *et al*, 1974) in a specific anthropometric measure or growth parameter. Several anthropometric growth charts which have been prepared from well-nourished populations have been proposed for international use in diagnosing malnutrition. These charts are discussed next.

2.4.2. Anthropometric Growth Charts

Anthropometric growth charts are curves depicting continuous change in several anthropometric measures over a period of time. These curves reflect the growth patterns of well-nourished individuals at different age levels. Those anthropometric indices which form the basis for these growth charts are weight, height, weight for height, optimal circumferences (head and arm circumferences) and skinfold thicknesses. One purpose of these growth charts is to monitor the growth of individuals over a period of time, and hence are called reference data. A more important use of these charts is to classify the nutritional status of subjects and thereby identify malnourished individuals.

There has been increasing criticism to the use of those growth charts (specifically of weight and height) which have been constructed in developed countries for employment in developing countries. There have subsequently been suggestions that population specific growth charts be employed in classifying nutritional status. The main issue

in this argument is that of genetic differences in physical growth. This controversy will be discussed by examining two aspects, the criteria employed in constructing charts and the evidence for genetic influences on growth in weight and height.

Several criteria have been proposed by the International Union of Nutritional Sciences (IUNS, 1972) for the construction of reference growth charts. Of these, a need for data to be drawn from well-nourished subjects and large sample sizes from two important requirements. In fact, the IUNS (1972) has suggested that at least 100 to 200 individuals be included at each age level, and sexes presented separately. It has long been accepted that these conditions can hardly be met in developing countries for several reasons. Waterlow (1976) cautioned that in drawing growth curves from the data of well-nourished and medically "well-cared-for" subjects in developing countries, there is the risk that numbers may be inadequate and unrepresentative of the country to warrant use as reference data. Conversely, if a representative sample is drawn in a developing country, then children with poor medical care and illness are included in the reference standards (Wolanski, 1974). Evidence for such problems of population - specific standards are suggested in certain studies. For example, when the Indian Council of Medical Research (ICMR, 1972) standard which represented data from Indian children were used in nutritional studies, a lower percentage of children were classified as malnourished, when compared to the figures obtained on the international Harvard growth charts. (Neumann, Shankar and Uberoi, 1969).

All reference standards are further complicated by the "secular" or generational trend, which, according to Garn, Robinow and Bailey (1979) has added one centimetre to adult stature every decade for the last 100 years. They

report that the secular increase in size seem to have levelled off for the middle income groups, so that the "secular trend" may not be a limitation on growth standards in the USA, the United Kingdom and Western Europe. From this observation, it appears that growth charts constructed in developing countries need to be revised every few years to detect secular changes.

With regard to the question of genetic influences on physical growth, several investigations have been reported to clarify this issue. Watson and Lowry (1975) compared the growth of 7 000 Black and White American children, aged six to ten years. They found no significant differences on height measures. On weight measures, Black girls evidenced an earlier pubescent spurt than White girls. The researchers concluded that there were no significant differences in height and weight measures between White and Black groups and that it was not necessary to publish separate standards for the two races.

Habicht, Martorell, Yarbrough, Malina and Klein (1974) compared the growth data of children from several countries. Subjects from developed countries include White middle-class American, British and Australian children, lower-class Black American and middle-class Japanese children. Children from developing countries were rural and urban lower-class Indians, lower-class Colombians, the Thailand and West African village children and rural Guatemalan Indians and Ladinos.

The authors reported that the children studied from the various ethnic groups, SES, and geographical regions showed uniform growth in length and weight during the first three to six months of life. After six months of age, the children from developing countries, with the exception of the Colombian children, lagged behind the children from developed countries on these measures.

Another observation was that the height curves for lower SES Black and middle-class White American children were indistinguishable, probably indicative of relatively small ethnic differences in stature between these children.

The weight curves of children from developed countries were reported as very similar. The weight curves of children from developing countries with the exception of Colombian children, were lower than those of children from developed countries. The rural Indian and Guatemalan children showed the poorest weight curves. Comparisons of children from similar ethnic groups but different SES conditions revealed the better-off children to approximate the growth patterns of children from developed countries.

Thus, taken as a group these studies suggest that environmental factors (SES) influence preschool growth in height and weight much more than do genetic factors.

On accepting these findings, one must acknowledge that although ethnic groups may be similar in mean preschool growth, this observation does not contradict a genetic influence on the growth of individuals within a well-nourished ethnic group. Similarity in optimal preschool growth between groups indicates only that there has been no differential selection for this characteristic between groups.

The argument presented indicates that growth charts from developed countries may be employed in developing countries. There are four growth charts that have been popularly used, the Iowa, Harvard, the Boston and the National Centre for Health Statistics (NCHS) standards. These charts have percentile lines which enables the assessor to establish the growth pattern of the subjects relative to the standards. Certain cut-off points have been suggested to

The four frequently used growth charts will be described next.

(i) Boston Growth Charts

Vickers and Stuart (1943) recorded the length and weight measures of low and middle class White children living in Boston, USA. The children were mainly of Northern European stock and were assumed to be well nourished since they enjoyed free periodic health and nutritional advice. Their mean weights, recumbent lengths, head and chest circumferences were recorded from birth to ten years of age, at six month intervals. The standing heights of the children were recorded only from two years of age. Separate tables were presented for the sexes. The values at the tenth, 25th, 50th, 75th and 90th percentiles were also established.

The use of the Boston growth charts as an international reference standard is unacceptable due to several considerations. No appropriate random sampling technique was employed in drawing the sample. As a result, the subjects chosen are not representative of economic and ethnic groups. The maximum number of subjects selected at any age level was 136. This does not satisfy the requirements specified by Waterlow, Buzina, Keller, Lane, Nichaman and Tanner (1977) that 200 individuals be included at each age level.

It appears that while the Boston standards may be used on American low and middle class White children, its use internationally is doubtful.

(ii) Iowa Growth Charts

Iowa growth charts have been prepared for height and

weight for age measures. The data were obtained from 1 500 White boys and girls, respectively, drawn from higher socio-economic groups. The mean heights and weights were used to prepare separate graphs for males and females.

Three separate developmental charts were prepared, infants, preschoolers and school children. The infant growth charts include the first year of life with the age scale divided into monthly periods. The charts for preschoolers are given for the first six years of postnatal growth with the age scale divided into semiannual intervals. The charts for school children extend over the range of five to 18 years.

On each curve there is a set of three curves for height and weight. The middle curve gives the average for height and the median for weight. The outside curves for height represent points on the height scale that are one standard deviation above and below the average, respectively. For weight, the outside curves represent the values for the eighty-fourth and sixteenth percentiles.

The chief problems with these charts are that the data are outdated, and, more important restricted to a specific genetic and ethnic groups. These features prevent the worldwide usage of the charts.

(iii) Harvard Growth Charts

The Harvard growth charts reflect the changing values of Caucasian subjects on height, weight, head circumference and arm circumference from two to 21 years of age. The data were obtained from White, middle-class children in the USA (Nelson, Vaughan, McKay and Behrman, 1979). Although these charts were first published in 1947, they

have been used by the WHO since 1966.

The contention has subsequently been that these charts may not reflect the characteristic growths of other ethnic, genetic, or socio-economic groups. This limitation has stimulated the release of other growth charts, the most recent being that of the National Centre for Health Statistics (NCHS) which is presented next.

(iv) National Centre for Health Statistics (NCHS) Standards

The NCHS growth charts depict changes in weight, height, optimal circumferences and skinfold thicknesses over the period extending from birth to 18 years of age. The data for these charts were obtained from subjects selected on the basis of a national probability sampling technique. The sample used was representative of the population, a cross-section of ethnic and economic groups. Accordingly, some genetic, ethnic, and socio-economic differences are imbedded in the final data (Nelson *et al*, 1979; Garn, Robinow and Bailey, 1979). These data are in contrast to that of the Harvard standards which were established on biased samples of limited socio-economic and ethnic characteristics.

The NCHS growth charts have been prepared using data from the following sources:

- | | | | |
|-----|--------------------|---|--|
| (1) | Birth to 36 months | : | Fels Research Institute |
| (2) | Two to six years | : | Center for Disease Control
(CDC) Health and Nutrition
Survey I |
| (3) | Six to 12 years | : | CDC Health and Nutrition
Survey II |
| (4) | Twelve to 18 years | : | CDC Health and Nutrition
Survey III. |

Nelson *et al*, (1979) emphasized that the data may be regarded not as descriptive of any single racial, social, economic or nutritional group, but as reference standards or data which prove useful in nutrition surveys worldwide. For the current study, the NCHS standards will be employed to classify nutritional status.

Since anthropometric growth charts may be used to diagnose malnutrition, several classification systems have been proposed. These classification systems will be discussed next.

2.4.3 Classification_Systems_Using_Anthropometric_Growth_Charts

Several criterion systems using the growth charts for the classification of nutritional status have been proposed. Some of these employ both clinical and anthropometric measures, while others use only the latter. As a result, different criteria for classifying malnutrition are apparent.

2.4.3.1 Percentile-Classification_Systems

Percentile lines are drawn on all anthropometric growth charts previously discussed. On the more popularly used Harvard growth charts, cases with weight, height, weight for height or head circumference (the latter for children under two years of age) values falling below the third percentile are classified as severely malnourished. Those with anthropometric values falling between the third and tenth percentiles are classified as moderately malnourished. According to Neumann (1979), mildly malnourished cases are those with anthropometric values between the tenth and 25th percentiles. Those values falling between the 25th and 97th percentiles represent normal growth, while those above the 97th percentile indicate obesity.

The classification system employed regarding the NCHS growth charts will be discussed next.

(i) NCHS_Percentile_Classification_System

On the NCHS growth charts, cases with anthropometric values of weight, height, and weight for height falling below the fifth percentile are regarded as severely malnourished. Moderate malnutrition is represented by anthropometric values falling between the fifth and tenth percentiles. Adequate nutrition is considered to be represented by values falling between the tenth and 95th percentiles. Values above the 95th percentile are interpreted as indicative of obesity (NCHS, 1976; Miller, Nichaman and Lane, 1977; Neumann, 1979).

Since the NCHS growth charts will be employed in the current study, the percentile classification system presented above will form the basis for the classification of nutritional status.

Another classification system based on the Harvard growth charts is the Gomez system. A discussion of this scheme is presented next.

2.4.3.2. Gomez_Classification_System

The Gomez classification system was derived by Gomez, Galvan, Cravioto, Frenk, Chavez and Vasquez in 1956. The authors used weight for age values which were plotted on the Harvard growth charts. They originally derived this system as a "guide for clinical use, and to simplify the nomenclature of a large group of diverse and confusing ailments, the common basis of which is deficient nutrition". (Gurney, 1979).

Gomez *et al.*, (1956) used Mexican "average theoretic weights" which represented values varying between 60 and 97 per cent of the Harvard reference data. They proposed that PEM be divided into first, second, and third degrees of severity corresponding, respectively, to 90-75 per cent, 75-60 per cent, and less than 60 per cent of the Harvard weight for age standards.

The main criticisms of the Gomez classification system are the use of the fairly outdated Harvard growth charts, and the exclusive use of weight for age as a classifying index. Neumann (1979) notes that this selective utilization of weight for age may yield misleading results. The author states that children with very low weight for age values do not necessarily have marasmus but may have stunting or nutritional dwarfism, and their low body mass is appropriate for the low height. Another criticism is that there is no attempt made to distinguish between marasmus and kwashiorkor in the "severe" or third degree category.

The Wellcome Trust (1970) proposed a classification based on weight for age and the presence of clinical oedema. This classification system will be discussed next.

2.4.3.3. Wellcome Classification System

The Wellcome Trust (1970) used weight for age and the clinical sign oedema to classify malnutrition. The proposers used the 50th percentile value of the Harvard weight growth charts as normal or expected weight for age. The following categories of malnutrition were suggested.

(i) Marasmus:

These cases are those evidencing weight values less than 60 per cent of the expected weight for age values, with

no oedema.

(ii) Marasmic kwashiorkor:

These are cases with weight measures less than 60 per cent of the expected weight for age, with clinical oedema.

(iii) Kwashiorkor:

These are cases which evidence weight measures between 60 and 80 per cent of the expected weight for age with oedema.

(iv) Undernourished:

These cases are subjects with 60 to 80 per cent of the expected weight for age value, but they have no oedema. (Wellcome Trust Working Party, 1970; Gurney, 1979). Although this classification system provides a framework for the more systematic analysis of other data (Waterlow, 1976), the system is limited to severe PEM and does not provide for the classification of the less severe syndromes in malnutrition. Added to this is the utilization of the fairly outdated Harvard growth charts as the expected weight for age standards which further limits its usefulness.

From the foregoing discussion, it is realised that a uniform classification system for describing the various syndromes of PEM in terms of severity, approximate duration and predominate type is lacking. However, with respect to the type of survey and the personnel involved, the percentile, Gomez and Wellcome classification systems have been utilized with comparative frequency.

2.4.4 Summary

Anthropometric growth charts contain data which depict the course of development in a specific anthropometric measure over time. There seems to be sufficient evidence (Watson *et al*, 1975; Habicht *et al*, 1974) to suggest that growth charts constructed in developed countries are employable in developing countries. The Harvard and NCHS growth charts are the two most popularly used anthropometric data. The Harvard standards have been criticised as being biased in structure. The NCHS standards are considered to be acceptable reference data for international use since they satisfy most of the criteria for such data proposed by the IUNS.

The percentile, Gomez and Wellcome classification systems have been proposed for diagnosing the various forms of malnutrition. The NCHS percentile classification system proposed by the NCHS (1976), Miller *et al*, (1977) and Neumann (1979) has been adopted for the current investigation since it is in line with the goals of the study.

A detailed review of studies done on the incidence, and the psychological sequelae of malnutrition is presented next.

INDEX TO CHAPTER THREE

- 3.1 Literature review
- 3.2 Studies on the incidence and/or prevalence
of malnutrition
- 3.3 Prevalence and/or incidence studies done in
South Africa
- 3.4 Protein-energy malnutrition (PEM) as reflected
in mortality figures
- 3.5 Summary



CHAPTER THREE

3.1. Literature Review

The literature on malnutrition is vast. For the purposes of this review, the studies will be divided into the following categories:

- (i) Research on the incidence of malnutrition.
- (ii) Laboratory animal studies on malnutrition and its sequelae.
- (iii) Studies on malnutrition and psychological functioning of children.

A review of the studies on the incidence and/or prevalence of malnutrition follows.

3.2. STUDIES ON THE INCIDENCE AND/OR PREVALENCE OF MALNUTRITION

According to Scrimshaw and Gordon (1968) malnutrition has reached epidemic levels. To contain such diseases, Behar (1968) and Jelliffe and Jelliffe (1969) suggested that figures revealing the incidence and/or prevalence of protein-energy malnutrition (PEM) provide excellent bases for health strategies.

Studies on the incidence of malnutrition are generally of two types, incidence and prevalence studies.

(i) Incidence Studies

Incidence studies reveal the number of subjects who are currently experiencing an episode of malnutrition, and also those who have had such experiences in the past. These studies typically employ hospital records and the anthropometric measures of height for age and weight for height to derive these figures.

(ii) Prevalence Studies

Prevalence studies endeavour to reveal the number of current cases of PEM at the given moment of time. Clinical signs and weight for age and weight for height measures are commonly used to derive these figures (Cravioto, De Licardie and Birch, 1966).

Bengoa (1974) reported on the prevalence of malnutrition throughout the world. He revealed that on the basis of clinical signs, the prevalence of severe forms of PEM, kwashiorkor and marasmus is seldom more than about two per cent.

Bengoa (1974) also reported prevalence figures using

weight for age data. He based his findings on surveys carried out between 1963 and 1972. He estimated that the proportion of children with either severe or moderate malnutrition was 19 per cent in Latin America, 26 per cent in Africa, and 31 per cent in Asia.

Although these figures present a wholistic picture of the worldwide problem of malnutrition, it helps little in providing effective rehabilitation programmes. If incidence and/or prevalence figures are restricted to specific communities, they will be more enlightening. Several such studies are reported in the literature.

Van Duzen, Carter, Secondi and Federspiel (1969) reviewed the number of severely malnourished cases that they had treated at the Public Health Service Hospital in Arizona, USA. The analysis was restricted to Navajo children, under five years of age. The period under investigation was from 1963 to 1967, inclusive. Of the total 4355 admissions during that period, 616 were diagnosed as malnourished.

On the basis of the Boston growth charts, 15 of the 616 malnourished cases were classified as kwashiorkor patients on the following criteria:

- (i) A weight for age value below the third percentile and a total serum protein level below 6,0 grams(gm.) per 100 millilitres(ml.) of blood.
- (ii) A weight for age value below the third percentile with oedema, misery and dermatosis.
- (iii) A weight for age value below the third percentile and an albumin level below 3,5 gm. per 100 ml. of blood serum.

Any child evidencing any one of these categories of symptoms was classified as a kwashiorkor patient.

Furthermore, a total of 29 children were classified as marasmic. The diagnosis of marasmus was confirmed if the child presented with weight and height for age measures below the third percentile of the Boston standards, and had a typical appearance of wasting with a marked loss of subcutaneous fat.

The 572 other children not classified as kwashiorkor or marasmus patients were those whose weights were below the Boston reference data for their chronological ages, and were thus considered to be malnourished. These subjects did not present with the clinical picture of marasmus and did not have oedema, misery or skin changes.

In an effort to see if Navajo preschool children were small in stature, 1 000 Navajo Head Start children from all over the reservation had their heights and weights recorded by their teachers. These measures were plotted on the Boston growth curves. The Navajo values were found to be significantly ($p \leq 0,01$) lower than that of the Boston norms. The authors attributed the differences more to nutritional than to genetic influences - the decrease being a useful adaptation to a low intake of protein and calories (Waterlow, 1968).

While providing useful information on the nutritional state of the Navajo children, the data are of limited use since they were obtained only from those children who were voluntarily brought to the hospital. The authors estimated that 20 750 Navajo families lived on the reservation at that time and were not included in the sample. Therefore, the biased sample used would more likely produce biased results. In addition, the report failed to elucidate procedures whereby the anthropometric data were obtained by the authors. For example,

it is not clear whether supine or standing height was used. Failure to provide such specifications limits the value of the information. The information on the Head Start children also was not clearly defined. The Head Start programme consists of nutritional, educational and environmental stimulation for underprivileged children. The authors do not specify whether one or many teachers obtained the anthropometric data, or whether the 1000 children who were selected constituted a random sample of the total number of Head Start children. These factors should be considered if the information is to portray nutritional patterns of a community.

Neumann, Shankar and Uberoi (1969) reported on the nutritional and anthropometric profiles of 391 young rural Punjabi children up to 40 months of age, living in India. The subjects included nearly all the children from seven villages "who allowed themselves to be examined by paediatricians". Clinical, laboratory and anthropometric methods were all employed. The results of the clinical assessment are shown in table 1 below.

TABLE I : CLINICAL FINDINGS OF NUTRITIONAL SIGNIFICANCE
IN RURAL PUNJABI CHILDREN UP TO 40 MONTHS
OF AGE

CLINICAL FINDING	PERCENTAGE OF GROUP	NUMBER OF CHILDREN
Emaciated (wasting)	2,0	8
Reduced subcutaneous fat	18,1	71
Flabby poorly-developed musculature	12,8	50
Hair - Sparse	13,5	53
Hair - Discoloured tips	20,9	82
Hair - Discoloured whole	3,6	14
Skin xerosis (drying)	6,1	24

Neumann *et al.*, (1969) classified emaciated children and those with reduced subcutaneous fat and also those with flabby, poorly developed musculature as marasmic patients, a total of 129 children comprising 32,99 per cent of the sample. The clinical assessment did not utilize oedema, considered to be a cardinal feature of kwashiorkor in its report. The authors subsequently concluded that the most commonly - encountered clinical syndrome was that of PEM of the marasmic type.

The anthropometric profiles of 384 children were compared with the Harvard reference data. The subjects in the study evidenced lower weight and height values than the Harvard standards from the time of birth. Furthermore, the subjects' weight and height curves revealed flattened plateaux between 24 and 30 months of age, in marked contrast to the steadily rising Harvard curves. This phenomenon which appears to be coincident with the weaning ages of the subjects is indicative of no significant increase in these growth parameters during this period.

Analyses of head circumference growth revealed favourable comparisons with the Harvard reference standards. Chest circumference values of the study group were lower than the Harvard values. Triceps skinfold thickness values of the subjects were also significantly lower than Harvard standards.

The authors subsequently classified the weight, height and head circumference measures of subjects up to 30 months of age, using the third percentile of the Harvard standards as the cut - off value to indicate severely malnourished cases.

The findings obtained by the authors are shown in table 2 below.

TABLE 2 : PERCENTAGE OF PUNJABI CHILDREN SEVERELY MALNOURISHED, WITH ANTHROPOMETRIC VALUES FALLING BELOW THE THIRD PERCENTILE ON THE HARVARD REFERENCE STANDARDS

AGE (MONTHS)	PERCENTAGE OF CHILDREN SEVERELY MALNOURISHED ON ANTHROPOMETRIC MEASURES		
	WEIGHT (POUNDS)	HEIGHT (CM.)	HEAD CIRCUMFERENCE (CM.)
1 - 6	31	18	21
7 - 12	62	35	38
13 - 24	82	67	49
25 - 30	84	74	43

Two findings are apparent from the results in table 2:

- (1) There was an increase in the number of severely malnourished cases with an increase in age.
- (2) The percentage of subjects severely malnourished depends on the criterion used for diagnosis. For example, consistently lower percentages of children were severely malnourished on height than on weight for age measures.

The authors then used the 50th percentile of the Harvard reference standards for weight measures as a reference and derived the following categories:

- (i) Normal range: 91 to >100 per cent of Harvard reference data.
- (ii) Mild - to - moderate PEM: 61 to 90 per cent of the reference standards.
- (iii) Severe PEM: 60 per cent and below of the reference data.



Table 3 shows the results that the investigators obtained on the above classification system.

TABLE 3 : PERCENTAGE OF PUNJABI CHILDREN CLASSIFIED AS NORMAL, MILD-TO-MODERATE, AND SEVERE CASES OF PEM, ON THE BASIS OF WEIGHT FOR AGE MEASURES

AGE (MONTHS)	TOTAL NO. CHILDREN	PERCENT.		PERCENT.	
		NORMAL	MILD-TO-MODERATE	SEVERE	PERCENT. SEVERE
0 - 6	60	40,0	55,0	5,0	
7 - 12	84	13,1	77,3	9,5	
TOTAL					
0 - 12	144	24,3	68,0	9,7	
13 - 18	84	6,0	70,2	23,8	
19 - 24	87	2,3	85,1	12,6	
25 - 40	74	4,1	73,5	13,5	
TOTAL					
13 - 40	245	4,9	78,3	16,7	

The results in table 3 indicate the following:

- (i) There was a marked increase in the percentage of malnourished cases in the 13 - 40 month age group, which coincided with the period of weaning.
- (ii) There were more mild - to moderate than severe cases of PEM.

Next, the investigators employed the All - Indian Standards of the Indian Council of Medical Research (ICMR, 1968) for classifying nutritional status. The 50th percentile weight for age value was used as the reference. The results obtained are shown in table 4.

TABLE 4 : CLASSIFICATION OF NUTRITIONAL STATUS OF
PUNJABI CHILDREN, USING THE 50TH PERCENTILE
WEIGHT VALUE OF THE ALL - INDIAN STANDARDS
AS REFERENCE DATA

AGE (MONTHS)	PERCENT. NORMAL	PERCENT. MILD-TO-MODERATE	PERCENT. SEVERE
0 - 12	68,0	29,1	2,9
13 - 40	53,4	42,5	4,1

The results in table 4 indicate that a lower percentage of the subjects were classified as malnourished on the All - Indian Standards. Since the ICMR(1968) have readily acknowledged that the All - India anthropometric charts are not representative, it is apparent that local growth charts are inappropriate for use in establishing the nutritional patterns of a community. However, the use of international growth charts as reference data, namely, the Harvard growth charts was justified by the observation of Currimbhoy (1963) that children of the wealthier Punjabi farmers obtain and even surpass western standards.

While providing useful information on the nutritional patterns of a community, sex, birth order and family size relationships to malnutrition were not investigated in this study. These variables appear to form important demographic characteristics in Indian communities (Currimbhoy, 1963).

Wray and Aguirre (1969) attempted to identify all malnourished children in the town of Candelaria, Colombia. To achieve this purpose, they obtained some basic anthropometric measurements (weight and height or length) on all preschool children. Teams of two workers (a medical student and a paediatric resident) went from

house to house using a spring scale (Detecto "Infantometer" providing weights in kilograms), and a three - quarter inch thick plywood device for measuring height in cm., or the lengths of infants. Five hundred and six families, and a total of 1 094 children under the age of six years were tested.

The investigators subsequently employed the Gomez classification system for the categorization of nutritional status. In addition to this first, second, and third degree classification system, two further categories were designed. "N+" was used to refer to those children whose weight values were above the 25th percentile of the Boston norms. "N-" indicated those children whose weights were located between the third and 25th percentiles on the Boston norms. Comparisons were also made graphically with the Boston growth curves.

The Gomez standard used as "normal" is almost identical to the Boston 25th percentile value, while the 85 per cent level falls between the third percentile curves for boys and girls. Thus, almost all children classified as malnourished fell below the third percentile levels of the Boston standards.

A total of 446 children were malnourished, thus representing 40,77 per cent of the sample. Of these, 284 had first, 148 had second, and 14 had third degree of malnutrition, respectively.

The 18 to 23 month age group with 59 percent malnutrition, and the 24 to 35 month age group with 51 per cent malnutrition showed the highest incidence of malnutrition. This finding corresponds to that of Neumann *et al* (1969) in that the critical period of weaning seems to be associated with the highest incidences of malnutrition.

The authors reported that 38,24 per cent of the males, as compared to 42,98 per cent of the females in the sample was malnourished. The difference was not significant.

A total of 648 subjects were classified as well nourished in the "N+" and "N-" categories. Of these, 202 fell in the "N+" grouping.

Several methodological problems become apparent in the study. Although heights and weights were recorded, the classification system used, that is, the Gomez system, was restricted to weight measures. As a result it was not possible to distinguish acute and chronic cases of malnutrition. Another problem was that about 65 per cent of the subjects who were classified as malnourished on the Gomez system reported to have suffered from diarrhoea in the week prior to the study. The episode of diarrhoea so close to the time of weight measurement may have affected the weights of the children, thereby confounding results.

Due to these problems, the results of this study should be treated with caution.

Sandstead, Carter, House, McConnell, Horton and Zwaag (1971) reported on the nutritional status of 100 preschool - attending children in Tennessee, USA. Height, weight, head and chest circumferences and skinfold thickness recordings were obtained in duplicate by two physicians from 92 children. Laboratory examinations on 78 of these children included the erythrocyte (red blood cell) and white blood cell count, and an appraisal of blood film morphology. Comparison of the skinfold measures with the English standards of Tanner and Whitehouse(1963) revealed that 22 per cent of the children had values falling



below the tenth percentile. On the same standards, 24,7 per cent of the children had height for age values below the tenth percentile, and seven cases had weight for age values below the tenth percentile. Moreover, all children with the exception of three had head circumference values within two standard deviations of the mean of the reference standards.

Laboratory investigations revealed the following findings:

(i) Mean corpuscular haemoglobin concentrations (MCHC) were less than the lower value of the normal range of 32 per cent in all but eight cases. Furthermore, 35 per cent of the children had values less than 30 per cent below the normal range.

(ii) Only three subjects evidenced haemoglobin values below 10,5 gm. per 100 ml. blood range.

Although Sandstead *et al* (1971) claim that their observations suggest that undernutrition is prevalent in the study community, several weaknesses in methodology are apparent. Firstly, only children attending preschool were included in the sample. This feature indicates a bias in representativeness of the population. Children from private nurseries are likely to yield qualitatively better results. Furthermore, the outdated and unrepresentative standards of Tanner and Whitehouse (1963) were employed, thereby confounding results.

Sastri and Vijayaraghavan (1973) reported the incidence of malnutrition among 360 Bangladesh refugee preschool children, one to five years of age. On the basis of a clinical examination, each child was initially classified into one of three nutritional categories, apparently normal, emaciated, or marasmic. Anthropometric measures employed were weight, height, weight for height, mid - upper arm circumference and triceps skinfold thickness. For the first three of these measures, the 90 per cent value of the ICMR (1968) was used as a demarcating point between malnourished and adequately nourished cases. Mid - upper arm circumference and skinfold thickness values were compared to the Jelliffe (1966) reference data.

The results obtained by the authors are shown in table 5.

TABLE 5 : PERCENTAGE OF MALNOURISHED BANGLADESH CHILDREN, CLASSIFIED ON WEIGHT, HEIGHT FOR AGE, WEIGHT FOR HEIGHT, MID - UPPER ARM CIRCUMFERENCE AND TRICEPS SKINFOLD THICKNESS MEASURES

CLINICAL GROUPS	ANTHROPOMETRIC INDICES			MID - UPPER ARM SKINFOLD THICKNESS
	WEIGHT	HEIGHT	WEIGHT FOR HEIGHT	
Apparently Normal	58	20	23	44,1
Emaciated	91	32	62	89,1
Marasmus	98	45	95	98,2

From the results in table 5, it becomes apparent that the incidence of malnutrition is related to the index used to classify nutritional status. As shown consistently in other studies, weight for age measures gives a higher incidence of malnutrition in a community.

The authors used the ICMR(1968) standards for weight, height and weight for height measures. As shown in the study by Neumann *et al* (1969), these reference data may communicate a biased view of nutritional patterns.

The composition of the sample itself, presents a problem. The subjects were refugees and it is difficult to present an overall picture of their nutritional status in view of the several confounding variables that are apparent.

Sims and Morris (1974) attempted to establish the incidence of malnutrition in Michigan, USA by studying 163 children who attended either a nursery or a health clinic. The distribution of males and females was approximately equal. Two - thirds of the sample were White, and one quarter was Black. No mention was made of the racial constitution of the remaining subjects. The mean age of the subjects was four years.

Data were collected as follows:

- (i) Blood tests were done for the analysis of haemoglobin, haematocrit, serum proteins and albumins.
- (ii) A series of weight and height for age as well as weight for height values were obtained three times during the year of data collection.
- (iii) Three one - day dietary records were provided by the mothers of the subjects.

the reference population, on the bases of weight and height measures. Moreover, only those children attending a health clinic were included in the investigation, a poor sampling technique which prejudices the results obtained.

Chong and Lim (1975) attempted to ascertain the prevalence of malnutrition among Malay preschool children by employing anthropometric indicators. All children who were under five years of age were weighed naked or in their underwear. Infants were weighed with a SECA beam balance to the nearest 10 gm. and older children on an Avery beam balance to the nearest 100 gm.

Lengths were measured to the nearest 0,1 cm. with the child lying *supine* on a horizontal board (infantometre). The heights of older children were measured to the nearest 0,1 cm. with a portable human measure. The ages of all the children, except those from the Ulu Trengganu area whose ages were estimated to an accuracy of one month, were determined from birth certificates. The subjects were divided into five groups as follows.

- (i) Upper income group : comprised 48 children.
- (ii) Army children : comprised 660 children whose fathers had been in the army since before their birth.
- (iii) Ulu Trengganu : an area where the toddler mortality rates were the highest in the country. This group had 209 children.
- (iv) Kuala Langat : comprised 475 children.
- (v) Kuala Trengganu : comprised 278 children of the study group.

The prevalence of malnutrition was determined by using the following reference standards :

- (a) The weight for age growth charts of Dugdale, McKay, Lim and Notaney (1972) were employed in the study.

These charts were constructed using Malay preschool children of the army category to obtain the data.

Those children whose weight for age values fell below the tenth percentile on these standards were regarded as malnourished.

- (b) On the Harvard standards, the authors regarded the 70 per cent weight for age limit as indicative of "third degree underweight" (Jelliffe, 1966) or "significant malnutrition" as defined by Garrow (1966).
- (c) The Wellcome classification system for malnutrition was also employed.
- (d) When weight for height was used as a criterion index for classifying nutritional status, the graphs of Jelliffe (1966) were used as reference data. Values less than 80 per cent of the expected weight for height were considered to be indicative of malnutrition, a classification system advocated by Waterlow (1972).
- (e) Height for age criteria employed the 85 per cent cut - off value on the Harvard standards, as defined by Waterlow (1972), to indicate malnutrition.

The prevalence figures for malnutrition that were obtained by the authors are shown in tables 6 and 7 below.

TABLE 6 : PREVALENCE OF "SIGNIFICANT MALNUTRITION" AS DEFINED BY GARROW (1966) ON THE BASIS OF WEIGHT FOR AGE MEASURES, AMONG MALAY PRESCHOOL CHILDREN UNDER FIVE YEARS OF AGE

CATEGORY OF CHILDREN	NUMBER OF CHILDREN	PERCENT. OF CHILDREN CLASSIFIED AS "SIGNIFICANTLY MALNOURISHED" REFERENCE STANDARDS	
		DUGDALE ET AL	HARVARD
UPPER INCOME	48	NIL	NIL
ARMY GROUP	660	10	8
KUALA LANGAT	475	16	10
KUALA TRENGGANU	278	24	20
ULU TRENGGANU	209	44	32

When weight for age measures were used as the criterion index, the upper income group showed the best nutritional status evidence, while the children from the Ulu Trengganu group displayed the poorest growth according to this measure. It must be remembered that these results cannot be taken *verbatim* since the authors have acknowledged that only an approximation of the ages of the Ulu Trengganu children was obtained. When an age-dependent measure like weight for age is used for classifying nutritional status, a knowledge of the ages of the subjects to the month is irreconcilable.

The results in table 6 indicate that similar prevalence figures for malnutrition were obtained when the Dugdale *et al*, (1972) or the Harvard standards were used.

The authors also identified two cases of marasmic kwashiorkor on the basis of the Wellcome classification system.

The authors reported the percentages of children with low weight for height values (evidence of wasting), and with low height for age values (evidence of stunting).

The results obtained are shown in table 7.

TABLE 7 : PREVALENCE OF "WASTING" AND "STUNTING"
AMONG MALAY PRESCHOOL CHILDREN

STUDY GROUP	NO. CHILDREN	PERCENT. WASTED	PERCENT. STUNTED
KUALA LANGAT	475	7	3
KUALA TRENG- GANU	278	15	4
ULU TRENGG- ANU	209	18	14

It seems evident from the results in table 7 that fewer children were malnourished according to weight for height and height for age measures, as compared to the figures obtained on weight for age measures. A markedly higher prevalence of "stunting" was apparent among the Ulu Trengganu children.

Two major criticisms may be levelled at the study. Firstly, the authors failed to define at what age *supine* length was discontinued, and *erect* height was commenced when measuring the subjects. They state that infants were *supinely* measured, implying that children up to the age of two years were measured in this way. This issue remains unclear, though, since other systems of

developmental age categorization exist, This problem may lead to faulty results since the Harvard standards are based on supine length up to two years of age.

Secondly, the use of approximations of age for the Ulu Trengganu children limits the reliability of the results obtained.

Naik, Zopf, Kakar, Singh and Sandhu (1975) used weight, height and upper - arm circumference measures to establish the incidence of malnutrition among Punjabi primary school children living in India. A total of 2019 subjects were selected, in the age range five years and below, to 13 years and above. Comparisons of anthropometric data were made to the Harvard and ICMR (1968) reference standards.

The results showed that both male and female children weighed 72 per cent of the Harvard standards (106,7 and 107,7 per cent of the ICMR (1968) average for males and females, respectively). The results indicate that more children were malnourished according to the Harvard standards. In general, more males than females were malnourished.

Height measures revealed that males and females averaged 91 per cent of the Harvard standards, and 101,9 per cent and 103,8 per cent of the ICMR standards, respectively. These results suggest that more children were malnourished according to the Harvard standards.

Arm circumference measures were compared to the Wolanski (unpublished data) standards. The male and female values averaged 79 and 84 per cent, respectively, of the reference standards.

A survey of the results obtained in the various studies indicate that with the different anthropometric indices, varying incidence figures for malnutrition were obtained. It is apparent that high incidence were consistently reported when weight measures were employed as the criterion index of malnutrition, and low figures when arm circumference values were used.

While studies done in countries situated on those continents other than Africa are useful in providing a global picture of malnutrition, those done in South Africa and probably neighbouring homelands are more relevant for the current thesis. South African reports are few and varied but have nevertheless contributed valuable information on the nutritional patterns of communities. A review of these will be presented next.

3.3 STUDIES ON THE INCIDENCE AND/OR PREVALENCE OF MALNUTRITION DONE IN SOUTH AFRICA AND NEIGHBOURING HOMELANDS

Margo, Lipschitz, Joseph, Green and Metz (1976) reported on the prevalence of malnutrition among Black preschool children living in the Muldersdrift area, South Africa. Fifty - four small - holdings were randomly sampled and all children between one and five years of age were subjected to clinical examinations and anthropometric measurement.

Supine length was taken for children under two years, and older children were measured while standing. Sub - scapular and triceps skinfolds were measured on the left side with a Harpenden caliper. Head, chest and left mid - arm circumferences were measured with a tape measure.

Biochemical analyses involved haemoglobin and mean cell volume (MCV) assessments of blood, as well as the measurement of serum albumin levels.

The clinical examination revealed few overt signs of nutritional disease. Comparisons of anthropometric measures with the standards indicated revealed the results presented in table 8.

TABLE 8 : PERCENTAGE OF BLACK PRESCHOOL CHILDREN CLASSIFIED AS MALNOURISHED ACCORDING TO VARYING ANTHROPOMETRIC INDICES AND REFERENCE STANDARDS

ANTHROPOMETRIC INDEX	INCIDENCE (PER CENT)	REFERENCE STANDARDS
HEIGHT FOR AGE	22,8	HARVARD
WEIGHT FOR AGE	27,6	HARVARD
MID-ARM CIRCUMFERENCE	13,8	JELLIFFE
TRICEPS SKINFOLD	11,4	TANNER AND WHITEHOUSE
SUBSCAPULAR SKINFOLD	4,1	TANNER AND WHITEHOUSE
HEAD CIRCUMFERENCE (12 - 36 MONTHS)	4,3	HARVARD
CHEST CIRCUMFERENCE (12 - 60 MONTHS)	25,7	HARVARD

For the mid - arm circumference measures, the 85 per cent value of the standards of Shakir and Morley (1974) were used as the cut - off point to divide 'normal' from 'abnormally low' results. In all other measures, the third percentile was used as this cut - off point.

Using the criterion of weight for age, 27,6 per cent of the sample was judged to be suffering from PEM. It is interesting to note that if PEM was judged on the criterion of Shakir and Morley (1974), that is, on the basis of mid - arm circumference, the incidence of PEM was halved to a value of 13,8 per cent. Low mid - arm circumference values indicate more advanced PEM. Height for age measures revealed an incidence of 22,8 per cent malnutrition.

It becomes apparent that different incidence figures for malnutrition were obtained with varying anthropometric indices. Moreover, the inconsistency in the use of reference standards confounds the results obtained.

Margo, Baroni, Brindley, Green and Metz (1976) reported on the prevalence of malnutrition among Coloured children aged one to 16 years, living in Johannesburg, South Africa. Anthropometric data obtained were weight, height (recumbent length was recorded for children under two years of age), left mid - arm, head and chest circumferences, and skinfold thicknesses (left triceps and subscapular). Comparisons of height, weight, chest and head circumference measures were made with the Harvard standards. Skinfold values were compared with the standards of Tanner and Whitehouse (1962), and mid - arm circumference measures with the data of Jelliffe (1966).

Biochemical analysis involved serum albumin assessment.

Table 9 shows the results obtained when anthropometric measurements were considered to be 'abnormally low' if they fell below the third percentile value of the standards employed. For the mid - arm circumference measures, the 85 per cent value of the standards was the designated cut - off point indicating malnutrition.

TABLE 9 : PREVALENCE OF MALNUTRITION AMONG COLOURED SUBJECTS ONE TO SIXTEEN YEARS OF AGE, DIAGNOSIS BASED ON VARIOUS ANTHROPOMETRIC INDICES AND EXPRESSED IN PERCENTAGES

AGE GROUP (YEARS)	ANTHROPOMETRIC INDICES					TSF ⁴	SSSF ⁵
	HEIGHT	WEIGHT	MUAC ¹	HC ²	CC ³		
1 - 4	11,2	22,2	13,3	36,2	16,7	1,1	0
5 - 8	18,6	52,2	8,5	-	-	15,3	1,7
9 - 12	22,8	48,1	26,6	-	-	13,9	7,6
13 - 16	12,3	28,1	22,8	-	-	10,5	8,8
-----	-----	-----	-----	-----	-----	-----	-----
OVERALL	16,1	36,5	14,4	36,2	16,7	9,5	4,2

In table 9, the following key for the superscripts was used:

- 1 = mid - upper - arm circumference
- 2 = head circumference
- 3 = chest circumference
- 4 = triceps skinfold
- 5 = subscapular skinfold

The results obtained indicate that varying incidence figures for malnutrition were found with varying anthropometric indices. Low values were obtained on height for age measures and high values on weight for age measures. Further such inconsistencies are shown in table 9 above.

One child was classified as a kwashiorkor patient on the basis of oedema and low weight.

Three cases were classified as marasmus.

These subjects presented with weight for age values that were less than the 60 per cent weight value on the reference standards.

Biochemical analyses revealed a mean serum albumin level of 4,28 gm. per 100 ml. blood which the authors used to confirm the prevalence of mild PEM.

The results in this study indicated and supported previous findings that the incidence and/or prevalence of malnutrition is related to the index used to classify nutritional status.

Shuenyane, Mashigo, Eyberg, Richardson, Buchanan, Pettifor, MacDougall and Hansen (1977) studied the prevalence of malnutrition among Black children living in the Diepkloof area in Soweto, South Africa. Random sampling was used to include 2,15 per cent of the total 8 634 homes in the sample. A total of 523 children aged up to 16 years were weighed and their heights taken. Two hundred and eight preschool children up to five years and 11 months of age were included in the sample.

The children's weights and heights were compared with the Harvard standards to assess the prevalence of PEM. The cut - off value for both indices was the third percentile limit. Weight values below this point indicated malnutrition, while such height values indicated stunting. Wasting was diagnosed when weight for height values fell below the 90 per cent point on the Harvard standards.

The figures for the prevalence of malnutrition, stunting and wasting as defined by Shuenyane *et al*, (1977) are shown in table 10.



TABLE 10 : PREVALENCE OF MALNUTRITION, STUNTING, AND
WASTING AMONG BLACK CHILDREN UNDER
SEVENTEEN YEARS OF AGE, LIVING IN THE
DIEPKLOOF AREA, SOUTH AFRICA

CATEGORY OF PEM	AGE GROUPS (IN YEARS)				
	2	2 - 5	6 - 9	10 - 12	13 - 16
MALNUTRITION ^a (PERCENT.)	18,9	29,1	38,9	45,4	38,3
STUNTING ^b (PERCENT.)	63,5	66,4	55,5	59,2	45,7
WASTING ^c (PERCENT.)	9,6	20,1	25,4	24,1	16,0
NO. CHILDREN IN AGE GROUP	74	134	126	108	81

In table 10,

a = weight for age below third percentile

b = height for age below third percentile

c = weight for height at 90 per cent of standard
and below

From the results in table 10 it is apparent that on weight measures the prevalence of malnutrition rose from a value of 18,9 per cent during infancy (below two years of age) to peak in the 10 to 12 year olds age group at a value of 45,4 per cent. The analyses revealed that although stunting occurred at all ages, a marked prevalence was found among the preschool children, that is, in the two - to - five year age group. Wasting was shown to be less prevalent than both malnutrition and stunting at all ages, indicating

that the majority of children had normal body proportions.

Westcott and Stott (1977) reported on the incidence of malnutrition among children under five years of age, living in a Transkeian village. The weights, heights, and arm circumferences of 193 children were recorded, but the measures of 135 children were utilized since their exact ages were obtainable. The diets, family incomes and maternal educational levels of the subjects were recorded.

The weight, height and arm circumference measurements were compared with the Boston reference data, using the third percentile as the cut - off value to indicate malnutrition. On weight measures, 36 per cent of the children were malnourished. In the one-year-and-over age group, 49 per cent of the subjects were malnourished, while the incidence figure reached 57 per cent in the one - and - a - half to two - and - a - half year age group.

The authors stated that lower incidence figures were obtained on height measures, but equivalent to the figures found when weight was employed in the respective age categories. They reported an incidence figure of 33 per cent in the one - and - a - half to two year age range.

A maximum of 12 per cent malnutrition was obtained when arm circumference measures were used to classify nutritional status.

The authors noted that more of the adequately nourished children (according to weight measures) were supported by their own fathers. There was a significant difference between the proportion of children who were well - and malnourished according to weight measures in those families that earned more, and those that earned less than 30 rands per month ($\chi^2 = 6,28$; $p \leq 0,05$).

No significant relationships were found between malnutrition classified on weight for age measures, and maternal educational levels. The authors reported a significant relationship between the lack of dietary knowledge (and thus the diets followed), and the incidence of malnutrition.

The apparent weakness of this survey is the use of the fairly outdated Boston growth charts as reference data. No detailed information was given on whether supine or erect lengths were obtained, or at what ages either was measured. Since the Boston growth charts were drawn on the basis of supine length measurements up to two years of age, the results obtained may be inconsistent.

Richardson (1977) reported on the incidence of malnutrition among White, Indian, Black and Coloured preschoolers living in South Africa. The third percentile of the Harvard reference standards was used as the cut-off value to indicate malnutrition.

The results obtained are shown in table 11.

Jinabhai (1979, unpublished) used weight and height for age measures to assess the incidence of malnutrition among Indian preschoolers in the Tongaat South community, South Africa. All children under eight years of age were summoned to a health clinic. A total of 1 339 children responded. He used the Harvard standards to classify their nutritional status.

The results obtained are shown in table 12.

TABLE 12 : INCIDENCE OF MALNUTRITION AMONG INDIAN CHILDREN, CLASSIFICATION BASED ON WEIGHT AND HEIGHT FOR AGE MEASURES USING THE HARVARD STANDARDS AS REFERENCE DATA

DEGREE OF MALNUTRITION	PERCENT. MALNOURISHED ON ANTHROPOMETRIC INDICES	
	WEIGHT FOR AGE	HEIGHT FOR AGE
SEVERELY MALNOURISHED	46,8	25,2
MODERATELY MALNOURISHED	22,0	24,5

From the data in table 12 it can be seen that the percentage of children classified as malnourished on the basis of weight for age measures exceeded the value obtained when height measures were used as the criterion index.

POWER (1982) reported on the incidence of malnutrition among Cape Coloured children in South Africa, using the *National Centre for Health Statistics (NCHS)* data as reference standards. The children were weighed on a spring scale, and their heights measured. Incidence figures were reported on weight, height, and weight for height measures. Only the results reported on children under seven - and - a - half years of age will be considered for this review.

Table 13 shows the results obtained by the author.

TABLE 13 : INCIDENCE OF MALNUTRITION AMONG CAPE COLOURED CHILDREN, USING THE INDICES OF WEIGHT, HEIGHT, AND WEIGHT FOR HEIGHT WITH REFERENCE TO THE NCHS STANDARDS

PERCENTILE CLASSIFICATION	PERCENT. MALNOURISHED ON VARIOUS ANTHROPOMETRIC INDICES		
	WEIGHT	HEIGHT	WEIGHT FOR HEIGHT
LESS THAN FIFTH	32	30	11
LESS THAN TENTH	46	37	19

From the results in table 13 it is apparent that consistently high figures for the incidence were obtained on weight for age measures, while weight for height indices yielded low incidence figures.



Booth (1982) surveyed the number of Black paediatric cases under five years of age at a homeland hospital in an effort to establish the incidence of malnutrition in the community. Various clinical signs and the Wellcome classification system were employed as the diagnostic criteria. The author reported that 32,7 per cent of the subjects were malnourished according to weight for age measures. A further 21,3 per cent was diagnosed as kwashiorkor and 10,3 per cent as marasmus patients.

It is apparent that although the study by Booth (1982) communicates important nutritional information of the population studied, a random sample is lacking and a large section of the community (that is, the unhospitalized cases) has not been assessed.

A comparison of the studies reviewed raises several issues:

- (i) It is strongly evident that a random sample would best portray the nutritional patterns, particularly the incidence and/or prevalence of malnutrition of a community.
- (ii) There is a gross inconsistency in the use of reference standards, thereby constraining any meaningful comparison of results.
- (iii) There is evidence of a relationship between the index used to diagnose malnutrition, and the incidence figures for malnutrition obtained.

These issues are examined in the current investigation.

Another indicator that has been suggested for use in reflecting the incidence and/or prevalence of PEM is mortality rates. A brief review of these studies is presented next.

3.4 PROTEIN - ENERGY MALNUTRITION (PEM) AS REFLECTED IN MORTALITY FIGURES

Wills and Waterlow (1958) suggested that the death rate of children aged 12 to 59 months (one to five years) may be considered as indicative of the prevalence of PEM and infectious disease in a community. More specifically, it has been reported that the second - year mortality rate appears to give a better picture of the prevalence of PEM (Gordon, Wyon and Ascoli, 1967). It is unfortunate that the one - to - five year mortality rates are not widely collected and documented.

Bengoa (1962) reported the mortality figures for one - to - four year olds in several countries. The data were collected during the periods 1950 to 1952, 1960 to 1962, and in the year 1966 using various data collection systems.

The figures obtained by Bengoa (1962) are shown in table 14.

TABLE 14 : MORTALITY RATES AMONG ONE-TO-FOUR YEAR OLDS
IN SEVERAL COUNTRIES, AS AN INDICATION
OF PEM DURING THAT DEVELOPMENTAL PERIOD

COUNTRY	MORTALITY RATES PER 1 000 CHILDREN		
	1950 - 1952	1960 - 1962	1966
SWEDEN	1,3	0,0	0,7
UNITED KINGDOM	1,4	0,9	0,8
CHILE	12,9	8,2	5,0
COLOMBIA	20,4	15,4	10,8
EL SALVADOR	31,1	17,1	13,5
GUATEMALA	46,3	32,4	29,5
MEXICO	28,6	13,8	10,9
PERU	19,8	15,7	10,5
VENEZUELA	11,9	5,7	4,9

From table 14 it becomes apparent that there was a decline in mortality rates over the study period and this may suggest a decrease in the incidence and/or prevalence of PEM. Also, there is a great difference in the mortality rates of the two European countries, Sweden and the United Kingdom, and the other countries in the study. The chief problem with these figures is that it is not known from what samples they were extrapolated.

Puffer and Serrano (1973) studied the deaths of 34 197 children below the age of five years, living in seven countries in Latin America and the Caribbean. Nutritional deficiencies were found to be either the underlying causes of death, or associated causes in 52 per cent of postneonatal deaths. Immaturity, which is often claimed to reflect a poor nutritional state of the mother, was associated with 63 per cent of neonatal deaths, which accounted for 22 per cent of all deaths. It seems that in Latin America and the

Caribbean, PEM is a major and often hidden cause of the deaths of young children and may provide an assessment of the incidence of PEM in these countries.

In a press report (Daily News, 1982), the United Nations Children's Fund stated that five million children died from malnutrition or associated diseases in 1982. The countries included in the survey were from Africa, Asia and Latin America.

There have been few reports of PEM based on mortality rates in South Africa. Moosa (Sunday Times, 1983) reported that based on the statistics of hospitals throughout the country, 96 children die of malnutrition every day in South Africa. He noted further, that the Black formed the majority of these cases and that 45 per cent of all children admitted to the King Edward VIII hospital suffered from malnutrition. Of these, 20 per cent usually died of the disease or accompanying infections.

Moosa (Sunday Times, 1983) contends that most of the children who suffer from malnutrition come from families that cannot afford to buy enough food. This picture is compounded by the observation that marked ignorance, diseases, and deprived environments coexist.

Wyndham (Sunday Tribune, 1983) reported that for the period 1968 to 1977, nutrition - related diseases were responsible for 80 000 or 65 per cent of the deaths of Coloured children under five years of age. This mortality rate included deaths from gastro-enteritis, pneumonia and measles. The mortality figure was 28 times that obtained for White children over the same study period.

It is apparent that hospital statistics (on which mortality figures are usually based) have little value for the assessment of the incidence of malnutrition in a



community for obvious reasons of selection bias. Such data can only suggest whether a disease is rare, common or very common, since without knowing the size and composition of the population served by the hospital and the degree to which the facility is utilized, it is difficult to relate such information to the population at risk (Cravioto *et al*, 1966). Moreover, it is seldom that cases other than those of the severe category are hospitalized. Although the figures remain unrepresentative, they nevertheless suggest that malnutrition in varying degrees of severity is widely prevalent in the Non - white South African communities.

3.5 SUMMARY AND CONCLUSIONS

Several studies have reported the incidence and/or prevalence of malnutrition employing either anthropometric measures, biochemical indices, or both. Other reports have relied on mortality figures.

When biochemical tests were used, the reference standards and the rigorous controls for obtaining blood samples were not always adhered to (Van Duzen *et al*, 1969).

Anthropometric studies have revealed several problems. For example, Van Duzen *et al*, (1969) did not draw a representative sample, nor did the authors specify whether erect or supine lengths were obtained from their subjects. Another problem was the inconsistency in the use of reference standards for the classification of nutritional status. The choice of such standards was also unsatisfactory in some cases. For example, Wray *et al*, (1969) reported that a proportion of their subjects presented with diarrhoea the week before weight measurements were taken. Weight for age was the sole criterion used to diagnose malnutrition.

Other studies have relied on the mortality rates of young children to estimate the incidence and/or prevalence of malnutrition. In general, these reports considered deaths at various hospitals, and have included deaths from diseases linked to nutritional deficiencies. No random sampling techniques were employed, and only severe cases of malnutrition that were hospitalized were included in these studies.

It becomes apparent that there are a large number of children who do not die of malnutrition. It is this group of individuals who have stimulated interest. Several studies have investigated the behavioural sequelae of malnutrition suffered in early life, when brain growth occurs at an optimal rate. Many of these investigations have sought animal subjects in an attempt to elucidate the relationship between malnutrition and the behavioural correlates of intelligence. Such subhuman research will be reviewed next, and its contributions to the understanding of the relationships between early malnutrition and mental development in humans assessed.

INDEX TO CHAPTER FOUR

- 4.1 Introduction to animal studies on malnutrition and mental development
- 4.2 Factors motivating the use of animal models in studies on malnutrition
- 4.3 Review of studies published from 1963 to 1977.
- 4.4 Review of animal studies reported from 1980 to 1982.
- 4.5 Critical analysis of animal studies on malnutrition and mental development.
- 4.6 Conclusions

CHAPTER FOUR
ANIMAL STUDIES ON MALNUTRITION AND
MENTAL DEVELOPMENT

4.1 INTRODUCTION

Several animal studies investigating the relationship between malnutrition and mental development have been published. This review will be limited to behavioural data reported in the last 20 years from studies done on the rat, the species most frequently used as the experimental subject.

The majority of the studies have appeared between 1963 and 1977, after which there appears to be a relative lull in animal research on malnutrition. An attempt was made to trace most of the available reports and present them in summary form (table 15).

The studies that appeared between 1980 and 1982 will be reported in more detail, as well as in summary form (table 16).

It is pertinent to consider the factors that motivated the use of animal models in studies on malnutrition and mental development. A brief discussion of the major ones will precede the literature review.