



University
of Glasgow

Ezeofor, Ifeyinwa Obiageli (2015) *Diagnosis of undernutrition in the first 6 months of life in Enugu city, southeast Nigeria*. PhD thesis.

<http://theses.gla.ac.uk/7061/>

Copyright and moral rights for this thesis are retained by the author

A copy can be downloaded for personal non-commercial research or study

This thesis cannot be reproduced or quoted extensively from without first obtaining permission in writing from the Author

The content must not be changed in any way or sold commercially in any format or medium without the formal permission of the Author

When referring to this work, full bibliographic details including the author, title, awarding institution and date of the thesis must be given



**University
of Glasgow**

**Diagnosis of undernutrition in the first 6 months of
life in Enugu city, southeast Nigeria**

Ifeyinwa Obiageli Ezeofor, M.Sc.

**Thesis submitted in fulfilment of the requirement for the degree
of
Doctor of Philosophy (Ph.D.) to
College of Medical, Veterinary and Life Sciences**

School of Medicine

University of Glasgow

Scotland

Under the Supervision of

Professor Charlotte M. Wright

&

Dr Ada L. Garcia

Submitted September 2015

Abstract

The World Health Organisation (WHO) recommends exclusive breastfeeding during the first six months of life for optimal growth. However, the rapid growth of early infancy is limited by undernutrition, and this has been assumed rare. Nonetheless, there has been reported evidence of this problem, particularly in infants with underlying disease.

Identifying infants at the risk of undernutrition using growth charts is simple, quick, invaluable, but suggested ineffective. The possible cause is poor health staff understanding, application and interpretation of growth patterns in early infancy, particularly in developing countries. In Nigeria, little is known about patterns of growth, how growth velocity relate to nutritional status, standardised methods for assessing nutrition risk, and prevalence of undernutrition in infants younger than 6 months, particularly hospitalised infants. Therefore, this project based at the University of Nigeria Teaching Hospital (UNTH), Enugu, set out to answer the following research questions:

- 1) What is the prevalence of undernutrition in infants younger than 6 months, particularly hospitalised infants?
- 2) What are the implicated feeding patterns and medical conditions of these infants?
- 3) Can feeding information and growth patterns be used to predict undernutrition in these infants?
- 4) Is health staff use of growth patterns in identifying undernutrition in early infancy effective?

Methods

Data were collected for the project's three cross-sectional, observational studies.

- 1) Feeding information from birth to date of assessment was collected from mothers/carers of healthy infants attending the *Infant Welfare Clinic (IWC)* of the UNTH, Enugu. Their retrospective weight measurements at birth, 6 weeks, 3 months and 6 months were documented from their mother-held Road-to-Health (RTH) growth charts
- 2) Feeding and growth information was collected from infants at admission (from birth to 26 weeks of age) to the *Hospital Wards* of the UNTH. These data were collected using a structured interviewer-administered questionnaire based on the Subjective Global Nutrition Assessment (SGNA); including anthropometric measures of weight, length, head circumference, mid-upper arm circumference, and skinfolds (triceps and subscapular)

- 3) Paediatric *Health Staff* were surveyed in two teaching hospitals and four government-controlled primary health facilities using a structured self-completion questionnaire to:
- determine how growth charts are used to detect childhood undernutrition
 - determine the accuracy in plotting and rating/applying/interpreting weight gain patterns shown on the RTH and WHO growth charts for appropriate action
 - test the understanding of growth trajectories displayed on charts

Results

Infant Welfare Clinic Study

The retrospective weights of 411 healthy infants (0 – 26 weeks old) attending the IWC of the UNTH, Enugu was compiled and used to generate a reference to compare that of their hospitalised peers in the same hospital. There was a steady weight gain increase in the first half and slower gain in the latter half of first six months of life. During this period, the weight Z-scores distribution of the infants compared well to the WHO Child Growth Standards (WHO-CGS). Moreover, 5% of the infants had -2SD (CWG), setting the 5th percentile as slow weight gain threshold, the reference to compare the weight velocity of their hospitalised peers. Therefore, the data compiled from the IWC was transformed successfully into a dataset qualified as a norm for comparing the data collected from the hospitalised infants. However, suboptimal breastfeeding patterns were observed in the majority (391, 95%) of the infants at assessment.

Hospital Ward Study

Assessment of growth was done in 210 infants admitted to the paediatric wards from birth to 6 months, of which 143 (80.6%) were younger than 3 months. These younger infants were most commonly admitted for respiratory tract disorders 39 (18.6%), while the older infants were most commonly admitted for sepsis 21 (10.0%). The least of the morbidities were diarrhoea/vomiting 10 (4.8%) and severe undernutrition 8 (3.8%). SGNA-rating showed that the majority (161, 76.7%) of the infants were at low risk for undernutrition. The mean CWG of the hospitalised infants from birth was low, with 23% of the infants recording weight gain since birth below the 5th percentile for slow weight gain. Around one quarter of the hospitalised infants recorded low anthropometric Z-scores of weight, CWG, length, BMI or MUAC.

A reference for skinfolds for under-3-month-olds was not available in the WHO-CGS. On applying a reference developed using the infant Paediatric Yorkhill Malnutrition Screening Group's UK data (iPYMS Reference), over one third of all the infants recorded low sum of

skinfolts. Using crude MUAC measurements, two-thirds of the infants were moderately undernourished (<115mm) and over a half severely undernourished (<110mm), significantly ($P<0.0001$) decreasing with increase in age of admission.

The majority (184, 87.6%) of the infants was initially breastfed, however, only 43 (20.5%) of the infants were exclusively breastfed (breastfed without water or other liquids) at any age. Breastfeeding status was related to the reasons for admission and nutritional status: the mean weight change for exclusively breastfed infants was -0.6 Z-score as compared to -1.1 Z-score for partially breastfed infants.

Health Staff Study

Of the 222 health staff that responded to the survey in 2 referral hospitals and 4 government-controlled primary health facilities in Enugu city, 78% were hospital-based, 55% nurses, 46% highly experienced. About a third of the respondents often plotted; 87.8% often interpreted growth charts; over a half often identified and treated undernutrition, 88.7% with confidence. However, low accuracy was observed in recognising slow weight gain, particularly with average size; and fast weight gain was also poorly recognised. The respondents were as likely to be as worried about a small infant growing fast as an average weight infant growing slowly. Growth trajectories were better understood and interpreted on the WHO than RTH chart format. Most correct responses came from the medical doctors and moderately experienced respondents.

Conclusions

The growth of young Nigerian infants fit the WHO-CGS well and the SGNA-rated nutrition risk is low, but other measures suggest undernutrition in up to one third of the hospitalised infants. Moreover, faulty breastfeeding patterns were prevalent and need to be addressed in future studies involving this population. Furthermore, the ineffectiveness of health staff understanding, application and interpretation of growth trajectories displayed on growth charts as practical tools, suggests the need for training.

Table of Contents

Abstract	ii
Table of Contents	v
List of Tables.....	viii
List of Figures	x
Preface.....	xi
Acknowledgements	xii
Author's Declaration.....	xiii
Supervisors' Declaration.....	xiii
List of Abbreviations.....	xiv
Glossary	xv
CHAPTER 1 INTRODUCTION AND LITERATURE REVIEW	1
1.1 Introduction.....	1
1.2 Review of the literature.....	6
1.2.1 Definitions of undernutrition	8
1.2.2 Causes of undernutrition in infants	14
1.2.3 Effects of undernutrition in infants	20
1.2.4 Inter-relationship between undernutrition, infection and growth	25
1.2.5 Growth in healthy infants.....	28
1.2.6 Growth-based classification of undernutrition in infants.....	31
1.2.7 How growth is measured in infants using growth charts/standards.....	34
1.2.8 Prevalence of undernutrition in infants	43
1.2.9 General management of undernutrition in infants	51
1.3 Summary and Implications of review of the literature	55
CHAPTER 2 RESEARCH DESIGN AND METHODOLOGY	58
2.1 Research Design and Methodology	58
2.1.1 Research Design.....	58
2.1.2 Research Methodology.....	58
2.1.3 Diagnosing undernutrition in hospitalised infants using screening tools.....	66
2.1.4 Standard operating procedures/instruments used for the studies of the project..	69
2.2 Broad Settings.....	74
2.2.1 Nigeria.....	74
2.2.2 Enugu City	76
2.3 Instruments/Procedures used for data collection and timelines.....	81
2.3.1 Pilot Study.....	81
2.3.2 Infant Welfare Clinic Study	83
2.3.3 Hospital Ward Study	87
2.3.4 Health Staff Study	93
2.4 General data handling considerations and Analytical methods	102
2.5 Ethics approvals/considerations and funding.....	103
CHAPTER 3 INFANT WELFARE CLINIC STUDY RESULTS	104
3.1 Basic characteristics of the healthy infants.....	104
3.1.1 Birth-related characteristics	104
3.1.2 Weight measurements/Weight-for-age Z-scores.....	104

3.2	Growth characteristics of the healthy infants	105
3.3	Weight change since birth in the healthy infants	106
3.3.1	Conditional weight change	107
3.3.2	Relation of breastfeeding status and nutritional status	107
3.4	Discussion	108
3.4.1	Main findings	108
3.4.2	Strength of the Study	113
3.4.3	Weaknesses of the study	114
3.4.4	Limitations of the methods	114
3.5	Conclusion from the study	116
CHAPTER 4 HOSPITAL WARD STUDY RESULTS		117
4.1	Basic characteristics of the hospitalised infants	117
4.1.1	Age distribution in the hospitalised infants	117
4.1.2	Birth-related and feeding characteristics of the hospitalised infants	118
4.1.3	Diagnoses in the hospitalised infants	119
4.2	Nutritional and growth characteristics in the hospitalised infants	119
4.2.1	SGNA rating in the hospitalised infants	119
4.2.2	Growth patterns in the hospitalised infants	120
4.3	Weight Z-score and conditional weight changes since birth in the hospitalised infants	121
4.4	Body composition and nutrition risk estimation in the hospitalised infants	122
4.4.1	Generating and using skinfolds reference to estimate nutrition risk in the hospitalised infants	122
4.4.2	Using different thresholds/measures to estimate undernutrition prevalence in the hospitalised infants	124
4.4.3	Association of feeding pattern with nutrition risk and body composition in the hospitalised infants	129
4.5	Discussions	130
4.5.1	Main findings	130
4.5.2	Strengths of the study	141
4.5.3	Weaknesses of the study	142
4.5.4	Limitations of the methods	142
4.6	Conclusion from the study	143
CHAPTER 5 HEALTH STAFF STUDY RESULTS		144
5.1	Participants of the health staff survey	144
5.1.1	Recruitment of participants	144
5.1.2	Characteristics of the respondents	145
5.1	Respondents' paediatric healthcare practices	145
5.1.1	Use of growth charts in monitoring and assessing growth in infants	145
5.1.2	Referral criteria for nutrition intervention or offer of treatment	146
5.2	Respondents' growth pattern assessment	146
5.2.1	Results of the plotting exercise on the RTH and WHO charts	146
5.2.2	Application / interpretation of growth trajectories	148
5.2.3	Overall accuracy scores	150
5.2.4	Respondents' comments on growth charts	151
5.2.5	Respondents' general comments	152
5.3	Discussion	153
5.3.1	Main findings	153
5.3.2	Strengths of the study	159
5.3.3	Limitations of the methods	160
5.3.4	Reliability of the data collected	161
5.4	Conclusion from the study	162

CHAPTER 6	GENERAL DISCUSSIONS AND RECOMMENDATIONS.....	163
6.1	Key findings and quality of the evidence from the research project.....	163
6.1.1	Key findings	163
6.1.2	Relevance of the employed approach	165
6.1.3	Significance of the research project	166
6.2	Tackling the problem of undernutrition in early infancy.....	167
6.2.1	Preventing undernutrition in early infancy	167
6.2.2	Making a correct diagnosis of undernutrition in infants	169
6.2.3	Practicality and “real world” potential of the various tools/measures used for detecting undernutrition	170
6.2.4	Supporting lactation in individual hospitalised infants.....	171
6.2.5	Promoting and supporting breastfeeding in paediatric wards	173
6.2.6	Implications of the findings of the current research project	176
6.3	Positioning the data from the current research project	177
6.3.1	Contributions to the WHO guidelines for the treatment of SAM	177
6.3.2	Contributions to the SUN movement.....	178
6.3.3	Scaling up the findings of the research project for use in practice	179
6.4	Conclusions	180
	Appendices	181
	Annexe 1	182
	Annexe 2	183
	Appendix A.1 Information Sheet for the Infant Welfare Clinic Study	184
	Appendix A.2 Consent Form for the Infant Welfare Study	186
	Appendix B.1 Information Sheet for the Hospital Ward Study	187
	Appendix B.2 Consent Form for the Hospital Ward Study	189
	Appendix B.3 Paediatric SGNA Questionnaire	190
	Appendix C.1 Information Sheet for the Health Staff Study	194
	Appendix C.2 Consent Form for the Health Staff Study	196
	Appendix C.3 Health Staff Questionnaire A.....	197
	Appendix C.4 Health Staff Questionnaire B	208
	Appendix C.5 Health Staff Questionnaire C	219
	Appendix D.1 iPYMS Local Reference for the Comparison of Skinfolts	230
	Appendix E.1 Nigerian Road-to-Health Chart	231
	Appendix E.2 Datasheet for the Infant Welfare Clinic Study.....	232
	Appendix E.3 Datasheet for the Hospital Ward Study	233
	List of References	234
	Author Biography	253

List of Tables

Table 1.1 The current WHO definitions of major types of undernutrition in infants (World Health Organisation, 1995).....	2
Table 1.2 Statistics for Nigeria.....	3
Table 1.3 Studies on effects of morbidity on growth of infants	1
Table 1.4 Studies on growth velocity of infants.....	30
Table 1.5 Different implications of WHO case-definitions in clinical and public health practice.....	32
Table 1.6 Studies that used growth charts to detect undernutrition	41
Table 1.7 Prevalence of undernutrition in hospitalised infants in developed countries	45
Table 1.8 Prevalence of undernutrition children (0 – 5 years) (population and hospital settings) in developing countries.....	48
Table 1.9 Prevalence of undernutrition in Nigerian children (0 – 5 years) at the population level, based on the WHO-CGS (February – June 2013).....	48
Table 1.10 Nigerian studies on infant growth	49
Table 1.11 Prevalence of undernutrition in infants in developing countries	50
Table 2.1 Scenarios for the assessment of growth patterns of infants	96
Table 2.2 Permutation data from the self-completion questionnaire	96
Table 2.3 Per response data.....	96
Table 2.4 Categorisation of number of correct plots	98
Table 2.5 Recoding of the ratings of the weight gain patterns and proposed actions.....	98
Table 2.6 Categorisation of overall accuracy scores	99
Table 3.1 Birth-related and feeding characteristics of the healthy infants (0 – 26 weeks old) N (%).....	101
Table 3.2 Average weight gain in the healthy infants	102
Table 3.3 Mean (SD) weight Z-scores change by birthweight Z-scores categories of the healthy infants.....	103
Table 3.4 Regression analysis on the weight-for-age Z-scores in the healthy infants.....	103
Table 3.5 Conditional weight gain in the healthy infants N (%).....	104
Table 3.6 Comparison of means between breastfeeding status and nutritional status in the healthy infants.....	104
Table 3.7 Studies on conditional weight change in infants.....	114
Table 3.8 Studies on conditional weight change in infants.....	115
Table 3.9 Studies on conditional weight change in infants.....	116
Table 4.1 Birth-related and feeding characteristics of the hospitalised infants N (%)	118
Table 4.2 Diagnoses in the hospitalised infants N (%).....	119
Table 4.3 SGNA rating in the hospitalised infants N (%)	119
Table 4.4 Anthropometric measures and anthropometric Z-scores in the hospitalised infants	120
Table 4.5 Prevalence of low values of anthropometric indicators in the hospitalised infants	120

Table 4.6 Mean (SD) weight change Z-scores and conditional weight changes in the hospitalised infants (N=119)	123
Table 4.7 Using the iPYMS reference to compare the mean (SD) skinfolds Z-scores, according to SGNA rating in the hospitalised infants	125
Table 4.8 Using field measures versus clinical measures to detect nutrition risk in the hospitalised infants	127
Table 4.9 Proportions of the hospitalised infants with low anthropometric Z-scores.....	128
Table 4.10 Proportions of the hospitalised infants below thresholds of the different measures (N, %) by SGNA rating	129
Table 4.11 Comparing the use of simple to clinical measures in the hospitalised infants ...	130
Table 4.12 Relation of SGNA rating/nutritional status and breastfeeding status in the hospitalised infants	130
Table 5.1 Characteristics of the respondents (N = 222)	146
Table 5.2 Use of growth measures by the respondents (N, %) (N = 222).....	146
Table 5.3 Categorisation of summary of plots of the given ages and weights on the RTH and WHO charts (N=222)	147
Table 5.4 Total number of correct plots of the given ages and weights on the RTH and WHO charts.....	148
Table 5.5 Number of correct plotting of the given ages on the RTH and WHO charts by variable category (N=222)	148
Table 5.6 Total number of correct plotting of the corresponding weights on the RTH and WHO charts by variable category (N=222)	148
Table 5.7 Correct ratings of weight gain patterns and proposed actions for weight gain patterns by size N (%).....	150
Table 5.8 Correct ratings of weight gain patterns and proposed actions for weight gain patterns by chart type N (%)	150
Table 5.9 Overall ratings of growth patterns according to weight gain patterns.....	150
Table 5.10 Accuracy of ratings of the weight gain patterns scenario and proposed actions according to professional characteristic category N (%).....	150
Table 5.11 Overall accuracy scores N (%).....	152

List of Figures

Figure 1.1 Flowchart presenting an overview of the literature search process	7
Figure 1.2 Conceptual framework for causes of malnutrition in infants < 6 months of age ...	15
Figure 1.3 Lifecycle and Intergenerational Linkage of Malnutrition	24
Figure 1.4 Interactions between malnutrition and disease.....	26
Figure 2.1 The researcher measuring the weight of an infant admitted to the paediatric ward of the UNTH, Enugu	68
Figure 2.2 The researcher measuring the recumbent length of same infant as above	68
Figure 2.3 Map of Nigeria in relation to Africa	72
Figure 2.4 Per Scenario Presentations	94
Figure 3.1 Weight Change Trend in the Healthy Infants	102
Figure 3.2 Box Plot of Weight change Z-scores by Birthweight categories in the healthy infants.....	103
Figure 4.1 Age distribution according to age at assessment, in the hospitalised infants	117
Figure 4.2 Box Plot of weight Z-scores by Birthweight weight Z-scores in the hospitalised infants.....	122
Figure 4.3 Average weight gains in the hospitalised infants	123
Figure 4.4 Scatter Plot of the sum of skinfolds by age in the hospitalised infants	124
Figure 4.5 Boxplot comparing the mean triceps and subscapular skinfolds of the hospitalised infants (3 – 6 months old), using WHO standards and iPYMS reference	124
Figure 4.6 Prevalence of undernutrition in the hospitalised infants (N = 210)	126
Figure 4.7 Mean anthropometric Z-scores by SGNA-rated nutrition risk levels in the hospitalised infants	126
Figure 4.8 Scatter Plot of the MUAC by age, according to SGNA rating in the hospitalised infants.....	127
Figure 4.9 Concurrence of low anthropometric indicators (N, % of infants with low Z-scores) using the clinical methods in the hospitalised infants	128
Figure 5.1 Flow diagram of the progress through the phases of the Health Staff Survey	145
Figure 5.2 Categorisation of response scores.....	151
Figure 5.3 Rating of accuracy of response scores.....	151

Preface

Three years ago, I started this research project as a pilot study at the Royal Hospital for Sick Children (RHSC), Yorkhill, Glasgow, but it eventually turned out to be an extended investigation into Enugu city, southeast Nigeria. The University of Nigeria Teaching Hospital (UNTH), Enugu was the base for the project that was comprised of three studies. This aimed to explore ways of assessing the risk for undernutrition in early infancy in a developing world setting, using Nigeria as a case reference. This thesis is the report of the findings of this extended investigation. It cannot express the long journeys taken between the data-collection points at the chosen health institutions located far distances apart and the pleas made to mothers/carers of both healthy and hospitalised infants, for their written consents to allow their infants to participate in the two respective studies on growth assessment. In addition, the persuasive invitation made to the health staff to volunteer with written consent to participate in the study to explore their use of growth patterns to identify infants at the risk of undernutrition. Including several phone calls, text messages and visits made to the health staff that later participated at their different health facilities to retrieve the completed copies of the survey questionnaire which were earlier issued to them. However, the joy of collecting an appreciable analysable data, the hope of obtaining good results and contributing to the body of knowledge in this area of child health practice submerged all those stressful experiences. Moreover, the confidence that the results from this research would trigger further research in this area of nutrition, evolving evidence-based strategies aimed at the survival of Nigerian infants to manifest their full potential as the productive adults of the next generation. To conclude, I must thank you, the reader among the many who would read this thesis, for reading at least one page of my thesis.

Thank you.

Ifeyinwa Obiageli Ezeofor

2015

Glasgow

Acknowledgements

I thank the Almighty God for granting me the grace and strength to successfully scale through this PhD research programme. I am grateful to acknowledge the financial support that I received from the Ford Foundation International Fellowships Program (IFP), New York, USA for this programme from 2010 to 2013, including my fieldwork in Nigeria to collect data for the three studies constituting this research project. I fondly remember my late father who greatly inspired my academic life, and other family members (my mother, sisters and brothers) for all their support through phone calls and mails from Nigeria. Pastor (Dr) Alfred Itiowe (Enugu, Nigeria), Pastor Ugonna Onyekwere (Glasgow, Scotland), and my Christian brethren at both locations are highly appreciated for their support towards the success of this programme, particularly at the times of greatest stress. Many thanks to the mothers who participated with their infants in the two infant studies and the medical doctors, dietitians/nutritionists, and nurses who participated in the health staff survey. Included are the various categories of staff at the different health facilities who contributed variously to the success of the project at Enugu city, southeast Nigeria.

I am very grateful to my supervisors, Prof Charlotte Wright and Dr Ada Garcia, for having patiently nurtured me through this research to turn out something presentable to the academic community. I thank my academic adviser, Prof Christine Edwards, for her scholarly and motherly encouragement, that boosted my morale through the period of this research. I appreciate the members of the PYMS Project Group, particularly Dr Konstantinos Gerasimidis (Lecturer in Clinical Nutrition) and Anne Maclean (Chief Dietitian/Manager, Department of Nutrition & Dietetics) for their guidance during the pilot study at the RHSC, Yorkhill in Glasgow. My Nigerian supervisor, Dr Stella Ngozi Ibeziako (Senior Lecturer, College of Medicine, University of Nigeria, Nsukka/Consultant Paediatrician, University of Nigeria Teaching Hospital (UNTH), Enugu) is also highly appreciated for her contribution to the success of my data collection in Nigeria. I am thankful to the University and National Health Services staff (particularly our now-retired academic secretary, Rita Margaret Dobbs) at the Paediatric Epidemiology and Community Health (PEACH) Unit, RHSC, Yorkhill, Glasgow for all their assistance to me during the period of my PhD studentship there.

Author's Declaration

“I declare that that the work contained in this thesis is original, and is the work of the author, Ifeyinwa Obiageli Ezeofor. The information reported from other authors was quoted with their names and sources of publication. All data were collected according to Good Clinical Practice guidelines. All analyses and data processing was carried out by the author under the supervision of Prof Charlotte M. Wright and Dr Ada L. Garcia.”

Ifeyinwa Obiageli Ezeofor

Supervisors' Declaration

“We certify that the work reported in this thesis has been performed by Ifeyinwa Obiageli Ezeofor and that during the period of study, she has fulfilled the conditions of the ordinances and regulations governing the Doctor of Philosophy”.

Professor Charlotte M. Wright (Principal supervisor)

Dr Ada L. Garcia (Second supervisor)

List of Abbreviations

BF	Breastfeeding
BFHI	Baby Friendly Hospital Initiative
BMS	Breastmilk Substitute
BMI	Body Mass Index
CDC	Centre for Disease Control and Prevention
CHER	Children Emergency Room
CMAM	Community Management of Acute Malnutrition
EBF	Exclusive Breastfeeding
ESUTH	Enugu State University of Science and Technology Teaching Hospital
GMP	Growth Monitoring and Promotion
ICH	Institute of Child Health
iPYMS	Infant Paediatric Yorkhill Malnutrition Screening
IWC	Infant Welfare Clinic
MAM	Moderate Acute Malnutrition
MAMI	Management of Acute Malnutrition in Infants
MDGs	Millennium Development Goals
MUAC	Mid-Upper Arm Circumference
NBSCU	New Born Special Care Unit
NCHS/WHO	National Centre for National Statistics/World Health Organisation
NOH	National Orthopaedic Hospital
RHSC	Royal Hospital for Sick Children
RUTF	Ready to Use Therapeutic Food
SAM	Severe Acute Malnutrition
SDS	Standard Deviation Scores
SGNA	Subjective Global Nutrition Assessment
SSFT	Subscapular Skinfold Thickness
TSFT	Triceps Skinfold Thickness
UNICEF	United Nations Children's Fund
UNTH	University of Nigeria Teaching Hospital
USAID/BASICS	Basic Support for Institutionalising Child Survival for the United States Agency for International Development
WHO	World Health Organisation
WHO-CGS	World Health Organisation Child Growth Standards

Glossary

Body Mass Index: Weight in kilograms divided by length/height in metres squared, is a simple and reproducible index that reflects body composition being correlated with body fatness

Breastmilk Substitute: Any food marketed or otherwise represented as a partial or total replacement for breastmilk, whether or not suitable for that purpose

Complementary food: Any nutrient-containing foods or liquids other than breast milk given to young children

Conditional weight change: The change in weight within the first six months of life relative to the birthweight, in the context of the mean growth pattern of the population

Exclusive breastfeeding: Feeding an infant with only breastmilk from its mother or a wet nurse, or expressed breastmilk, and no other liquids or solids except vitamins, mineral supplements, or medicines in drop or syrup form

F-75: A low protein milk-based formula diet of 75 kilocalories per 100 millilitres, given as therapeutic food in the stabilisation phase of the treatment of severe acute undernutrition

F-100: A milk formula with higher protein and energy content than F-75 (containing 100 kilocalories per 100 millilitres), recommended as therapeutic food in the rehabilitation phase of the treatment of severe acute undernutrition

Growth: Increase in body dimensions (such as weight, length/height, head circumference) and composition (such as lean and adipose tissues)

Growth charts: Graphic presentations of body measurements of a population applied in the assessment of body size and shape including patterns of growth performance

Growth Monitoring: The serial weighing and measuring of the length/height (and head circumference if aged 0 – 2 years old) of a child and plotting the measurements on a growth chart

Growth reference: Description of what the growth pattern of a defined population is

Growth Standards: Description of what the growth pattern of all children should be

Growth velocity: Average change in a specific anthropometric measure over a specific time period, ideally one year and no shorter than six months

HEMIX: A high protein high-energy mixture equivalent to F 100 milk, locally prepared for undernourished children at the UNTH, Enugu

Infancy: Period of life from birth to two years

Kangaroo skin-to-skin contact method: Providing warmth and nurture to an infant through keeping it upright in skin-to-skin contact between its mother's breasts

Low birthweight: Birthweight that is less than 2500 grams

Neonatal period: The interval from birth to 28 days of age

Nutritional screening: A process to identify an individual who is undernourished or who is at risk for undernutrition, to determine if a detailed nutritional assessment is indicated

Partial breastfeeding: Feeding of an infant with some breastmilk but also given other foods or food-based fluids, such as infant formula or complementary foods

Predominant breastfeeding: Breastmilk as an infant's predominant source of nourishment, but with the possible addition of water and water-based drinks (for example sweetened and flavoured water, teas, infusions), fruit juice, oral rehydration salts solution, drops and syrup forms of vitamins, minerals, and medicines (in limited quantities)

Ready to Use Therapeutic food (RUTF): An energy and nutrient dense paste, a therapeutic food that is nutritionally equivalent to F 100 milk, but needs no preparation and can be eaten direct from its container

Supplementary Feeding: Feeding an infant less than 6 months of age to supplement its intake of breastmilk, where this is insufficient

Stunting: ($<-2SD$ length/height-for-age) Chronic severe undernutrition indicating long-term, cumulative effects of inadequate nutrition/health and failing to reach generic potential

Undernutrition: A net deficit of energy irrespective of the limiting effect of any other specific nutrient, hence a state of negative energy balance

Underweight: ($<-2SD$ weight-for-age) Manifestation of both acute and chronic undernutrition

Wasting: ($<-2SD$ weight-for-length/height) Acute undernutrition indicating recent weight loss resulting from recent food deprivation and/or disease

Z-scores (Standard Deviation Scores): Dimensionless quantity used to describe how far a measurement is from the mean (average) or median, when the distribution is normal

CHAPTER 1 INTRODUCTION AND LITERATURE REVIEW

1.1 Introduction

The WHO infant and young child feeding guidelines recommend exclusive breastfeeding (EBF) as the optimal nutrition for an infant from birth to 6 months of age, for optimal growth and protection from morbidity (Kramer and Kakuma, 2012); however, the rapid growth of early infancy is limited by undernutrition. Undernutrition is a medical condition that manifests in many ways reflecting a net deficit in energy irrespective of the effect of any other limiting nutrient, for example proteins or fatty acids, thus manifesting a state of negative energy balance (Wright and Garcia, 2012). The WHO uses -2SD cut-off values of these anthropometric indicators to define undernutrition, either as low weight-for-age (underweight) or low length/height-for-age (stunting) or low weight-for-length/low body mass index-for-age (BMI-for-age)/low mid-upper arm circumference-for-age (MUAC-for-age)/low skinfolds-for-age (wasting) (Table 1.1).

Undernutrition in the first six months of life is usually considered a rare occurrence (Ezeofor and Okeke, 2005, Patwari et al., 2015) because of the general view that very young infants are less likely to be undernourished since they are breastfed and have not had time to be undernourished after birth. However, the findings of recent studies in early infancy prove this assumption untrue. A secondary data analysis of demographic and health survey datasets in 21 developing countries found wasting to be prevalent among infants younger than 6 months, based on the WHO standards (Kerac et al., 2011). It was also reported from India that a higher percentage of infants younger than 6 months were wasted, in comparison with the older age group (Patwari et al., 2015). Community-based programmes had focused on tackling wasting in children aged from 6 to less than 60 months; thus neglecting, often excluding from nutrition surveys and not appropriately addressing infants younger than 6 months in nutrition-related/rehabilitation programmes (Lopriore et al., 2007, Kerac et al., 2011). The contribution of this population towards the undernutrition burden has been underestimated; therefore, undernutrition in early infancy is still a worldwide public health problem, particularly in developing countries like Nigeria.

Table 1.1 The current WHO definitions of major types of undernutrition in infants (World Health Organisation, 1995)

Definition	Description	Grading
Underweight is a deficit defined as low weight-for-age	<ul style="list-style-type: none"> Body mass relative to age influenced by weight and length/height, thus a composite of stunting and wasting 	Moderate underweight (weight-for-age between -3SD and -2SD)
	<ul style="list-style-type: none"> Reflects both acute and chronic undernutrition, but may not appropriately distinguish between taller but wasted children and shorter children of adequate weight 	Severe underweight (weight-for-age < -3SD)
Stunting is a deficit defined as low length/height-for-age and /or head circumference-for-age in chronic severe undernutrition	<ul style="list-style-type: none"> Linear growth achieved pre- and post-partum with its deficits indicating long-term, cumulative effects of inadequate nutrition/health and failing to reach genetic potential 	Moderate stunting (length/height-for-age and/or head circumference-for-age between -3SD and -2SD)
	<ul style="list-style-type: none"> Reflects chronic undernutrition indicating chronic weight loss resulting from prolonged food deprivation and/or illness 	Severe stunting (length/height -for-age and/or head circumference-for-age < -3SD)
	<ul style="list-style-type: none"> The age of a child modifies the interpretation below 2 – 3 years, low length-for-age probably reflects a continuing process of ‘failing to grow’ or ‘stunting’ for older children 	
Wasting (acute undernutrition) is a deficit defined as low weight-for-length/ height and/or low BMI-for-age and/or low MUAC-for-age and/or low skinfolds	<ul style="list-style-type: none"> Measurement of wasting does not require reference to the child’s age, which may benefit in population surveys where age of children is unknown 	Moderate wasting or Moderate Acute Malnutrition (MAM) (weight-for-height/length and/or BMI and/or skinfolds between -3SD and -2SD and/or MUAC < 125 mm)
	<ul style="list-style-type: none"> Reflects acute undernutrition indicating recent substantial weight loss resulting from recent food deprivation and/or illness 	Severe wasting (weight-for-height/length and/or BMI and/or skinfolds < -3SD and/or *MUAC < 115 mm)

*MUAC alone is not currently recommended for infants younger than 6 months

In Nigeria, undernutrition (based on z-scores below -2 for weight-for-age, length-for-age, and body-mass-index-for-age) was found to be prevalent (13.8% of underweight, 30.8% for stunting and 10.0% for wasting) in the first three months of life and detected early at routine immunisation clinics shortly after birth (Olusanya et al., 2010).

According to the WHO classification for assessing the severity of undernutrition by prevalence ranges among children less than five years of age, Nigeria (Table 1.2) has a low underweight (9% against <10% for low), fairly high wasting (10.2% against 10 – 14% for high), and moderately high stunting (35.8% against 30 – 39% for high) rates. Compared to other countries in sub-Saharan Africa like Mali (World Health Organisation, 2012a), underweight is very low (9% against 18.7%), wasting is fairly high (10.2% against 8.9%) and stunting high (35.8% against 27.8%). Access to health

services, particularly maternal and childcare services is fairly poor in most rural areas; therefore this poor state of healthcare has exacerbated the problem of undernutrition in Nigeria (Adelekan, 2003), affecting more children in the north than in the south.

Table 1.2 Statistics for Nigeria

Description	%
Population/Economic/Health Indicators	
Population below international poverty line of US\$1.25 per day (2007-2011)	54.4
Population living in urban areas (2012)	50.3
Gross Domestic Product per capita average annual growth rate (1990-2012)	2.1
Public spending as a % of GDP allocated to health (2007-2011)	2.0
Total adult literacy rate (2008-2012)	51.1
Health/Nutrition Indicators	
Delivery care, Institutional delivery (2007-2012)	35.0
Neonatal mortality rate (2012)	39.0
Early initiation of breastfeeding (2008-2012)	22.9
Exclusive breastfeeding <6 months (2008-2012)	15.1
Introduction of solid, semi-solid or soft foods 6-8 months (2008-2012)	32.9
Breastfeeding at age 2 (2008-2012)	34.5
Low birthweight (2008-2012)	15.2
Underweight (moderate and severe) (2008-2012)	9.0
Stunting (moderate and severe) (2008-2012)	35.8
Wasting (moderate and severe) (2008-2012)	10.2
Overweight (moderate and severe) (2008-2012)	3.0

(Adapted from UNICEF, 2012)

Scarcity of disease-prevalent data contributes to the difficulty in identifying the problem of undernutrition in this population. Even the WHO/UNICEF joint statement endorsing the use of the new WHO growth reference standards for the ‘identification of severe acute malnutrition in infants and children’ did not discuss its implication on this age group (Joosten and Hulst, 2008). However, challenges of managing acute malnutrition in this population were widely reported resulting in different interventions by non-governmental organisations. An example was the Management of Acute Malnutrition in Infants (MAMI) project that aimed to investigate the management of acute malnutrition in this age-group in emergency programmes, focussing on available treatment in selective feeding programmes (ENN/UCL/ACF, 2010). Set out to establish the burden of acute malnutrition in this age-group, the MAMI project focussed on identifying guidelines, policies and strategies for case management; and determine practice in the field, including recommendations for future practice and research. The project reported that wasting prevalence in this age-group ranged from 1.1% to 15% with NCHS and 2.0% to 34.1% using WHO Child Growth Standards (WHO-CGS, and severe wasting increased >3.0 fold and moderate wasting 1.4 fold when transitioning from the NCHS to the WHO-CGS. Consequently, admission into WHO-CGS-based selective feeding programmes would increase and need to be explored urgently.

However, the current evidence base for managing malnutrition in this age group is relatively weak, posing a challenge to applying the current guidelines.

Infants and children constitute the most vulnerable group in any community, and childhood nutritional status is a sensitive indicator of the health and nutrition in that community. Therefore, investments in child health, particularly child nutrition have a potentially high dividend for the long-term development of the individual and society (Harttgen et al., 2013, Black and Dewey, 2014). Worldwide, recognition of childhood undernutrition is an important public health indicator for monitoring nutritional status and health in populations, which prompted advances in child feeding practices and medical care. However, childhood undernutrition remains a major public health problem worldwide, particularly in infants younger than 6 months. Childhood undernutrition is less prevalent in developed countries than in developing countries, where undernutrition prevalence in children is higher in rural than urban settings (see Table 1.10 below). Moreover, wasting is higher in infants younger than 6 months, noting this population's often exclusion from nutrition surveys and marginalisation in nutrition programmes (Kerac et al., 2011). Lopriore and colleagues argue that the global estimates of undernutrition prevalence in children under 5 years of age mask variation in age ranges not having included infants (0 – 5 months old), resulting in underestimation of the overall prevalence of undernutrition in this population (Lopriore et al., 2007). The authors of that paper note that the exclusion of these very young infants from surveys results in different prevalence of wasting among children less than 5 years of age. This overestimation was larger for rates of stunting and underweight, which were exceptionally large in countries with high prevalence (some Asian and African countries). Therefore, they suggest that it is important to include infants from birth, in order to standardise the collection, analysis, and use of nutrition indicators among organisations.

In early infancy, there is increased vulnerability to nutrition-related events and insults because this period of life is dependent on breastmilk supply for the provision of high energy demands needed for rapid growth as well as for developing immunity.

Suboptimal breastfeeding is associated with high risk of mortality with a reported 3.1 million child deaths annually (Black et al., 2013). However, the WHO/UNICEF joint statement (WHO/UNICEF, 2009) in the recommendation of a transition to the WHO-CGS to identify wasting, only reviewed the implications for children aged 6 – 60 months. Patwari and colleagues, therefore suggest the addition of infants younger than 6 months in future WHO guidelines for SAM children (World Health Organisation,

2012b), in response to the needs of this vulnerable group (Patwari et al., 2015). In developed countries, undernutrition in infants and children mostly occurs as an effect of chronic disease conditions (Hulst et al., 2010), and may be made worse by frequent hospital stays and diagnostic examinations (Stratton et al., 2003). Surveys in hospitalised children have suggested that undernutrition is often overlooked (Moyen et al., 2011) or underestimated (Pawellek et al., 2008); though an average of 10% prevalence has been reported in some developed countries (Sissaoui et al., 2013). However, little knowledge exists about the prevalence rates of undernutrition in hospitalised children in developing countries like Nigeria. Moreover, making the correct diagnosis of undernutrition is of paramount importance in its prevention and education on the management of cases, where they exist. Therefore, raising awareness of the prevalence of undernutrition in young hospitalised infants could prompt nutrition assessment and subsequent nutrition interventions for the 'at-risk' group and thus, have a long-term effect on the strategies aimed at forestalling the adverse consequences of undernutrition on child health and growth. For a novel contribution to be made, using Enugu city, southeast Nigeria as a case reference, gaps in the current knowledge and management of early childhood undernutrition, need to be identified through critical analysis of the literature.

1.2 Review of the literature

Literature search strategies

Strategies to identify data sources included searching electronic survey databases such as the WHO Global Database on Child Growth and Malnutrition, and the Cochrane Database of Systematic Review; and searching electronic general citation databases such as Google Scholar, Pub MED, Web of Science, and African Journals Online (particularly the Nigerian Journal of Paediatrics). The search terms used are listed in Annexe 1 of the Appendix. Searches based on topics and authors were refined/filtered according to research areas, including general and internal medicine, tropical medicine, gastroenterology, paediatrics, child health, public health, nutrition and dietetics; document types such as article and review; publication years sorted from newest to oldest (1995 – 2015); and countries of the world according to developed and developing. Furthermore, reference lists for retrieving documents were searched for additional documents of interest. Email alerts set on the key words of the current research topic in some scientific journals also yielded links to relevant recent publications. Data sources included nutrition surveys, community and hospital-based epidemiological studies, randomised controlled trials, systematic reviews, cross-sectional, case-control and cohort studies. An overview of the literature search process shows the existing approaches (Moher et al., 2009) (Figure 1.1) used in reviewing documented evidence of the problem and prevalence of childhood undernutrition. The review of published literature aimed to answer the following questions:

- 1) What is the pattern of growth in infants younger than 6 months, particularly hospitalised infants?
- 2) How does their growth velocity relate to their nutritional status?
- 3) What are the case-definitions of undernutrition in these infants?
- 4) What are the measures/tools employed in assessing undernutrition in these infants?
- 5) What is the prevalence of undernutrition in these infants?
- 6) How is undernutrition managed in these infants?
- 7) What is the accuracy of paediatric health staff use of growth patterns displayed on charts in identifying undernutrition in this population?

Review of abstracts assessed their alignment with our objectives. Publications included in the review were limited to articles that:

- based their assessment mainly on WHO child growth recommendations and other considered factors
- assessed nutritional status in relation to breastfeeding status in infants
- assessed growth in infants younger than 6 months, including hospitalised infants
- estimated undernutrition prevalence in infants younger than 6 months
- surveyed health staff understanding, application and interpretation of infant growth patterns displayed on charts

Exclusion of studies if they:

- primarily assessed undernutrition using local or NCHS growth reference
- assessed nutritional status in relation to complementary feeding
- the population consisted of specific subgroups, for example children older than 6 months or 6 – 60 months of age

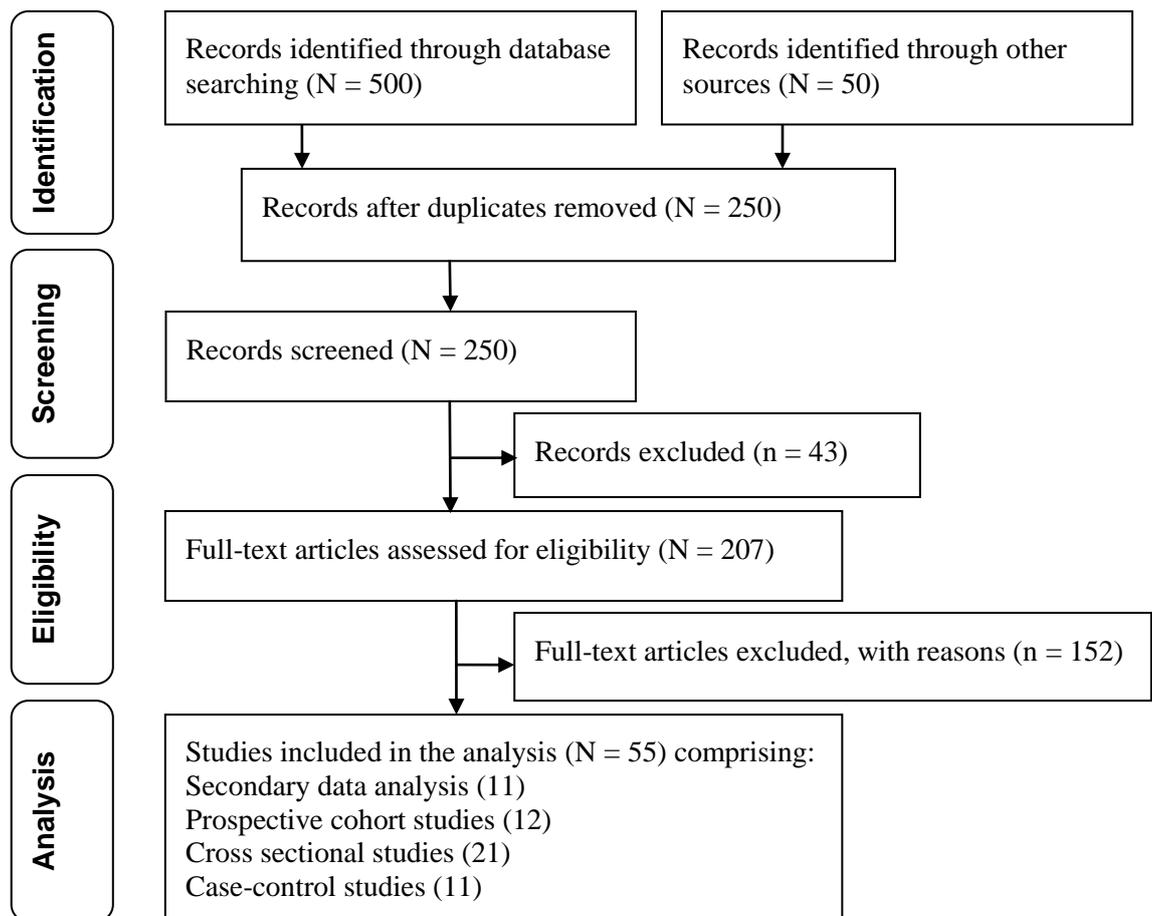


Figure 1.1 Flowchart presenting an overview of the literature search process
Adapted from: Moher D, Liberati A, Tetzlaff J, Altman DG, the PRISMA Group (2009)

1.2.1 Definitions of undernutrition

Since there is no universally accepted definition of undernutrition, attempts are made using different elements, such as nutrients balance, nutrition status, energy balance, metabolism, body functions, body mass or weight maintenance, water and electrolyte balance, and inflammation. The WHO defines malnutrition as “the cellular imbalance between the supply of nutrients and energy and the body’s demand for them to ensure growth, maintenance, and specific functions” (de Onis et al., 1993). Focusing on effects on metabolism, the American Society for Parenteral and Enteral Nutrition (A.S.P.E.N) defines malnutrition as “any disorder of nutrition status, including disorders resulting from a deficiency of nutrient, impaired nutrient metabolism, or overnutrition” (A.S.P.E.N, 1995, A.S.P.E.N, 2002). Highlighting the disparity between intake and requirement, malnutrition has been described as an imbalance between intake and requirement which results in altered metabolism, impaired function and loss of body mass (Kinosian and Jeejeebhoy, 1995). Jeejeebhoy describes malnutrition as a continuum that starts when food intake fails to meet body needs and progresses through a series of functional changes that precede any changes in body composition in relation to the duration of reduced intake and its severity (Jeejeebhoy, 2000). This author postulates that it is only by recognising the different facets of malnutrition could its various manifestations be defined in relation to clinical objectives.

Stressing the importance of energy balance, Stratton and colleagues defined malnutrition as a state of nutrition in which a deficiency or imbalance of energy, protein, and other nutrients causes measurable adverse effects on tissue/body form (body shape, size and composition) and function, and clinical outcome (Stratton et al., 2003). Similarly, Loch and colleagues note that undernutrition is often described as a state of deficiency of energy or protein intake or absorption (Lochs et al., 2006). Concentrating on body weight maintenance, Sacker and colleagues assert that a uniform definition of undernutrition in children is yet to be realised by science/nutrition experts, but suggest that diagnosing undernutrition should include involuntary weight loss, body mass index, and nutritional intake (Sacker et al., 2006). In a Delphi study, where science/nutrition experts in an attempt to define undernutrition, proposed including some elements such as: deficiency of energy, deficiency of protein, and decreases in fat-free mass; and importantly applied function and inflammation. They were unable to reach agreement on cut-off points for the defining elements, but most of the science/nutrition experts indicated that the development of a set of measurements

for the assessment of nutritional status is important in the operationalisation of the definition of undernutrition (Meijers et al., 2010). Emphasising nutrient interactions, Mehta and colleagues argue that defining undernutrition in terms of protein energy malnutrition, marasmus, and kwashiorkor would describe the effects of undernutrition but not the varieties of aetiologies and dynamic interactions relevant to nutrition depletion in children (Mehta et al., 2013). Therefore, these authors defined paediatric undernutrition as an imbalance between nutrient requirement and intake, resulting in cumulative deficits of energy, protein, or micronutrients that negatively affect growth, development, and other relevant outcomes.

Norman and colleagues assert that not having an internationally-accepted criterion for diagnosing undernutrition is part of the reason for the wide range of reported hospital undernutrition prevalence (Norman et al., 2008). Therefore, the pattern of occurrence of undernutrition can differ according to nutritional assessment method. This was demonstrated by the results from a secondary analysis of data from a historical longitudinal study which addressed the dynamics of clinically and anthropometrically defined undernutrition (Kismul et al., 2014). Both clinical and anthropometric assessments measured the wasting processes while only anthropometric assessment measured the stunting processes. These researchers followed 5,657 preschool children 3-monthly for 15 months using the WHO-CGS resulting in undernutrition rates increasing from the 0 – 5 to 6 – 11 months category. Alteration from severe to mild undernutrition was more characteristic for anthropometrically than clinically defined undernutrition. The anthropometric measure case-definitions of undernutrition applied in any given situation, determine the estimates of the prevalence of undernutrition realised. For example, the application of the weight-for-height and MUAC case definitions in agrarian and pastoralist Ethiopian children yielded different estimates of the prevalence of acute undernutrition (Myatt et al., 2006).

In a broader sense, insufficient, excessive, or unbalanced consumption of dietary energy and nutrients result to malnutrition which manifests in different forms as undernutrition, overnutrition, and micronutrient malnutrition (Smith and Haddad, 2000). Shetty highlights that although the terms ‘malnutrition’ and ‘undernutrition’ are often used loosely and interchangeably, malnutrition is a broader term that includes undernutrition and overnutrition (Shetty, 2006). However, for the purpose of this review, the term ‘undernutrition’ will be used instead of ‘malnutrition’. Overall, there is need to account for the chronicity of the nutrient imbalance in defining undernutrition,

thus allowing the difference between acute and chronic undernutrition to reflect in the intervention strategy used in its management. Therefore, screening infants and children for undernutrition on admission to hospital or at the beginning of an illness allows the assessment of current nutritional status and facilitates early detection of subsequent nutrition deterioration related to the illness. The type and severity of the illness is an important variable that determines nutrient needs and the ability to deliver and assimilate nutrients needed for child growth.

Key anthropometric measures used in defining undernutrition in infants

Growth measurement is the single measurement that best defines the health and nutritional status of children (World Health Organisation, 1995). The key tools employed in measuring growth in children have been anthropometric measures (weight, length, head circumference, mid-upper arm circumference, and skinfold thickness at different sites of the body) in comparison with a normative reference dataset. The most commonly used anthropometric indices for assessing child growth in early infancy are weight-for-age, length-for-age, weight-for-length, MUAC-for-age. The use of these measures is central in identifying growth failure and undernutrition, suggesting that clinical examination alone is inadequate (Cross et al., 1995). However, the current WHO recommended guidelines for the early identification of undernourished children for treatment, include a measurement of MUAC<115mm or a weight-for-length/height <-3Z-score or a physical finding of bilateral pitting oedema (World Health Organisation, 2013).

MUAC, as a simple measure of nutritional status to detect changes in body composition, has been found to be the best indicator for screening and detection of undernutrition in children in the community, particularly appropriate for difficult purposes such as emergencies (Myatt et al., 2006). Clinical practice often uses MUAC in assessing and monitoring therapeutic/supplementary nutrition interventions. The case-definition of undernutrition using MUAC<115 mm identified high risk children better than weight-for-length/height <-3Z-score (Briend et al., 2012). The WHO and UNICEF proposed to use two independent criteria for diagnosing non-oedematous severe acute malnutrition (SAM) in children aged 6 – 60 months: MUAC<115mm and weight-for-length/height Z-score based on the WHO-CGS <-3SD (WHO/UNICEF, 2009). Therefore, WHO/UNICEF in the new guidance for programmes treating SAM in children, has reinforced the use of MUAC<115mm as an independent admission

criteria. Although, the criteria for discharge have been debated, the findings from an emergency nutrition programme have suggested that using MUAC >125mm as a discharge criteria is more feasible and led to acceptable durations of treatment and weight gains (Dale et al., 2013). A cohort study had earlier concluded that MUAC is a practical screening tool that performs at least as well as weight-for-height in predicting subsequent inpatient mortality among severely undernourished hospitalised children (Berkley et al., 2005).

MUAC rates as a better practical, feasible, and cost-effective tool than weight-for-length/height in identifying, monitoring severely undernourished hospitalised children in the community (Berkley et al., 2005, Myatt et al., 2008, Briend et al., 2012). For example, a study in Kenya reported that MUAC was more reliably measured by community health workers than weight-for-length Z-score among infants younger than 6 months (Mwangome et al., 2012b). Hence, MUAC is highly rated as a diagnostic tool for severe acute malnutrition because of its simplicity and superior correlation to risk of death (World Health Organisation, 2013). This trend could enable the early detection and management of acute undernutrition in early infancy. Nonetheless, the evidence guiding the recommendations also highlighted that the sensitivity and specificity of measurements of MUAC compared to weight-for-length/height differ significantly at both upper and lower age (and/or length/height) ranges and by sex. Thresholds of anthropometric measures are normally assigned for interventions based on their predictive value with respect to mortality, ideally calculated using data from untreated populations. Due to lack of data on the reliability, practical measurement, and predictive value for mortality in infants younger than 6 months, MUAC is not currently recommended for use in this population. However, a study in Kenya reported that inter-observer reliability of MUAC among infants (0 – 6 months of age) was greater than that of weight-for-length Z-score (Mwangome et al., 2012b). Moreover, these investigators showed from a retrospective cohort study in the Gambia that a single MUAC measurement less than 110mm in infants (6 – 14 weeks of age) has good predictive value while weight-for-length Z-score has poor predictive value, for detecting undernutrition with respect to infant mortality (Mwangome et al., 2012a). Furthermore, combining MUAC with skinfolds (used as proxies for body fatness although they are measures of subcutaneous fatness only) was useful in identifying undernutrition in hospitalised medical patients, though an older population, in the UK (Burden et al., 2005). On the other hand, including other method(s), for example, a screening tool like the Subjective Global Nutrition Assessment (SGNA) (see section

2.1.2.2) is suggested effective for categorising hospitalised infants according to levels of nutrition risk (Aurangzeb et al., 2012), thus facilitating the diagnosis of undernutrition.

Complexities in defining undernutrition in infants

Anthropometric deficits are described according to severity, duration and age of onset of undernutrition. Hence, applying different measures and thresholds could appreciably, though differently, estimate the prevalence rates of undernutrition in different age groups of infants and children in different settings. For example, low length/height or low BMI may more likely identify healthy children who are simply at the lower end of the normal range in affluent societies, but detect undernutrition in another world setting with a high prevalence rate (Wright and Garcia, 2012). These authors assert that the use of any single measure in affluent societies could greatly overstate true childhood undernutrition prevalence. Using weight-for-age to define undernutrition in hospitalised infants rather than relating weight to length/height is likely to show some overestimation of undernutrition (Pichler et al., 2014). However, using as a single measure of MUAC in a developing world setting could be effective in predicting mortality from severe wasting in infants younger than 6 months because the risk of mortality in acute malnutrition is associated with severity (Mwangome et al., 2012a). Since the different forms of undernutrition have different causes and require different treatments, there is need to differentiate them. Severe acute malnutrition (SAM) is defined by WHO and UNICEF as a weight-for-length/height index (WHZ) less than -3 Z-score or MUAC less than 115mm, or presence of oedema (WHO/UNICEF, 2009). The context in which a case-detection for severe undernutrition is taking place determines the characteristics that define the appropriateness of that case-detection method (Myatt et al., 2006).

On the other hand, Myatt and colleagues conclude that available evidence in the literature indicates that MUAC is the best case-detection method for severe malnutrition in the community, in terms of age-dependence, precision, accuracy, sensitivity, and specificity. MUAC measurement is also simple, cheap, and acceptable; therefore, it is recommended that programmes treating severe malnutrition move towards a MUAC-based case-detection, referral, and admission criteria (Myatt et al., 2006). However, since there are currently no threshold values for infants younger than 6 months, investigators often apply the recommended values for children 6 – 60 months

of age. Nonetheless, setting threshold values for infants younger than 6 months needs to be addressed in future research, to avoid missclassification of these infants as undernourished when they may not actually be undernourished. Hence, the complexity of the subject of undernutrition and its impact on clinical outcomes has led to lack of uniform definitions, heterogeneous nutrition screening practices and failure to prioritise nutrition as part of patient care.

It was observed that major advances in the quality of care in developed countries, did not reduce the prevalence of undernutrition in hospitalised children over the years. Hence, screening for nutrition risk was called for by the European Society for Paediatric Gastroenterology, Hepatology, and Nutrition (ESPGHAN) in 2005 to prevent the occurrence and development of undernutrition (Agostoni et al., 2005). Therefore, different nutritional screening tools were developed and validated for use in identifying children who are at risk for undernutrition. These include the SGNA (Secker and Jeejeebhoy, 2007); Screening Tool for the Assessment of Malnutrition in Paediatrics (STAMP) (McCarthy et al., 2008); Screening Tool for Impaired Nutritional Status and Growth (STRONG_{KIDS}) (Hulst et al., 2010); and Paediatric Yorkhill Malnutrition Screening Tool (PYMS) (Gerasimidis et al., 2010). The sensitivity and specificity of screening tools is greatly determined by the choice of cut-off values for considering a child nutritionally at risk (Huysentruyt et al., 2013); moreover, there is presently insufficient evidence to choose a screening tool over another. The risk assessment information acquired from the use of these tools has been poorly utilised by health staff in preventing further deterioration of the nutritional status of hospitalised children (Milani et al., 2013, Grek and Puntis, 2013), however, these tools are still relevant in improving nutritional outcome. However, there is little knowledge existing about the application of screening tools in hospitalised children in most developing countries, including Nigeria. Overall, the elements applied in defining undernutrition in infants and children need to relate to its aetiology (both clinical and other causes), including the settings.

1.2.2 Causes of undernutrition in infants

An International Consensus Guideline Committee proposed an approach to diagnosing undernutrition in adults based on aetiology, thus integrating the present understanding of inflammatory responses to disease and trauma (Jensen et al., 2010). Undernutrition diagnosis was proposed as: 1) starvation-related undernutrition, which is chronic starvation without inflammation; 2) chronic disease-related undernutrition, where inflammation is chronic and of mild to moderate degree; and 3) acute disease or injury-related undernutrition, where inflammation is acute and severe (Mueller et al., 2011). Therefore, the aetiology of undernutrition in infants and children can determine its nomenclature as follows:

- 1) Starvation-related undernutrition: Undernutrition caused by inadequate availability of food occurring when there is famine, war, conflict, natural disaster, poverty, or social deprivation. There is increased risk for undernutrition in infants and children due to their limited energy reserves and high-energy requirement per unit body mass compared with adults.
- 2) Disease-related undernutrition: Undernutrition caused by illness, though children with underlying chronic diseases admitted to hospital with acute illness can also present with chronic malnutrition (Sacker et al., 2006, McCarthy et al., 2008).

Overall, reduced dietary intake is the single most important aetiological factor for undernutrition. However, the MAMI Project Conceptual Framework for causes of malnutrition in infants younger than 6 months developed from the 1998 UNICEF Conceptual Framework (Figure 1.2) shows that the causes of malnutrition are multi-sectorial, embracing food, housing, health, and caring practices. These causes are classified as immediate (maternal and child level), underlying (household or family) and basic (impact on population), triggered by natural disasters, wars and political and economic shock; whereby factors at one level influence other levels. Hence, the complex interplay of social, economic and political determinants of undernutrition result in substantial inequalities between population subgroups. Using the framework at national, district, and local levels help in planning effective actions to improve nutrition. Thus, serving as a guide in assessing and analysing the causes of the nutrition problem and help to identify the most appropriate blending of actions (UNICEF, 1998)

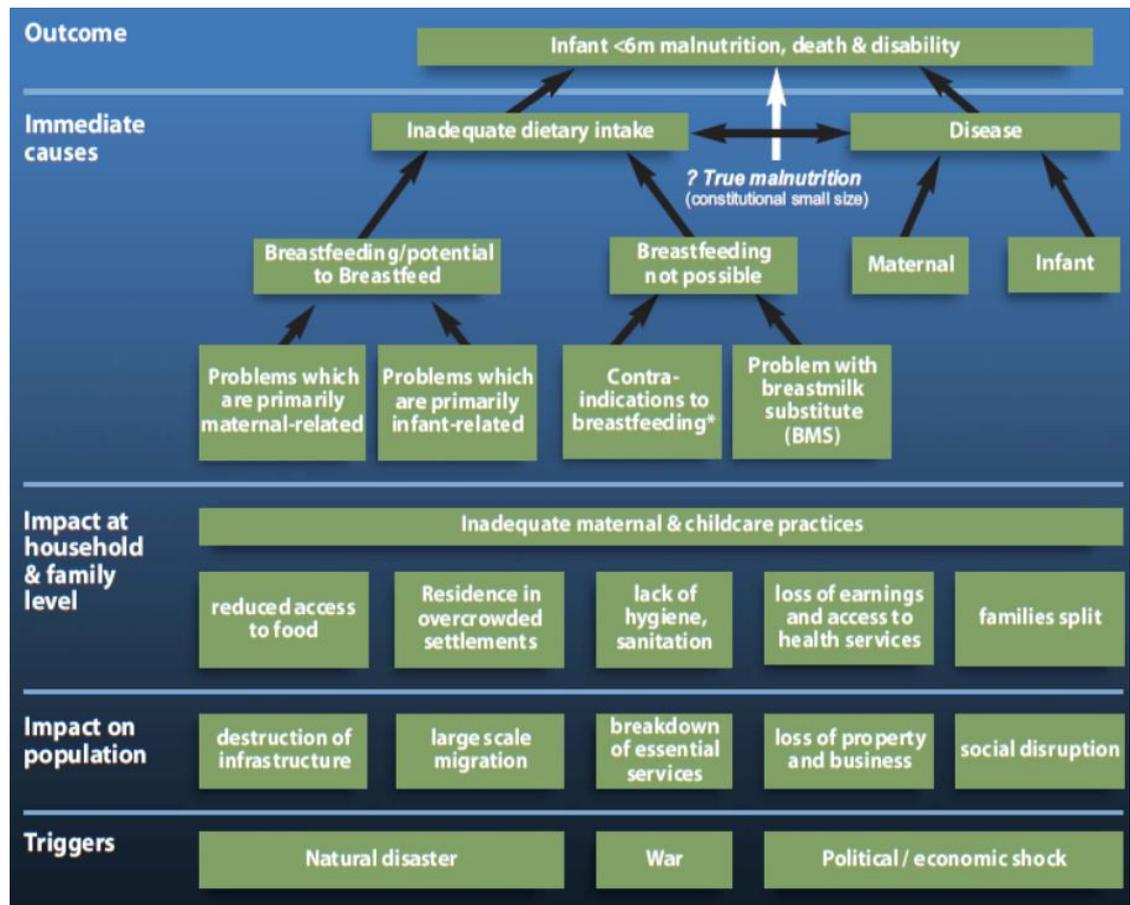


Figure 1.2 Conceptual framework for causes of malnutrition in infants < 6 months of age
 Source: The MAMI Project developed from the 1998 UNICEF Conceptual Framework

The role of socioeconomic factors

Although the causes of undernutrition are complex, there is a consensus about the two immediate causes: insufficient intake of nutritious food and increased incidence of infections, which are associated with inadequate childcare practices (Wuehler et al., 2011). Hence food insufficiency, poor water and sanitation, and restricted access to high quality primary care, all associated with household and community poverty is the main cause of childhood undernutrition worldwide (WHO/UNICEF, 2003). Poverty accounts for 260 million underweight children under the age of 5 years in developing countries suggesting that improving children's anthropometric status requires enhancing nutrition, the living environment, and healthcare for the poor. Equitable economic development, maternal education, and improvement of agriculture, food, and healthcare policies and programmes could effect this improvement (Stevens et al., 2012). A community based nested case-control study found wasting to be significantly associated with household poverty in cohorts of Ethiopian children aged 6 – 36 months (Egata et al., 2014). Olusanya and colleagues also suggest that starvation-related undernutrition is due to poverty (Olusanya et al., 2010). Results from other

investigations include diverse risk factors such as poor socioeconomic background, infectious diseases or failure of vaccination, inadequate birth spacing, food insecurity, intestinal parasitic infections (Bloss et al., 2004). Other identified risk factors include younger maternal age and low maternal social status (Linnemayr et al., 2008); low birthweight and low maternal literacy (Meshram et al., 2012); early initiation of bottle feeding, large household size (Brhane and Regassa, 2014) and lack of maternal access to health facilities (Egata et al., 2014). Particularly, prematurity, low birthweight and being born to young, rural, poorly nourished mothers of low socio-economic or educational status increases the risk of undernutrition in infancy (Saleemi et al., 2001, Santos et al., 2009, Medhin et al., 2010).

The relationship between poverty and nutrition is double-sided. First, economic growth (which is generally associated with an eradication of poverty) leads to reduced undernutrition. Secondly, nutrition is one of the key ingredients of human capital formation, which in turn represents one of the basic factors of growth. Estimate for effects of increases in GDP per capita between 1970 and 1995 in 63 developing countries showed that these increases led to roughly half of the total reduction in the prevalence of child undernutrition (Smith and Haddad, 2002). A small effect at the microeconomic level was reported from a cross-sectional data from Egypt, Jamaica, Kenya, Kyrgyzstan, Morocco, Mozambique, Nepal, Pakistan, Peru, Romania, South Africa, and Vietnam (Haddad et al., 2003). Using cross-country data to determine the determinants of child undernutrition in sub-Saharan Africa also yielded a small effect at the microeconomic level (Klasen, 2008). This was also observed in a series of cross sectional surveys at household level in India, between 1992 and 2006, in which the estimation of the association between economic growth at the state level and child showed no significant effects (Subramanyam et al., 2011).

Furthermore, the association between increases in GDP per capita and child undernutrition in 28 countries in sub-Saharan Africa between 1991 and 2009 was investigated at both micro- and macro-economic levels and a rather modest effect found (Harttgen et al., 2013). These authors found that a 10% increase in GDP was associated with 1.5 – 1.7 % lower odds of being stunted, 2.2 – 3.0 % lower odds of being underweight, and 3.5 – 4.0 % z. Although, economic growth contributed to reducing child undernutrition, the magnitude of the association would not eliminate undernutrition in sub-Saharan Africa in the near future. The evidence from 121 Demographic and Health Surveys from 36 low- and middle-income countries showed a

weak, and often absent, association between economic growth and reductions in stunting, underweight, or wasting (Vollmer et al., 2014). These authors therefore emphasise the need for direct health investments to improve the nutritional status of children in low- and middle-income countries. For example, Chile experienced a rapid economic growth that contributed to decline in both poverty and extreme poverty evidenced by very low rates of stunting (Atalah et al., 2014).

Finally, a review on the evidence for intergenerational influences on child growth and undernutrition found that birthweight is correlated across generations and short stature (which reflects intrauterine and infant growth) is associated with low birthweight, child stunting, delivery complications and increased child mortality, even after adjusting for socioeconomic status (Martorell and Zongrone, 2012). These authors clearly agreed that improving socioeconomic, nutrition and health conditions must break this intergenerational cycle of growth failure, particularly in developing countries. For example, the *Bolsa Familia* programme (a conditional cash transfer programme) in Brazil that increased poor families' access to goods and services in order to improve nutrition and subsequently improve health (Paes-Sousa et al., 2011), with reduction of under-5 mortality and poverty-related causes such as undernutrition and diarrhoea (Rasella et al., 2013). Overall, policies to promote economic growth in conjunction with public health and proven interventions targeted at nutrition could have an important role in reducing child undernutrition (Singh, 2014). Examples include the elimination of stunting in Chile using the supplementary nutrition programme that protected the vulnerable groups with long-term focus on the at-risk groups made up of children and pregnant and lactating mothers (Atalah et al., 2014); and the *Bolsa Familia* programme in Brazil (Paes-Sousa et al., 2011, Rasella et al., 2013).

The role of childcare practices

Suboptimal breastfeeding patterns or intake of nutritionally inadequate diets highly contributes to early childhood undernutrition, leading to inadequate nutrition. Although breastfeeding tends to be a common practice in low- and medium-income countries, early cessation of breastfeeding and early introduction of complementary feeds are often the practice observed among mothers (Black et al., 2013). Poor child feeding practices were reported as the major contributor to child stunting consequent to poor maternal/caregiver education in peri-urban areas of western Uganda (Turyashemerwa et al., 2009). Non-exclusive breastfeeding was significantly associated with child wasting in east Ethiopia (Egata et al., 2014). An investigation in a Nigerian tertiary hospital demonstrated that early cessation of breastfeeding and early introduction of complementary feeds before 6 months was associated with 73.4% wasting and 8.3% stunting in children admitted to a Nigerian tertiary hospital (Ocheke et al., 2014). Other African studies reported cessation of breastfeeding at 6 weeks, introduction of complementary feeds (as early as one month and between 3.1 and 6 months of age) in association with undernutrition and morbidity (Kazimi and Kazimi, 1979, Uwaegbute, 1991, Nwankwo, 2002, Bloss et al., 2004, Ezeofor and Okeke, 2005, Uchendu et al., 2009, Kimani-Murage et al., 2011, Lamberti et al., 2011, Uvere and Ene-Obong, 2013, Agho et al., 2011, Imdad et al., 2011b, Ubesie et al., 2012, Lim et al., 2012). Moreover, interruption of childcare practices could occur during hospital admissions, thereby increasing the likelihood of risk for undernutrition.

The role of underlying disease

A newly proposed classification scheme by the A.S.P.E.N working group incorporates chronicity, aetiology, mechanisms of nutrient imbalance, severity of malnutrition, and its impact on outcomes. Based on the consensus reached, disease-related undernutrition in children both in acute and chronic illnesses may be attributed to decreased nutrient intake, nutrient loss, increased energy expenditure, or altered nutrient utilisation (Mehta et al., 2013). Many investigators assert that undernutrition in developed countries has been mainly related to disease, chronic conditions, trauma, burns, or surgery (Norman et al., 2008, Mehta et al., 2013) mostly observed in hospitals (Sermet-Gaudelus et al., 2000, Hankard et al., 2001, Marteletti et al., 2005, Joosten and Hulst, 2008, Hankard et al., 2012, Sissaoui et al., 2013).

Inadequate dietary intake results from:

- Lactation failure/problems
- Improper formula preparation/poor diet
- Reduced/poor appetite
- Pain/nausea with food
- Starvation
- Food aversion
- Dysphagia
- Psychosocial problems

There is altered nutrient processing due to increased/altered metabolic demands and liver dysfunction; nutrient losses resulting from vomiting and diarrhoea; and malabsorption of nutrients (Saunders et al., 2015). Possible causes of nutrient loss include:

- Poor digestion and malabsorption
- Vomiting and diarrhoea
- Parasitic infections (endogenous nutrient loss)
- Skin exudates from burns and wounds
- Blood loss due to trauma or surgery

Increased energy expenditure results from:

- Immune reactions
- Increased breathing
- Increased body temperature

Altered nutrient utilisation caused by:

- Infection – shifting nutrients towards immune response (reduced protein synthesis and increased protein degradation)
- Inflammation – inducing protein breakdown from endogenous protein stores for energy production
- Repair of tissue damage
- Oxidative stress

Therefore, independent of the aetiology of undernutrition in early infancy, its consequences adversely influence growth and subsequently the health status of later years.

1.2.3 Effects of undernutrition in infants

The imbalance between the limited energy reserves and higher energy needs for the rapid growth of infancy increases the risk for undernutrition during the early months of life, resulting in weight loss or slow growth or growth failure, lowered immunity, mucosal damage, pathogenic invasion, and impaired growth and development.

Immunity

Undernutrition leads to physiological and metabolic adaptations to conserve energy and preserve essential processes, including reductions in the functional capacity of the organs and slowing of cellular activities (Karaolis et al., 2007). With an increase in the severity of the nutritional deficit, these adaptations weaken the body's immunity to infection with the risk of high-case fatality (Collins et al., 2006a). The presence of infection also increases the demand for metabolically derived anabolic energy and associated substrates to stimulate an immune response. This leads to a synergistic vicious cycle of adverse nutritional status and increased susceptibility to infection. In the presence of inflammatory conditions (for example, sepsis), this arginine-enhanced catabolic disease state is increased. Further inducing arginase leads to the increased use of arginine as a substrate and its depletion leading to impairment of T cells responses, and exceeding the body's production of arginine leads to a negative balance (Schaible and Kaufmann, 2007). The reduction in T cells production that occurs with vitamin A deficiency resulting from undernutrition depresses immune responses, and the associated immune depression and increased risks of infection in turn aggravate undernutrition (Blössner and de Onis, 2005). The profound effects of a number of infections on nutrition complicates the relationship between undernutrition and immune suppression. For example, gastroenteritis can lead to diarrhoea; HIV/AIDS, tuberculosis, malaria and other chronic infections can cause cachexia and anaemia; and intestinal parasites can cause anaemia and nutrient deprivation. Linking this reciprocal cycle of undernutrition and infection to pneumonia and diarrhoea accounts for nearly one in three child deaths worldwide (Schlaudecker et al., 2011). Overall, undernutrition in infants reflects a health outcome as well as a risk factor for disease and worsened undernutrition that affects child growth.

Growth

The commonest feature of undernutrition is insufficient nutrient intake needed to cover nutritional demands, resulting in loss of tissue and functional problems (Sissaoui et al., 2013). Hence, the most obvious clinical consequence of undernutrition is weight loss caused by depletion of fat stores and particularly muscle and lean mass, leading to wasting. Excess lean tissue wasting occurs in the presence of underlying disease due to catabolic draw on the body's nutritional reserves, mainly fat and muscles, resulting in negative energy balance. During this period, there is a consumption of endogenous sources of energy to produce fuel to ensure that key organs have adequate fuel supply for metabolic reactions (Cahill, 2006). With the depletion of body stores of glycogen, fat, and protein, body weight declines and loss of protein-related cellular functions occurs. This poor nutritional status deteriorates further in the presence of diarrhoea, malabsorption, loss of appetite, diversion of nutrients for immune response, and urinary nitrogen loss. All these lead to nutrient losses and further damage to defence mechanisms, thereby causing reduced nutrient intake, which coupled with fever, increases both energy and micronutrient requirements. The metabolic adjustments occurring during undernutrition result in decreased fat and muscle masses that worsens with underlying inflammation or infection. These body composition changes are directly reflected by anthropometric indices of wasting and stunting with functional implications (Briend et al., 2015).

The joint analyses conducted in 2011 by UNICEF/WHO/World Bank estimated that globally 165 million children less than 5 years of age had a height-for-age Z-score (HAZ) of -2 or lower (stunting) based on the WHO-CGS. Given that, young infants and children have a low muscle mass in relation to body weight, continuing dietary inadequacy in this population due to illness/infection result in chronic energy and protein deficiency that slows down growth leading to stunting. Both stunting and wasting could increase mortality risk through decreased muscle mass, however, because of greater decrease in muscle mass associated with wasting, higher mortality risk is associated with wasting compared with stunting. On the other hand, intrauterine growth retardation has an impact on postnatal growth, but the severity depends on which stage of pregnancy the growth retardation occurred. With an early insult, the infant is born underweight, with a short stature, and often possessing a small head. Such infants are likely to have reduced growth potentials and remain short in stature throughout life; unless a catch-up of growth occurs in the first 2 or 3 years through

appropriate nutrition intervention and close monitoring. However, suboptimal breastfeeding and complementary feeding practices, recurrent infections and micronutrient deficiencies are important proximal determinants of stunting, particularly in developing countries. Therefore, the Lancet maternal and child nutrition series focus on the crucial period of pre-pregnancy, pregnancy and the first 1,000 days of life to support preventive efforts, while continuing to target severe wasting with therapeutic efforts (Black et al., 2013). These authors concluded that growth restriction resulting from undernutrition, measured by anthropometric status, is an important cause of morbidity and mortality in infants and children.

Morbidity

The prevalence of sub-optimal infant feeding patterns coupled with the risk of exposing infants to nutritionally-inadequate complementary foods and water contaminated with pathogens, increase the burden of diarrhoea on growth (Alvarado et al., 2005). Severe and persistent diarrhoea (also interlinked with poor resistance due to low immunity) and repeated exposures to pathogens that affect the gut have serious consequences such as loss of fluid and essential nutrients as electrolytes. Without replacing these losses, there would be severe dehydration, undernutrition, growth failure, and death in extreme cases. For example, a high burden of diarrhoea in the first 2 years of life was associated with a much higher risk of linear growth failure manifesting as stunting in children (Wamani et al., 2006, Dewey and Mayers, 2011). Similarly, morbidity as one of the causes of undernutrition which in turn influences growth, was found to strongly correlate with infant weight loss in the short term (Sawadogo et al., 2008), and manifested as severe wasting and severe stunting in children with acute illnesses (Ocheke et al., 2014). Overall, undernutrition is associated with morbidity and mortality, including a higher risk of infections due to poor immune defence, wound healing problems, and reduced/impaired gut function, dependency on mechanical ventilation and longer hospital stay (Marteletti et al., 2005, Joosten et al., 2010). Long hospital admissions further create the risk of developing serious nutritional deficiencies (Rocha et al., 2006, Joosten and Hulst, 2008).

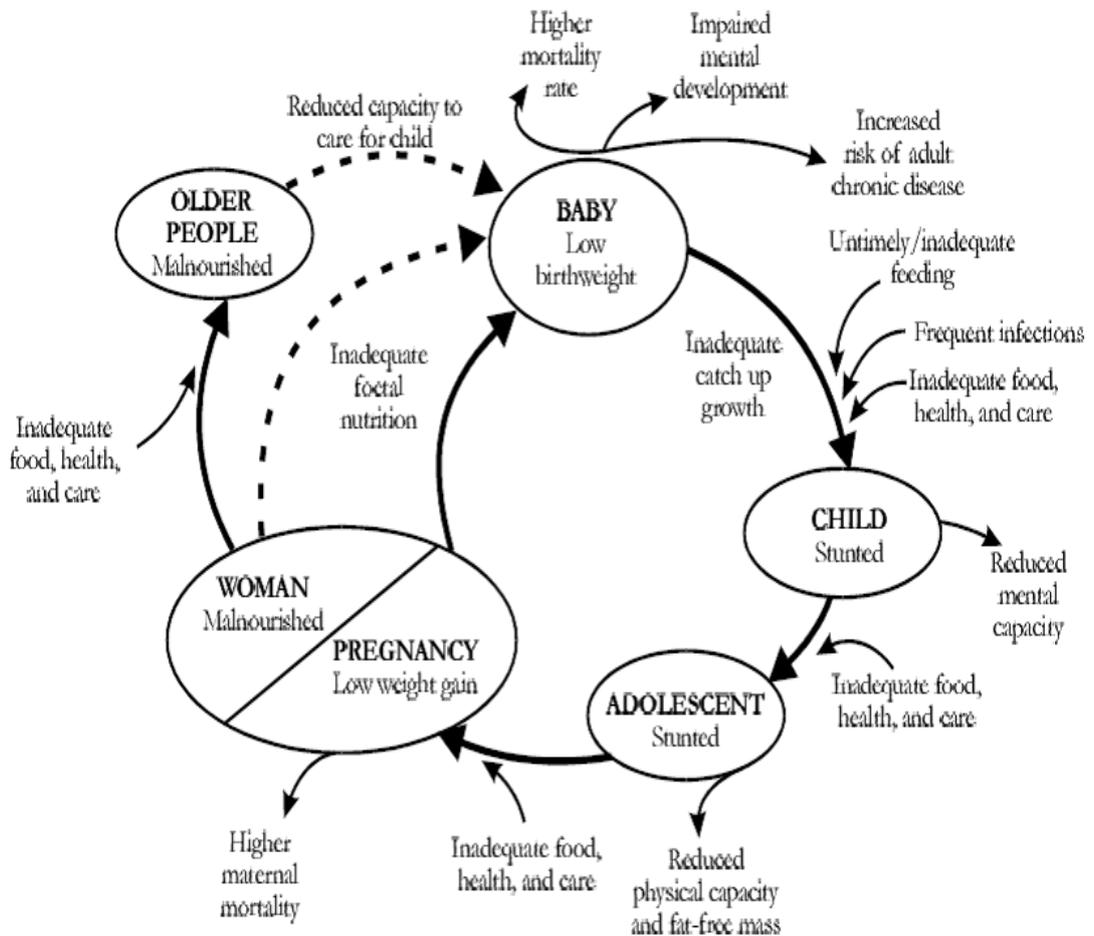
Mortality

The effects of undernutrition on physiological function have an important impact on clinical outcome among children. Hence, child undernutrition is a powerful determinant of child mortality, which along with other social, economic and policy factors affect child undernutrition itself (Pelletier and Frongillo, 2003). The latest estimates in the period 2000-2010 show that of 7.6 million deaths in children younger than 5 years in 2010, 64.0% (4.879 million) were attributable to infectious causes and 40.3% (3.072 million) occurred in neonates from causes that included nutritional diseases (Liu et al., 2012). Moreover, the UNICEF reported poor nutrition as the cause of one third of the under-five mortality of 50 – 150 million, most of which live in Africa and Asia (UNICEF, 2012). Similarly, Black and colleagues found undernutrition, including foetal growth restriction, suboptimum breastfeeding, stunting, wasting, and deficiencies of vitamin A and zinc, to have caused 45% of child deaths, resulting in 3.1 million deaths annually (Black et al., 2013).

Influence on child development

Undernutrition is identified as a risk factor for poor motor, cognitive, and socio-emotional development in infants (Prado and Dewey, 2014). Poor development is associated with early child growth retardation and absolute poverty, and early child growth retardation is likely to turn into stunting. Stunting affects 167 million children (0 – 5 years old) in developing countries in 2010 with the following highest rates: 45% in eastern, 39% in central and 38% in western Africa (de Onis et al., 2012a). Stunting, as a cyclical process results in childhood-stunted women being more likely to give birth to stunted children, creating an intergenerational cycle of poverty and reduced human capital, that is difficult to break (Martorell and Zongrone, 2012). Moreover, this vicious cycle of undernutrition, infection, poor growth, and poverty shows an intergenerational linkage of serious health implications (Figure 1.3). Therefore, more than 200 million children under 5 years in developing countries fail to reach their potential in cognitive development because of poverty, poor health and nutrition, and deficient care. The largest numbers of these children reside in south Asia, but it is in sub-Saharan Africa that the highest percentages of child population are stunted (Grantham-McGregor et al., 2007). These children will subsequently perform poorly at school and are more likely to transfer poverty to the next generation, hence the effect of undernutrition in childhood goes beyond the individual, affecting the society and future generations through its potential negative impact (Ramakrishnan et al., 1999, Grantham-McGregor

et al., 2007, Victora et al., 2008, Martorell and Zongrone, 2012). The risk of undernutrition in infancy is increased by prematurity, low birthweight, and being born to young poorly nourished mothers of low socio-economic and/or low educational status, particularly in developing countries (Saleemi et al., 2001, Medhin et al., 2010). Overall, undernutrition in children is a significant risk factor for sub-optimal overall health, morbidity, mortality, growth and development from infancy into adulthood (Victora et al., 2008).



Source: Prepared by Nina Seres for the ACC/SCN-appointed Commission on the Nutrition Challenges of the 21st Century.

Figure 1.3 Lifecycle and Intergenerational Linkage of Malnutrition

Source: World Nutrition Situation, 4th Report (ACC/SCN, 2000)

1.2.4 Inter-relationship between undernutrition, infection and growth

There is a close link between disease and undernutrition, with disease either resulting in undernutrition or contributing to it. There is a mutual synergism in the interrelationship between undernutrition and infection, thus poor nutritional status increases the susceptibility to an infection and the severity of the episode of an infectious disease. An infectious disease further reduces the nutritional status leading to faltering of the growth of the affected infant or child (Fig 1.4). This synergism is clearly shown in infections such as gastroenteritis and pneumonia as poor nutritional status (Kumar et al., 2014), while diarrhoea, lower respiratory infections and malaria are associated with growth faltering (Crookston et al., 2010). Furthermore, undernutrition predisposes to the infection of the gastrointestinal tract through gut mucosal barrier dysfunction, thus generating a vicious infection-undernutrition cycle (Rose et al., 2014). Overall, the nutritional status of the affected infant or child critically determines the outcome of infection. Infection is often associated with anorexia. Hence, acute infections lead to reduced food intake, although breastmilk intake may be largely unaffected, but the severity of the infection determines the magnitude of this decrease in dietary intake (Stephensen, 1999). Infection can potentially contribute more to undernutrition than dietary inadequacy, therefore, undernutrition manifesting as slow growth is often a consequence of disease (World Health Organisation, 1999b). The utilisation of nutrients are shifted for immune response, and less energy and protein are utilised for growth purposes during infection; and these infections are very common in the first two years of life.

Undernourished children are more likely to suffer from infectious diseases of respiratory and intestinal origins; and have infestations of hookworm and malaria parasites with longer duration and greater severity than other children. Recurrent infections exacerbate undernutrition, which leads to greater susceptibility to infection (an undernutrition-infection cycle). Moreover, these conditions are more prevalent in developing than in developed countries, particularly in the presence of poverty (poor diet) and underlying disease. During morbidity, appetite is low or absent resulting in an inadequate dietary intake, which means reduced supply of nutrients to the tissues of the body. This process continues as weight loss or slow growth with impaired or suppressed immunity, thereby increasing susceptibility to repeated infections that increase in severity and duration. Even when there are no obvious symptoms, physiological conditions associated with infections can impair growth by suppressing

appetite; impairing absorption of nutrients and increasing nutrient losses; and diverting nutrients away from growth (Dewey and Mayers, 2011). The rate of growth slows down during a period of morbidity or starvation, after which the infant usually grows more rapidly so that catch-up towards, or actually to, the original growth curve occurs. The timing of the onset and duration of slow growth determines the degree to which catch-up is successful, particularly in infants who suffered intrauterine growth retardation and likely to have reduced growth potential. Therefore, the practice of measuring growth using growth charts and standards could promptly identify the infants at risk for growth faltering (Table 1.3).

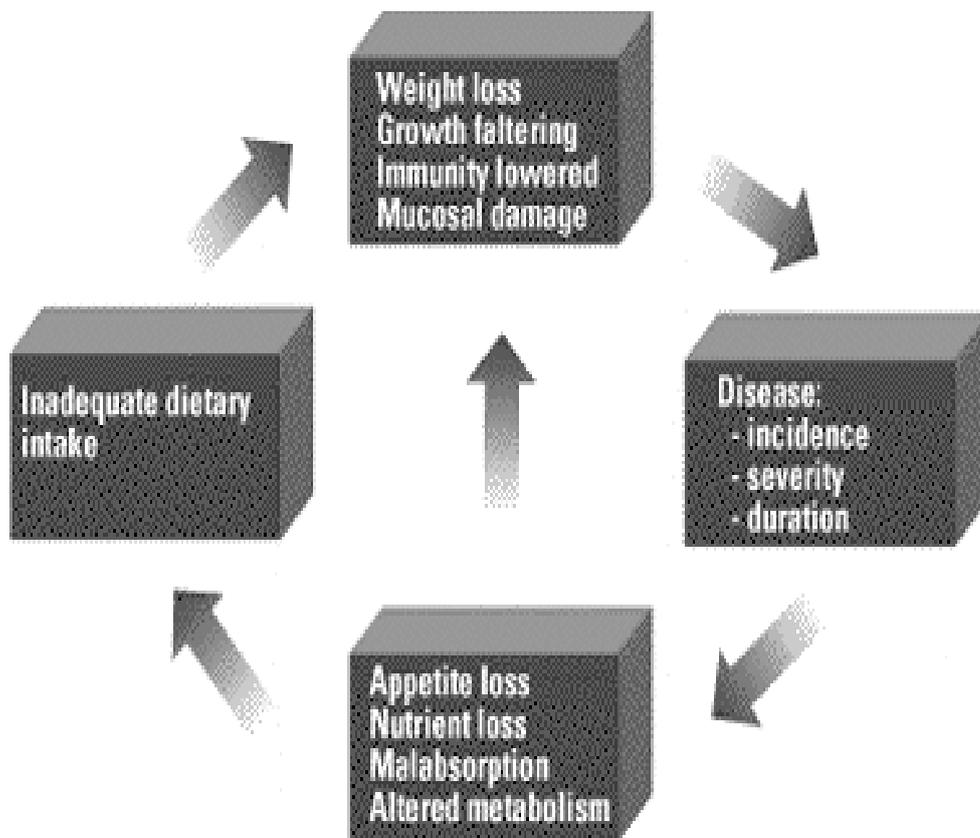


Figure 1.4 Interactions between malnutrition and disease

Source: Tomkins & Watson, ACC/SCN, Geneva 1989 (UNICEF, 1998)

Table 1.3 Studies on effects of morbidity on growth of infants

Source	Location	Study Design	Population/Setting	Sample size	Method Used	Outcome
Alvarado et al. (2005)	Colombia	Prospective birth cohort	Children aged 5 – 7 months in a rural community.	133 infants	Anthropometry/ Interview	Breastfeeding after 6 months of life mitigated the negative effects of poor social conditions and diarrhoea on infant growth.
Wamani et al. (2006)	Uganda	Cross-sectional	Children aged 0 – 23 months in a rural district.	720 infants	Questionnaire	Morbidity factors independently predicted wasting and underweight. Socioeconomic, environmental, and healthcare factors predicted stunting in addition to morbidity.
Sawadogo et al. (2008)	Burkina-Faso	Prospective birth cohort	Children aged 6 – 24 months in 30 villages of a community	114 children	Anthropometry/ Record of morbidities	Morbidity strongly correlated with weight loss in the short term, and weakly correlated with a slowdown in growth.
Ramachandran and Gopalan (2009)	India	Prospective	The National Family Health Survey-3 database	56, 438 preschool children	Anthropometry/ Interview	The relative risk of morbidity due to infections was higher and most consistently seen in children with low BMI and wasting as compared to weight-for-age and height-for-age.

1.2.5 Growth in healthy infants

Growth before birth results from an interaction between genetic and environmental influences; and intrauterine factors mostly influence the infant's weight and length at birth. The major determinants of growth in the first two years of life are environmental factors such as maternal nutritional status, feeding practices, hygiene and sanitation, frequency of infections and access to healthcare (Martorell and Zongrone, 2012). Normal growth, as a proxy measurement for the healthy development of an infant, requires adequate conditions of life, low levels of infections, and adequate nutrition. Therefore, adequate nutrition during infancy and early childhood contributes to survival, growth, development and long-term health through adulthood; otherwise irreversible faltering in linear growth and cognitive deficits manifest (Grantham-McGregor et al., 2007, Shrimpton, 2012). Growth is the main characteristic of childhood and the growth of infancy only less rapid than intrauterine or prenatal growth that is the most dramatic growth period in life. Thus, growth assessment is one of the most relevant tools for the assessment of nutritional status in infants and children, but unfortunately it is often given less attention than the more sophisticated examinations (Goulet, 2010). Ramsden and Day assert that growth is an important indicator of child health; marker of nutrition and overall indicator of child well-being (Ramsden and Day, 2012). In addition, childhood growth is an important influence on health and wellbeing later in life. Therefore, health professionals and parents/carers use growth to judge the physical condition of infants and children; and medical researchers identify the determinants and consequences of variation from healthy growth and development.

Growth velocity, often considered a superior measure of growth compared to attained body size for age (Argyle, 2003), is one indicator of nutritional status in child healthcare at any stage of development (Goulet, 2010) (Table 1.4). The first half of the first six months of life shows an acceleration of growth velocity followed by a deceleration in exclusively breastfed birth cohorts (Ezeofor and Okeke, 2005, Iannotti et al., 2009). Moreover, the first 6 – 8 weeks postpartum provides a unique opportunity to use growth velocity to identify infants at risk of sub-optimal growth or growth faltering, even in resource-poor settings (Olusanya and Renner, 2011). Furthermore, sub-optimal growth results in further health and developmental problems (McDougall et al., 2009) such as failure-to-thrive. The criteria for failure-to-thrive has been the Z-score for weight-gain of infants below the 5th centile at 6 – 8-week check (Wright et al., 1994a, Wright et al., 2006a, McDougall et al., 2009, Olusanya and Renner, 2011). More feeding problems and any developmental delay

show in infants whose early weight gain is slower than in controls, suggesting poor weight-gain in the early months of life is either a cause or a result of feeding and developmental delay. On the other hand, increased weight-velocity and length-velocity has been observed in low birthweight/high gestational-age infants as “catch-up” growth while decreased weight-velocity/length velocity showed in high birthweight infants (Regnault et al., 2010). However, infant growth assessment focussing on the attained infant weights and heights failed to show this (Xiong et al., 2007). Furthermore, exclusively breastfed infants have been shown to have slower weight-growth velocity than formula-fed infants at one month (Butte et al., 2000, Regnault et al., 2010).

Table 1.4 Studies on growth velocity of infants

Source	Location	Design	Population/Setting	Sample	Method used	Outcome
Ezeofor and Okeke (2005)	Nigeria	Prospective birth cohort	Birth cohort followed from birth to 24 weeks of age at the Infant Welfare Clinic of a Teaching Hospital	180	Anthropometry/ Questionnaire	Exclusively breastfed consistently had an acceleration of growth velocity for the first 14 weeks of life and then a marked deceleration in growth velocity over the following 10 weeks. This decline was suggestive of a protective mechanism against obesity and diseases later in adulthood. Overall, these infants grew above the NCHS-WHO reference standards.
Xiong et al. (2007)	Louisiana	Prospective birth cohort	Birth cohort measured at 8 – 18 month-follow-up in an infant and children's supplemental food programme.	3302	Anthropometry	Infant growth assessment focussing on attaining infant weights and heights at specific ages fails to identify accelerated weight gain or catch-up growth in low birthweight or small-for-gestational age infants and decelerated weight gain or slow-down growth in high birthweight or large-for-gestational age infants.
McDougall et al. (2009)	England	Case-control birth cohort	Birth cohort measured at 6 – 8-week check and at 9 months in 18 family practices.	1996	Anthropometry/ Health visitors' records	Using the 'thrive index' (z-score for weight gain): 24% of cases identified at 6- 8 weeks met criteria for failure to thrive over the period of 9 months, compared with the remainder of the cohort. Infants whose early weight gain is slow show more feeding problems than controls, and any developmental delay. Poor weight-gain in the early months of life is a risk factor.
Iannotti et al. (2009)	Peru	Prospective birth cohort	Low-income birth cohort followed from birth to 12 months of age	232	Anthropometry	All growth trajectories had steeper ascending slopes in the first half of infancy, followed by decelerating rate or plateauing of growth in the second half. All through infancy, the Z-scores of all three anthropometric indicators (weight-for-age, length-for-age, and weight-for-length) were close to zero.
Regnault et al. (2010)	France	Prospective birth cohort	Birth cohort aged 0 – 3 months, measured in two university hospitals.	1418	Anthropometry/ Questionnaire	Exclusively breastfed infants had a slower weight-growth velocity as early as 1 month of age compared with exclusively formula-fed infants. Length-growth velocities were significantly lower in breastfed and mixed-fed infants compared with formula-fed infants at 3 months of age.
Olusanya and Renner (2011)	Nigeria	Prospective birth cohort	Birth cohort measured at 6 – 8-weeks routine postnatal check in a Maternity Hospital.	658	Anthropometry	Higher weight velocity was strongly associated with lower birthweights ($p<0.001$) indicative of "catch-up" growth as well as with higher gestational age ($p<0.001$). Overall, 24% of the infants demonstrated evidence of failure to thrive based on z-score below the 5 th centile for the cohort

1.2.6 Growth-based classification of undernutrition in infants

Undernutrition can manifest as a failure in growth over time or as a poor nutritional status resulting at specific points in time (Stratton et al., 2003). Therefore, there is need to standardise ways of classifying growth measures, in order to better interpret the outcome of assessments.

The Z-score classification of growth measures

The Z-score for any growth measure is calculated as follows:

Z-score = (observed value minus median value of the reference population) divided by the standard deviation value of reference population (World Health Organisation, 1995). Z-scores have the same statistical relation to the distribution of the reference around the mean at all ages, making results comparable across age groups and indicators. There are different Z-score tables for each sex, and once calculated Z-scores for girls and boys can be presented together. The characteristics of Z-scores allow further computation of summary statistics such as means, standard deviations and standard errors to classify a population growth status. The Z-score classification provides distribution of undernutrition and allows for extrapolation below the lowest percentile by presenting the deviation of anthropometric measurements from the reference median, in terms of standard deviation or Z-scores (World Health Organisation, 1995). Hence, the Z-score classification is recommended for establishing the profile of undernutrition in a population since it reflects the reference distribution and is comparable across ages and across indicators. These anthropometric indicators are derived with measurement values of weight, length/height, MUAC, skinfolds in relation to the age of the infant. Applying the WHO (-2SD) threshold would imply that 2.3% of the reference population are classified as undernourished, even if they are truly “healthy” infants and their growth is not impaired. Hence, regarding 2.3% as the baseline or expected prevalence above normal. High rates of child morbidity and mortality risks; delayed physiological and mental development; and intergenerational cycle of malnutrition are great burdens on clinical and public health practice (Table 1.5) worldwide, particularly in developing countries.

Table 1.5 Different implications of WHO case-definitions in clinical and public health practice

Indicator	Implication	Reference
Underweight	<ul style="list-style-type: none"> • Mortality risk of mildly underweight children is increased and severely underweight children are even at greater risk 	World Health Organisation (1995)
Stunting	<ul style="list-style-type: none"> • Delayed mental development, poor school performance and reduced intellectual capacity, which in turn affects economic productivity at the national level. • Short-statured women are at greater risk of obstetric complications because of smaller pelvic size and delivering an infant with low birthweight. • These contribute to the intergenerational cycle of malnutrition, as infants of low birthweight or retarded intrauterine growth tend to be smaller as adults 	Victora et al. (2008) World Health Organisation (1995) Martorell and Zongrone (2012)
Wasting	<ul style="list-style-type: none"> • Immune system dysfunction, leading to increased severity, duration of, and susceptibility to infectious diseases and increased risk for death 	Myatt et al. (2006) Schlaudecker et al. (2011)

The WHO Global Database on Growth and Malnutrition

The non-availability of comparable data to monitor child malnutrition from nutrition surveys prompted the beginning of the systematic collection and standardisation of information on the nutritional status of the world's under-5 population. The WHO Global Database on Growth and Malnutrition was initiated in 1986 to compile, standardise, and disseminate results of nutritional surveys performed in this population worldwide (de Onis and Blössner, 1997). This database uses the above-mentioned Z-score classification of growth measures. The criteria guiding the entry of the surveys into the database include:

- a clearly defined population-based sampling frame
- a probabilistic sampling procedure involving at least 400 children
- use of appropriate equipment and standard measurement techniques
- presentation of results as Z-scores in relation to the NCHS/WHO international reference (which was the globally-accepted reference population at that time) or availability of the raw data, allowing a standardised analysis (de Onis and Blossner, 2003).

However, the introduction of the WHO-CGS in 2006 has further ensured the standardisation of child growth data globally. Hence, the enhancement of the monitoring of trends in child growth worldwide with the use of the new WHO growth charts, though there are still problems encountered in developing countries.

Problems with generating anthropometric indicators in developing countries

The measurement of weight and MUAC may be simple and quick to obtain using weighing scale and non-stretchable tape, respectively. However, measurements of length/height and skinfolds are not often taken because the respective measuring equipment for these measures are not available in the most hospitals and communities of developing countries. Moreover, baseline data for comparison of later measurements are often unavailable, for example, birthweight are often unknown because most infants are delivered outside health facilities, where weighing scales are lacking. Furthermore, age-specific anthropometric indicators are difficult to derive in such settings because most mothers/carers cannot readily tell their child's actual date of birth. Difficulties in getting most young infants to fully relax as well as fully stretch to record weight and length, makes it difficult to get exact values of these measurements (World Health Organisation, 1995). Therefore, generating anthropometric indicators for use in identifying infants at risk for undernutrition, and interpreting the results are often challenging in developing countries.

Since the current research project set to estimate the prevalence of undernutrition in young Nigerian infants (particularly hospitalised infants), the focus should be on case-detection in the community that is served by a clinical setting, case-finding and diagnosis in clinical contexts. Hence, the case-definitions were based on weight-for-age, length-for-age, BMI-for-age, weight-for-length, head circumference-for-age, MUAC-for-age, sum of skinfolds-for-age. The indicator-measures, or derives from measured components included weight, length, head circumference, MUAC, skinfolds (triceps and subscapular). The value of each indicator compares with a threshold value, and the infants whose values fall below the threshold values are classified as undernourished. Thus, it would be most appropriate to apply multiple indicators, including the application of a nutrition screening tool, in order to maximise the chances of correctly identifying most infants who are at risk for undernutrition.

1.2.7 How growth is measured in infants using growth charts/standards

What are growth charts/growth standards?

Since growth is the best indicator of nutritional status, growth measurements (such as weight, length, and head circumference) have little meaning without their transformation into anthropometric indices (weight-for-age, length/height-for-age weight-for-length/height, head circumference-for-age, MUAC-for-age). On the other hand, growth measurements can give a pictorial display of growth patterns of infants and children when accurately plotted on the growth chart. Therefore, the use of growth curves remain the simplest way of assessing nutritional status in children (Joosten and Hulst, 2011). Children are usually weighed and measured in many settings and their measurements plotted on growth charts to identify and treat disorders of nutrition or growth (Wright, 2002). A series of these growth measurements taken and plotted accurately on a growth chart reflects a child's size in relation to a reference of the population of the same age and sex. Growth charts are used for preventive purposes (for monitoring growth) or curative purposes (for special medical conditions). For example, the growth charts such as those based on the NCHS/WHO reference or WHO-CGS are mainly used for routine growth monitoring, but there are also specialised charts such as those used for disorders like Down syndrome or for monitoring pre-term infants.

Growth charts are designed to describe how a measurement at any particular age compare with other children of the same age and sex; and are commonly used to assess the growth trajectory of individual children over time. Therefore, growth charts are a valuable part of the paediatric clinical and research toolkit for evaluating the degree to which psychological needs for growth and development are being met (Goulet, 2010). For example, the adequacy of nutrition is evaluated by assessing the growth and nutritional status of children (Turck et al., 2013). Assessing the growth of children requires comparison of growth measurements with normative references of children who are considered normal and living in a defined geographic area, usually presented in form of growth charts (Ziegler and Nelson, 2010). The evaluation of these growth trajectories and the consequent decision to intervene are highly dependent on the growth charts used (Turck et al., 2013). If a child is compared with a particular population that is subjected to the potential constraints upon growth common to children of average socioeconomic and nutritional status then this is termed a 'reference' (Cameron and Hawley, 2010).

Growth reference charts are descriptive in nature; therefore potentially depicting the growth of some infants probably fed inappropriately, brought up in substandard circumstances, or suffering from infectious or chronic illness or disease. Thus, different growth charts are developed based on different references at different periods to suit different conditions. Since growth reference charts only describe growth at a particular time in the reference population, more children in affluent populations tend to grow above the upper centiles while children in resource-poor settings show suboptimal growth. Such a limitation would make the construction of local reference charts difficult if not unethical (Wright, 2005). However, growth 'standards' present the description of physiological growth for children raised under optimal health conditions. These standards are prescriptive in nature, embodying optimal growth, thus depicting the rate of growth that should be the target for all children, regardless of ethnicity, socioeconomic, and type of feeding. The obvious example of this is the WHO-CGS (see below) which shows the growth pattern of all children if they have optimal nutrition, socioeconomic status and environmental conditions, thus using breastfed infants as the norm. In summary, a growth reference is simply the distribution used for comparison of child growth, while a growth standard reflects optimal growth, implying that all children have the potential to achieve that level (WHO-MGRS, 2006).

Nigerian Road-to-Health growth chart

The Nigerian RTH growth chart (Appendix E.1) is a variant of the multipurpose growth charts developed by United States National Centre for Health and Statistics (NCHS) in 1977 and adapted by the WHO in 1978 for international use since most of the small and developing countries did not have national growth charts. These growth reference charts were based on the Fels Longitudinal Study of primarily formula-fed, white middle-class infants living in Southern Ohio in Yellow Springs, Ohio, from 1929 to 1975. Moreover, the results of the Davis Area Research on Lactation, Infant Nutrition and Growth (DARLING) study indicated that the growth patterns of breastfed infants differ from both that of their formula-fed peers and the NCHS/WHO growth reference. Hence, there was a need for new growth charts based on breastfed infants (Dewey et al., 1992), to reflect growth patterns consistent with those of infants following the WHO recommendations (Dewey et al., 1995). Therefore, the clinically significant differences existing between the growth patterns of healthy breastfed infants and the NCHS/WHO international growth references prompted the WHO recommendation to replace the NCHS/WHO reference data (WHO, 2001).

WHO Child Growth Standards

In April 2006, the WHO in conjunction with the United Nations Children's Fund (UNICEF) released new WHO-CGS for children from birth to five years to replace the 1978 NCHS growth references and the CDC 2000 growth charts. The development of the WHO-CGS based on primary data collected through the WHO Multicentre Growth Reference Study (WHO-MGRS). This was a population-based study conducted between 1997 and 2003 in Brazil, Ghana, India, Norway, Oman, and USA recruiting only infants who were born at term to non-smoking mothers, relatively affluent mothers after a healthy pregnancy. All were breastfed exclusively or predominantly for about the first six months of life (Joosten and Hulst, 2008). New WHO-CGS were published to allow evaluation of growth from birth to age 5 years, with use of the same conceptual methods across populations worldwide (WHO Multicentre Growth Reference Study Group and de Onis, 2006). This study group found birthweight and growth velocity to be similar between different countries, on carefully selecting an optimal and healthy population. Hence, the WHO-CGS reflect the range of children's growth seen in optimal conditions showing that preschool children, from different parts of the world, have the same growth pattern if they have optimal nutrition, socioeconomic and environmental conditions. These standards provide a universal set of references of normal growth, stunting, underweight and wasting (length-for-age, weight-for-age and weight-for-length z-scores < -2 , respectively), independent of race or ethnicity, and are now applied by the WHO to measure undernutrition at both the individual and population level (WHO/UNICEF, 2009).

The WHO-CGS are applicable to all children of the world regardless of ethnicity, socioeconomic status and feeding mode and they have been widely implemented (de Onis, 2013). These standards are endorsed by international bodies such as the United Nations Standing Committee on Nutrition, the International Union of Nutritional Sciences and the International Paediatric Association, and adopted in more than 90 countries (WHO/UNICEF, 2009). The breastfed infant is the norm for child growth assessment. Adopting the WHO-CGS has triggered many studies worldwide. In developing countries, results showed that prevalence rates for stunting, underweight, and wasting were higher using the WHO-CGS than the NCHS/WHO reference; and made more diagnoses of severe wasting, particularly among infants younger than 6 months. Evidence from using these standards in the situations of developing countries results in two to four times increase in the number of infants and children falling below $-3SD$ compared to using the former NCHS reference (de Onis et al., 2006b, Seal and © Ifeyinwa Obiageli Ezeofor 2015

Kerac, 2007). However, studies in developed countries called for the use of local standards to certain levels while adopting the new standards (Wright et al., 2008, Júlíusson et al., 2011, Zuguo and Grummer-Strawn, 2011). Therefore, Soeters and colleagues assert that there is risk of overestimation and underestimation of malnutrition rates compared with country-specific growth references (Soeters et al., 2008). Nonetheless, countries have adopted the WHO-CGS and best practices in child growth assessment harmonised, with breastfeeding established as the norm (de Onis et al., 2012b). However, the report of the MAMI project highlighted the implication of the relatively weak evidence base of the current WHO-CGS guidelines for managing malnourished infants younger than 6 months, with the care for older infants extended to younger ones to presume that this population of infants are all adequately nourished (ENN/UCL/ACF, 2010). Hence, the call for immediate considerations to guiding practices in the short-term and subsequent evolution of a community-based management of acute malnutrition in this population.

Growth monitoring in infants using growth charts

Parents/caregivers are always often comparing an infant/child's size with that of its peers; however, health staff would use a growth reference chart to achieve the same purpose, thus assessing growth. Growth is an important indicator of child health; marker of nutrition and overall indicator of child well-being (Ramsden and Day, 2012). Early infancy is marked with rapid growth; however, disturbances in health and nutrition usually affect growth at this time necessitating close growth monitoring. The focus of growth monitoring is regular weighing of infants from birth to the first six months of life as a routine child healthcare service in every well-baby clinic. Growth monitoring linked with promotion (usually counselling) is a preventive activity called growth monitoring and promotion (GMP). When GMP is appropriately conducted, it increases awareness about child growth, improves caring practices, increases demand for other services as needed; and serves as the core activity in an integrated child health and nutrition programme (Griffiths and Del Rosso, 2007). GMP has been advocated worldwide as one of the key elements of child survival and primary health strategies (Olugbenga-Bello et al., 2011). GMP is the most cost effective intervention, thus forming the basis of comprehensive child care (Qudsia and Aliya, 2007) and is the central component of primary healthcare for infants and children. The growth measurements of a child compared with a reference population on a growth chart allows for early identification of potential nutritional and health problems, thus

prompting action before the child's health is seriously compromised (Dietitians of Canada et al., 2010b). The main objectives of growth monitoring and promotion of optimal growth are to:

- provide a tool for nutrition and health evaluation of individual children
- initiate effective action in response to abnormal patterns of growth
- teach parents how nutrition, physical activity, genetics, and illness can affect growth and, in doing so, motivate and facilitate individual initiative and improved childcare practices
- provide regular contact with primary healthcare services and facilitate their utilisation (Garner et al., 2000, Ashworth et al., 2008).

A systematic review concluded that although little evidence was found to indiscriminately support the international promotion of GMP, the programme constitutes a valid strategy of public health nutrition in specific situations (Roberfroid et al., 2005). Hence, GMP can be used for opportunistic growth screening, which enables growth disorders to be identified in children and managed with early intervention.

Growth charts are graphic presentations of body measurements of a population that aid in the assessment of body size and shape, as well as the observation of patterns in growth performance (Dietitians of Canada et al., 2010b). These reference charts are mainly used for assessing and monitoring individual children and screening whole populations (Wright et al., 2002). Because growth charts are not diagnostic tools, they are used in conjunction with other information when evaluating general child health. Finding out whether growth is within recommended limits or falling outside of these limits is of fundamental importance to the assessment of the nutritional status of infants and children. From early childhood onwards, longitudinal measurement shows that crossing up and down through the centiles is not common in most children, however, there is a tendency for them to track along a given centile, indicating that growth is self-regulating and target-seeking (Tanner, 1963). Therefore, whatever the size of a child at any given time point, centile crossing could give the indication of a clinical growth abnormality. Hence, the use of growth charts both for clinical monitoring to detect individual abnormalities in growth trajectory and public health research/monitoring to understand variability and secular trends in child growth (Wells, 2014). The particular goal intended to be achieved determines the growth chart to be used (Cameron and Hawley, 2010).

Growth charts are a vital tool for child growth monitoring which makes it possible to compare with a population-based normative data and identify trends over time (Ramsden and Day, 2012). However, growth charts have been described as “complex clinical tools that are, at present, poorly understood and inconsistently used” (Wright, 2002). This may be attributed to poor knowledge of growth charts by health staff that monitor health and development in early infancy. The basic standard of taking a nutritional history and accurate completion of appropriate growth chart is a fundamental part of assessment for all paediatric patients (Grek and Puntis, 2013) detecting individual risks for health/nutritional disorders (de Onis et al., 1997). Children’s growth can also be screened for abnormal growth disorders (Hall, 2000, van Buuren et al., 2004, Ramsden and Day, 2012), thus allowing for early intervention. Accurate completion of the growth chart aims at developing accurate home-based record of child health and development; building a relationship between mother and health staff; and proper risk assessment of certain socioeconomic, biological, environmental and behavioural factors. This interaction between the mother and health staff is an essential component of GMP (Iliyas and Mubasher, 2003). In view of a well-known association between undernutrition and impaired growth, using growth charts to identify undernutrition in early infancy is an important goal of paediatric care. Accurate weighing and recording of weight trajectories are important for making clinical decisions; however, a misinterpretation could lead to inappropriate reassurance or inappropriate interventions by health staff (Sachs et al., 2005) thus disrupting EBF in early infancy. Moreover, growth assessments that are not supported by appropriate response actions to prevent or treat inadequate growth are not effective in improving child health. Therefore, there is need to ensure the health and development of infants and young children through integrated child development and nutrition interventions (Black and Dewey, 2014).

Using growth charts to detect undernutrition in early infancy

Using growth charts to detect undernutrition in early infancy is an important goal of paediatric care, in view of a well-known association between undernutrition and impaired growth through morbidities and vice versa. Studies that used growth charts to detect undernutrition in children (Table 1.6) showed that the WHO-CGS better identified younger children as underweight and wasted while stunting increased in all age groups, and the nutritional assessment method used determined the pattern of occurrence. Moreover, investigators from developed countries called for the use of their local standards alongside the WHO-CGS, which proved more appropriate for their environment. However, growth charts have been described as “complex clinical tools that are, at present, poorly understood and inconsistently used” (Wright, 2002). This observation is suggestive of poor health staff understanding, application, and interpretation of growth patterns of infants and children. Other reports include lack of interest and low competency (Griffiths et al., 1996), poor knowledge and skills (Ruel et al., 1991), unsatisfactory plotting of weights and interpretation of growth trajectories (Morley, 1994, Cooney et al., 1994, de Onis et al., 2004, Thandrayen and Saloojee, 2010, Mutoro and Wright, 2013), and poor practice in the application and interpretation of growth charts (Charlton et al., 2009). Furthermore, the inability to detect normal/abnormal growth by paediatricians’ self-assessment (Wallace and Kosmala-Anderson, 2006); failure to recognise abnormal/normal growth patterns (Wright et al., 2010); insufficient account of linear growth trend (Ahmad et al., 2014); and inability to appreciate the difference between size and weight gain but rather steady growth in average sized infants (Wright and Mutoro, 2012). However, frequent training resulted in improved the accuracy of plotting the growth chart by health staff in Zambia (Charlton et al., 2009). Hence, some authors advocate for improved health staff training on the implementation and interpretation of the WHO-CGS, accompanied by assigning a copy of the guideline document per health staff for their use (Ahmad et al., 2014). This would contribute to improved effectiveness in the use of growth patterns in detecting undernutrition in infants. Furthermore, the use of nutritional screening tools and growth charts have proved simple, quick and invaluable tools in attracting attention to infants who are at risk for undernutrition (Mueller et al., 2011).

Table 1.6 Studies that used growth charts to detect undernutrition

Source	Location	Design	Population/Setting	Sample size	Standards used	Outcome
Wright et al. (2008)	UK	Prospective birth cohort	i) Avon Longitudinal Study children ii) Gateshead Study children (0 – 5 years)	i) 1335 ii) 923	New WHO charts	Reduced number of UK infants classified as underweight and supported efforts to avoid excess weight gain in infancy. However, the WHO standard does not represent size at birth in the UK.
Schwarz et al. (2008)	Gabon	Prospective birth cohort	Children included in a sub study on socioeconomic risk factors for stunting and underweight-for-age in a hospital	289	New WHO versus NCHS and CDC charts	Reduced underweight among children above the age of 12 months; increased underweight among 3-month-old infants and increased stunting in children in all age groups
Prost et al. (2008)	Malawi	Prospective	A village-informant-driver Demographic Surveillance System	1328	New WHO versus NCHS charts	Risk factors identified using WHO standards remained comparable with findings based on NCHS reference in similar settings
Júlíusson et al. (2011)	i) Belgium ii) Norway	Cross-sectional	i) The Flanders Growth Study of participants aged 0 – 21 years ii) The Bergen Growth Study of participants aged 0 – 19 years	i) 18,051 ii) 8,299	New WHO charts	The use of a local reference based on a representative sample of healthy children was more appropriate for all children, bottle-fed or breastfed in these environments
Saha et al. (2009)	Bangladesh	Prospective cohort	Children aged 0 – 24 months in the Maternal and Infant Nutrition Intervention	1,343	New WHO versus NCHS charts	The use of the NCHS reference misidentifies undernutrition and the timing of growth faltering in infants and young children, which was a key rationale for constructing the new WHO standards
Olusanya et al. (2010)	Nigeria	Cross-sectional	Infants aged 0 – 3 months at community immunisation centres.	5888	New WHO charts	More diagnoses of severe wasting, particularly among infants younger than 6 months
Okoromah et al. (2011)	Nigeria	Case-control, observational	Children aged 3 – 192 months with uncorrected symptomatic CHD and healthy controls in a tertiary hospital	73 cases 76 controls	New WHO versus NCHS/CDC charts	90.4% of cases and 21.1% of controls had undernutrition ($p=0.0001$); and 61.2% and 3.6%, respectively, had severe malnutrition ($p<0.001$)
Zuguo and Grummer-Strawn (2011)	California	Prospective birth cohort	Children in the Kaiser Foundation Health Plan Study followed through adolescence	15,000	New WHO versus CDC charts	Fewer children aged 6 – 12 months crossed downward ≥ 2 major percentiles using the new WHO standards compared with that using CDC 2000 growth charts in weight-for-age
Kismul et al. (2014)	Democratic Republic of Congo	Secondary analysis of data from the historical, longitudinal Bwamanda study	Preschool children followed 3-monthly for 15 months aimed at addressing the dynamics of clinically and anthropometrically defined undernutrition	5,657	New WHO charts	Undernutrition rates increased from the 0-5 to 6-11 months category. Alteration from severe to mild undernutrition was more characteristic for anthropometrically than clinically defined undernutrition. The findings demonstrated that the pattern of occurrence of undernutrition can differ according to nutritional assessment method

Limitations of growth charts

Though simple and effective in ranking children relative to their peers, the features of growth charts pose limitations to its usefulness in this capacity. For example, growth charts which show only third, fifth, or second centiles are of limited value for screening, as too many false-positive cases are identified (Hall and Elliman, 2003). It was also noted that the UK 1990 reference growth charts were misleading in the first two week of birth, because they make no allowance for neonatal weight loss that occurs in the first few days of life (Wright and Parkinson, 2004). Similarly, the NCHS and CDC curves do not have growth rate curves from birth. The literature on health staff knowledge and application/interpretation of growth charts is scarce, particularly in developing countries where undernutrition is prevalent. Most of the available documentations in developing countries dwell on growth monitoring and promotion. Moreover, earlier investigations on the understanding of growth charts targeted the mothers/carers of infants and children rather than health staff who are expected to be knowledgeable in the use of growth charts as education tools for influencing the mothers/carers. Senanayake and colleagues investigated mothers' comprehension of two different growth charts, and their results suggested that governments and agencies would need to redesign parent-held growth charts to achieve better comprehension by mothers (Senanayake et al., 1997). Roberfroid and colleagues used a systematic literature review to evaluate maternal comprehension of growth charts, and concluded that the observed poor comprehension of growth charts among mothers/carers would be overcome by using activities aimed at improving communication skills of health staff and empowering parents' responsive parenting (Roberfroid et al., 2007). Finally, Ben-Joseph and colleagues concluded from examining the general public's (non-health professional's) comprehension of growth charts, that the literature has not proven that growth charts are easily understood by the general population (Ben-Joseph et al., 2007).

1.2.8 Prevalence of undernutrition in infants

Undernutrition in infants (0 – 26 weeks old) is both a common cause and consequence of disease, yet it remains an under-investigated problem and therefore under-recognised, both in the hospital and community. In the community, nonetheless, the assessment of nutritional status in children generates estimates of the prevalence of undernutrition using several objective indicators. These indicators include three anthropometric parameters related with the WHO-CGS as follows: $<-2SD$ weight-for-age indicates underweight, $<-2SD$ length/height-for-age indicates stunting and $<-2SD$ weight-for-length/height indicates wasting. Based on this standard, an estimated 52 million children worldwide aged less than 5 years are wasted (Black et al., 2013) and 8.5 million infants aged less than 6 months are wasted (Kerac et al., 2011). Kerac and colleagues also demonstrated that using the WHO standards against the NCHS reference case definition ($<-3Z$ -scores) for undernutrition results in a greater disease burden, particularly severe wasting in this population in many of the developing countries. The implications are increased eligibility for admission to therapeutic feeding programmes and increased human, political, and financial resources to meet that demand. On the other hand, in clinical practice, the assessment of nutritional status in infants is difficult since it appears no single indicator can be used in isolation (Aurangzeb et al., 2012). Moreover, measurement of nutritional status at any given time would only identify those that are already undernourished. Assessing the risk for undernutrition is required to detect those whose nutritional status is likely to deteriorate during hospitalisation or consequent to underlying disease. Using nutritional screening tools for this purpose is highly effective in reducing the prevalence of undernutrition in hospitalised paediatric populations, as practiced in developed countries (see section 2.1.2.2).

Prevalence of undernutrition in infants in developed countries

From the literature, most of the recent studies in developed countries concentrate on overnutrition rather than undernutrition, although a double burden can exist in a given location. The prevalence of undernutrition at population level in developed countries is still appreciable although less than that of developing countries, where it is mainly because of primary undernutrition. However, the prevalence of undernutrition in hospitalised infants is often unrecognised and therefore not treated (Agostoni et al., 2005). Depending on the criteria used, the population and type of disease, varying rates of undernutrition prevalence were reported among paediatric-hospitalised population in developed countries (Table 1.7). Using the Waterlow's and Gomez classifications: n=296, 19.0% France (Sermet-Gaudelus et al., 2000); n=475, 6.1% Germany (Pawellek et al., 2008); n=424, 11.0% Netherlands (Joosten et al., 2010); n=130, 8.5% France (De Luca et al., 2012). Using the WHO classification: n=226, 8.0% UK (Marteletti et al., 2005); n=496, 10.2% Italy (Campanozzi et al., 2009); n=157, 2.5% Australia (Aurangzeb et al., 2012).

Table 1.7 Prevalence of undernutrition in hospitalised infants in developed countries

Source	Location	Design	Population/Setting	Sample size	Anthropometry/ Method used	Reference used	Prevalence %		
							Underweight (<-2 z-scores weight-for-age)	Wasting (<-2 z-scores weight-for-length/height)	Stunting (<-2 z-scores length/height-for-age)
Moy et al. (1990)	Birmingham	Cross-sectional	Multi-racial group of children aged 3 months - 18 years in a regional referral centre	225	Weight, length/height, Mid-arm circumference, Triceps skinfold thickness	NCHS Reference	-	14 (Mean Z-score -0.58, SD 1.29)	16 (Mean Z-score -0.05, SD 1.42)
Hendrikse et al. (1997)	Glasgow	Cross-sectional	Children aged 7 months – 16 years of which 93% were Caucasian in a paediatric referral hospital	226	Weight, length/height, Mid-arm circumference	Tanner and Whitehouse Standards	16 (below 5 th centile)	8 (below 5 th centile)	15 (below 5 th centile)
Pawellek et al. (2008)	Germany	Cross-sectional	Children aged 7.9 ± 5 years in a children's referral hospital; *28% of which are infants >1 year of age	475	Weight, length	Waterlow's Reference	14.3 Mild Malnutrition (weight for-age 81-90 th centile)	7.1 Moderate Malnutrition (weight for-length/height 70-80 th centile)	7.1 Severe Malnutrition (length/height-for-age <70 th centile)
Aurangzeb et al. (2012)	Australia	Cross-sectional	Children older than 1 month of age admitted to a tertiary paediatric hospital	157 (50 of the children were < 2-year olds)	Anthropometry of weight and length/height Nutrition screening tool	WHO Reference	2.5 (Mean BMI-for-age 53.3)	4.5 (Mean weight-for-length/height)	8.9 (Mean length/height-for-age 51.8)

Prevalence of undernutrition in infants in developing countries

At population level, the prevalence of undernutrition in children (0 – 5 years old) in developing (resource-poor) countries continues to be a serious and persistent public health problem in spite of significant improvements in the past three decades (Muller and Krawinkel, 2005, Marino et al., 2006, Lutter et al., 2011, Black et al., 2013). However, most studies report lower undernutrition prevalence in infants (0 – 6 months old) compared to older infants, particularly with prospective study designs (Table 1.8). Probably, the effect of breastfeeding in these infants might have accounted for that. Other reports show that 90% of the stunted children worldwide live in 36 developing countries (Bhutta et al., 2008, Black et al., 2013). A systematic analysis of the Global Burden of Disease Study observed only slight change in sub-Saharan Africa, despite the significant worldwide decline in the prevalence of child undernutrition in the period 1990 to 2010 (Lim et al., 2012). That analysis found childhood underweight and suboptimal breastfeeding (non-exclusive and cessation of breastfeeding) among the leading risks in 2010. However, studies that explored the prevalence and pattern of undernutrition in early infancy, particularly considering seasonal variations in incidence are rare, probably due to the challenges of case detection through anthropometric measurements (Myatt et al., 2006, Egata et al., 2013, Kismul et al., 2014).

From the limited available studies in developing countries, using Nigeria as a case reference (WHO Country Database on Malnutrition), the prevalence of undernutrition in infants and children is still high, particularly in the rural areas (Tables 1.8 – 1.10 below). The disparities in nutritional status recorded show that severe underweight was 2.1, stunting 1.6 and wasting 1.4 times more prevalent in rural areas than in the urban areas. Moreover, the substantial inequalities between population subgroups result from the complex interplay of social, economic, and political determinants of undernutrition (Black et al., 2013). For example, stunting which is a good indicator of inequalities in human development demonstrating the importance of socioeconomic factors is notably high among the children. Thus, reflecting the inequalities in nutritional status and the extent to which socioeconomic and geographical factors determine these inequalities. Examples show that prevalence rates vary according to study design and setting (Table 1.11). Therefore, a cross-sectional community-based study of infants (0 – 3 months old) reported 30.8% stunting, 10.1% wasting, and 13.8% underweight; and showed infants aged less than 6 months being overall undernourished (Olusanya et al., 2010). While a hospital-based/case-controlled study of children (3 – 192 months old) reported 40.15% stunting,

28.8% wasting, and 20.5% underweight in the cases and 2.6% stunting, 3.9% wasting, and 14.5% underweight in the controls (Okoromah et al., 2011). Elsewhere, a cross-sectional study in Ugandan infants (0 – 23 months old) reported 12% underweight, 4% wasting, and 25% stunting (Wamani et al., 2006). Similarly, a community-based cross-sectional study in under-five children living in central India reported 34.4% severe stunting, 18.7% severe underweight, and 7.1% severe acute undernutrition (Dani et al., 2015). A prospective birth cohort study in western Kenyan children (0 – 5 years old) reported 30% underweight, 47% stunting, and 7% wasting (Bloss et al., 2004). Finally, a population-based cohort study of rural Ethiopian infants (0 – 6 months old) reported 21.7% underweight, 26.7% stunting and 16.7% wasting (Medhin et al., 2010).

On the other hand, place of birth is a marker of risk for undernutrition in early infancy, particularly in low-income countries. For example, a matched community-based/case-controlled urban Nigerian study of infants (0 – 3 months old) to determine the association between place of delivery (being born in public hospitals and being born private hospitals or in residential homes) and the prevalence of severe undernutrition (Olusanya and Renner, 2012). Based on the WHO-CGS, the findings of that study showed a two-to-three fold odds of being severely underweight ($p=0.002$), severely stunted ($p<0.001$), and severely stunted ($p=0.008$) after controlling for confounders. Severe stunting ($p=0.032$) was also observed in the infants born in private hospitals; therefore, those authors demonstrated that delivery in homes and private hospitals are potential makers for severe undernutrition in this population. Similarly, a case-control study of born-before-arrival to hospital (BBA) and in-hospital-born infants in a peri-urban setting in South Africa showed that the BBAs were more likely to require admission to the neonatal unit for prematurity, very low birthweight, neonatal jaundice, respiratory syndrome, hypoglycaemia, septicaemia and patent ductus arteriosus (Parag et al., 2014). Those authors concluded that the BBAs had significantly lower birthweight and lengthier hospital stays than in-hospital-born infants. However, despite the recognition of the prevalence of undernutrition in children, nutritional assessment of hospitalised children is often neglected, contributing to the occurrence of complications, and prolonged hospital stays (Marino et al., 2006). Therefore, conducting a nutritional assessment in children during hospital admission using the WHO-CGS is likely to aid in the early diagnosis and management of undernutrition. Properly structured nutrition interventions could forestall complications and shorten the length of hospital stay.

Table 1.8 Prevalence of undernutrition children (0 – 5 years) (population and hospital settings) in developing countries

Source	Location	Design	Population/Setting	Sample size	Anthropometry used	Prevalence %		
						Underweight (<-2 z-scores weight-for-age)	Wasting (<-2 z-scores weight-for-length)	Stunting (<-2 z-scores length-for-age)
Bloss et al. (2004)	Kenya	Cross-sectional	Children aged 9 to 60 months in 3 villages of a community	175	Weight, length	30.0	7.0	47.0
Olusanya et al. (2010)	Nigeria	Cross-sectional	Infants aged 0 – 3months at the community immunisation centres	5,888	Weight, length, BMI	13.8	10.1	30.8
Medhin et al. (2010)	Ethiopia	Prospective cohort (Population-based)	Birth cohort followed to 1 year in a rural community	1,065	Weight, height	21.7 (6months) 21.2 (12months)	16.7 (6months) 8.4 (12months)	26.7 (6months) 48.1 (12months)
Kerac et al. (2011)	21 developing countries	Secondary data analysis of 21 demographic and health survey (DHS) datasets	Infants <6 months	15,534	Weight, height	-	2.0 – 34	-
Okoromah et al. (2011)	Nigeria	Case-control, observational	Children aged 3 – 192 months admitted with uncorrected symptomatic CHD and healthy controls	73 cases 76 controls	Weight, length/height, head circumference, mid-upper-arm circumference	20.5 (cases) 14.5 (controls)	28.8 (cases) 3.9 (controls)	41.15 (cases) 2.6 (controls)
Kuti et al. (2014)	The Gambia	Prospective, observational	Children aged 2 – 59 months admitted with severe pneumonia over 6 months to the paediatric ward of a rural comprehensive health centre	420	Weight, height	(150) 35.7	(145) 41.7	(71) 16.9
Musa et al. (2014)	Sudan	Cross-sectional descriptive	Children under 5 years old within households in the community	370	Weight, length/height	15.4	21.1	24.9

Table 1.9 Prevalence of undernutrition in Nigerian children (0 – 5 years) at the population level, based on the WHO-CGS (February – June 2013)

Category	Sample size	Percentage %							
		Weight-for-age		Height-for-age		Weight-for-height		BMI-for-age	
		-3SD	-2SD	-3SD	-2SD	-3SD	-2SD	-3SD	-2SD
Infants (0 – 0.49 months)	3,149	10.7	20.9	9.1	17.0	12.4	24.7	11.9	25.0
Urban children (0 – 5 years)	10,470	10.8	24.7	13.3	26.0	8.7	17.6	8.6	16.9
Rural children (0 – 5 years)	18,322	16.3	34.5	25.5	42.5	9.3	18.5	8.7	17.3

Source: WHO Global Database on Child Growth and Malnutrition - August 16, 2014

Table 1.10 Nigerian studies on infant growth

Source	Design	Population/Setting	Sample	Method Used	Outcome
Olusanya et al. (2010)	Cross-sectional to determine the prevalence, pattern and risk factors for under nutrition during early infancy	All infants 0 – 3months old attending four (4) primary healthcare centres for routine Bacille de Calmette-Guérin (BCG) immunisation in Lagos from July 2005 to March 2008	5888 full-term infants	Anthropometric measures of weight and length used to derive nutritional indices. A comparison made by the WHO-Multicentre Growth Reference based on z-scores below -2 for weight-for-age, length-for-age, weight-for-length-for-age and body-mass-index-for-age.	Undernutrition (based on z-scores below -2 for weight-for-age, length-for-age, and body-mass-index-for-age) found to be prevalent in the first three months of life in this population and detected early at routine immunisation clinics shortly after birth. Maternal/perinatal history offers valuable predictors in resource-poor communities where the majority of births occur outside hospital.
Olusanya and Renner (2011)	Prospective birth cohort to determine the pattern and predictors of growth velocity early infancy in a resource-poor setting	All preterm and term infants (excluding those less than five completed weeks of age at follow-up) in a birth cohort who returned for the first/routine postnatal check at 6 – 8 weeks or for any other purpose within the first three months of life at the Lagos Island Maternity Hospital from May 2005 to December 2006.	658 infants	Birthweight and gestational age data extracted from hospital records and additional anthropometric measurements made.	Higher weight velocity was strongly associated with lower birthweight ($p<0.001$) indicative of “catch-up” growth as well as with higher gestational age ($p<0.001$).
Olusanya and Renner (2013)	Descriptive cohort to determine the pattern of and factors associated with changes in nutritional status in early infancy in a resource-poor setting	All infants (excluding preterm infants) in a birth cohort who returned for the first/routine postnatal check at 6 – 8 weeks or for any other purpose within the first three months of life at the Lagos Island Maternity Hospital from May 2005 to December 2006.	445 full-term singleton infants	Birthweight and gestational age used in classifying each infant extracted from the hospital records and additional anthropometric measurements made. Nutritional status at birth compared with status at 6 – 8 weeks based on the WHO-Multicentre Growth Reference (WHO-MGR) and the Centres for Disease Control and Prevention 2000 (CDC 2000) growth charts.	The mean length-for-age and weight-for-length based on 2000 CDC growth charts were higher than the corresponding WHO-MGR reference values at birth and at follow-up, while mean weight-for-age was lower at birth but higher subsequently. About 20.7% of infants undernourished by at least one nutritional measure initially, declined at follow-up. In addition, 8.1% of the infants remained undernourished, 8.3% became undernourished, and 5.6% became adequately nourished at follow-up. Low birthweight full-term infants were significantly likely to remain undernourished ($p<0.001$) or become well nourished ($p<0.001$) at follow-up while the offspring of elderly mothers ($p=0.024$) or first-time mothers ($p=0.036$) had elevated risk of remaining undernourished by at least one measure at follow-up.

Table 1.11 Prevalence of undernutrition in infants in developing countries

Source	Location	Design	Population/Setting	Sample size	Anthropometry used	Prevalence %		
						Underweight (<-2 z-scores weight-for-age)	Wasting (<-2 z-scores weight-for-length)	Stunting (<-2 z-scores length-for-age)
Wamani et al. (2006)	Uganda	Cross-sectional	Mother-infant (0 – 23 months) pairs	698	Weight, length	12.0	4.0	25.0
Bucens and Maclennan (2006)	Indonesia	Prospective observational	Children aged 2 to 12 years admitted to the paediatric wards at the National Hospital	880	Weight, length/height	-	6.7	60.4
Schwarz et al. (2008)	Gabon	Prospective cohort	Children from birth to 15 months of age	289	Weight, length	3 months – 4.0 6 months – 2.0 15 months – 6.0	-	23.5 22.5 30.5
Engebretsen et al. (2008)	Uganda	Cross-sectional	Mother-infant (0 – 11months) pairs	723	Weight, length	-	4.2	16.7
Norris et al. (2009)	South Africa	Birth Cohort	Children 0 – 5 years old from the 1990 Birth to Twenty cohort in Johannesburg-Soweto	1) 6 months (n=623) 2) 12 months (n=623) 3) 24 months (n=623) 4) 60 months (n=623)	Weight, length/height	3.7 7.8 8.7 5.7	10.0 3.0 6.5 1.7	15.0 7.8 26.5 9.1
Iannotti et al. (2009)	Peru	Prospective birth cohort	Low-income birth cohort followed from birth to 12 months of age	232	Weight, length/height	6 months – 2.6 12 months – 3.5	1.3 1.3	1.7 2.2
Meshram et al. (2012)	India	Community-based Cross-sectional	Children aged 1 to 5 years in 120 villages	1751	Weight, length/height	64.0 [Moderate underweight higher (p<0.001) among 3 – 5-year olds]	29.0	61.0 (Severe stunting higher [p<0.001] among 1 – 3-year olds)
Patwari et al. (2015)	India	Secondary data analyses of National Family Health Surveys-3	Children aged 0 to 5 years	1) <6 months (n=3807) 2) 6-59 months (n=45,376)	Weight, length/height	18.7 27.6	17.5 13.2	11.8 25.5

1.2.9 General management of undernutrition in infants

With failure of preventive strategies, such as breastfeeding, GMP, immunisation against communicable diseases, food/nutrient supplementation, nutrition education to mothers/carers, there is the need for either community-based or hospital-based management to prevent mortality from SAM. However, admission to hospital has disadvantages, which include nosocomial infections for the undernourished infant and high expenses for the family. Therefore, the management of acute malnutrition in developing countries usually employ the use of cheap and locally available nutrition-based interventions in the community. For example, the use of the community-based model called ‘Community-based Therapeutic Care’ (CTC) based on the principles of coverage, access, and cost-effectiveness (Collins et al., 2006b). Thus, CTC programmes use decentralised networks of outpatient treatment sites (usually located at existing primary healthcare facilities), small inpatient units (usually located in existing local hospital facilities), and large number of community-based volunteers to provide case-detection and some follow-up of patients in their home environment. The CTC approach combines three modes of care and treatment, all embedded in active measures to encourage community understanding, mobilisation, and participation. The CTC model treats severe acute malnutrition using a combination of three treatment modalities, inpatient therapeutic, outpatient therapeutic, and supplemental feeding according to clinical and anthropometric characteristics at presentation. Cases of moderate acute malnutrition with no medical complications are supported through the humanitarian-related operation, Supplementary Feeding Programme (SFP) that provides dry take-home rations for infants and children older than 6 months. Cases of severe acute malnutrition with no medical complications are treated in an Outpatient Therapeutic Programme (OTP) that provide ready-to-use therapeutic food (RUTF), a course of antibiotics, anthelmintic treatment, folic acid, and if appropriate vitamin A, measles vaccination and antimalarial treatment on a weekly or fortnightly basis. CTC is the old/original name for a model of care for SAM called Community Management for Acute Malnutrition (CMAM) today.

SAM is associated with increased severity of common infectious diseases, and mortality in children with SAM often results from infections. Children with SAM are classified as ‘complicated’ if they have clinical features of infection or metabolic disturbance, severe oedema or poor appetite while children with ‘uncomplicated’ SAM are clinically well, alert and have retained their appetite (Jones and Berkley, 2014). To reduce the incidence of nosocomial infections, the ‘uncomplicated’ cases are managed as outpatients with suitable

services, including access to either locally produced or imported RUTF while the ‘complicated’ cases are managed as inpatients (WHO/UNICEF/WFP/SCN, 2007). The new WHO 2013 guidelines also suggest a similar uncomplicated/complicated SAM distinction for infants younger than 6 months (World Health Organisation, 2013). The treatment of severe SAM runs between clinical medicine and public health. There is a need to prevent most starvation-related cases by dealing with their causes through public health measures designed to increase the quantity and quality of dietary intake alone, without need for clinical input. In practice, extremely ill malnourished children need intensive medical and nursing care, considering the poor socio-economic background, particularly in developing countries. Therefore, there is the need to take the situational background into account in order to balance the potentially conflicting demands and ethics of clinical medicine with those of public health (Collins et al., 2006a). Cases of severe acute malnutrition with additional serious complications are treated in inpatient Stabilisation Centres (SCs) until they are well enough to be transferred into the OTP. The inpatient protocols used in CTC are essentially the same as those recommended by the WHO (World Health Organisation, 1999a) with the exception on the admission criteria, discharge criteria, and the dietary protocols in the transition phase. Moreover, higher coverage is achieved with CTC than facility-based programmes, and patients’ retention and treatment outcomes are better, therefore, the WHO and UNICEF endorsed CTC in 2009 (Kramer and Allen, 2015). Success stories abound with the CTC approach of managing acute malnutrition, particularly among children in Ethiopia, Malawi, Sudan, Mali, and Bangladesh.

Management of undernutrition in Nigerian infants

The Nigerian government tackles childhood undernutrition mainly through policies that promote preventive strategies, such as breastfeeding, GMP, immunisation against childhood diseases, food/nutrient supplementation, and nutrition education to mothers/carers, at all levels of healthcare. The management of undernutrition in children is mainly hospital-based, however, non-governmental and international organisations, such as the UNICEF, USAID, and WHO intervene through community-based programmes. Nigeria is a member of the Scaling Up Nutrition (SUN) Movement, which is a global initiative led by 55 countries working together to scale up nutrition, focussing on the critical 1000-day window of opportunity, with the vision of a world without hunger and malnutrition. The Nutrition Division of the Federal Ministry of Health coordinates the movement in a multi-sectorial and inter-agency manner, thus, involving health, education,

agriculture, women affairs, finance, information, science and technology, water resources and the planning commission. However, this set has not fully established nutrition interventions towards tackling childhood undernutrition.

Some nutrition interventions have effectively contributed in tackling the problem of childhood undernutrition at the population level. For example, the Children's Investment Fund Foundation supports Nigeria's Federal and State Ministries of Health and UNICEF to deliver life-saving treatment to children with SAM. This programme delivers CMAM to children less than 5 years of age in eleven states in northern Nigeria. Health workers offer care and treatment at sites located within the communities, providing easy access to services for families of undernourished children. Clinics run on weekly or two-weekly basis at the local health facility for:

- Growth monitoring to track undernutrition status
- rationing of RUTF
- screening and treatment for common childhood diseases such as malaria, intestinal parasites and bacterial infections

Regular clinic visits enable health workers to track progress and identify severe and complicated cases that may need referral for professional management. The programme enrolment runs for 6 – 8 weeks until the children attain adequate weight gain and regain health. Reports from June 2013 to June 2014 showed that caring and treating 251, 314 severely wasted children (Children's Investment Fund Foundation, 2014), the programme yielded 81% success compared to that of the previous year. Therefore, this programme's effectiveness for that period of report exceeded the international minimum standard of 75% cure rate for CMAM programmes in non-emergency settings. However, the impact of CMAM coverage is faced with the challenges of lack of awareness about SAM and CMAM services among caregivers, particularly in the most affected communities in Nigeria (ACF International, 2015).

At the UNTH, Enugu, the paediatricians usually refer undernourished children as either outpatients or inpatients to the dietitian-nutritionists for the institution of medical nutrition therapy as an intervention. The referred undernourished children aged 6 – 60 months of age receive a locally formulated high protein high-energy mixture from the hospital's department of Nutrition and Dietetics. As a local equivalent of F-75 and F-100 supplied by the UNICEF, this mixture uses 'akamu' (locally prepared cereal porridge from fermented corn/maize, sorghum, or millet) as its base. The constituents are vegetable oil, equal quantities of sugar and glucose, powdered milk (ground dried meat or processed soybean flour replaces powdered milk, for cases of diarrhoea or lactose-intolerance), vitamin C, and

vitamin B complex. The protein and energy compositions of this mixture are calculated according to the age and nutrient requirement of the individual undernourished child. Reconstituting these ingredients with boiled water, produces a high protein high-energy mixture (otherwise known as ‘HEMIX’) kept in a thermos flask for feeding the infant over a 24-hour period. For the first 3 – 5 days of treatment, the undernourished child receives three-hourly feeds of half strength of this fluid diet, including vitamin A supplement prescribed by the paediatrician on the ward. Thereafter, the strength, quantity, and intake frequency of the feed decreases or increases according to the tolerance and observed clinical state of the individual child. During this period of nutrition intervention, the dietitian-nutritionist assigned to the paediatric ward, counsels its mother/main carer on how to prepare and feed the child with the high protein high-energy mixture, when discharged home from hospital.

Management of undernutrition in Nigerian infants younger than six months

There is no ‘gold standard’ management for SAM in infants younger than 6 months, but managing most cases in in-patient settings optimise the quality of care offered to individual cases. However, physiological processes, including thermoregulation and renal and gastrointestinal functions, are relatively immature in early infancy. Hence, the current guidelines do not recommended RUTF for infants younger than 6 months; similarly, the use of high protein high-energy mixture excludes this population because their immature kidneys cannot cope with the high solute load. Moreover, there is the risk of interfering with the EBF aim (Kramer and Kakuma, 2012), as the infant could become ‘dependent’ on receiving this rather sweeter mixture than breastmilk and become ‘unintentionally’ weaned off the breast. The literature suggests that the commonest cause of the development of severe acute undernutrition in this age group reflects suboptimal breastfeeding practices (Black et al., 2013). Therefore, the common practice is undertaking a thorough interview of the mother, focussing on establishing, or re-establishing EBF. Thereafter, offering individual nutrition and EBF counselling to mothers of very young infants, according to the specifically identified cause of the poor nutritional state. Nutrition education efforts should aim to involve the child’s father and/or other significant members of the family, and emphasis made on the benefits of EBF and the risks of using breastmilk substitutes for infant feeding. Lactation management, includes enhanced breast support, correct positioning of the infant on the breast, increased frequency of infant suckling, and increased duration of breastfeeding sessions. Moreover, addressing the sources of maternal stress, such as tiredness and high maternal working hours in addition to taking care of a

large family, could promote breastmilk production and flow. Further verifying if maternal undernutrition is the cause of undernutrition in the infant, could entail supplying the mother with high protein high-energy fluid diet. Thereafter, the energy and nutrients she assimilates through the ingested high protein high-energy fluid diet would be made available to her undernourished infant via her breastmilk. Furthermore, emphasis should be made on the need to increase maternal food and fluid intake, including water, local soups, soy based or milk drinks (if they are affordable), in order to increase breastmilk flow.

1.3 Summary and Implications of review of the literature

Determining the prevalence and pattern of undernutrition in early infancy helps to show the burden of the condition, and therefore form a template for intervention strategies to reduce the problem in an environment (Manyike et al., 2014). The literature search on childhood undernutrition yielded mainly reviews, modest cross-sectional studies and few longitudinal studies, particularly from developing countries. Although most of the literature focussed on children 6 – 60 months of age, the limited literature on infants younger than 6 months suggests that undernutrition is a problem during this period of recommended EBF for optimal growth and development. Young infants with underlying disease are mostly affected, particularly in developing countries (Bloss et al., 2004, Olusanya et al., 2010, Okoromah et al., 2011, Kerac et al., 2011, Patwari et al., 2015, Dani et al., 2014). In these countries, food insufficiency, poor water and sanitation, and restricted access to high quality primary care are all associated with household and community poverty, which is the main cause of childhood undernutrition (WHO/UNICEF, 2003). Moreover, sub-optimal infant feeding patterns or intake of nutritionally inadequate diets highly contributes to early childhood undernutrition (Black et al., 2013). Furthermore, using growth charts to identify infants and children at risk for undernutrition is suggested ineffective due to poor health staff understanding, application, and interpretation of growth patterns in early infancy (Ruel et al., 1991, Morley, 1994, Cooney et al., 1994, de Onis et al., 2004, Qayad, 2005, Thandrayen and Saloojee, 2010, Mutoro and Wright, 2013, Ahmad et al., 2014). At this period of life, the risk for undernutrition increases the rate of morbidity and mortality (Jeejeebhoy, 2003, Friedman et al., 2005, Marteletti et al., 2005, Ehrhardt et al., 2006, Joosten et al., 2010, Black et al., 2013), with increase in length of stay and expenses in hospitalised infants (Correia and Waitzberg, 2003).

Undernutrition, though common in hospitalised children, is often unrecognised by health staff (Hendrikse et al., 1997). Rather the primary focus is the primary medical problem (Joosten and Hulst, 2008) and little attention given to the child's nutritional status. Nonetheless, identifying the child's nutritional state at the time of admission enables the early establishment of appropriate nutrition intervention to minimise the risk of undernutrition (Pichler et al., 2014), improve clinical outcomes and reduce healthcare costs. However, there is little information on the growth patterns of Nigerian infants younger than six months, particularly hospitalised infants; how growth velocity of these infants relate to their nutritional status; standardised methods for assessing risk for undernutrition and morbidity in infants; and evaluation of health staff use of growth patterns to identify infants at risk for undernutrition. Attempting to fill this information gap led to the formulation of some research questions:

- 1) What is the prevalence of undernutrition in hospitalised infants under six months old?
- 2) What are the implicated feeding patterns and medical conditions of these infants?
- 3) Can feeding information and growth patterns be used to predict undernutrition in these infants?
- 4) Is health staff use of growth patterns in identifying undernutrition in early infancy effective?

Focussing on hospitalised infants, therefore, the aim was to investigate ways of diagnosing undernutrition in this population towards suggesting a better evidence-based approach to improve practice with the following objectives:

- To compile weight velocity in healthy infants used to generate the reference to compare that of their hospitalised peers in relation to WHO-CGS
- To determine undernutrition prevalence using the SGNA, mid upper arm circumference (MUAC) and skinfolds, and determine predictors of undernutrition
- To investigate health staff understanding, application/interpretation of growth patterns in identifying undernutrition in young infants

The project was based at the University of Nigeria Teaching Hospital (UNTH), Enugu, southeast of Nigeria, from February to July 2012. The process involved the researcher who is a registered dietitian-nutritionist who worked with research assistants to investigate the problem of undernutrition from three perspectives, stratifying the project into three studies. The first study set out to document a population representative dataset of the growth patterns of healthy breastfed infants (0 – 26 weeks old) and generate a reference for

comparing that of their hospitalised peers in relation to the WHO-CGS. The second study set out to explore ways of assessing the risk for undernutrition in hospitalised infants (0 – 26 weeks old) using feeding and growth information. The third study set out to test the accuracy of health staff understanding and application/interpretation of growth patterns in identifying undernutrition in infants (0 – 26 weeks old). In order to verify earlier investigations in this very important area of research, evaluate methodologies employed by those researchers, and identify the gaps that the current project could fill, there was the need to review the literature. Evidence from the literature, therefore, justified the research design and methodology adopted for the three studies that constitute the project, as described in chapter 2.

CHAPTER 2 RESEARCH DESIGN AND METHODOLOGY

2.1 Research Design and Methodology

2.1.1 Research Design

A pilot study was conducted to pre-test and prove the research instruments at the Royal Hospital for Sick Children (RHSC), Yorkhill, Glasgow, Scotland, in March 2011, prior to the three studies of the project conducted at Enugu city, Nigeria. All these studies, including the pilot study adopted a cross-sectional, observational design.

2.1.2 Research Methodology

Growth monitoring using anthropometry

Assessment of growth, as the epidemiological measurement that best defines the health and nutritional status of infants and children, has anthropometry as a basic component. Anthropometry remains the most practical tool for assessing nutritional status in infants and children in developing countries, despite its inherent limitations (World Health Organisation, 1995). Anthropometric measures are easy to collect, inexpensive, non-invasive, and accurate, however, anthropometric indices combine two or more measures to give more detailed information about nutritional status and adequacy of child growth than single measurements. Therefore, anthropometric markers are important in classifying patients according to their nutritional conditions for admission to hospital; and using anthropometric measurements of body dimensions and body composition quickly assesses nutritional status.

i) Anthropometry of body dimensions

Body dimensions typically reflect a cumulative exposure to the diet (especially the energy content of the diet) and illness. The most basic measurements in infants, weight and length, are fundamental because they give the simplest measures of attained size and tissue mass. Head circumference measurement takes the maximal occipito-frontal circumference and is used to identify children with a head size or growth pattern that attracts further evaluation for pathology.

*ii) Anthropometry of body composition**Body Mass Index (BMI)*

BMI, which is defined as weight in kilogrammes divided by length/height in metres squared, is a simple and reproducible index that reflects body composition by proxy. Measures of body proportionality, such as BMI and ponderal index (PI) (weight in kilogrammes divided by length in metres cubed), had earlier been proposed as complementary tools for assessing growth and nutritional status in newborns since both measures take into account the weight/length ratio (Onyiriuka and Okolo, 2007). Using BMI in assessing body proportionality therefore, may give information about growth patterns in early infancy. BMI Z-score has been suggested for use as a complementary measure in neonatal growth assessment over PI; however, both measures are poor predictors of adiposity at birth (De Cunto et al., 2014). Below the age of 2 years, weight and length are the preferred parameters for monitoring growth rather than BMI. Nonetheless, BMI-for-age is a good indicator of variability in energy reserves in infants despite its age-dependency. Early detection and correction of current energy deficit (indicated by low BMI-for-age and wasting) have been suggested to reduce the risk of infection and enable the child to continue in weight and height growth trajectories (Ramachandran and Gopalan, 2009). Although BMI-for-age is highly used in population studies, it is unable to provide accurate information about the body compartments and the changes they undergo in the course of illness or nutrition intervention.

Conditional Weight Gain (CWG)

When assessing the weight change in infants, there is a change in standard deviation scores (SDS) – either positive or negative depending on whether it is a gain or loss in weight. This indicates the individual infant's position relative to the population within two time-periods of weight measurement ($SDS_{time2} - SDS_{time1}$). The value of difference must be interpreted in the light of the value of SDS_{time1} used in its calculation (Wright et al., 1994a). The phenomenon of “regression to the mean” had earlier been described as “a tendency in biological measurements for individuals at the extreme of the distribution to subsequently move inwards towards the average, their place being taken at the extreme by new individuals moving outwards” (Healy and Goldstein, 1978). Smaller infants tend to move upwards through the centiles and large infants tend to cross downwards. A method was described based on conditional standards to correct for this “regression to the mean” and produce a measure of the discrepancy between predicted and actual growth – the ‘thrive

index' (Wright et al., 1994a, Cole, 1995). Assessing change in SDS considers the prediction of the expected value of SDS_{time2} with the observed value of SDS_{time1} , which is the idea behind conditional standards (Healy, 1974, Cameron, 1980, Heimendinger and Laird, 1983, Wright et al., 1994a).

Practically, the SDS at time 2 is predicted from that at time 1 and the former compared with this prediction. The statistical tool required for making a prediction of the expected value of SDS_{time2} is regression, but as SDS has, by definition, mean 0 and SD 1, the regression takes a particularly simple form:

$$SDS_{predict} = r * SDS_{time1}$$

where:

r = correlation between SDS at times 1 and 2 (Wright et al., 1994). This quantifies the regression to the mean making an infant who was initially above or below the population mean to stay on the same side of the population mean on the average but closer to it. The change in weight is derived by the difference $SDS_{time2} - SDS_{predict} = SDS_{time2} - r * SDS_{time1}$. Transformation of the data (otherwise known as conditionality) entailed adjusting or compensating for the tendency of infants to regress to the mean, thereby determining how much variation their weights showed and its direction from the population mean of 0, as earlier described (Wright et al., 1994a). Conditional weight change represents the change in weight within the first six months of life relative to the birthweight, in the context of the mean growth pattern of the population. Thus, slow weight gain was identified using conditional weight change and the 'thrive index' method (the slowest weight gaining 5% of the population) which takes into account the phenomenon of regression to the mean (Wright et al., 1994a, Wright et al., 2006b). The 'thrive index' identifies and quantifies abnormal weight gain in early infancy, and therefore suggested useful in identifying a vulnerable group of children (Wright et al., 1994b).

Patterns of weight gain in infancy are more appreciated using the conditional weight change Z-score system (Argyle, 2003). In the UK, a descriptive analysis of the Cambridge Infant Growth Study database (comparative dataset) and a Newcastle dataset (the normative dataset) expressed CWG as an SD score or centile based on the UK 1990 growth reference (Cole, 1995) (Table 2.1). The comparative dataset recorded a mean SDS_{gain} of -0.12, SD SDS_{gain} of 1.00 while the normative dataset recorded a mean SDS_{gain} of 0.11, SD SDS_{gain} of 1.05 (Cole, 1995). In another investigation, infants' weights in the same dataset (Growth and Development Study) were transformed into SD scores using the Cambridge Growth Standards applying the LMS method (see section 2.1.3.2), which

ensures that SDS is essentially normally distributed (Wright et al., 1994a) (Table 2.2). These authors reported that the ‘thrive index’ was initially defined as the 3rd centile and later the 5th centile generating a conditional weight growth score of -1.69 for the former and -1.48 for the latter. A similar investigation assessed infant growth by calculating the difference in z-scores between two time points and adjusting for regression towards the mean using the UK 1990 growth reference. A mean Z-score of -0.66 was derived at birth, 8 weeks and 9 months for the UK Avon Longitudinal Study of Parents and Children (ALSPAC) dataset (Emond et al., 2007) (Table 2.2). A corresponding conditional weight growth score of -1.645 and a growth Z-score with a mean (SD) of -2.12 (0.49) were generated from 8 weeks to 9 months of age. In Denmark, using CWG and the ‘thrive index’ method taking into account the normal phenomenon of regression to the mean (Olsen et al. 2010), the ‘thrive index’ value defining the 5% with the slowest weight gain (CWG) was ≤ -1.46 (Table 2.3). The slowest weight gain of 5% was observed in the age interval: 0 – 2 weeks, 2 weeks to 4 months, and 4 – 8 months, corresponding to the ‘thrive index’ at or below -1.6033, -1.0721 and -1.0217, respectively (Olsen et al., 2010). In Nigeria, a prospective birth cohort study based on Z-scores below the 5th centile with standardised weight gain, reported that 3.6% of the infants demonstrated evidence of failure to thrive (Z-score ≤ -1.645) for the cohort (Olusanya and Renner, 2011). Furthermore, an investigation applied low weight for age, low BMI, low CWG and Waterlow’s criterion, to compare the seven criteria of failure to thrive to the birth cohort, and found that no single measurement on its own seemed to be adequate for identifying nutritional growth delay (Olsen et al., 2007a).

Table 2.1 Studies on conditional weight change in infants

Source	Location	Study Design	Population/Setting	Sample size	Method	Outcome
Cole (1995)	UK	Description of a conditional reference charts for assessing the weight gain of British infants.	1) The Cambridge Infant Growth Study database, which was set up in 1983 to monitor the pattern of growth of infants fed according to the Department of Health dietary guidelines. 2) The Newcastle Regional Health Authority database used to validate the conditional weight gain reference generated from 1) above.	1) Four separate cohorts of infants of 244 mothers from the City of Cambridge 2) A total of 4879 weights of 761 infants from the Newcastle Regional Health Authority database	1) The infants were weighed and measured every four weeks (± 3 days), from the age of 4 to 52 weeks, and at 18 and 24 months. At each visit, weight and five other anthropometric measures obtained using standard methods. 2) The validation of the conditional weight gains reference using a dataset of 4879 weights from 761 infants, 727 infants from the Newcastle Regional Health Authority database. These infants were seen twice or more, weighed whenever the infant was brought to the clinic between the ages of 4 and 24 months. The median number of visits per infant was seven, maximum 10. All the Cambridge and Newcastle weights converted to SD scores using the UK 1990 weight reference; regression analysis and correlation performed on both datasets; validation of the result with the Newcastle data.	The conditional reference provided a valid assessment of the weight gain of British infants, over time-periods of four or more weeks, throughout the first two years of life.

Table 2.2 Studies on conditional weight change in infants

Source	Location	Study Design	Population/Setting	Sample size	Method	Outcome
Emond et al. (2007)	UK	Prospective birth cohort	Infants from the Avon Longitudinal Study of Parents and Children (ALSPAC) born at 37 – 41 weeks gestation; without major malformations and with weight measurements in infancy (83% of the original (ALSPAC cohort)	11,900 infants	The conditional weight gain of the infants calculated for the periods from birth to 8 weeks and 8 weeks to 9 months. Cases of growth faltering defined as those with a conditional weight gain below the 5th centile.	Of the 528 cases of growth faltering from birth to 8 weeks, only 30 (5.7%) also had poor growth for the second period. Although only 0.6% were of Asian origin, of the 495 cases from 8 weeks to 9 months growth faltering was 3 – 4 times as common in this group, which had a similar mean weight Z-score of -0.66 at birth.
Wright et al. (1994a)	UK	Prospective birth cohort	An annual cohort of children, resident in Newcastle in November 1989 identified using the Child Health Computer system	3418 full term children aged 18 – 30 months	Infants' weights were transformed into SD scores using the Cambridge Growth Standards, constructed using the LMS method that ensures that SDS is essentially normally distributed. The 'thrive' index was defined.	The value of the 'thrive index' below which only a minority of children fell provided a lower threshold for normality. While most children below the 3 rd centile for weight at 9 – 24 months of age also had a subnormal weight gain, 41% of those with subnormal weight gain had not fallen below the 3 rd centile.

Table 2.3 Studies on conditional weight change in infants

Source	Location	Design	Population/Setting	Sample	Method used	Outcome
Olsen et al. (2007a)	Denmark	Prospective birth cohort	The Copenhagen Child Cohort 2000 (CCC 2000) consisting of births in the Copenhagen County during the calendar year 2000, constituting 9% of children born in Denmark during that year. Data from the first year of life came from three sources: 1) standardised public health nurses' records; 2) the National Birth Register; and 3) the National Patient Registry.	6090 children	Seven criteria of failure to thrive, including low weight for age, low BMI, low conditional weight gain and Waterlow's criterion were applied to the birth cohort. The criteria were compared in two age groups: 2 – 6 and 6 – 11 months	No single measurement on its own seemed to be adequate for identifying nutritional growth delay
Olsen et al. (2007b)	Denmark	Prospective birth cohort	The Copenhagen Child Cohort 2000 (CCC 2000) consisting of births in the Copenhagen County during the calendar year 2000, constituting 9% of children born in Denmark during that year. Data from the first year of life came from three sources: 1) standardised public health nurses' records; 2) the National Birth Register; and 3) the National Patient Registry.	6090 children	The 'thrive index' method, which takes into account the normal phenomenon of regression to the mean. Three different anthropometric criteria were investigated: (A) the 5% of children with the slowest weight gain, conditional on birthweight (conditional weight gain below 5%); (B) the combination of criterion (A) and BMI under 5 th percentile; and (C) downward crossing of weight with two or more major centiles.	Different anthropometric criteria currently used for the identification of failure to thrive, identify different subgroups of children with different risk profiles and different rates of prevalence ranging from 2% to 21%. Slow conditional weight gain seems to truly identify children at risk, with prenatal growth retardation and postnatal symptoms of developmental delay, thus indicating risk mechanisms operating already in foetal development.
Olsen et al. (2010)	Denmark	Prospective birth cohort	The Copenhagen Child Cohort 2000 (CCC 2000) consisting of births in the Copenhagen County during the calendar year 2000, constituting 9% of children born in Denmark during that year. Data from the first year of life came from three sources: 1) standardised public health nurses' records; 2) the National Birth Register; and 3) the National Patient Registry.	6090 children	Weight faltering defined as the slowest weight gaining 5% of all children within three separate periods: 0 – 2 months, 2 – 6 months, and 6 – 11 months. The average ages of measuring within the three age bands were approximately 2 weeks, 4 months, and 8 months. Slow weight gain identified using conditional weight gain and the 'thrive index' method, taking into account the normal phenomenon of regression to the mean.	Regardless of the age of onset, slow weight gain was strongly associated with feeding problems, but the risk factors involved differed according to the age of onset. Thus, onset within the first weeks of life clearly differed from faltering later on, the former being strongly associated with low birthweight and gestational age. Conclusively, weight faltering in infancy is clearly associated with contemporary measured feeding problems, but the risk mechanisms involved differ in early versus late onset.

Mid-upper arm circumference (MUAC)

Both subcutaneous fat and muscle mass is contained in the arm of a human being. In situations of reduced food intake, lower levels of these two entities correspond to decrease in MUAC and is used to diagnose undernutrition (Fernandez et al., 2010). As a simple measure of nutritional status to detect changes in body composition, MUAC has been found to be the best indicator for screening and detection of undernutrition in children in the community (Myatt et al., 2006) and during emergencies. In clinical practice, MUAC often used in assessing and monitoring nutrition interventions; and in combination with skinfolds, MUAC is useful in identifying undernutrition in hospitalised medical patients. A validity study compared MUAC with indicators of undernutrition [BMI and Triceps skinfold thickness (TSFT)] in conjunction with SGNA for outcome (Burden et al., 2005). From that study, MUAC<5th percentile was found to have a higher specificity, but lower sensitivity and not a good predictor of clinical outcome. Although MUAC was not justified to be used as a single measure for assessing the risk for undernutrition, MUAC and TSFT were shown to be reliable measures for assessing changes in body composition but not good methods of assessment of nutritional status in hospitalised patients like SGNA and BMI (Burden et al., 2005).

Skinfolds

Anthropometric measurements serve as easily performed, non-invasive techniques to estimate infant growth. Skinfold thickness, as one of the anthropometric measures, is a validated parameter of subcutaneous fat accumulation (Fok et al., 2006, Addo and Himes, 2010). Subcutaneous fat is very specific to adipose tissue and can be measured noninvasively; therefore, skinfold thickness remains an important and valid anthropometric indicator of regional and total body fatness, especially in research settings (Bellisari and Roche, 1996, Bedogni et al., 2003, Addo and Himes, 2010). The correlation between the subcutaneous fat measurement by skinfold calipers and direct measurements of fat-width by x-ray is high (from 0.85 to 0.90). Thus, such measurements have been variously used in the nutritional assessment of children and adults over four decades (Tanner and Whitehouse, 1962, Farr, 1966). Skinfold thickness measurement has been shown to be a convenient and non-invasive method for the assessment of total body fat and perinatal nutritional status (Farr, 1966). Adjusting skinfold thickness measurement for body weight is a more precise assessment of total body fat deposition (Schmelzle and Fusch, 2002) and has been shown to be a better indicator of perinatal nutritional status (Harrington et al., 2004).

2.1.3 Diagnosing undernutrition in hospitalised infants using screening tools

Currently, there is no consensus on the ideal method to determine which children on admission are at risk to develop undernutrition during hospital stay since no universally accepted paediatric nutritional screening tool exists. Such a screening tool is different from measuring actual nutritional status with weight and height (Joosten et al., 2010). The purpose of nutrition screening is to predict the probability of a better or worse outcome due to nutritional factors and if nutritional treatment is likely to influence this (Mueller et al., 2011). A nutrition screening tool may determine the extent of undernutrition within the population group and is associated with a decrease in length of hospital stay, morbidity and mortality, and impaired nutritional status (Kondrup et al., 2003). Most screening tools address four basic questions: recent weight loss, recent food intake, current body mass index and disease severity (Gerasimidis et al., 2010, Chermesh et al., 2011). The “reference measure” for assessing the risk for undernutrition appears to be dietetic review.

i) Paediatric Subjective Global Nutritional Assessment (SGNA)

Subjective Global Nutrition Assessment (SGNA) screening tool assesses nutritional status based on the application of medical history and physical examination making it the most commonly used tool for hospitalised patients in developed countries (Detsky et al., 1987). Initially clinical judgement was validated for evaluating nutritional status in adults (Baker et al., 1982). A structured clinical approach (SGA) emerged, was refined (Detsky et al., 1987), applied, and finally validated internationally for clinical, epidemiological and research purposes (Ulander et al., 1993, Niyongabo et al., 1999, Duerksen et al., 2000, Stephenson et al., 2001, Wyszynski et al., 2003, Steiber et al., 2004, Gupta et al., 2004). A review of SGA, found it to be “a simple, safe and inexpensive tool allowing for widespread use by trained clinicians and remains the ‘gold standard’ for new bedside assessment tools” (Keith, 2008). An adapted version of SGA for use in a paediatric population for identifying children at risk for malnutrition during hospitalisation was developed and called the SGNA (Secker and Jeejeebhoy, 2007). SGNA has been proven a valid tool for assessing nutritional status in children and identifying those at higher risk of nutrition-associated complications and prolonged hospitalisations (Secker and Jeejeebhoy, 2007, Mahdavi et al., 2009, Gerasimidis et al., 2010). Moreover, SGNA has been found to be an inexpensive, quick method and reliable tool for conducting nutrition assessment and predicting outcomes (readmission and mortality) at the bedside of patients, particularly the critically

ill patients (Yamauti et al., 2006, Fontes et al., 2014). Furthermore, SGNA is more in-depth than a nutrition-screening tool, being used to assess nutritional status children in circumstances that expose them to the risk of undernutrition. For example, children living in poverty, children who are hospitalised, children with neurocognitive disabilities or chronic illnesses/diseases. However, SGNA does not measure acute change in nutritional status, by design (Secker and Jeejeebhoy, 2012).

Documentations of the use of SGNA in children in developing countries are scarce. However, SGNA (Secker and Jeejeebhoy, 2007) was used in the current study. The SGNA considers seven specific features of a nutrition-focused medical history and three features of a nutrition-focused physical examination for signs of inadequate energy and/or protein intake. Nutritional status is an important factor that determines hospital stay, and the SGNA is a candidate tool for screening on admission based on the practitioner's clinical judgement rather than objective, quantitative measurements (Secker and Jeejeebhoy, 2007). Secker and colleague assert that paediatric SGNA employs historical, symptomatic, and physical parameters while aiming to identify the subject's initial nutritional state and consider the interaction between the factors that influence the progression or regression of nutritional abnormalities. SGNA considers seven specific features of a nutrition-focused medical history and three features of a nutrition-focused physical examination for signs of inadequate energy and/or protein intake. In addition, the nutrition-focused medical history includes appropriateness of current height-for-age, appropriateness of current weight-for-height, unintentional changes in body weight, adequacy of dietary intake, gastrointestinal symptoms, nutritionally related functional capacity, and metabolic stress. Furthermore, the nutrition-focused physical examinations include loss of subcutaneous fat, muscle wasting, and nutrition-related oedema. The subjects are categorised into 'normal/well nourished', 'moderately malnourished', and 'severely malnourished'. The progression of the subject's nutritional status is considered in relation to the subject's usual status; therefore, the overall SGNA ranking of the subjects is subjective and not based on a numerical scoring system. For any subject, the more the checkmarks are on the right side of the questionnaire, the more likelihood of being malnourished; and the more of them on the left, the more the likelihood of being normal/well-nourished (Secker and Jeejeebhoy, 2012). These workers tested and proved that SGNA is a valid tool for assessing nutritional status in children and identifying those at higher risk for nutrition-associated complications and prolonged hospitalisations. These workers observed a statistically significant increase in postoperative length of stay, infectious complications, and minor complications in children classified as malnourished using SGNA standards. SGNA has also been reported as possessing a

potential to predict clinical outcomes that influence health-related costs and morbidity (Wessner and Burjonrappa, 2014). Therefore, SGNA has been recommended as a simple method for identifying patients needing nutrition intervention (Barbosa-Silva, 2008). However, although SGNA is designed to identify undernourished children, it does not differentiate children with adiposity from well-nourished children (Secker and Jeejeebhoy, 2012).

ii) The Paediatric Yorkhill Malnutrition Score (PYMS)

The Paediatric Yorkhill Malnutrition Score (PYMS) was developed (Gerasimidis et al., 2010) as a nurse-administered screening tool. PYMS is a four-stage evaluation based on four questions considering the BMI value, recent weight loss, decrease of food intake the previous week, and expected affect on nutrition by the admission/condition for the next week. The performance of PYMS was validated for use in identifying children at risk of malnutrition in Glasgow (Gerasimidis et al., 2010) by classifying the children as having 'low', 'medium' or 'high' malnutrition risk. Using a full dietetic assessment (dietary history, anthropometric measurements, nutrition-associated physical examination, ability to maintain age-appropriate energy levels, and review of medical notes) as a 'gold standard' for nutritional assessment rated 47% of the children as 'high risk' against 59% nurse-rating. A pilot investigation was conducted under the current research project, in March 2011 at the RHSC, Yorkhill in Glasgow, in order to test and prove the research instruments and further apply PYMS in the main study conducted in Nigeria (a developing world setting). Although the latter was not realized, the findings from that study showed that among 10 hospitalised infants aged 9 days to 11 months, 6 (60%) were never breastfed and 4 (40%); were breastfed ranging from 2 days to 2 months. The weight SD scores of these infants ranged between -2.81 and 1.43 while the change in weight SDS from birth ranged between 0.20 and 1.34. The morbidities recorded were respiratory tract infections (4, 40%), congenital cardiac disease (1, 10%), urinary tract infection (2, 20%), and surgical cases (3, 30%) while the mean hospital stay was 3.1 ± 1.7 days. Although the small size of this pilot dataset posed a limitation to further analysis, the picture was that the majority of very young infants were at 'moderate' to 'severe' risk for undernutrition.

2.1.4 Standard operating procedures/instruments used for the studies of the project

Anthropometric measurements

According to the WHO-recommended measurement protocols (World Health Organisation, 1995), anthropometric data collection includes:

- i) Weight measurement taken, using a SECA 385 electronic baby scale that is regularly calibrated with a known weight. The infant, without any clothes and diaper, is placed on the scale so that the weight distributes equally about the centre of the pan. When the infant lies quietly, weight is measured and recorded to the nearest 10g (see Figure 2.1).
- ii) Recumbent length measurement taken, using a SECA 416 infantometer. The infant lies in a supine position on the infantometer with the crown of its head touching the stationary, vertical headboard. An assistant holds the infant's head, with the line of vision-aligned perpendicularly to the plane of the measuring surface, with the shoulders and buttocks flat against the table top, and the shoulders and hips aligned at right angles to the long axis of the body. The legs are gently extended at the hips and knees and lie flat against the table top, and the arms rested against the sides of the trunk. The measurer ensures that the legs remain flat on the infantometer and shifts the mobile board against the heels, to measure and record the length to the nearest 0.1 cm (see Figure 2.2).
- iii) Head circumference measurement taken, using a Child Growth Foundation re-usable LASSO tape. The infant, without wearing a hat or bonnet, is held or seated on the laps of its mother/main carer. Objects such as or hairpins are removed from the hair. The tape is positioned just above the eyebrows and placed posteriorly to give the maximum circumference. The tape is pulled sufficiently tight to compress the hair and yield a measure that "approximates" cranial circumference, to measure and record the circumference to the nearest 0.1 cm.
- iv) MUAC measurement taken, using a narrow re-usable non-stretch tape, with the infant wearing loose clothing without sleeves to allow total exposure of the arm and shoulder area. The infant's trunk is kept erect, with the arms hanging freely at the sides of the trunk, and the palms towards the thighs, for the circumference at the midpoint of the arm to be measured. To locate the midpoint, the infant's elbow is flexed to 90° with the palm facing upward, the measurer locates the lateral tip of the acromion at the shoulder, and a small mark made at the identified point. The most

distal point on the olecranon process of the ulna (at the point of the elbow) is located and marked. The measuring tape is placed over these two marks used to find the midpoint between them, which was marked. With the infant's arm relaxed, the elbow extended and hanging just away from the side of the trunk, and the palm towards the thigh, the tape is placed around the arm and positioned perpendicular to the long axis of the arm at the marked midpoint. The tape is placed snug to the skin but not compressing soft tissues, to measure and record the circumference to the nearest 0.1 cm.

- v) Triceps and subscapular skinfolds measurements taken, using the Holtain skinfold calipers.
- a) The triceps skinfold is measured in the midline of the posterior aspect of the arm, over the triceps muscle, at a level midway between the lateral projection of the acromion process of the shoulder and the olecranon process of the ulna (at the point of the elbow). With the infant's arm hanging loosely at the side and the elbow flexed to 90° , the midpoint is determined by measuring the distance between two landmarks using a tape measure and marked on the lateral side of the arm. With the right hand, the measurer holds the calipers and with the left thumb and index finger gently picks up a vertical fold of skin and subcutaneous tissue, approximately one cm proximal to the marked level. The tips of the calipers are applied perpendicular to the skinfold at the marked level, to measure and record the triceps skinfold to the smallest unit of graduation (the last completed 0.2 mm).
 - b) The subscapular skinfold is picked up gently on a diagonal, inclined infero-laterally at approximately 45° to the horizontal plane in the natural cleavage lines of the skin. The site to be measured is just inferior to the inferior angle of the scapular, with the infant's trunk kept erect and the arms relaxed at the sides of the body. To locate the site, the measurer palpates the scapula, running the fingers inferiorly and laterally along its vertebral border to identify the inferior angle. The calipers are applied 1cm infero-lateral to the thumb and finger raising the fold, to measure and record the thickness to the smallest unit of graduation (that is the last completed 0.2 mm).



Figure 2.1 The researcher measuring the weight of an infant admitted to the paediatric ward of the UNTH, Enugu



Figure 2.2 The researcher measuring the recumbent length of same infant as above

WHO Anthropometric software

The ‘WHO Anthro’ – anthropometric software designed and developed for assessing the growth and development of the world’s children (Blössner et al., 2010) – uses the LMS method to generate variables such as Z-scores (standard deviation scores) for anthropometric measures. The LMS method summarises the distribution of an anthropometric measure by age and sex in terms of three curves called *L* (lambda), *M* (mu) and *S* (sigma). The *M* curve is the median of the anthropometric measure by age, the *S* curve is the coefficient of the anthropometric measure, and the *L* curve expresses the skewness of the distribution of the anthropometric measure in terms of the Box-Cox power needed to transform the data to near normality (Cole, 1990, Cole and Green, 1992, Cole, 2007).

RTH growth chart

The RTH growth chart is a variant of the 1978 NCHS/WHO growth reference, therefore it is the old WHO growth chart based on the RTH format first designed by Prof David Morley for use in developing countries. The RTH chart comprises two reference curves – upper 50th centile for boys and lower 3rd centile for girls. The space between the two curves is the weight channel or road to health-zone of normality for most children in the population. Normal growth is shown above the 3rd percentile and will run parallel to the two reference curves. The RTH growth chart is a simple, cheap and convenient home-based method of monitoring child growth in developing countries (Tarwa and de Villiers, 2007). This growth chart is contained in the cards that act as mobile databanks with relevant records on the child's important health events. The data include the personal/birth-related details, parents and sibling history, illness history, reasons for special care, immunisation history, vitamin A supplementation; rating of growth patterns, developmental milestones, infant feeding guidelines, and preparation of salt sugar solution for home treatment of diarrhoea (Morley, 1973). The format of the RTH growth chart has the weight vertical axis (weight axis) represented in kilograms both on the left and right margin of each year, starting at 0 kg with the 2.5 kg line. These axes are marked at 0.5 kg intervals (in dotted lines) with the 1.0 kg intervals (solid lines) exactly one centimetre apart. The horizontal axis (age axis) has one space (column) per month for the entire period represented by a block for entering the appropriate month.

WHO growth chart

The new WHO growth chart is based on the WHO-CGS used worldwide for assessing and monitoring the growth and development of children (0 – 5 years old). This chart was designed with the LMS format (Cole et al., 2007) (see section 2.1.3.2). Five reference curves are contained in the chart as follows: +3SD uppermost, +2SD next below, 0SD at the centre, -2SD next below, and -3SD the lowermost curve. The effect from comparing growth chart is not so relevant when monitoring individual children, but substantial when assessing the health of groups of children (Ziegler and Nelson, 2010). Comparing the RTH and new WHO growth charts reveals important differences with implications for child health monitoring. For the realisation of effective child health monitoring which is the purpose of developing the new WHO charts based on a totally different format from the RTH charts, health staff should be trained before embarking on their use. Nonetheless, it has been suggested that the WHO chart is more suitable for inter-country comparisons

while country-specific growth references are better used for describing the growth of children at a given locality (Ziegler and Nelson, 2012) .

Modified Latin Square Design

A *Latin Square* (LS) is an experimental plan in the square form whereby randomised distribution of treatments takes two courses, namely in the rows and in the columns. Each treatment analysed is known to appear only once in each row and each column. In this way the effect of two sources of non-homogeneity of experimental material is being eliminated. LS serves as the model for experimental design as well as the basis and generator for other experimental designs (Lakic, 2002). LS is used in experimental designs for comparing treatments and controlling two other known sources of variation. For an experiment comparing n treatments, n levels of each of the two sources of variation to be controlled are needed (Clarke-O'Neill et al., 2002). LS was first used in agricultural experiments. In agronomy, the LS design is a category of complete block design, which is suitable for allocating a small number of treatments to plots or experimental units and handling two sources of variations among experimental units. Every treatment occurs only once in each row and each column. The total sources of variation are made up of row, column, treatment differences, and experimental error. The experimental error which is a measure of the sum of variation between plots or units receiving same treatments should be controlled in order to be able to estimate the treatment effects properly and compare effects of various treatments effectively (Rojas and White 1957).

An $(n \times n)$ *k Semi-Latin Square* has been defined as an arrangement of nk symbols (treatments) in an $(n \times n)$ square array such that each row-column intersection contains k symbols and each row and each symbol occurs once in each row and each column (Chigbu, 1995); (Bailey and Chigbu, 1997). The *Modified Latin Square* (MLS) design is a rectangular square distribution with n rows and t columns, classified into n sections, whereby each contains k continuous columns and thereby each treatment appears only once in each row and once in each section. The MLS design possesses two features, which make it attractive. In agronomy, it controls soil heterogeneity in two directions as does the ordinary LS, but does not require as large number of replications (Rojas and White, 1957). The MLS design does not require as large a number of replications as the LS design. Therefore, the MLS design was applied in allocating the two growth charts containing two different scenarios in three versions of the self-completion questionnaire giving a $2 \times 2 \times 3$ design. This approach was used in order to avoid using fewer permutations or more charts

per respondent, which would create errors in the results from data analysis. Two different scenarios of the growth patterns of infants (0 – 26 weeks old) were shown on both the old growth chart (RTH growth chart currently used in Nigeria) and the new growth chart (WHO growth charts) for boys from birth to 6 months (percentiles). The two chart formats were used to show different scenarios of the growth patterns of the infants. The accuracy of the growth chart plotting exercises and overall interpretations of the growth patterns of the infants contained in the three versions of the survey questionnaire (Appendix C.3 – C.5) administered to the health staff was tested. The weight gain of the infants, the degree of anxiety over an infant who was not growing well, the need for further assessment, and the need for nutrition intervention were rated using Likert scales.

2.2 Broad Settings

2.2.1 Nigeria

Nigeria is a federal constitutional republic made up of 36 states and its federal capital territory situated at Abuja. Located in West Africa, Nigeria shares boundaries with Chad and Cameroon in the east, Benin in the west, Niger in the north, and the Gulf of Guinea in the south (Figure 2.1). There are over 250 ethnic/language groups in Nigeria with Hausa/Fulani tribe in the north, Igbo tribe in the southeast, and Yoruba tribe in the southwest being the major ethnic groups and others rated as the minority groups. The location of Nigeria in the tropics gives her a seasonally damp and humid climate with temperatures as high as 44°C in the far north, and ranges between 21°C and 25°C on the Jos plateau (central Nigeria). There are two distinct seasons in Nigeria determined by rainfall, the rainy season starting around March/April and extending into September/October and the dry season covering the rest of the year. With a total land area of 910,770 square kilometres, Nigeria is divided into six geopolitical zones: north east, north west, north central, south east, south west and south south. Nigeria is the most populous country in Africa accounting for approximately one-fifth of the sub-Saharan African population. There are two majorly practiced religions in Nigeria, Christianity in the south and central parts, and Islam in the north. However, a minority of the people practise traditional and local religions, including Igbo and Yoruba religions (Wikipedia, 2014).



Figure 2.3 Map of Nigeria in relation to Africa
Source: Demographic and Health Survey, 2008

The UNICEF statistics for Nigeria in 2012 (see Table 1.2) show a fast growing population of 168,833,000 at an annual of 2.6% but a fairly low life expectancy of 52.1 years. Over half of this population live below the poverty threshold. Urbanisation, with a very low national economic growth reflected in an equally very low public spending on health. The maternal and child health sector shows a low rate of hospital delivery with a high annual birth rate (7028 thousands per annum) reflecting a fairly high rate of delivery of infants below 2500g weight and overall high neonatal mortality rate. With an equally high under-five mortality rate of 124 per 1000 live births in a high under-five children population (29,697,200), that is 17.6% of the general population against 5 per 1000 live births in 6.4% of the general population of the UK. The commonest causes of child morbidity are malaria (26%); diarrhoea (15%), acute respiratory infections (15%) (World Health Organisation, 2012a). Despite high rates of early initiation of breastfeeding, there are reported sub-optimal infant feeding patterns with very low rates of EBF and high rates of early introduction of complementary feeds to infants accompanied by decreased breastfeeding before the age of two years (Uvere and Ene-Obong, 2013).

2.2.2 Enugu City

During the colonial era, Enugu city (also known as coal city because of its rich coal deposit, the largest in Africa) was the headquarters where the seat of government of eastern Nigeria was located. Enugu city is now the capital of Enugu state, which is situated in the southeast geopolitical zone of Nigeria. Enugu is located in a tropical rain forest zone with a derived savannah climate with the highest humidity between March and November and a mean daily temperature of 26.7 °C. According to the national population census of 2006, the population of Enugu state and Enugu city are 3.5 million and 722,664, respectively (National Population Commission, 2006). The inhabitants of Enugu are mainly Igbos and cut across all social-economic classes. The population of Enugu is predominantly Christian, as is the rest of southeast Nigeria. Like the rest of Nigeria, most people in Enugu speak Nigerian English alongside the dominant language of the region, which is Igbo. Nigerian English is often used because of ethnic diversity and sometimes because of the diversity of dialects in the Igbo language. Most of the non-indigenous people of Enugu are migrants from other parts of Nigeria, which include the majority Yoruba, Hausa, Fulani tribes; and the minority Tiv, Idoma, Ijaw, Efik, Ibibio, Urhobo tribes. The former eastern Nigeria was famed for producing half the world's total output of palm kernels. Other agricultural products include palm oil, yam, cassava, cocoyam, plantain/banana, rice, maize, varieties of fruits and vegetables. The main social and economic activities include farming, small, and medium scale trading, skilled manual works while a significant number of people are also employed in the various goods manufacturing companies, government, and educational institutions.

Healthcare facilities/services in Enugu city

Healthcare services can be accessed at moderate cost from several government-controlled referral health institutions in Enugu city, including the University of Nigeria Teaching Hospital (UNTH), Enugu University of Science and Technology Teaching Hospital (ESUTH).

*University of Nigeria Teaching Hospital (UNTH), Enugu**New Site*

The UNTH, which is located 21 kilometres from the Enugu capital city along Enugu-Port Harcourt expressway, as a centre of excellence for cardiothoracic medicine and surgery has broad objectives of service, teaching, and research. The hospital aims to achieve these objectives through the provision of in-patient and outpatient services to its clients through her highly trained staff, and provision of adequate clinical materials for service and training. Others include equipment for research, provision of teaching facilities for training her students and other professionals in the health delivery team as well as conducting and promoting research on all matters pertaining to health. Altogether, there are 41 main departments in the hospital with three out-posts as follows: comprehensive health centres at Obukpa near Nsukka, Enugu state, Abagana in Njikoka local government area of Anambra state and Isuochi in Abia state. There are nine training schools/programmes in the hospital: the schools of nursing, midwifery, medical laboratory science, anaesthesia, community health, post ophthalmic nursing, peri-operative nursing, cardiothoracic nursing, and medical records. These schools currently operate at the old site, but plans are already on the ground to provide structures for them at the new site as soon as possible. It is also worthy to mention that community services rendered by the UNTH extend to various states in the country, particularly those in the southeast geopolitical zone. The hospital serves as the main referral centre for Enugu state residents as well as other neighbouring states in the southeast, including Anambra, Imo, Abia, Ebonyi and Benue states. The location of the new site of the hospital, far from the city centre and in a rural setting, makes it a catchment of both the urban and rural populations of patients. The paediatric inpatient services are accessed through a neonatal ward called the 'New Born Special Care Unit' (NBSCU) with full complement of modern equipment for neonatal resuscitation and ventilation; two paediatric medical wards; and one paediatric surgical ward each of which has 30 beds and full complement of nursing, resident, and consultant medical staff. Most infants and children were admitted via the children's emergency room (CHER), children outpatient clinic (CHOP), or specialist clinics.

Old Site

The infant welfare clinic (IWC) was established in April 1987 at the Institute of Child Health (ICH) of the UNTH, Enugu. The ICH functions as an establishment of research, teaching of maternal and child health in the training of various categories of health professionals and delivery of health services. The main objectives of the ICH are:

- 1) To deliver efficient preventive and promotive child health services to the community within and outside Enugu through its child health clinic (IWC)
- 2) To determine the normal rate of growth of healthy children
- 3) To determine the normal haematological and biochemical parameters (to act as reference values) in children
- 4) To organize lectures/demonstrations to mothers
- 5) To organize guest lectures, seminars/workshops and refresher courses for different cadres of medical doctors, nurses, other health professionals and students

Outpatient services offered by this unit are infant immunisation, growth monitoring, under-five clinics for health education, parent counselling, assessment of infants' development and referral of sick infants to appropriate clinics. Other services include the sickle cell clinic; nutrition rehabilitation clinic; mother craft classes; health education and immunisation for pregnant mothers; and vitamin A supplementation for infants, children, and lactating mothers. The ICH interacts with the department of paediatrics and department of community medicine to achieve its objectives and utilises the services of research fellows, nutritionists, laboratory scientists, nurses, midwives, health visitors, health educators, medical records clerks, medical statisticians, and administrative staff among others. At the time of data collection, the ICH that houses the IWC was still at the old site of the UNTH since the portion of land allocation for the ICH at the new site had not been developed. Therefore, ICH toggled its services between the old and new sites on days allocated for each of the services, for example, routine immunisations and vitamin A supplementation held on Thursdays at both sites.

Enugu State University Teaching Hospital (ESUTH), Park Lane, Enugu

The Enugu State University of Technology established the Enugu State University Teaching Hospital (ESUTH) in 1979 from the former Enugu state general hospital for the training of medical doctors, nurses, midwives, and laboratory scientists. Medical professional students use ESUTH for postings and clinical practice. This tertiary health facility is situated in Enugu metropolis where it serves as a referral centre for the primary and secondary health facilities in Enugu state and environs. The hospital is structured into clinical departments: community medicine and primary health care, obstetrics and gynaecology, paediatrics, medicine, surgery, radiology, accident & emergency, ear, nose and throat (ENT), ophthalmology, and anaesthesia. The medical department includes dermatology and cardiology. The surgery department includes paediatric surgery; urology; orthopaedics and plastic surgery. The Paediatric department includes the paediatric clinic, paediatric wards and IWC. The teaching hospital is also well equipped with x-ray and ultrasound facilities, service laboratories, outpatient facilities, operating theatres, recovery room, intensive care unit, and wards for the various disciplines. There is also a befitting newly built and well-equipped Accident and Emergency complex. The UNTH and ESUTH are similar with respect to their structure, objectives, and cadre of health staff, but the former is federal government-controlled while the latter is Enugu state government-controlled.

Enugu state government-controlled primary health facilities

The State Ministry of Health established free medical care for pregnant women and all children less than five years of age attending government-owned health institutions in the State. The child healthcare programme was founded under the ‘District Health System’ (DHS), which runs the health centres in the state. On the other hand, the private health sector thrives with many hospitals that are mainly accessible to a higher socioeconomic class or staff of companies while the government-controlled health facilities are accessible to the medium and low socioeconomic classes. Growth monitoring of infants and children are usually conducted as drop-in services at child health clinics attached to government-owned health facilities and health centres where routine immunisations and vitamin A supplementation are administered. Such services are accessed by an estimated 77% of Nigerian mothers/carers for their infants and children (UNICEF Statistics, 2012). The four most populous government-controlled health centres chosen for the current research project include:

- 1) Asata sub-district poly clinic situated at the north of Enugu
- 2) Uwani cottage hospital situated at the south of Enugu
- 3) Abakpa health centre situated at the east of Enugu
- 4) Amaechi cottage hospital, Awkunanaw situated at the west of Enugu

Justification for the choice of the representative health facilities

The UNTH, Enugu moved from its former city-centre location, for want of space for expansion, to a permanent site at Ituku-Ozalla (an extensive virgin rural setting). However, during the time of data collection at that location, the space of land mapped out for the new ICH complex at that site was yet to be developed for it to be fully functional. Therefore, the ICH functioned at the old site on weekdays, but operated both at the UNTH old and permanent sites on Thursdays, covering both urban and rural populations while the coverage of ESUTH is mainly urban due to its city-centre location. These two referral hospitals and four health centres were chosen for the health staff survey in order to have a representation of tertiary and primary, federal and state, urban and rural populations. Moreover, the four health centres were each chosen from the north, south, east, and west location in order to be representative of Enugu city.

2.3 Instruments/Procedures used for data collection and timelines

2.3.1 Pilot Study

Objectives

- 1) To elicit information on feeding and growth in infants younger than one year
- 2) To gain familiarity with the use of well-established tools
- 3) To determine which tools could be used in Nigerian setting

Methods

The chief dietitian/manager of the department of nutrition and dietetics formally introduced the researcher to the medical, nursing, and administrative staff on the wards. At each daily visit, the researcher introduced herself to the staff working in each paediatric ward and checked the admission register for new admissions within the preceding 24 hours. Thereafter, the researcher approached the mother/carer of each newly admitted infant aged less than one year, and introduced the mother/carer to the study using the study information sheet, three consent forms, and an infant feeding questionnaire. One of the three completed consent forms received from each mother/carer that consented to participate was attached to the infant's hospital file, the second was given to the mother/carer for record purposes and the researcher kept the third copy alongside the completed infant feeding questionnaire. Each mother/carer volunteered to assist the researcher to steady the infant while the researcher took the anthropometric measurements (see section 2.1.3.1). Bioelectric impedance analysis (BIA) was used to measure the infant's body composition. Bioelectrical impedance was measured from hand to foot using Bodystat 1500. The instrument's self-adhesive electrodes were attached to the left hand palm and foot of the infant while lying on the bed and the researcher recorded the reading on the metre (in ohms). For each child, the researcher took three measurements of each body dimension and composition measure, computed an average and entered the final value into the study datasheet (similar copy to Appendix E.3). Included in this datasheet was the date of discharge, which was later collected from the medical records of each ward, for the calculation of the length of hospital stay. The combined data from this study were entered into an excel file where further calculations were made and the final dataset saved in an anonymised way as the 'Pilot Study Dataset'. This dataset was secured with a personal password in a computer located at the PEACH unit, RHSC, Yorkhill, Glasgow, for further analyses.

Justification for the methods used

Although there seems to be no universally accepted way of measuring undernutrition, combining different methods has proved effective in previous studies: weight, height and mid-upper-arm circumference (Hendrikse et al., 1997); and weight, height, mid-upper-arm circumference, four skinfolds and BIA (Edefonti et al., 2001). However, BIA bases its evaluation of body composition on regression equations that use resistance and reactance parameters to estimate total body water, lean body mass or fat-free mass, body cell mass, and body fat (Barbosa-Silva et al., 2003). The BIA method is simple to perform and non-invasive but its accuracy needs verification when used in infants, because of the identified limitations of interpretation of BIA results (Kyle et al., 2004) from the effects of:

- variable tissue hydration that occur in severely undernourished infants
- extremes of BMI that occur with weight loss in severely underweight infants
- abnormal tissue hydration that occur in nutritional oedema
- weight loss due to physiological changes such as neonatal postnatal weight loss that occur in the first two weeks of life

Therefore, further use of the BIA method for the evaluation of body composition in the main study was not considered. Nonetheless, the pilot study enabled the researcher to gain confidence through the testing and proving of the research instruments for later use on hospitalised infants at the UNTH, Enugu, Nigeria.

2.3.2 Infant Welfare Clinic Study

Background

The ‘gold standard’ for assessing the growth of children worldwide is the 2006 WHO-CGS, which has been designed and validated for monitoring the growth of children from birth to five years (de Onis et al., 2006b). These standards were constructed using the growth measurements of breastfed infants living under optimal conditions, as the normative model for growth and development, to show the way all healthy children should grow. Monitoring the growth and health of infants and children is widely done by routine weighing at child health clinics spread across Nigeria. The IWC of the UNTH, Enugu (a tertiary level referral health institution) has different cadres of specialist paediatric health staff that deliver various child healthcare services to the public on different days of the week. These services include routine growth monitoring and counselling, routine immunisations combined with vitamin A supplementation (three days a week), and health/nutrition talks and demonstrations. Infants are routinely weighed in the nude, using a paediatric weighing scale with a pan (the weighing scales used at this clinic are routinely checked and calibrated by the instruments unit of the hospital). The weight measurements are plotted on the RTH growth chart, which is contained in the immunisation card (Appendix E.1) issued to the mother/carer of every infant at the first visit to the IWC.

Since infants are routinely immunised within the first year of life at that clinic, mother/carer-held immunisation cards are accessed, to capture the growth pattern of their infants from birth to six months of age. Monitoring the weight changes from birth enables the nursing staff to predict weight faltering, the infants identified at risk for health, and nutrition problems are referred to the appropriate health and nutrition professionals working at this clinic. Moreover, growth assessment of infants would normally require comparison of growth measurements with a normative reference in order to identify any deviation from normal for that population in a particular environment. However, there is no available dataset for the exploration of variations in weight gain in infancy in order to set a population norm at the UNTH, Enugu, Nigeria. Therefore, this study set out to establish the nutritional status of healthy Nigerian infants in relation to the WHO-CGS, ascertaining whether these infants have a healthy growth pattern to compare their hospitalised peers.

Objectives

A compilation of the retrospective weight measurements of healthy infants and their breastfeeding patterns in the first six months of life was the focus, with these objectives:

- 1) To compile the weight velocity of healthy breastfed infants (0 – 26 weeks old) attending the IWC of the UNTH, Enugu, Nigeria
- 2) To transform the data and generate a reference for comparing the weight velocity of their peers admitted to the paediatric wards of the same hospital.

Methods

After the nutritionist had measured the current weights of individual infants at the IWC, the researcher approached and introduced herself to the mother/carer of each infant. The mother/carer received the study information sheet (Appendix A.1) and three consent forms (Appendix A.2) from the researcher who offered a further individual explanation using the native language of the study location to increase the understanding of the purpose of the study to each mother/carer. The majority of the mothers/carers of these infants consented to participate while the minority of them were in a hurry and therefore refused to participate. The researcher received the infant's immunisation card (Appendix E.1) from each consenting mother/carer, entered the infant's weight measurements from the RTH growth chart at birth, 6 weeks, 3 months, and 6 months, into the study datasheet (Appendix E.2). The infants were weighed in the nude using paediatric weighing scales with pan, which were routinely maintained and calibrated by technicians from the instruments unit of the hospital. The first copy of the three completed consent forms was stapled to the infant's immunisation card. This card and the second copy were returned to the mother/carer for record purposes, while the researcher kept the third copy. Furthermore, the researcher made an inquiry from each mother/carer on the method of feeding of their infant from birth to date and entered this information for each point into the study datasheet. The responses were recorded as either 'Breastmilk Only (BM)' or 'Breastmilk + Breastmilk Substitute (BM + BMS)' or 'Breastmilk + Solids (BM + SLS)'. Each infant's retrospective and current weight measurements, and method of feeding were documented only once during the period of data collection for this study. All the data were entered into an excel file that generated the weight velocity, CWG s, and breastfeeding patterns of the healthy infants. The compiled dataset was later made a norm (the normative dataset), and a local reference for weight gain generated for use in comparing that of the hospitalised infants on the paediatric wards of the same hospital. The final dataset was saved in an anonymised way

as the 'Infant Welfare Clinic Dataset' and secured with a personal password in a computer located at the PEACH unit, RHSC, Yorkhill, Glasgow, for further analyses.

Justification for the methods used

Growth assessment of infants would require comparison of growth measurements with a normative reference in order to identify any deviation from normal for that population in a particular environment. However, there was no compiled population representative dataset (normative dataset) of infants (0 – 26 weeks old) at the UNTH, Enugu, Nigeria; hence the purposive sampling method was used for data collection at this location. Therefore, using a local reference alongside the WHO-CGS would show how the children of Nigeria grow under normal conditions and fit to the international standards, showing how they should grow. Moreover, growth datasets of healthy breastfed children, particularly infants (0 – 26 weeks old) for the comparison of the growth of individual and population groups are scarce in Nigeria. Although the WHO-CGS has been designed and validated for comparing the growth of children (0 – 5 years old) worldwide, there is a need for the rate of weight gain of the hospitalised infants to be compared with that of their healthy breastfed peers who are the biological norms for their locality. Furthermore, the use of the CWG approach in analysing infant growth:

- Overcomes the statistical phenomenon of regression to the mean, where extreme values tend to move closer to the sample mean
- Incorporates the different ages at the assessment date
- Deals with the collinearity of dependent weight measures (Cole, 1995, Cole, 1998).

Earlier, CWG using the 5th percentile threshold had been successfully used to identify infants at risk for growth faltering in Nigerian infants at the 6 – 8-week postpartum check (Olusanya and Renner, 2011). In addition, breastfeeding and complementary feeding patterns would show how the nutritional status of the healthy infants is related to their growth velocity.

Analytical methods

The weights of the healthy infants were transformed based on the WHO-CGS and re-coded according to age into four Z-score categories – 1) birthweight Z-score, 2) 6 weeks Z-score, 3) 3 months Z-score, and 4) 6 months Z-score. The birthweight Z-scores were also categorised into three groups: 1) <-1SDS, 2) -1SDS to +1SDS, and 3) >+1SDS.

Calculating norms for conditional weight gain

CWG (see section 2.1.2.1) was calculated as the change in weight Z-scores (SD scores) from birth to a later age, adjusted for the regression to the mean. A regression analysis was performed on the data by using the birthweight Z-score as the independent variable and the weight-for-age Z-scores of the infants at different data points as the dependent variables.

The slope constant B from the regression analysis was used to derive the CWG as follows:

- 1) Weight $Z_{6 \text{ weeks}}$ minus Birthweight $Z^* B_{6 \text{ weeks}} = \text{CWG}_{6 \text{ weeks}}$
- 2) Weight $Z_{3 \text{ months}}$ minus Birthweight $Z^* B_{3 \text{ months}} = \text{CWG}_{3 \text{ months}}$
- 3) Weight $Z_{6 \text{ months}}$ minus Birthweight $Z^* B_{6 \text{ months}} = \text{CWG}_{6 \text{ months}}$

These conditional weight changes were re-coded using the normal SD score ranges of conditional weight change at 6 weeks (between -2.7 and -1.5), 3 months (between -3.4 and -1.6) and 6 months (between -3.6 and -1.8), in order to derive the expected weight gain in the healthy infants. Conditional ages for conditional weight changes were calculated by recoding the ages at assessment (days) into four groups:

- 1) 7 through lowest = 0
- 2) 7 through 63 = 1
- 3) 63 through 121 = 2
- 4) 121 through Highest = 3

The conditional weight change was re-coded into conditional weight change categories (excluding the 0 – 7days-age group because they would be losing instead of gaining weight since after birth) as follows:

- 1) Weight gain category at 6 weeks, IF conditional age = 1
- 2) Weight gain category at 3 months, IF conditional age = 2
- 3) Weight gain category at 6 months, IF conditional age = 3

2.3.3 Hospital Ward Study

Background

Identifying the infants at risk for undernutrition at an early stage allows for the initiation of appropriate nutritional intervention, in order to forestall complications and reduce the prevalence of undernutrition in this population. Over the years, there has been a slow but steady decrease in the prevalence of undernutrition in hospitalised children with mixed diagnoses, from earlier studies in some developed countries. These include: UK 14% (Moy et al., 1990); UK 8% (Hendrikse et al., 1997); USA 7.1% (Hendricks et al., 1995); France 12% (Hankard et al., 2001); France 11% (Martelletti et al., 2005); Brazil 6.9% (Rocha et al., 2006); Germany 6.1% (Pawellek et al., 2008). However, there is limited available data on the prevalence of undernutrition in children at admission to hospital and on the nutritional status of hospitalised children in developing countries like Nigeria. Nutrition surveys had in the past excluded infants younger than 6 months and there is difficulty in identifying undernutrition in the presence of underlying disease, with little information existing on undernutrition in this population. Nonetheless, early identification of hospitalised children with nutrition risk is imperative, in order to provide adequate and timely nutrition support and prevent hospital-acquired undernutrition. Therefore, this study aimed to explore ways of assessing the risk for undernutrition using feeding information and growth patterns in hospitalised infants (0 – 26 weeks old) at the UNTH, Enugu, Nigeria.

Objectives

- 1) To compare the weight velocity of the hospitalised infants with that of their healthy breastfed peers documented at the IWC of that hospital
- 2) To determine the prevalence of undernutrition in hospitalised infants according to the SGNA ratings of nutrition risk using different measures, including CWG, MUAC and skinfolds
- 3) To determine the variables associated with undernutrition in the hospitalised infants.

Methods

The design of the pilot study (see section 2.3.1.2), using a combination of different methods proved effective in detecting nutrition risks in conformity with earlier studies (Hendrikse et al., 1997, Soeters et al., 2008, Gerasimidis et al., 2010, Santafe Sanchez et al., 2012). Therefore, the intention of applying a combination of these different methods at Enugu, Nigeria was to generate results from a developing world setting as compared to those of the developed world. Moreover, using a local reference alongside the WHO-CGS would show how the children of Nigeria grow under normal conditions as well as under disease conditions. Hence, hospitalised infants (0 – 26 weeks old) were recruited to this study at admission to the paediatric wards of the UNTH, Enugu, from April to July 2012. Growth assessment was conducted using anthropometric measures of size (weight, length, head circumference) and body composition [MUAC and skinfolds (triceps and subscapular)]. A similar standard operating procedure to that earlier used for the pilot study at the RHSC Yorkhill, Glasgow was applied here; however, MUAC exchanged for BIA, considering the developing world setting of this study. The researcher's Nigerian supervisor (Dr Ngozi Ibeziako, a consultant paediatrician at the UNTH, Enugu) formally introduced her to the different heads of paediatric departments, units, and wards, for data collection at the UNTH, Enugu.

Using standard operating techniques (section 2.1.3), the researcher with her assistant (both registered dietitian-nutritionists) collected growth and feeding data from the hospitalised infants. The researcher took three measurements of each anthropometric measure at a given time in each infant, with differences of value ranges of 0.01 – 0.05 accepted, averages computed and the final values entered into the study datasheet (Appendix E.3). In addition, this research team used a structured and validated infant feeding interviewer-administered questionnaire (Appendix B.3) as an interview schedule, to elicit the feeding information from the mothers/main carers of the hospitalised infants. This feeding information was also entered into the study datasheet (Appendix E.3). The combined data from this study were entered into an excel file where further calculations were made and the final dataset saved in an anonymised way as the 'Hospital Ward Dataset'. This dataset was secured with a personal password in a computer located at the PEACH unit, RHSC, Yorkhill, Glasgow, for further analyses.

Justification for the methods used

The results of the pilot study earlier conducted by the researcher at the RHSC, Yorkhill, Glasgow, combining different methods proved effective in diagnosing undernutrition in infants (Hendrikse et al., 1997, Soeters et al., 2008, Gerasimidis et al., 2010, Santafe Sanchez et al., 2012). However, due to the identified limitations of BIA (see section 2.3.1.3) the use of MUAC exchanged for that of BIA in the main study conducted at the UNTH, Enugu. Therefore, combining the use of the SGNA, anthropometric measures of weight, length, head circumference, MUAC, skinfold thickness (triceps and subscapular) in relation to the WHO-CGS could improve ways of assessing the risk for undernutrition in infants (0 – 26 weeks old) admitted to the UNTH, Enugu, Nigeria. The intention of applying this approach in Nigeria was to generate results from a developing world setting. Moreover, using a local reference in relation to the WHO-CGS would show how Nigerian infants grow under normal conditions as well as under disease conditions. Using anthropometry and growth charts would not identify all (but will identify some) infants in the early stages of undernutrition or those at risk of deterioration because of an acute medical condition (Gerasimidis et al., 2010). However, the use of growth charts and nutritional screening tools have proved simple, quick and invaluable in attracting attention to infants who are at risk for undernutrition (Norman et al., 2008). Therefore, integrating the use of anthropometric measures of body size and composition may improve ways of assessing the risk for undernutrition in hospitalised infants (0 – 26 weeks old). The triceps and subscapular skinfold thicknesses were chosen as indices of central and peripheral subcutaneous fat accumulation, respectively because these are the most commonly used parameters to date (Aboul-Seoud and Aboul-Seoud, 2001, Rodriguez et al., 2004, Rodriguez et al., 2005, Fok et al., 2006, Addo and Himes, 2010). A reference standard for triceps and subscapular skinfold thicknesses of Chinese infants was generated to be used in determining the nutritional status of infants at birth and in assessing the postnatal growth of Chinese infants (Fok et al., 2006) as was earlier done for British children (Tanner and Whitehouse, 1962). Addo and Himes (2010) also developed new percentile reference curves for triceps and subscapular skinfold thicknesses for US Children and adolescents by using the same national samples as those included in the reference curves for body mass index in the Centres for Disease Control and Prevention 2000 Growth Charts. The current WHO-CGS for triceps and subscapular skinfolds is only available for infants aged three months and above. Therefore, Prof TJ Cole of University College London generated a local reference (Appendix D.1) using data collected in the Glasgow arm of a linked project – the Infant Paediatric Yorkhill Malnutrition Screening (iPYMS) project.

Analytical methods

Power and Sampling considerations

The sample size was calculated using the formula:

$$n = [t^2 * p (1-p)] / m^2$$

where:

n = sample size

p = estimated prevalence of underweight in hospitalised infants in Nigeria => 14.5%

[according to Okoromah et al. (2011)]

t = confidence level at 95% (standard value of 1.96)

m = margin of error at 5% (standard value of 0.05)

The calculated sample size (n) = 190.50, adding 5% contingency (9.53) => 190.50 + 9.53 = 200.03. Therefore, the required sample size was approximately 200.

Considerations in data handling

The data collected were entered into the 'WHO Anthro' (see section 2.1.3.2) to generate Z-scores (standard deviation scores) for the anthropometric measures. The infants were distributed into two groups as follows:

Group One – Infants under 14 days of age

Group Two – Infants over 14 days of age, stratified into two subgroups:

- 1) Infants aged 2 weeks – 3 months
- 2) Infants aged 3 – 6 months

The infants under 14 days of age were re-coded into three different age categories in order to identify the very young infants who were mainly affected by perinatal risk factors such as prematurity, intrauterine growth retardation, congenital abnormalities, and neonatal jaundice (Olusanya et al., 2010). Entering this dataset into the WHO 2006 reference in the LMS growth software (WHO Anthropometric software), transformed the weight-for-age of these infants into SDS (weight-for-age Z-scores). Birthweight, as an important surrogate for infant well-being, is a strong predictor of infant morbidity and mortality providing a base for clinical indicators. Therefore, the birthweight Z-scores of the infants were categorised into three subgroups: 1) <-1SDS (low birthweight), 2) -1SDS to +1SDS (normal birthweight), and 3) >+1SDS (high birthweight). Running the syntax of the formula for the calculation of the conditional weight changes of the healthy infants (see section 2.3.2.5 on this dataset, generated the conditional weight changes of their hospitalised peers.

Thresholds for poor growth using anthropometric indicators

To detect slow growth in the hospitalised infants, the 5th percentile CWG was applied as a threshold for slow weight gain. The expected weight changes were derived by recoding conditional weight changes according to the conditional age categories using the lower 5% threshold of CWG for the healthy infants:

- 1) At 6 weeks (-1.9SD)
- 2) At 3 months (-2.1SD)
- 3) At 6 months (-2.2SD)

Since there is no MUAC threshold for infants younger than 6 months, the WHO thresholds for infants aged 6 to 60 months (MUAC<115mm for moderate undernutrition, and MUAC<110mm for severe undernutrition) were applied in assessing the risk for undernutrition in the hospitalised infants. Using the WHO undernutrition threshold of -2SD, the low anthropometric indicators were derived by recoding the Z-scores generated for MUAC, BMI, conditional weight change, and sum of skinfolds according to the variable categories:

- 1) Low MUAC Z-score (LMUAC)
- 2) Low BMI Z-score (LBMIZ)
- 3) Low conditional weight change Z-score (LCWZ)
- 4) Low sum of skinfolds Z-score (LSSFZ)

Testing the efficacy of the different measures used for estimating nutrition risk

Determining the appropriateness of using the different methods employed for estimating undernutrition prevalence, using sensitivity, specificity, positive predictive values, and prevalence:

$$\text{Sensitivity} = [a / (a + c)]$$

$$\text{Specificity} = 1 - [b / (b + d)]$$

$$\text{Positive predictive values (PPV)} = a / (a + b)$$

where:

a = number of true-positives

b = number of true-negatives

c = number of false-positives

d = number of false-negatives

(a + c) = concordance pair

(b + d) = discordant pair

Breastfeeding patterns of the hospitalised infants

The definitions of breastfeeding patterns adopted for this study were based on the WHO standard definitions (World Health Organisation, 2007, Binns et al., 2009):

- 1) No breastfeeding (No Breastmilk): The infant receives no breastmilk at all
- 2) Exclusive breastfeeding (Breastmilk Only): The infant receives only breastmilk (including expressed breastmilk) and no other type of milk or solids or liquids like water, but includes vitamins, drops or syrups (vitamins, minerals, medicines)
- 3) Partial breastfeeding (Breastmilk + Breastmilk Substitute or/and cereal porridge or ‘akamu’): The infant receives breastmilk (including expressed breastmilk), and some artificial feeds, either milk or cereal, including liquids (water, water-based drinks, fruit juice, oral rehydration solution)
- 4) Complementary feeding: The infant receives breastmilk or/and breastmilk substitute and solid or semi-solid (soft spoon-able) foods, including fluids like water.

The 24-hour recall indicators for measuring EBF contained in the interviewer-administered questionnaire employed for the data collection were not applied in this research project, to avoid large over-estimations in EBF prevalence (Binns et al., 2009).

2.3.4 Health Staff Study

Background

Although growth charts do not constitute a tool for making a diagnosis, they could be a guide to that, with weights measured, plotted, and interpreted appropriately. For example, a child who falls through two centile spaces over time only shows a high risk for closer investigation before a final diagnosis is to be made (Wright, 2002). However, challenges in health staff use of growth charts have been widely reported, particularly in developing world settings. Reports include inaccurate plotting (Cooney et al., 1994, de Onis et al., 2004, Thandrayen and Saloojee, 2010, Mutoro and Wright, 2013), poor knowledge and skills (Ruel et al., 1991), unsatisfactory interpretation (Morley, 1994, de Onis et al., 2004, Thandrayen and Saloojee, 2010, Ahmad et al., 2014), and inappropriate actions for growth faltering (de Onis et al., 2004, Qayad, 2005). Therefore, the ineffectiveness observed in health staff plotting, application and interpretation of growth patterns for the early identification of growth faltering in infants show the conceptual complexity of understanding growth charts (Morley, 1994, Wright et al., 2012, Wright et al., 2013). Nonetheless, health staff should be knowledgeable about the effective use of growth patterns displayed on charts to identify undernutrition in early infancy and make this impact.

Since the WHO growth chart has not been introduced in Nigeria, the RTH growth chart is the currently used growth-monitoring tool. Hence, the importance of assessing how health staff would understand, plot, apply and interpret growth patterns, on both the RTH and WHO growth charts for the nutritional assessment of infants. The assessment of health staff proposed action was included since the proper assessment and interpretation of physical status are of little value without appropriate action to improve the health and nutritional status of an infant. Therefore, testing health staff understanding, application, and interpretation of growth patterns displayed on both RTH and WHO growth charts would lead to a better understanding of factors that affect the use of growth patterns to identify infants at risk for undernutrition. However, there is limited documentation from previous studies of a similar nature, but one similar previous study found significant differences using 324-chart rating from 73 respondents (Wright et al., 2012). Nonetheless, it is, important to explore health staff use of growth patterns in order to identify early childhood undernutrition in Enugu city, Nigeria, because no similar study has been conducted in that environment. Health staff at representative health facilities was surveyed

to identify any lapses in using growth patterns to diagnose undernutrition in infants. Identifying this missing link would be a guide to improving the quality of training for health staff on growth monitoring and the effective application/interpretation of growth patterns in detecting undernutrition in infants.

Objectives

- 1) To determine how growth charts are used to detect childhood undernutrition
- 2) To determine the accuracy in plotting and rating/applying/interpreting weight gain patterns displayed on the RTH and WHO growth charts for appropriate action
- 3) To test the understanding of growth patterns displayed on charts.

Methods

This cross-sectional, observational study used a structured self-completion questionnaire to survey health staff in Enugu city, Nigeria (see Section 2.2.1). Since this was a novel research study in Nigeria, the purposive sampling method (Teddlie and Yu, 2007) was used to recruit 233 participants from representative health facilities in Enugu city, from February to July 2012. The subject population of the current survey constituted a sample of paediatric health staff, including all cadres of medical doctors, dietitians/nutritionists, nursing officers public health nurses, health educators, health visitors, and community health officers. The chosen health facilities comprised of two teaching hospitals and four most populous government-controlled health centres situated at the North, South, East and West of Enugu City, Enugu, Nigeria.

The researcher's Nigerian supervisor (Dr Ngozi Ibeziako) formally introduced her to the health staff at the weekly paediatric mortality conferences held the UNTH Enugu. Dr Ngozi Ibeziako mandated the Head of Paediatrics at the ESUTH, Enugu to perform a similar function at a similar forum in that teaching hospital. Thereafter, the researcher continually used these forums, including visits to the paediatric wards and clinics of those teaching hospitals to approach the health staff. At the four government-controlled health centres, the researcher used the letter of permission received from the zonal headquarters of the DHS to introduce herself to the medical officers-in-charge. The researcher approached each health staff with the study information sheet (Appendix C.1), two consent forms (Appendix C.2) (when completed, one copy to be given to the researcher and the second to be kept by the respondent for record purposes), and a version of a structured self-completion questionnaire.

Questionnaire

The structured self-completion questionnaire used, was an adaptation of a previous questionnaire used in a similar study based on the RTH growth chart in Kenya (Mutoro, 2011). The WHO growth chart was included in this modified version to make for a comparison of the effect of the old and the new growth charts. The questionnaire design for this study was similar to that earlier used by Wright et al. (1998) in the UK, to evaluate a new chart designed for evaluating weight faltering. Each questionnaire contained three sections; the first section asked questions on growth chart use:

- 1) Plotting
- 2) Interpreting
- 3) Identifying/treating undernutrition
- 4) Level of confidence in the practice

The second section aimed to test plotting and included two empty growth charts (one in RTH format and another in WHO format) onto which each respondent would plot the weights of three infants (boys) of different ages as follows:

- 1) Age of 2 months with a weight of 4.7 kg
- 2) Age of 4 months with a weight of 5.9 kg
- 3) Age of 6 months with a weight of 7.5 kg

The third section contained scenarios used to assess the respondents' proposed actions on weight gain patterns in different growth situations, according to chart type (Fig 2.4):

- 1) Average size with slow weight gain and small size with slow weight gain, showing either weight faltering or failure to thrive
- 2) Average size with steady weight gain and small size with a steady weight gain showing normal growth
- 3) Average size with fast weight gain and small size with a fast weight gain showing catch-up growth

The weight gain patterns varied in the following characteristics:

- 1) Actual final weight centile in scenario (final size)
- 2) Actual weight gain in scenario (weight gain)
- 3) Chart type

Unique scenario number	Growth pattern / Final size	Road-to-Health (RTH) chart	World Health Organisation (WHO) chart
1	Fast, Average		
2	Steady, Average		
4	Fast, Small		

Unique Scenario Number	Growth pattern/ Final size	Road-to-Health (RTH) chart	World Health Organisation (WHO) chart
3	Slow, Average	<p>WEIGHT 1st YEAR</p> <p>KILOGRAMS</p>	<p>Weight (kg)</p> <p>Months Birth 1 2 3 4 5 6 7 8 9 10 11 12 1 y</p> <p>Age (completed)</p>
5	Steady, Small	<p>WEIGHT 1st YEAR</p> <p>KILOGRAMS</p>	<p>Weight (kg)</p> <p>Months Birth 1 2 3 4 5 6 7 8 9 10 11 12 1 y</p> <p>Age (completed)</p>
6	Slow, Small	<p>WEIGHT 1st YEAR</p> <p>KILOGRAMS</p>	<p>Weight (kg)</p> <p>Months Birth 1 2 3 4 5 6 7 8 9 10 11 12 1 y</p> <p>Age (completed)</p>

Figure 2.4 Per Scenario Presentations

Per scenario presentations

For even distribution and good representation of the respondents, the two growth charts were allocated to each respondent using the MLS method (see section 2.1.3.5). This design gave a chance to each respondent for each grouping to assess each scenario with each infant size on each chart type, thus allowing for testing infant size, growth pattern and chart type. The ratings from 222 respondents (888 chart ratings) will give the power to detect a difference in rating of charts (on a five-point graded scale) between subgroups of the order of 0.3 SD. The accuracy of the respondents' rating of the growth patterns of infants was the main outcome but also assessed was the action respondents would take and whether they would associate specific growth patterns with different growth syndromes such as weight faltering, failure to thrive or catch-up growth.

Each respondent was expected to rate four charts giving 888 ratings with 110 ratings for the slow weight gain scenarios, 114 ratings for the steady weight gain scenarios and 135 ratings for the fast weight gain scenarios. Each questionnaire version showed four scenarios giving 444 ratings of the RTH chart and 444 ratings of the WHO chart (Table 2.4). For each chart, three standard questions were asked about the assessment of weight gain, proposed action to be taken and Likert-rating of growth pattern shown, as follows:

a) What is your assessment of his weight gain?

Very slow

Slow

Steady

Rapid

Very rapid

b) What would you do with this child?

Not worried, reduce level of care/continue current care

Monitor more closely

Refer to/offer further assessment

The assessment of the scenario, “this child is showing: weight faltering; failure to thrive; catch-up growth; or becoming obese” was rated using Likert scales, with responses as “strongly agree (1)”; “agree (2)”; “neutral (3)”; “disagree (4)”; or “strongly disagree (5)”.

Table 2.4 Scenarios for the assessment of growth patterns of infants

Final size of infant	Scenarios (Growth pattern)	Old growth chart	New growth chart	Unique scenario number
----------------------	----------------------------	------------------	------------------	------------------------

Average (50 th centile, 0SD)	Fast (-2SD rising to 50 th centile, 0SD)	Number 1	Number 5	1
	Steady (tracking 50 th centile, 0SD)	Number 2	Number 6	2
Small (2 nd centile, -2SD)	Slow (+1SD drop to 50 th centile, 0SD)	Number 3	Number 9	3
	Fast (-3SD rising to 2 nd centile, -2SD)	Number 4	Number 10	4
	Steady (tracking 2 nd centile, -2SD)	Number 7	Number 11	5
	Slow (50 th centile, 0SD drop to 2 nd centile, -2SD)	Number 8	Number 12	6

The scenarios were distributed systematically among three versions of the questionnaire, so that each respondent viewed four charts, two in the RTH format, and two in the WHO format. No respondent viewed the same growth pattern more than once in either chart format. For each chart, three standard questions were asked about the assessment of weight gain, proposed action to be taken and Likert rating of growth pattern shown. The permuted data from the self-completion questionnaire were converted into an analysable format (per respondent data) by entering into an excel file and sorted by moving around in the blocks (Table 2.5).

Table 2.5 Permutation data from the self-completion questionnaire

Questionnaire version	1 st seen	2 nd seen	3 rd seen	4 th seen
A	Number 1	Number 2	Number 9	Number 10
B	Number 3	Number 4	Number 11	Number 12
C	Number 7	Number 8	Number 5	Number 6

The data were re-sorted with one line per scenario response, adding in information about each scenario, converted into an analysable format (per response data) (Table 2.6).

Table 2.6 Per response data

Respondents' ID number	New scenario number	Original number	Final size	Growth pattern	Chart type	Responses ...
	S1	N 1	Average	Fast	Old	
	S1	N 7	Average	Fast	New	
	S2	N 2	Average	Steady	Old	
	S2	N 8	Average	Steady	New	
	S3	N 3	Average	Slow	Old	
	S3	N 9	Average	Slow	New	
	S4	N 4	Small	Fast	Old	
	S4	N 10	Small	Fast	New	
	S5	N 5	Small	Steady	Old	
	S5	N 11	Small	Steady	New	
	S6	N 6	Small	Slow	Old	
	S6	N 12	Small	Slow	New	

The combined data from this study were entered into an excel file where further calculations were made and the final dataset saved in an anonymised way as the 'Health Staff Dataset'. This dataset was secured with a personal password in a computer located at the PEACH unit, RHSC, Yorkhill, Glasgow, for further analyses.

Justification for the methods used

There was no record of a similar study of health staff on growth charts in Enugu city, Nigeria. Therefore, the results from a pilot study conducted in Kenya (Mutoro, 2011) acted as the basis for the design of the current study. Since this is a novel study, the purposive sampling method was allowed for the recruitment of the participants. In addition, the MLS method was applied in allocating the two growth charts in three versions of the self-completion questionnaire for even distribution and good representation of the respondents. Furthermore, testing the understanding and interpretation growth patterns by health staff at representative health facilities would help identify the peculiar problematic areas. Identifying this missing link would be a guide to improving the quality of training for health staff on growth monitoring as well as the effective application and interpretation of growth patterns in detecting early childhood undernutrition. Eventually, health staff would influence the knowledge, attitude, and practice of mothers/carers of infants and children as regards use of growth charts.

Analytical methods

Recoding data on respondents' use of growth charts

Responses on plotting and interpretation of growth charts were re-coded in terms of being “often” or “not often”, ‘plotted’ and ‘interpreted’. Identifying and treating undernutrition was re-coded in terms of being “often” or “not often”, ‘identified’ and ‘treated’. Various measures of growth were re-coded in terms of being “often” or “not often” and “confidently” or “not confidently” measured and “often” or “not often” used. Old question numbers 1 and 2 were re-coded as 1 and labelled “Often” while the old question numbers 3 and 4 were re-coded as 0 and labelled “Not often”.

Manipulation of the plotting exercise data

The individual plot of each given age or the corresponding weight was coded as 0 and labelled ‘correct’, if completely and correctly plotted as regards positioning the correct age or weight at the right correct point on either the RTH or WHO chart. Otherwise, the difference between each actual plotted value and each given age or the corresponding weight was labelled ‘incorrect’. The accuracy of the plotting exercise data was determined by calculating the plotting errors, as the differences between the plotted and actual values of each of the three given ages with their corresponding weights on both chart types.

The re-coded data were categorised according to levels of plotting:

- 1) Accurate plotting labelled 'Correct plotting' (0)
- 2) Error below the actual values labelled 'Lower plotting' (-1)
- 3) Error above the actual values labelled 'Higher plotting' (+1)

Across the three age plots and three corresponding weight plots for either the RTH or WHO chart, the count command was used to find 'Total number of plots', 'Completely correct plots', and 'Very incorrect plots'. Respectively rating the numbers of correct age or weight plots on either the RTH or WHO chart, against the total number of given ages or the corresponding weights, generated the 'Category of plots' (Table 2.7).

Table 2.7 Categorisation of number of correct plots

Number of correct plots	Category of plots
0/3	Very incorrect plots
1/3	Very incorrect plots
2/3	Completely correct plots
3/3	Completely correct plots

Subtracting the number of 'Very incorrect plots' from the number of 'Completely correct plots' generated the 'Summary scores'.

Recoding of the responses to the weight gain and proposed action scenarios

The ratings of weight gain patterns and proposed actions were re-coded in terms of whether they were correct or incorrect for the individual scenarios. 'Correct ratings' of weight gain were labelled 1; 'Partly wrong' labelled 0 and 'Wrong' labelled -1, defined for each scenario (Table 2.5). 'Correct proposed actions' for weight gain patterns were labelled 1; and 'Wrong proposed actions' labelled 0.

Table 2.5 Recoding of the ratings of the weight gain patterns and proposed actions

Response	Patterns shown			Proposed actions	
	Slow weight gain	Steady weight gain	Fast weight gain	Not worried/ Continue current action	Monitor more/ Refer out
Slow	1	0	-1	0	1
Steady	0	1	0	1	0
Fast	-1	0	1	1	0
Weight Faltering	1	0	-1	0	1
Failure to thrive	1	0	-1	0	1
Catch-up	-1	0	1	1	0

Across the four possible responses for each chart seen, the count command was used to generate ‘Number of questions answered’; ‘Number of correct responses’; and ‘Number of wrong responses’. Finally, the latter two categories were used to produce ‘Summary score’ as follows: Summary scores = Number of correct responses – Number of wrong responses. These were then re-coded, to categorise the overall accuracy scores (Table 2.8).

Table 2.8 Categorisation of overall accuracy scores

Old	New
-1 to -3	Wrong responses
0 to 2	Partially wrong responses
3 to 5	Correct responses

2.4 General data handling considerations and Analytical methods

Data cleaning

Using unique identification numbers (IDNUM) on each dataset identified entry errors which were deleted accordingly. Consistency checks identified the data that were out of range, logically inconsistent or had extreme values. Repeat measurements on the datasheets and the responses on the completed questionnaires were checked and corrections effected accordingly. The missing values were treated as non-responses, because they were less than 10% of the total data in each dataset. The WHO anthropometric software did not indicate the presence of any extreme Z-scores outside the expected ranges since correction of errors followed the data entry that was done immediately after the data collection for each day. Datasets, each bearing the name of the study of the project that generated it, were imported via excel into SPSS (IBM SPSS Statistics for Windows, Version 22.0 – IBM Corp, Armonk, NY) software for analysis.

Data exploration

Scatter plots and histograms (to check the “normality” of the data) were used at the initial exploratory stage to familiarise with the data. The data were scrutinised using descriptive statistics for continuous variables, which were summarised in tables as number of observations, mean, median, and standard deviation, then cleaned by identifying the data that were entered erroneously and corrections effected accordingly. Chi-square was used to test significant association of categorical variables while One-Way Analysis of Variance (ANOVA) was used to test for significant association of the continuous variables – a p-value of less than 0.05 was regarded as significant.

2.5 Ethics approvals/considerations and funding

The ethics approval earlier applied for and received by the PYMS research group from the NHS and the University of Glasgow covered the pilot study at the RHSC, Yorkhill, Glasgow. Ethics application forms were completed by the researcher and submitted to the College of Medicine Ethics Committee for non-clinical research involving human subjects at the University of Glasgow, Scotland. Similar applications were later made to the Medical Research Ethics Committee of the UNTH, Enugu, Nigeria, where the data collection for the three studies of the project was based. Ethics approvals were later received from these two institutions as follows: University of Glasgow (Certificate No 2011018) on the 22nd of December 2011, and UNTH, Enugu (Certificate No NHRE/05/01/2008B – FWA00002458 – IRB00002323) on the 29th of March 2012. The researcher later applied for and received permission to conduct research at these locations. Permission to conduct the health staff survey was also applied for and received from the Enugu State Ministry of Health and the zonal headquarters of the Enugu District Health Authority that manage the chosen health centres. Written informed consent was also obtained from mothers/carers of the healthy infants, mothers/main carers of the hospitalised infants, and health staff who participated in the studies at all points of data collection. The hard copies of the completed questionnaires are kept in a locked place, and the electronic copies of different datasets (each dataset bearing the name of the study that generated it) are stored in an anonymised way on a computer in the Peach Unit, RHSC in Yorkhill, Glasgow. The researcher's PhD full-time studentship was covered by a grant award from the Ford Foundation International Fellowships Program (IFP), New York, USA. This international organisation also funded the cost of the travels to and from Nigeria, including the cost of data collection for the three studies that generated three datasets described in the following result chapters.

CHAPTER 3 INFANT WELFARE CLINIC STUDY RESULTS

3.1 Basic characteristics of the healthy infants

3.1.1 Birth-related characteristics

The 411 healthy infants recruited into the study ranged in age from 0 to 6 months. The majority of the infants were born at full term 390 (94.9%), 21 (5.1 %) had low birthweight (<2500 grams), 195 (47.4%) were female, and 382 (92.2%) were of known birthweight. At assessment, the majority (391, 95.1%) of the infants were receiving breastmilk supplemented with either breastmilk substitute or complementary feeds while only 20 (4.9%) of the infants were receiving breastmilk only (being exclusively breastfed) (Table 3.1).

Table 3.1 Birth-related and feeding characteristics of the healthy infants (0 – 26 weeks old) N (%)

Age category	Female	Male	Age at assessment	Breastfeeding pattern			Total
				BM Only	BM + BMS	BM + SLS	
6 weeks	167	191	0 – 6weeks	18 (5.0)	2 (0.6)	338 (94.4)	358 (87.1)
	(46.6)	(53.4)					
3 months	23	35	> 6 weeks – 3 months	18 (4.8)	2 (0.5)	355 (94.7)	375 (91.2)
	(39.7)	(60.3)					
6 months	36	31	> 3 – 6 months	14 (4.8)	2 (0.7)	276 (94.5)	292 (71.0)
	(53.7)	(46.3)					
Total	195	216	Total	20 (4.9)	2 (0.5)	389 (94.6)	411 (100.0)
	(47.4)	(52.6)					

BM Only = Breastmilk Only

BM + BMS = Breastmilk + Breastmilk Substitute

BM + SLS = Breastmilk + Solids

3.1.2 Weight measurements/Weight-for-age Z-scores

There was a disparity in the proportions of the recorded weight measurements of the healthy infants at different data points of weight monitoring in the first 6 months of life. The reason being that some mothers/carers of the healthy infants defaulted in keeping appointments for weight measurements at different times, creating missing values in the data collected, noticeably for the 6th month-appointment (see Table in Annexe 2). The mean weight-for-age Z-scores of the healthy infants at birth were exactly on the WHO 50th centile though the SD was rather wider than the expected value of one. The median and mean weight-for-age Z-scores were slightly lower than the WHO-CGS at all ages after birth, including a decline that occurred between birth and 6 weeks of age accounting for the physiologic postnatal weight loss. However, the weights of these

infants remained close to the expected value of zero, indicating a normal growth pattern in relation to the WHO-CGS (Table 3.2 & Fig 3.1).

Table 3.2 Average weight gain in the healthy infants

Age category	Proportion N (%)	Weight (kg) Median	Weight-for-age Z-score	
			Mean (SD)	Median
Birth	382 (92.9)	3.3	-0.0 (1.2)	0.1
6 weeks	400 (97.3)	4.7	-0.3 (1.1)	-0.2
3 months	391 (95.1)	6.0	-0.3 (1.2)	-0.2
6 months	307 (74.7)	6.8	-0.4 (1.2)	-0.3

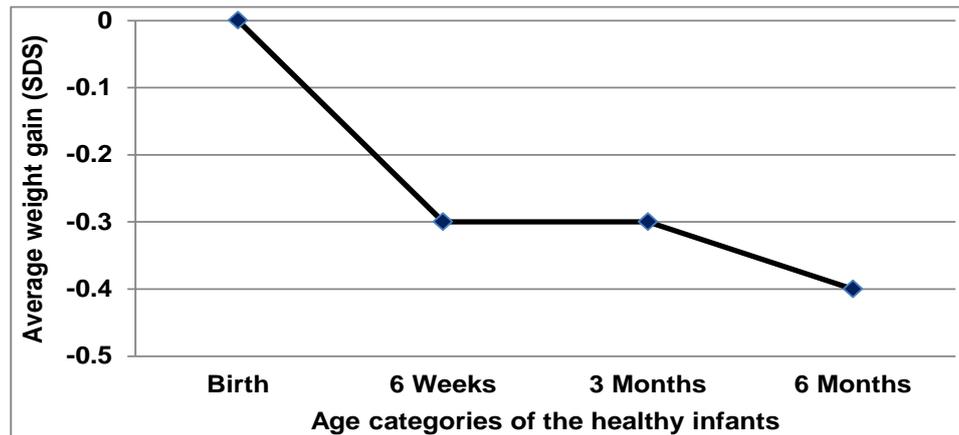


Figure 3.1 Weight Change Trend in the Healthy Infants

3.2 Growth characteristics of the healthy infants

The majority (287, 69.9%) of the healthy infants had birthweight between -1SD and +1SD (average birthweight infants), 15.1% <-1SD (low birthweight infants), and 15.1% +1SD (high birthweight infants). Overall, the weight gain pattern observed among these healthy infants was similar at all data points in the first 6 months of life. However, the average weight gain in the high birthweight infants was low, while that of the low birthweight healthy infants was high being suggestive of catch-up growth in the latter group. Similarly, the weight Z-scores of the low birthweight infants, on average, moved upwards while that of the normal birthweight and high birthweight infants moved downwards. Moreover, the weight Z-scores of the high birthweight infants moved further down than that of the normal birthweight infants. The mean weight Z-scores change of the low birthweight healthy infants was higher and above the WHO-CGS at 3 months than at 6 weeks and 6 months, all with normal variations. The change in the mean weight Z-scores of the average birthweight infants was almost similar at all data points while that of the high birthweight healthy infants was slightly less at 3 months, with higher variation earlier at 6 weeks and later at 6 months (Table 3.3 and Figure 3.2).

Table 3.3 Mean (SD) weight Z-scores change by birthweight Z-scores categories of the healthy infants

Birthweight Z-score category	Age at assessment/Weight Z-score			Total
	6 weeks (n=372)	3 months (n=363)	6 months (n=372)	
<-1SD	0.4 (1.0)	0.6 (1.0)	0.4 (1.0)	56 (15.0)
-1SD to +1SD	-0.3 (0.9)	-0.2 (1.0)	-0.3 (0.9)	260 (70.0)
>+1SD	-1.0 (0.9)	-1.2 (1.2)	-1.0 (0.9)	56 (15.0)
Total	-0.3 (1.0)	-0.2 (1.2)	-0.3 (1.0)	372 (100.0)

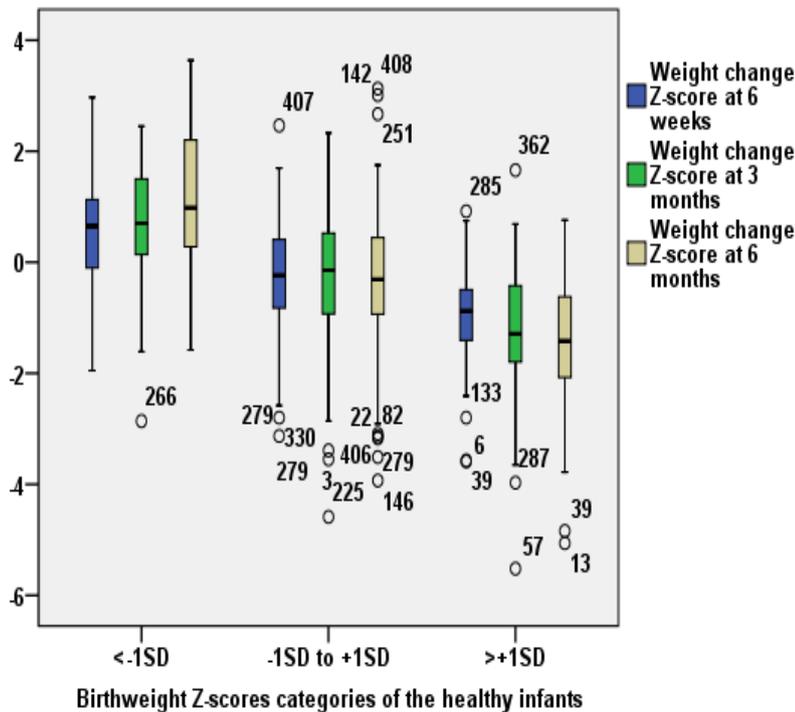


Figure 3.2 Box Plot of Weight change Z-scores by Birthweight categories in the healthy infants

3.3 Weight change since birth in the healthy infants

There was a consistent decline in the strength of the positive correlation between the birthweight and weights at 6 weeks, 3 months, and 6 months. The value for B (slope of the regression line) in the regression of birthweight Z-scores on weight Z-scores of the healthy infants decreased to 0.3 by 6 months, indicating a fairly weak correlation of birthweight with later weights (Table 3.4).

Table 3.4 Regression analysis on the weight-for-age Z-scores in the healthy infants

Independent Variable	Dependent Variable	N	B value	Constant	R	R ²
Birth weight Z-score	Weight_6 weeks Z-scores	400	0.60	-0.3	0.6	0.4
Birth weight Z-score	Weight_3 months Z-scores	391	0.53	-0.3	0.5	0.2
Birth weight Z-score	Weight_6 months Z-scores	307	0.30	-0.3	0.3	0.1

3.3.1 Conditional weight change

The crude and conditional weight changes were similar as would be expected, as these were average for healthy children; however, there was increasing variability with increase in age (Table 3.5). Using 5% cut-off for slow CWG corresponded to a value of -2SD for the conditional weight change scores in the healthy infants (Table 3.6). The infants with scores above this were graded as having a normal CWG in the first six months of life. Since this 5% corresponds to -2SD equivalent of the WHO-CGS, it has been set as the cut-off norm for the first six months of life. An average of 1% weight gain (conditional weight change between -2.7SD and -3.6SD) was recorded as ‘very low’; 1 – 5% (between -1.9SD and -2.2SD) as ‘low’; 5 – 10 % (between -1.5SD and -1.8SD) as ‘medium’; and >10% (above -1.5SD) as ‘high’ weight gains (Table 3.5).

Table 3.5 Conditional weight gain in the healthy infants N (%)

Empirically observed percentile	Age at assessment/Weight gain		
	6 weeks (n=400)	3 months (n=391)	6 months (n=307)
≤ 1	3 (0.8)	4 (1.0)	3 (0.6)
1 – 5	17 (4.2)	15 (3.8)	12 (3.9)
5 – 10	20 (5.0)	20 (5.1)	16 (5.2)
> 10	360 (90.0)	352 (90.0)	276 (89.9)
Missing	11 (2.7)	20 (4.9)	104 (24.5)
Total	411 (100.0)	411 (100.0)	411 (100.0)

3.3.2 Relation of breastfeeding status and nutritional status

The breastfeeding status of the healthy infants did not significantly influence their weight gains in the first six months of life (Table 3.6).

Table 3.6 Comparison of means between breastfeeding status and nutritional status in the healthy infants

Age at assessment	Breastfeeding status	Weight Z-score		P-value
		N	Mean (SD)	
6 weeks	°1	17	-0.2 (0.9)	0.683
	°2	355	-0.3 (1.0)	0.677
3 months	°1	16	-0.4 (1.4)	0.630
	°2	347	-0.2 (1.1)	0.686
6 months	°1	17	-0.2 (0.9)	0.683
	°2	355	-0.3 (1.0)	0.677

°1 = Breastfeeding Only

°2 = Breastfeeding + Solids

3.4 Discussion

The objectives of this investigation were set towards compiling the weight velocity of healthy infants (0 – 26 weeks old) attending the IWC of the UNTH, Enugu. In addition, transforming the data in relation to the WHO-CGS and using it to compare the weight velocity of their sick peers admitted on the paediatric wards of the same hospital. Therefore, the normal weight gain of healthy infants at the UNTH, Enugu, Nigeria were determined and a threshold for the slow weight gain set to compare the weight velocity of their hospitalised peers.

3.4.1 Main findings

- The majority (390, 94.9%) of the healthy infants were born at full term and 21 (5.1 %) had low birthweight (<2500 grams)
- Weight Z-scores in the infants remained close to the expected value of zero, indicating a normal growth pattern in relation to the WHO-CGS
- There was a consistent decline in the strength of the positive correlation between the birthweight and weights at 6 weeks, 3 months, and 6 months, indicating a fairly weak correlation of birthweight with later weights
- The crude and conditional weight changes were similar as would be expected, as these were average for infants; however, there was increasing variability with increase in age. Using 5% cut-off for slow CWG corresponded to a value of -2SD for the conditional weight change scores in the infants and equivalent to -2SD WHO-CGS. Therefore, 5th percentile cut-off CWG was set as the cut-off norm for the first six months of life and later used as the criterion for comparing their hospitalised peers
- The breastfeeding status of the infants did not influence their weight gains in the first six months of life

Birth size and weight gain since birth in the healthy infants

In the current study, the majority (390, 94.9%) of the healthy infants were born at full term. The recorded 5.1%-rate of low birthweight (below the internationally-accepted birthweight cut-off of 2500 grams which is equivalent to an SDS below -2) is similar to that earlier reported from a birth cohort study of a similar population at the same location (Ezeofor and Okeke, 2005). However, there were recent higher reports nationwide in Nigeria – 15.2% (UNICEF, 2008-2012) and 11.7% (Hecht et al., 2015). Relating birthweight to growth velocity in these infants shows that although some normal birthweight and high birthweight infants decelerated in weight, there was a probability of “catch-up” growth in the low birthweight infants. This is consistent with the observations in a similar study in southwest, Nigeria, that determined the pattern and predictors of growth velocity in early infancy (Olusanya and Renner, 2011). Their results showed that a higher weight velocity was strongly associated with lower birthweight ($p < 0.001$) indicative of “catch-up” growth as well as higher gestational age ($p < 0.001$). Therefore, they concluded that birthweight is the strongest predictor of growth velocity reflecting the rapid growth in infants with low birthweight in the first six months of life to compensate for intrauterine restraint. Weight declines before length is impaired and head growth is the last to be affected, however, early detection and treatment of infants and children with abnormal growth velocity is more likely to ensure the subsequent achievement of acceptable adult height.

Because the majority of these infants in the current study were average-sized at birth while a minority were low birthweight, the weight gain since birth at different ages showed less pattern of regression to the mean (catching up on growth). This is a statistical concept demonstrated by Prof Charlotte Wright in the New Castle Birth Cohort (Wright et al., 1994a), Prof Cole in the Cambridge Infant Growth Study (Cole, 1995), and Emond with colleagues in the Avon Longitudinal Study of Parents and Children (Emond et al., 2007). The findings from these cited studies show that the normal weight gain (average growth score) is higher in the UK (-1.3SDS) than in Nigeria (-2SDS), therefore, less undernutrition in the UK infants than in Nigerian infants.

Change in weight SD scores of the healthy infants

The WHO-CGS is the prescribed 'gold standard' for children's growth depicting normal growth under optimal environmental conditions and can be used to assess children everywhere, regardless of ethnicity, socioeconomic status and type of feeding (de Onis et al., 2006a). Remarkably, the weight Z-scores in the infants remained close to the expected value of zero, indicating a normal growth pattern in relation to the WHO-CGS with only a small decline by 6 months. This reflects a trend earlier reported by the researcher from a study (though prospective in design) of the same age group at the same location (Ezeofor, 2005). However, other workers earlier noted that infants gain less weight in resource-poor settings in developing countries (Ashworth et al., 1997, Subramanyam et al., 2010).

Average weight gain in the healthy infants

The observed fairly weak correlation of birthweight with later weights in the healthy infants resulted from a consistent decline in the strength of the positive correlation between the birthweight and weights at 6 weeks, 3 months, and 6 months. The decline in crude weight gain in the latter part of the first six months of life reflected the marked decline in stored energy against the high-energy requirements for growth and metabolism at this period. This observation is consistent with earlier findings from a prospective cohort study of the same age group at the same location (Ezeofor and Okeke, 2005) and elsewhere (Ergie and Abraham, 2000, Allen and Gillespie, 2001, Ejianya et al., 2003, Iannotti et al., 2009). These data provide a useful guide in identifying infants at risk for later growth faltering. Similarly, Ross and colleagues established this in a database analysis of healthy term infants born over a period of ten years in the United States of America (Ross et al., 2009). The Promotion of Breastfeeding Intervention Trial (PROBIT) also reported a similar infant growth pattern supporting the current WHO and UNICEF feeding recommendations (Kramer et al., 2002). Their results showed a period prevalence underweight of 14.7% using the WHO-CGS.

Conditional weight change in the healthy infants

Despite increasing variability with increase in age, the crude and conditional weight changes were similar, as would be expected, as these were average for healthy infants. The observed growth pattern that mainly showed regression to the mean was the evidence for CWG application in these healthy infants. To identify the infants who would need attention against further weight faltering, the crude weight change was used to derive the conditional weight change (Cole, 1995) (Wright et al., 1994a). Using 5% cut-off for slow CWG corresponded to a value of -2SD for the conditional weight change scores in the healthy infants and equivalent to -2SD WHO-CGS. Therefore, 5th percentile cut-off CWG was set as the cut-off norm for the first six months of life and later used as the criterion for comparing their hospitalised peers. This application of conditional weight change is consistent with that of a birth cohort study (Olsen et al., 2010) that used slow CWG in infancy to identify weight faltering. These workers had earlier reported that slow weight gain conditional on birthweight (CWG), as one of the criteria for failure to thrive, is associated with lower birthweight, small-for-gestational-age and deviant overall development (Olsen et al., 2007b).

Similarly, a prospective birth cohort study in Nigeria computed weight gain between birth and the routine postnatal check at 6 – 8 weeks standardised to weight gain (z-score ≤ -1.645) conditional on gender, gestational age and birthweight. These scores were adjusted for differences in gender, gestational age, and birthweight using a linear regression model. Overall, very few of those infants demonstrated evidence of failure to thrive based on Z-scores below the 5th centile for the cohort (Olusanya and Renner, 2011). The average conditional growth score of -2 recorded over a period of the first 6 months of life in the healthy infants in the current study is lower than that documented elsewhere in the literature. For example, cases of growth faltering in infants were found to correspond to the conditional growth score of -1.645 against controls of other infants in the Avon Longitudinal Study of Parents and Children (Emond et al., 2007).

Similarly, the Copenhagen Child Cohort recorded the slowest weight gaining 5% in the age intervals: birth to 2 weeks, 2 weeks to 4 months, and 4 – 8 months, corresponding to thrive index values at or below -1.6033, -1.0721 and -1.0217, respectively (Olsen et al., 2010) (Table 3.9).

Breastfeeding patterns of the healthy infants

At assessment, though the estimation of breastfeeding status was not in-depth, results showed a glimpse of the breastfeeding patterns of the healthy infants who act as a norm for comparing their hospitalised peers. There was an indication of non-exclusivity/short duration of breastfeeding and early introduction of complementary feeds (as early as 6 weeks of age). This is contrary to the WHO recommendations that infants should be exclusively breastfed for the first six months to achieve optimal growth and development; and thereafter, receive nutritionally-adequate and safe complementary foods, while continuing to breastfeed for up to two years or more (World Health Organization, 2001). These findings reflect the reported low EBF rates in Nigeria (Hecht et al., 2015). Assessing EBF rates in Nigeria had earlier revealed that it had consistently decreased over the first six months of life. For example, a study that assessed the determinants of EBF in Nigeria reported a rate of 16.4% among infants aged less than six months, but only 7.1% in infants in their fifth month of age (Agho et al., 2011). The authors reported that the tradition of giving water in addition to breastfeeding has been the major hindrance in the practice of EBF in Nigeria.

In the UNICEF report from the 2008 Demographic Health Survey on infant feeding practices from 0 – 1 month to 24 months of life, only 20% of infants (0 – 6 months old) were exclusively breastfed in Nigeria. About 40% were breastfed with plain water only; two other minority groups of infants received other milk/formula, and non-milk liquids, respectively in addition to breastmilk while about 20% had received solid/semi-solid foods in addition to breastmilk. Similarly, because of the tradition of giving water or other fluids to infants in addition to breastfeeding, very low rates of EBF were reported in some African countries (Jelliffe, 1976). In Kenya, a longitudinal study reported only 2% EBF in infants for the first six months of life (Kimani-Murage et al., 2011). In South Africa, a study on breastfeeding and complementary feeding practices in Limpopo province reported that the majority (97%) of mothers were still breastfeeding infants (0 – 12 months old) but only 7.6% of them practiced EBF (Mustaphi et al., 2008).

Lower rates of breastfeeding have been reported in developed areas of the world where slight variations of breastfeeding duration exist. In the UK, it is recommended that infants be breastfed exclusively for the first six months, and then to continue breastfeeding beyond six months while gradually introducing solid foods (World Health Organisation, 1986). For example, the Millennium Cohort Study in the UK reported that only 1.2% of infants were exclusively breastfed for at least six months, however, with large protective effects of breastfeeding in this group (Quigley et al., 2007). Similarly, another study in the UK reported that less than 1% of women were still exclusively breastfeeding at 6 months (World Health Organisation, 1991). On the other hand, reports from a study using the WHO-CGS to compare the effect of breastfeeding on Belgian and Norwegian children, showed that the prevalence of EBF for at least six months was 26.5% in the Belgian sample and 40.6% in the Norwegian sample (Júlíusson et al., 2011). Comparatively, a higher rate was reported in Iran at a national level: 56.8% at 4 months and 27.8% at 6 months (Olang et al., 2009).

3.4.2 Strength of the Study

First, the results from this study provide information about local growth patterns in healthy children, otherwise nothing is known. Second, the catchment area of the IWC, UNTH, Enugu, is both rural and urban. Third, the compilation of a large sample size of healthy infants (0 – 26 weeks old) within a short period made a useful comparison for their peers admitted to the same hospital. Despite the irregularity in the collection of the feeding information, results show that breastfeeding status did not significantly influence the weight change Z-scores. Fourth, the high turn up of the mothers/carers with their infants to the IWC on schedule immunisation days was a great boost to the quantity of data collected within the short period. Fifth, the credibility of the data collected at this clinic resulted from the high-level child healthcare practice that included nutrition/health talks and demonstrations by specialised paediatric health staff. For example, children were weighed naked with regularly-calibrated weighing scales and weights were mostly plotted correctly, thereby averting the major potential problems with the validity of retrospective weight measurements. It is noteworthy that the researcher had collected data at this clinic on two different earlier occasions for her BSc and MSc research projects, therefore, this long-standing relationship with the management and staff motivated her.

3.4.3 Weaknesses of the study

Although the normative dataset may prove to be a fair representative of the growth pattern of infants (0 – 26 weeks old) at the UNTH (old site and new site), and Enugu city in general, it is not an unbiased population sample. The poor reflection of the breastfeeding status of the healthy infants resulting from not using a structured questionnaire in collecting the information weakened the ‘normative characteristics’ of the generated dataset. Therefore, the generation of a norm of ‘healthy breastfed infants’, equivalent to that which resulted from the WHO-MGRS, for comparing their hospitalised peers, was not realised.

3.4.4 Limitations of the methods

Some of the mothers/carers defaulted in keeping appointments at the IWC at different times for weight monitoring creating missing data in the weight documentations, particularly at the sixth month appointment when there was no immunisation schedule but only vitamin A supplementation. Moreover, the personal information of the healthy infants may possess some confounding errors, including the correctness of the gestational age, date of birth and birthweight, since most deliveries took place outside the hospital. Furthermore, the ‘representativeness’ of the infants in this study stems from the open access of the IWC to all mothers/carers, including those living nearby, staff families and relations, and those residents who desire specialist paediatric healthcare. Therefore, the nutritional wellbeing/characteristics of the infants comprising the normative dataset may likely overestimate those of the population of infants (from birth to 26 weeks of age) in that locality.

Difficulties experienced during data collection at the IWC, UNTH, Enugu

The busy nature of the IWC, UNTH, Enugu, and the hurried attitude of the mothers/carers of the infants posed a constraint to detailed data collection at that location, consequently, some characteristics of the healthy infants were missing. For example, the gestational age of the infants and other factors associated with breastfeeding and complementary feeding practices, such as the socioeconomic status and educational attainment of the mothers. Moreover, data collection was done at one time of the year and at one location; therefore seasonal variations and multicentre reflections were not observed. Furthermore, there was no existing surveillance system for monitoring trends in nutritional status of the children of that locality.

Limitations with using conditional weight gain as a research tool in Nigeria

First, the busy nature of the clinics would not allow the maximum time needed for thorough attendance to mothers and their infants. Second, the conditional reference charts would be difficult to interpret for parents and even health professionals so there is need to educate the users. Third, some infants are born outside the hospital where birthweight is not measured because weighing scale is lacking; therefore non-availability of baseline weight for conditioning. Finally, high defaulting rates to hospital appointments are prevalent among mothers and caregivers of infants, particularly when they feel that their infants have not manifested any obvious signs of morbidity to stimulate worries about their health.

Limitations with feeding data collection in the healthy infants

Not employing the use of a structured questionnaire at the IWC, UNTH, Enugu, to elicit feeding information, but rather making a verbal inquiry to mothers/carers of the infants was a limitation of the current study. This inconsistency in assessing the breastfeeding status did not allow for making reliable associations with the growth of these healthy infants, therefore there is a need to aim at averting this problem in future research.

3.5 Conclusion from the study

Healthy Nigerian infants have a steady weight gain increase in the first half and slower gain in the latter half of first six months of life. During this period, the observed variations in the weight Z-scores distribution were relatively constant and compared well to the WHO-CGS. Moreover, 5% of the infants had -2SD CWG, setting the 5th percentile as slow weight gain threshold – the reference to compare the weight velocity of their hospitalised peers. Therefore, the data compiled from the IWC was successfully transformed into a population representative dataset qualified as a norm for comparing the data collected from the hospitalised infants on the paediatric wards of the UNTH, Enugu, Nigeria. The breastfeeding status of the infants did not influence their weight gains in the first six months of life. However, the non-exclusivity/short duration of breastfeeding and early introduction of complementary feeds that were prevalent in the population needs to be addressed in future studies involving this population.

CHAPTER 4 HOSPITAL WARD STUDY RESULTS

4.1 Basic characteristics of the hospitalised infants

4.1.1 Age distribution in the hospitalised infants

The 210 hospitalised infants recruited into the study ranged in age from 0 to 200 days. However, the highest proportions (114, 54.3%) were in their first 30 days of life among whom 85 (40.5%) were under 14 days old (Fig 4.1).

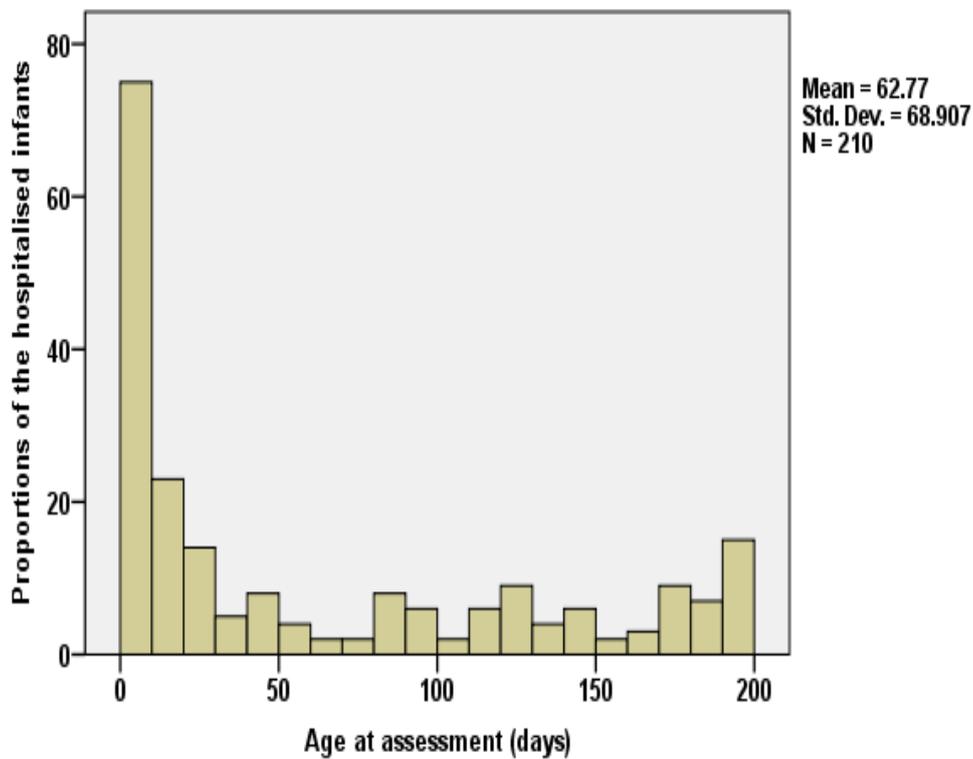


Figure 4.1 Age distribution according to age at assessment, in the hospitalised infants

4.1.2 Birth-related and feeding characteristics of the hospitalised infants

Overall, 15.1% of the hospitalised infants were born with birthweight <2500 grams, including one third of those under 14 days old, against the expected <10%, and 15 (7.1%) were of unknown birthweight. The proportion of males (112, 53.3%) was slightly higher than that of the females (98, 46.7%), though there was no statistical difference (Chi-square Trend of Association = 0.379). The majority of the infants (129, 61.4%) were of the 1st and 2nd birth order, among whom 54 (41.9%) were younger than 14 days. Very few (26, 12.4%) of the hospitalised infants were never breastfed except in the very youngest age group, but only a minority were exclusively breastfed (received breastmilk without water or other liquids) at any age (Table 4.1). The nurses/midwives in the NBSCU of the UNTH, Enugu, supplemented breastmilk (either directly fed or expressed) with a breastmilk substitute for most of hospitalised infants (under 14 days old). Very few infants (7, 3.3%) ceased breastfeeding altogether, with only 1.9% stopping within 1 – 6 weeks, 0.5% within 6 weeks – 4 months, and 1% more between 4 – 6 months of age. Very few infants had started receiving complementary feeds in the form of soft spoon-able foods before 3 months, but half of the infants between 3 and 6 months old had already commenced feeding of solids.

Table 4.1 Birth-related and feeding characteristics of the hospitalised infants N (%)

Age category	LBWT	Female	Male	NBF	EBF	PBF	CF
Under 14 days (N=85)	15 (18.8)	39 (45.9)	46 (54.1)	15 (17.7)	6 (7.0)	64 (75.3)	0 (0.0)
2 weeks – 3 months (N=58)	8 (16.0)	23 (39.7)	35 (60.3)	4 (6.9)	22 (37.9)	32 (55.2)	1 (1.7)
3 – 6 months (N=67)	5 (9.1)	36 (53.7)	31 (46.3)	7 (10.5)	15 (22.3)	45 (67.2)	37 (55.2)
Total (N=210)	28 (15.1)	98 (46.7)	112 (53.3)	26 (12.4)	43 (20.5)	141 (67.1)	38 (18.1)

LBWT = Low Birthweight term (<2500 grams)

NBF = No Breastfeeding

EBF = Exclusive Breastfeeding

PBF = Partial Breastfeeding

CF = Complementary Feeding

4.1.3 Diagnoses in the hospitalised infants

According to the documentations from the hospital case notes of the infants, the commonest diagnoses in the hospitalised infants were sepsis and respiratory tract disorders. The latter were more in the very young infants (younger than 14 days), reflecting their perinatal status as 14 (16.5%) was born before 37 weeks gestation. Only eight (3.8%) of the infants were hospitalised for severe undernutrition, with four of them aged 3 – 6 months (Table 4.2).

Table 4.2 Diagnoses in the hospitalised infants N (%)

Diagnosis	Age category			Total
	<14 days	2 weeks – 3 months	3 – 6 months	
Prematurity	10 (11.8)	6 (10.3)	5 (7.5)	21 (10)
Sepsis	20 (23.5)	17 (29.3)	21 (31.3)	58 (27.6)
Surgical	9 (10.6)	11 (19.0)	10 (14.9)	30 (14.3)
Neonatal Jaundice	11 (12.9)	5 (8.6)	0 (0.0)	16 (7.6)
Diarrhoea and Vomiting	1 (1.2)	3 (5.2)	6 (9.0)	10 (4.8)
Malaria	2 (2.4)	5 (8.6)	7 (10.4)	14 (6.7)
Respiratory Tract Disorder	30 (35.3)	9 (15.5)	14 (20.9)	53 (25.2)
Severe Undernutrition	2 (2.4)	2 (3.4)	4 (6.0)	8 (3.8)
Total (N=210)	85 (100.0)	58 (100.0)	67 (100.0)	210 (100.0)

4.2 Nutritional and growth characteristics in the hospitalised infants

4.2.1 SGNA rating in the hospitalised infants

The majority of the hospitalised infants were at low risk for undernutrition, though about one third of the infants admitted at less than 14 days old were moderately at risk (Table 4.3).

Table 4.3 SGNA rating in the hospitalised infants N (%)

Age category	Low risk	Medium risk	High risk	Chi P-value
Under 14 days (n=85)	60 (70.6)	25 (29.4)	0 (0.0)	
2 weeks – 3 months (n=58)	42 (72.4)	13 (22.4)	3 (5.2)	
3 – 6months (n=67)	59 (88.1)	6 (9.0)	2 (3.0)	
Total (N=210)	161(76.7)	44 (21.0)	5 (2.4)	0.84 [§]

§Trend of association

4.2.2 Growth patterns in the hospitalised infants

The birthweight of the hospitalised infants were mainly within normal range but 15.1% had birthweight \leq 2500 grams) and the mean birthweight Z-score was only 0.5SD below the expected SD. The infants admitted under 14 days had the lowest mean birthweight. At admission, the mean anthropometric measures were higher in older infants as expected, but the anthropometric Z-scores did not follow that trend. The mean weight Z-scores were generally and lowest for those aged 2 weeks to 3 months while the length was lowest for those admitted before the age of 3 months. The growth data depicted here suggests that there had already been some level of growth faltering in most of the infants prior to admission (Table 4.4). Around a quarter of the infants had low anthropometric Z-scores ($<$ -2SD) based on the WHO-CGS (Table 4.5).

Table 4.4 Anthropometric measures and anthropometric Z-scores in the hospitalised infants

Anthropometric measure/ Z-score	Age category		
	Under 14 days (n=80)	2 weeks – 3 months (n=50)	3 – 6 months (n=55)
At birth			
Birthweight (kg)*	3.1 (0.6)	3.1 (0.7)	3.3 (0.6)
Birthweight Z-score	-0.5 (1.4)	-0.4 (1.5)	-0.1 (1.4)
Admission data	(n=85)	(n=58)	(n=67)
Weight (kg)	3.0 (0.6)	3.9 (1.2)	6.4 (1.2)
Weight-for-age Z	-1.0 (1.4)	-1.4 (1.8)	-1.0 (1.7)
Length (cm)	48.1 (3.2)	53.1 (5.0)	64.4 (3.8)
Length-for-age Z	-1.1 (1.8)	-1.1 (1.9)	-0.3 (1.6)
BMI (kg/m ²)	12.6 (1.6)	13.5 (2.6)	15.4 (2.2)
BMI-for-age Z	-0.7 (1.3)	-1.2 (1.8)	-1.2 (1.7)
Head circumference (cm)	34.8 (2.1)	37.6 (3.7)	42.6 (2.2)
Head circumference -for-age Z	0.1 (1.8)	0.1 (2.8)	0.5 (1.7)
MUAC (mm)	100 (1.0)	106 (1.9)	128 (1.6)
MUAC-for-age Z	**	**	-1.0 (1.7)
Triceps (mm)	4.5 (1.1)	5.6 (2.0)	7.3 (1.9)
Triceps-for-age Z	**	**	-1.5 (1.4)
Subscapular (mm)	4.0 (1.1)	4.7 (1.8)	5.6 (1.8)
Subscapular -for-age Z	**	**	-1.8 (1.9)

*Only 185 known birthweight

**The references of MUAC, Triceps and Subscapular skinfolds for infants under 3 months old are not available in the WHO-CGS

Table 4.5 Prevalence of low values of anthropometric indicators in the hospitalised infants N (%)

Age category	Anthropometric indicator				
	WAZ	LAZ	WFLZ	MUACM	MUACS
Under 14 days (n=85)	20 (23.5)	25 (29.4)	10 (14.5)	83 (97.2)	70 (82.4)
2 weeks – 3 months (n=58)	20 (34.5)	16 (27.6)	11 (20.8)	42 (72.4)	35 (60.3)
3 – 6 months (n=67)	16 (23.9)	8 (11.9)	19 (28.4)	15 (22.4)	10 (14.9)
Total (N=210)	56 (26.7)	49 (22.3)	40 (21.2)	140 (66.7)	115 (54.8)

WAZ = Weight-for-age Z-scores ($<$ -2SD)

MUACM = Moderate undernutrition($<$ 115mm)

LAZ = Length-for-age Z-scores ($<$ -2SD)

MUACS = Moderate undernutrition ($<$ 110mm)

WFLZ = Weight-for-length Z-scores ($<$ -2SD)

4.3 Weight Z-score and conditional weight changes since birth in the hospitalised infants

Considering the physiological postpartum weight loss in the infants admitted younger than 7 days, these infants were not included in the weight change analysis. Infants admitted younger than 14 days may not have started gaining weight, and therefore excluded from weight gain evaluations. The other categories of infants tended to have shown falls in weight Z-scores. For those admitted under 3 months the low birthweight infants still tended to show an upward shift (catch-up growth) but the normal birthweight infants and high birthweight infants showed downward shifts, (Figure 4.2). This pattern of growth is not similar to those of both the normative dataset and the WHO-CGS, thus suggesting the effect of their morbidities.

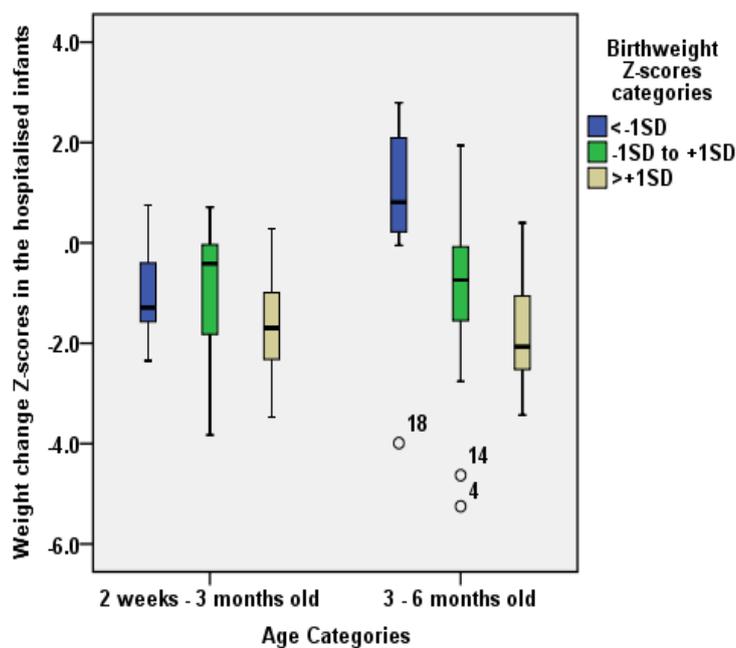


Figure 4.2 Box Plot of weight Z-scores by Birthweight weight Z-scores in the hospitalised infants

Applying the data periods for the Infant Welfare Study (Chapter 3) to yield the mean weight Z-scores change and calculate the conditional weight change, showed that weight gain was generally low (Table 4.6). Only 24 (11.4%) of the hospitalised infants recorded positive conditional weight changes. The 5th percentile for CWG in the healthy infants earlier described in Chapter 3 (-1.9SD at 6 weeks and -2.2SD at 6 months) was set as a threshold for slow weight gain. Nearly ¼ of infants had weight gain since birth below the 5% lower weight gain threshold, and 8 times the expected number were below the expected 1% threshold (see Table in Annexe 2). Figure 4.3 depicts the average weight gains in the infants, with the 5th percentile slow weight gain threshold shown as the blue line and the average weight gain level for the hospitalised infants as the red line.

Table 4.6 Mean (SD) weight change Z-scores and conditional weight changes in the hospitalised infants (N=119)

Variable category	Age at assessment		
	6 weeks (n=53)	3 months (n=22)	6 months (n=44)
Weight change Z-score	-0.97 (0.98)	-0.68 (1.64)	-1.25 (1.72)
Conditional weight change	-1.26 (1.06)	-0.72 (1.51)	-1.26 (1.61)

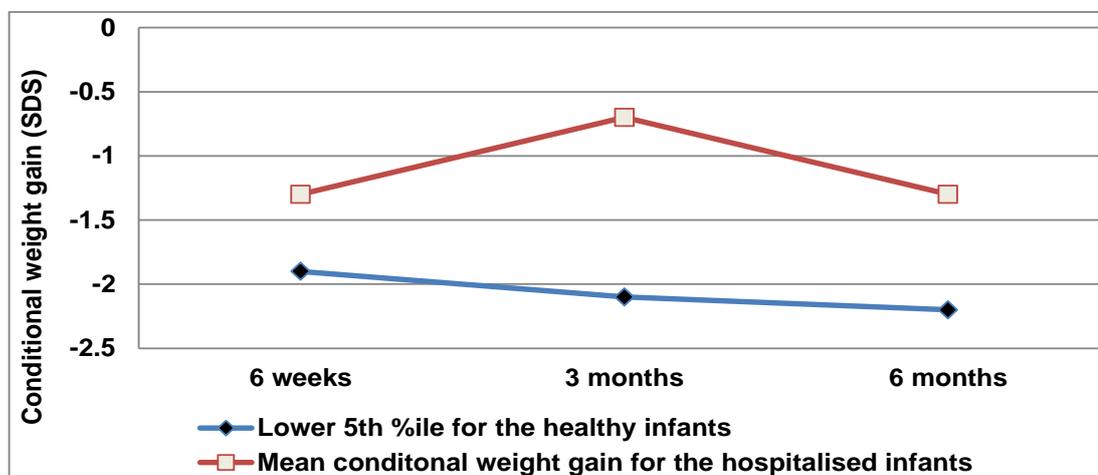


Figure 4.3 Average weight gains in the hospitalised infants

4.4 Body composition and nutrition risk estimation in the hospitalised infants

4.4.1 Generating and using skinfolds reference to estimate nutrition risk in the hospitalised infants

Because of the non-availability of skinfolds Z-score reference for infants younger than 3 months in the WHO-CGS, the analysable sample size was lowered, thus limiting the test of association between the level of nutrition risk and skinfolds Z-scores. Using the sum of skinfolds was considered, but this was not constant over the first six months and appeared to show a weak positive non-linear (quadratic) correlation trend across the first six months of life (Figure 4.4). Hence, the development of the iPYMS skinfolds reference (see section 2.3.3.4 and Appendix D.1), which was used for all the hospitalised infants.

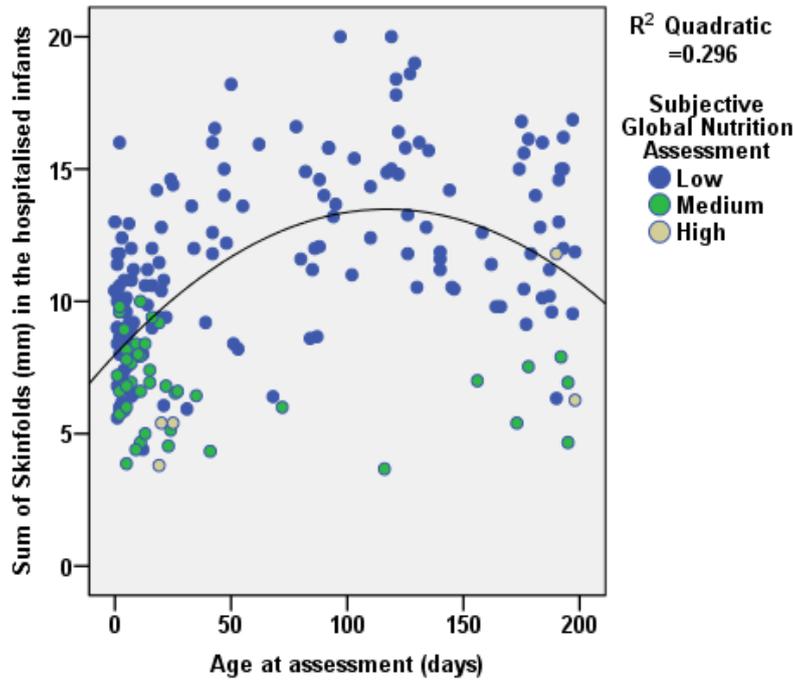


Figure 4.4 Scatter Plot of the sum of skinfolds by age in the hospitalised infants

For the hospitalised infants aged 3 to 6 months, where the WHO z scores were also available, the iPYMS reference compared well with the WHO-CGS, though the WHO subscapular skinfolds Z-scores were slightly lower and had a wider range (Figure 4.5).

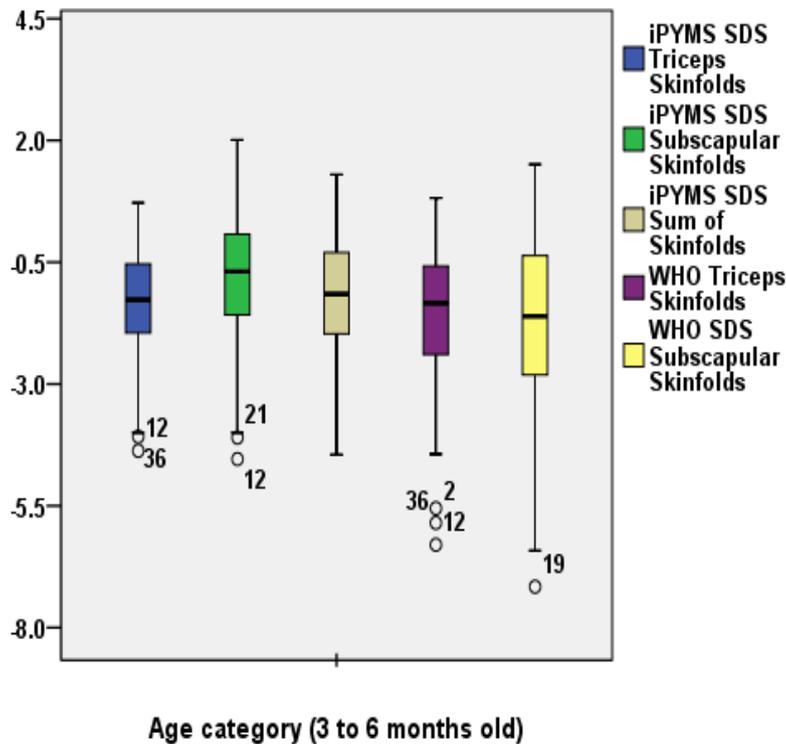


Figure 4.5 Boxplot comparing the mean triceps and subscapular skinfolds of the hospitalised infants (3 – 6 months old), using WHO standards and iPYMS reference

Overall, the hospitalised infants across the age categories had low mean skinfolds Z-scores and the very young hospitalised infants had the lowest (Table 4.7).

Table 4.7 Using the iPYMS reference to compare the mean (SD) skinfolds Z-scores, according to SGNA rating in the hospitalised infants

Age category	SGNA rating	iPYMS TSFZ	iPYMS SSFZ	iPYMS SSFZ
Under 14 days (n=85)	Low	-1.8 (1.0)	-1.7 (0.9)	-1.8 (1.0)
	Medium	-2.8 (1.0)	-2.5 (0.9)	-2.7 (0.9)
2 weeks – 3 months (n=58)	Low	-1.0 (1.2)	-0.8 (1.1)	-1.0 (1.1)
	Medium/High	-3.6 (1.2)	-3.2 (0.8)	-3.4 (0.9)
3 – 6 months (n=67)	Low	-1.0 (0.9)	-0.6 (1.1)	-0.9 (1.0)
	Medium/High	-3.3 (0.9)	-3.2 (0.9)	-3.4 (0.8)
Total (N=210)		-1.7 (1.3)	-1.5 (1.3)	-1.7 (1.3)
ANOVA P-value		0.001	0.000	0.000

iPYMS TSFZ = iPYMS Triceps skinfolds Z-score

iPYMS SSFZ = iPYMS Subscapular skinfolds Z-score

iPYMS SSFZ = iPYMS Sum of skinfolds Z-score

4.4.2 Using different thresholds/measures to estimate undernutrition prevalence in the hospitalised infants

Applying the ‘MUAC<110mm’ threshold (due to the non-availability of an internationally recognised MUAC reference for infants younger than 6 months), suggested that over half of the infants were undernourished under 3 months (Figure 4.4). Applying different thresholds of anthropometric indicators showed that 8.6 – 16.7% and 7.6 – 46.7% of the hospitalised infants had ‘moderate’ and ‘severe’ undernutrition, respectively. However, around half and one third of the infants were identified as having severe undernutrition using the ‘MUAC<110mm’ and ‘sum of skinfolds<80mm’ thresholds, respectively (Figure 4.6).

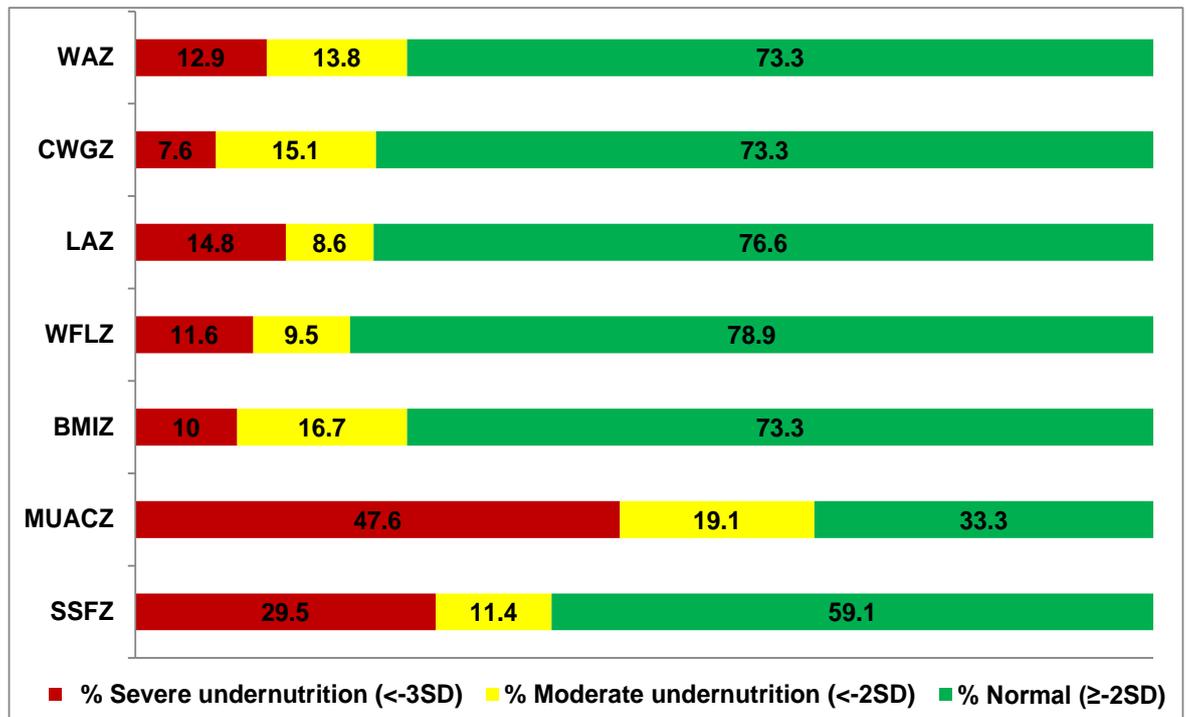


Figure 4.6 Prevalence of undernutrition in the hospitalised infants (N = 210)

There were significantly lower anthropometric and body composition Z-scores in the infants who were more at risk for undernutrition, as would be expected (Figures 4.7 – 8).

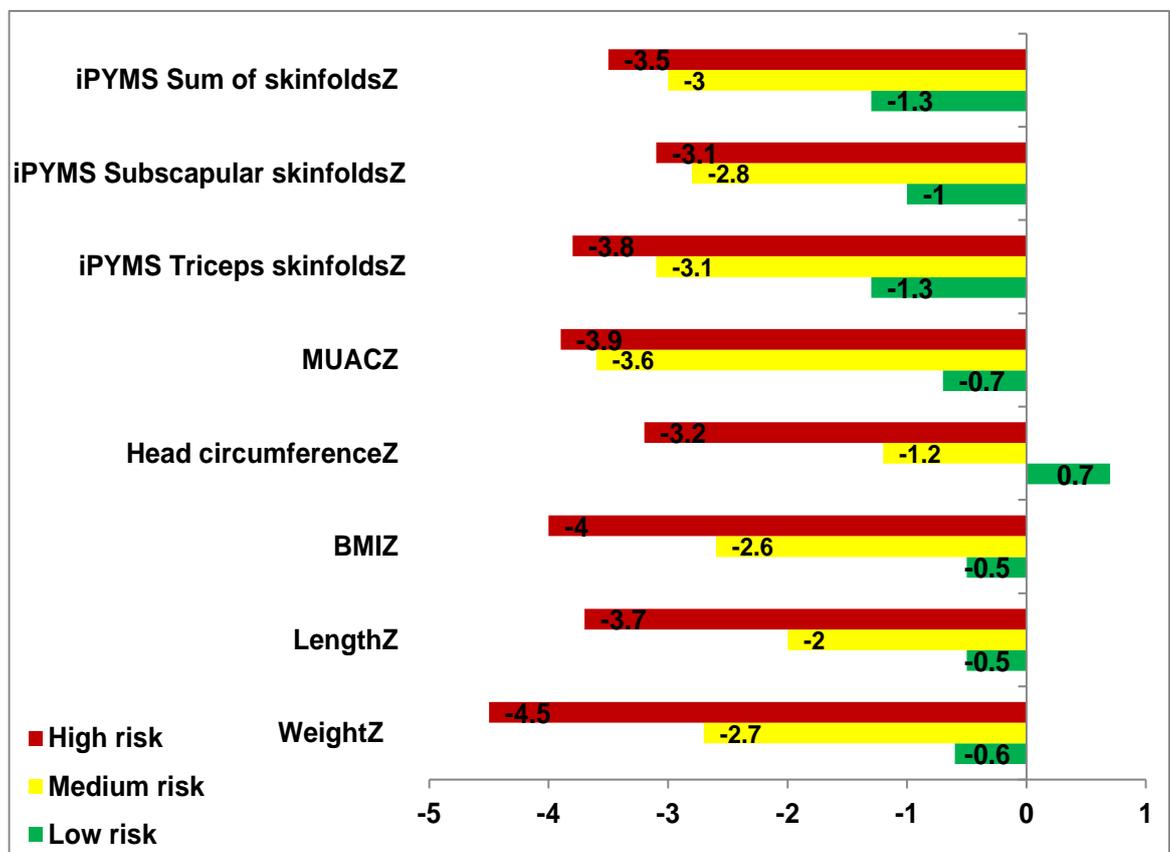


Figure 4.7 Mean anthropometric Z-scores by SGNA-rated nutrition risk levels in the hospitalised infants

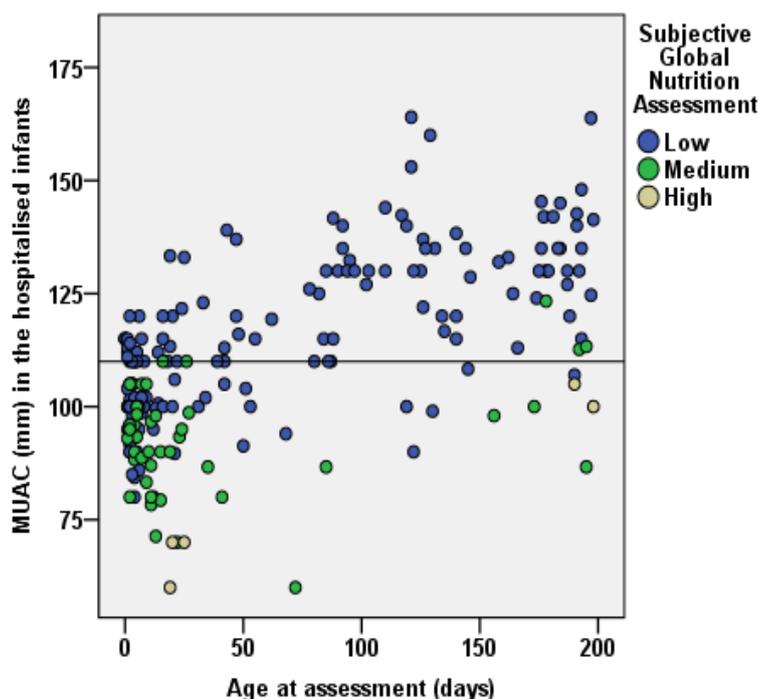


Figure 4.8 Scatter Plot of the MUAC by age, according to SGNA rating in the hospitalised infants

Comparing undernutrition prevalence: standard field measures (weight-for-age, weight-for-length and MUAC) were compared to the more novel clinical measures (CWG, BMI, and sum of skinfolds). Overall, ‘MUAC<110mm’ would identify the largest proportion of infants as at nutrition risk in the field, and ‘sum of skinfolds<80mm’ in the clinical setting (Table 4.8).

Table 4.8 Using field measures versus clinical measures to detect nutrition risk in the hospitalised infants

Nutrition risk	Field measure	N (%)	Clinical measure	N (%)
Low weight	WAZ (<-2SD)	56 (26.7)	CWGZ (<-2SD)	27 (12.9)
	WAZ (<-3SD)	27 (12.9)	CWGZ (<-3SD)	9 (4.3)
Thinness	WFLZ (<-2SD)	40 (19.0)	BMIZ (<-2SD)	56 (26.7)
	WFLZ (<-3SD)	22 (10.5)	BMIZ (<-3SD)	21 (10.0)
Low fat/wasting	MUAC (<115mm)	25 (11.9)	SSF (<90mm)	86 (41.0)
	MUAC (<110mm)	115 (54.8)	SSF (<80mm)	62 (29.5)
	MUACZ (<-2SD)	87 (41.4)	SSFZ (<-2SD)	80 (38.1)
	MUACZ (<-3SD)	10 (4.8)		

WAZ = Weight-for-age Z-score

WFLZ = Weight-for-length Z-score

MUAC = Mid-upper arm circumference

MUACZ = MUAC Z-score

CWGZ = Conditional weight gain Z-score

BMIZ = Body mass index Z-score

SSF = Sum of skinfolds

SSFZ = Sum of skinfolds Z-score

If the infants were truly undernourished, it might be expected that they would have low values for all or most undernutrition measures. Table 4.9 shows there was considerable concurrence (overlap) of the three novel anthropometric indicators of nutrition risk, with CWG having the greatest overlap (Figures 4.9), but around 15% of those with low BMI and 27% of those with skinfolds had isolated low values, and only 2% of those with any low marker were abnormal on all three. This suggests that CWG may be the most specific of the three markers.

Table 4.9 Proportions of the hospitalised infants with low anthropometric Z-scores

Anthropometric indicator	Total number of infants with low value	Number of infants with no overlap	% of infants with overlap
CWGZ	27	1	4
BMIZ	39	6	15
SSFZ	41	11	27

LCWGZ = Low conditional weight gain Z-score

LBMIZ = Low body mass index Z-score

LSSFZ = Low sum of skinfolds Z-scores (iPYMS reference)

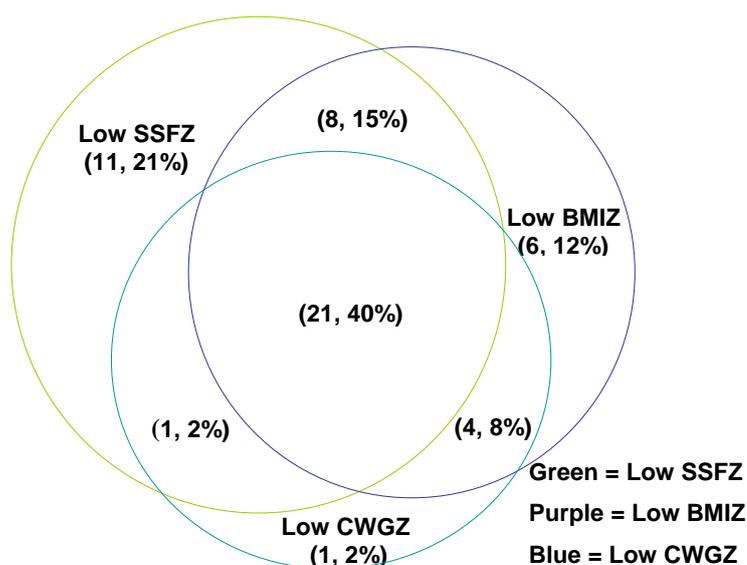


Figure 4.9 Concurrence of low anthropometric indicators (N, % of infants with low Z-scores) using the clinical methods in the hospitalised infants

It would also be expected that most of the infants with SGNA-rated medium or high risk would be below the various undernutrition thresholds but few of those at low nutrition risk. Table 4.10 shows the proportion of those with SGNA-rated medium/high risk who had low CWG, skinfolds or BMI as well as the field markers of low WFH, weight, and MUAC. The level of nutrition risk of the hospitalised infants was, as expected, strongly associated with lower anthropometric indicators (CWG, BMI, MUAC, and skinfolds Z-scores). All low Z-score thresholds showed reasonable discrimination between the low and moderately at-risk infants (that is, low % in the low risk versus high % in the medium risk), apart from

sum of skinfolds in infants under 2 weeks. The crude MUAC thresholds tended to screen the great majority of the younger infants (even at low nutrition risk) as undernourished, and even for age 3 months and above showed the lowest of discrimination to the other measures. However, the 'MUAC<115mm' threshold discriminates better than the 'MUAC<110mm' threshold, particularly in the infants older than 3 months (Table 4.10). This later finding suggests using MUAC measure as a screening tool for nutrition risk in infants from the age of 3 months.

Table 4.10 Proportions of the hospitalised infants below thresholds of the different measures (N, %) by SGNA rating

Age category	SGNA rating	LCWGZ	LBMIZ	LSSFZ	LWAZ	LWFLZ	MUACM	MUACS
Under 14 days (n=85)	Low (n=60)	N/A	1 (1.7)	23 (38.3)	5 (8.3)	3 (5.0)	58 (96.7)	45 (75.0)
	Medium (n=25)	N/A	15 (60)	20 (80.0)	15 (60.0)	7 (28.0)	25 (100.0)	25 (100.0)
2 weeks – 3 months (n=58)	Low (n=42)	4 (9.5)	7 (16.7)	7 (16.7)	7 (16.7)	4 (9.5)	26 (61.9)	19 (45.2)
	Medium/ High (n=16)	11 (68.8)	13 (81.3)	14 (87.5)	13 (81.3)	7 (43.8)	16 (100.0)	16 (100.0)
3 – 6 months (n=67)	Low (n=59)	4 (6.8)	12 (20.3)	9 (15.3)	9 (15.3)	11 (18.6)	8 (13.6)	5 (62.5)
	Medium/ High (n=8)	6 (75.0)	8 (100.0)	7 (87.5)	7 (87.5)	8 (100.0)	7 (87.5)	5 (62.5)

LCWGZ = CWGZ-score (<-2SD)

LBMIZ = BMIZ-score (<-2SD)

LWAZ = Weight-for-age Z-score (<-2SD)

LWFLZ = Weight-for-length Z-score (<-2SD)

LSSFZ = SSFZ-score (<-2SD)

MUACM = Moderate undernutrition (<115mm)

MUACS = Severe undernutrition (<110mm)

Comparing the sensitivity, specificity, and PPV of the simple measures (weight-for-age, weight-for-length Z-scores, MUAC, and sum of skinfolds) against the clinical measures (CWG, BMI, and sum of skinfolds Z-scores) shows that crude sum of skinfolds corresponds closely to SSF Z-score, suggesting that the actual measure could be used reasonably safely. Using weight alone identified 93% of infants with low weight gain, but it was relatively unspecific and 46% of those identified would not actually have had low gain. MUAC only identified 83% of those with low fat stores and was also relatively unspecific, so that 43% of those identified would not actually have had low fat stores (Table 4.11).

Table 4.11 Comparing the use of simple to clinical measures in the hospitalised infants

Variable	SSFZ (<-2SD)			Simple compared to clinical measure (%)	
	Positive	Negative	Total	Sensitivity	
SSF (90mm)					
Positive	72	14	86	90.0	
Negative	8	116	124	89.2	
Total	80	130	210	83.7	
CWGZ (<-2SD)					
WAZ (<-2SD)	Positive	Negative	Total	Sensitivity	92.6
Positive	25	12	37	Specificity	87.0
Negative	2	80	82	PPV	56.8
Total	27	92	119		
SSFZ (<-2SD)					
MUAC (<110mm)	Positive	Negative	Total	Sensitivity	82.5
Positive	66	49	115	Specificity	62.3
Negative	14	81	95	PPV	57.4
Total	80	130	210		
WAZ = Weight-for-age Z-score			SSFZ = Sum of skinfolds Z-score		
CWGZ = Conditional weight gain Z-score			SSF = Sum of skinfolds		
MUAC = Mid upper-arm circumference			PPV = Positive predictive value		

4.4.3 Association of feeding pattern with nutrition risk and body composition in the hospitalised infants

Level of nutrition risk was significantly associated with breastfeeding patterns in the hospitalised infants over 14 days old. Breastfeeding status was also significantly associated with conditional weight change, but the sum of skinfolds though lower was not significant (Table 4.12).

Table 4.12 Relation of SGNA rating/nutritional status and breastfeeding status in the hospitalised infants

SGNA rating (N=125)	Breastfeeding status		P-value
	EBF	PBF	
Low	34 (91.9)	67 (76.1)	0.041 ^c
Medium/High	3 (8.1)	21 (23.9)	
Mean Z-score (SD)			
CWG (N=105)	-0.7 (1.0)	-1.3 (1.6)	0.042 ^t
iPYMS SSF (N=115)	-1.0 (1.3)	-1.6 (1.4)	0.127 ^t
CWG = Conditional weight gain			EBF = Exclusive breastfeeding
iPYMS SSF = iPYMS Sum of skinfolds			PBF = Partial breastfeeding
^t Independent samples T-test			^c Chi-square test

4.5 Discussions

The set objectives of this investigation were to determine the prevalence of undernutrition in hospitalised infants, compare the weight gain velocity of the hospitalised infants with that of their healthy breastfed peers in relation to the WHO-CGS, and determine the variables that are associated with undernutrition in these infants.

4.5.1 Main findings

- More than a third of the hospitalised infants were under 14 days old; over a quarter of the infants had low birthweight (<2500 grams), and the growth data suggests that there had already been some level of growth faltering in the infants prior to admission
- The commonest reasons for admission among the hospitalised infants were sepsis and respiratory tract disorders while the least were severe undernutrition and diarrhoea/vomiting
- Overall, there was a low risk SGNA-rated nutrition risk across the different categories of infants, with the very young being comparatively at higher risk than the older infants
- A quarter of the infants had subnormal weight gain, and 89% of the infants showed a decline in conditional weight since birth. The iPYMS skinfolds reference compared well with the WHO-CGS. Overall, the infants across the age categories had low mean skinfolds Z-scores and the very young infants had the lowest, even those at low SGNA-rated nutrition risk had relatively low skinfolds
- The crude MUAC thresholds tended to screen the great majority of the younger infants (even at low nutrition risk) as undernourished, and even for age 3 months and above showed the lowest level of discrimination to the other measures.
- The use of ‘sum of skinfolds<80mm’ could be a secondary assessment to the initial use of ‘MUAC<110mm’, towards detecting early childhood undernutrition

Birth size and weight gain since birth in the hospitalised infants

In the current study, over half of the 210 hospitalised infants were younger than 3 months, of which more than a third was under 14 days old. Over a quarter of the infants had low birthweight (<2500 grams); and the growth data suggests that there had already been some level of growth faltering in the infants prior to admission. The very weak positive non-linear (quadratic) correlation ($R^2=0.053$) between the weight percentage change with age observed in the infants younger than 14 days was suggestive of a physiological postnatal weight loss; and this was unaffected by birth size. However, there was no significant overall upward shift in weight Z-scores among the infants over 14 days old because the majority of these infants were of normal birthweight, and the morbidities of most of the younger infants in this group influenced their growth pattern. Comparing with the WHO-CGS, growth faltering was observed to have commenced very early (within 6 months of age) in the hospitalised infants confirming reports from other studies (Ergie and Abraham, 2000, Shrimpton, 2012, Olusanya and Renner, 2013, Uvere and Ene-Obong, 2013). The poor growth pattern observed in the older infants was consistent with a previous report (Black et al., 2013), suggesting the influence of suboptimal breastfeeding and disease conditions.

Weight gain being more affected than triceps, subscapular, and sum of skinfolds, conforms to the findings from studies in the African sub-region. For example, a prospective birth cohort study of 114 infants in Burkina Faso in West Africa reported that morbidity was strongly correlated with weight loss in the short term and weakly correlated with a slowdown in growth (Sawadogo et al., 2008). Underweight was independently predicted by morbidity factors in another study of children (0 – 23 months old) in Uganda (Wamani et al., 2006). However, a range of factors including low educational status of mothers/carers, morbidity in the child and poor feeding patterns were identified as some of the key contributors to undernutrition in western Uganda (Turyashemerwa et al., 2009). Similarly, low birthweight (LBW), intrauterine growth retardation (IUGR) and maternal low weight status and height were important determinants of children's growth in a Beninese (West African) cohort of children followed up until 18 months of age (Padonou et al., 2014). These authors used these results to reinforce and justify continuing public health initiatives to fight LBW and IUGR and break the intergenerational cycle of malnutrition.

Reasons for admission of the hospitalised infants

The commonest reasons for admission among the hospitalised infants were sepsis and respiratory tract disorders while the least were severe undernutrition and diarrhoea/vomiting. The rates of the latter, though very low, were more among the older infants suggesting the influence of the problems associated with transition from milk-based feeds to semi-solid feeds. On the other hand, respiratory tract disorders, for example, neonatal asphyxia were the highest recorded reason for admission among the very young infants. The majority of the hospitalised infants were in their first month of life, among which over half were younger than 14 days, showing a very young population on hospital admission. The majority of the very young infants were likely to be suffering perinatal factors, for example, prematurity and low birthweight, as in earlier reports that perinatal status of infants has a strong influence on the early postnatal status (Njokanma et al., 2008, Olusanya et al., 2010, Agho et al., 2011, Olusanya and Renner, 2012, Bassingthwaightte and Ballot, 2013). Maternal problems, for example, complications of pregnancy, particularly hypertension are associated with an increase in premature and caesarean deliveries, and neonatal morbidities (Njokanma et al., 2008, Olsen et al., 2009). Most of the infants in the current study were admitted to the UNTH, Enugu from other places of delivery (either delivery at home or private maternity/hospital). Standardised equipment for baseline assessment, resuscitation, and maintenance of neonates, even weighing scales are not always available at such places of infant birth, reflecting in unrecorded birth weights for fifteen infants in the current study. Moreover, most mothers who deliver at such places have poor socioeconomic background and so lack access to government-controlled hospitals where antenatal/postnatal health talks on best practices of infant feeding practices are mostly promoted and provided. Therefore, the effect of the resultant suboptimal breastfeeding practices and poor living conditions associate this situation with increased risk for undernutrition in early infancy (Olusanya and Renner, 2012, Olusanya and Renner, 2013, Bassingthwaightte and Ballot, 2013).

The geographical location of Nigeria in the tropics means that this is a region of increased infections (from increased temperatures, which favours the growth of microorganisms) and infestations (from the endemic presence of malaria parasites – 49% incidence reported in under-fives in Nigeria by UNICEF from 2006 to 2010). The findings from the current study are consistent with those of earlier studies at this and other locations in Nigeria which reported that infections constituted the highest and overt undernutrition the least of the hospital admissions in children under 5 years (Ibeziako and Ibekwe, 2002, Chukwu et

al., 2013). Earlier studies in most parts of Africa and other developing countries implicated infections and other communicable diseases such as malaria, acute respiratory infections, diarrhoea, and measles as responsible for most hospital admissions and subsequent child deaths in this region (Bangboye and Familusi, 1990, Menge et al., 1995, Petit and van Ginneken, 1995, Ojukwu et al., 2004, Crookston et al., 2010). Elsewhere, respiratory diseases and digestive diseases were reported as the frequent causes for hospitalisation: Argentina (Gomila et al., 2009); Colombia (Santafe Sanchez et al., 2012, Pineros et al., 2013); Indonesia (Bucens et al., 2013); and the Gambia (Kuti et al. (2014). Overall, infections continue to pose serious challenges to child health in developing countries. Early introduction of mixed feeding to infants younger than 6 months is the major source of these infections as these very young infants are exposed to the risks of microbial contamination of feeds and undernutrition (Nwankwo, 2002, Fjeld et al., 2008).

Using SGNA rating to assess levels of risk for undernutrition

Applying the SGNA rating in the current study showed that majority of the hospitalised infants were at low nutrition risk, although some of the older infants were at high risk. An overall low rate of risk for undernutrition was also recorded across the different categories of the hospitalised infants, with the very young being comparatively at higher risk than the older infants. The SGNA has proved a valid tool for assessing nutritional status in hospitalised children (Secker and Jeejeebhoy, 2007, Mahdavi et al., 2009). However, the estimation of nutrition risk in hospitalised children shows diverse results depending on the screening tool applied. For example, Iranian children were assessed on admission to a tertiary hospital, using STAMP (McCarthy et al., 2008), STRONG_{KIDS} (Hulst et al., 2010), and PYMS (Gerasimidis et al., 2010, Moeeni et al., 2012). The proportion reported to be high risk varied from 34% to 55% and the proportion low risk from 24% to 41%, and the majority of the moderately (67%) and severely malnourished (78%) children were under-5-year-olds in that population.

Conditional weight change in the hospitalised infants

In comparison with the growth velocity of the healthy breastfed infants (described in Chapter 3 – Infant Welfare Clinic Study) that compared well with the WHO-CGS, the hospitalised infants recorded an average slow weight gain. The growth of the infants in the current study was poor on average and all growth measures correlated strongly with nutrition risk. One quarter of the hospitalised infants had weight gain since birth below the 5% slow weight gain threshold found in their healthy peers, suggesting a substantial rate of slow weight gain (weight faltering). This method proved effective in identifying infants at the risk of weight faltering in birth cohorts at many other locations by other workers (Wright et al., 1994a, Cole, 1995, Emond et al., 2007, Olsen et al., 2007a, Olsen et al., 2007b, Olsen et al., 2010). However, a very low rate (3.6%) of evidence of failure to thrive based on the same criteria was earlier reported in a 6 – 8 weeks-old cohort, southwest Nigeria (Olusanya and Renner, 2011). The explanation of the wide difference could be the younger age of the infants in that cohort.

Definition of undernutrition in the hospitalised infants

Defining undernutrition in children admitted to hospital highly depends on the criteria applied (Joosten and Hulst, 2008). MUAC and skinfolds have earlier been shown to be reliable measures of body composition but poor predictors of malnutrition compared to body mass index in paediatric medical patients (Burden et al., 2005). The current study set to define undernutrition in the hospitalised infants using the WHO thresholds for MUAC and skinfolds, but there are no internationally recognised references for these measures for detecting nutrition risk in infants younger than 6 months. Therefore, the ‘MUAC<110mm’ (Myatt et al., 2006) and ‘sum of skinfolds<-2SD’ (iPYMS skinfolds reference in comparison with the WHO-CGS – section 4.4.1) thresholds were applied. This MUAC threshold suggested that over half of the hospitalised infants, consisting mainly of infants younger than 3 months, were undernourished. However, the ‘MUAC<115mm’ threshold discriminated better in the older infants, suggesting the use of MUAC from the age of 3 months of life, although other workers reported the use of ‘MUAC<110mm’ in infants younger than 3 months (Mwangome et al., 2012a). Moreover, MUAC has been shown to be a consistent predictor of malnutrition and mortality in children under 5 years old in some developing countries (Berkley et al., 2005, Myatt et al., 2006, Briend et al., 2012). For example, ‘MUAC<110mm’ had a predictive value for detecting undernutrition with respect to mortality in rural Gambian infants aged 6 – 14 weeks (Mwangome et al., 2012a).

Furthermore, if unadjusted (by age), MUAC may be useful in clinical settings (Berkley et al., 2005).

There is a scarcity of information on body composition variables as predictors of malnutrition or survival among hospitalised children in Nigeria. Nigerian studies in older children (Owa and Adejuyigbe, 1997) and in neonates (Akinyinka et al., 1999), did not evaluate the relationship between malnutrition and mortality. Some investigators have demonstrated that MUAC, after controlling for other measured and derived parameters, independently predicted survival among hospitalised children under 5 years old in a Nigerian emergency unit (Akinbami et al., 2010). The current study further applied the iPYMS skinfolds reference. The iPYMS skinfolds reference compared well with the WHO-CGS and demonstrated an overall low mean skinfolds Z-scores across the age categories of infants with the very young infants having the lowest, even those at low SGNA-rated nutrition risk having relatively low skinfolds. It has been suggested that the sensitivity and positive predictive value of single criteria are poor at identifying children with growth patterns likely to reflect significant undernutrition (Olsen et al., 2007a). Moreover, for a diagnosis of undernutrition to be reliably made for a child, more than one anthropometric indicator should be low (Wright et al., 2002). Furthermore, because the assessment of nutritional status is difficult in clinical practice, and no single indicator can be used in isolation, therefore, it is suggested that adding other method(s), for example, a screening tool could improve results (Aurangzeb et al., 2012). A community based study of under-five children concluded that a combination of more than one criteria may be useful in identifying undernourished children, who otherwise would be missed by any single criterion alone (Dani et al., 2014). However, a study in the Gambia found that a single MUAC measurement predicted mortality in infants aged 6 – 14 weeks (Mwangome et al., 2012a). The current study explored the extent that being below the -2SD threshold of three anthropometric indicators (low CWG, low BMI, and low sum of skinfolds Z-scores) overlapped. Overall, two-thirds of those hospitalised infants who had low anthropometric Z-scores for any measure had more than one low anthropometric indicator with low CWG Z-scores overlapping most with the other two measures. This result contrasts that reported from a birth cohort of Danish infants (Olsen et al., 2007a), however, the literature review did not reveal such comparisons from earlier reports from Africa.

Prevalence of undernutrition in the hospitalised infants

The current study recorded an overall very low prevalence of severe undernutrition (according to the documentations from the hospital case notes of the infants), as the reason for admission among the hospitalised infants. This result accords with the general view that very young infants are less likely to be undernourished since they are breastfed and have not had time to be undernourished after birth. On applying different measures to estimate undernutrition prevalence in the hospitalised infants, the current study suggested that the actual prevalence of undernutrition was 30%. Comparing different thresholds showed that the crude MUAC thresholds tended to screen the great majority of the younger infants (even at low nutrition risk) as undernourished, and even for age 3 months and above showed the lowest level of discrimination. Among the clinical methods that might be used for secondary screening, CWG appeared likely to be more specific in detecting undernutrition than sum of skinfolds or BMI. However, the 'sum of skinfolds < 80mm' could be used as secondary assessment to 'MUAC < 110mm' specifically to detect wasting. This is consistent with other reports from the literature, though most were from older populations. Among hospitalised medical patients (≥ 16 years old), MUAC < 5th percentile better identified undernutrition than triceps skinfold, but has low sensitivity as a single predictive measure (Burden et al., 2005). Similarly among children (12 – 59 months old) at a cut-off below 135mm, MUAC was also found a poor sensitive indicator of undernutrition, but highly sensitive at 155mm, therefore those investigators recommended a higher value for screening for acute malnutrition among under-5 children (Dairo et al., 2012). Results from a data analysis recommended MUAC < 115mm for a higher specificity in identifying children (6 – 59 months old) at high risk of death in the community (Briend et al., 2012). Interestingly, the use of MUAC below 115mm among infants (6 – 14 weeks old) better identified infants who were more likely to die before the age of one year, therefore, a cut-off of 110mm was recommended (Mwangome et al., 2012a).

Risk factors for undernutrition in the hospitalised infants

Finding younger age to be a risk factor for undernutrition in the current study is consistent with that found among children in other developing countries. For example, an estimation of the prevalence and key risk factors of undernutrition in Ethiopia found an overall 56.6% undernutrition in children (0 – 5 years old), and age was one of the major factors associated with stunting (Brhane and Regassa, 2014). These authors suggested the influence of complementary feeding with regard to the timing of introduction and composition and subsequent breastfeeding practice. Another suggested condition is the increased frequency of diarrhoeal disease that is known to initiate the process of undernutrition being related to younger age. At admission to 10 Brazilian university-based hospitals, 28.6% of infants (0 – 6 months old) had weight-for-length below -2Z-scores, and the risk for undernutrition was associated with low birthweight and younger age (Sarni et al., 2009).

Breastfeeding/complementary feeding pattern of the hospitalised infants

Low EBF, but high partial breastfeeding rates were recorded among the infants, with a great proportion of the partially breastfed infants under 14 days old and therefore admitted to the NBSCU of the UNTH, Enugu, for neonatal problems. Since a Neonatal Intensive Care Unit (NICU) was non-existent at the time of data collection in that hospital, the NBSCU admitted all neonates whether preterm, critically or moderately ill or healthy neonates under observation for medical reasons. Consequently, the same nutritional care tended to be the common practice: feeding directly on the breasts or with expressed breastmilk supplemented with breastmilk substitute orally or via the nasogastric tube for nutritional inadequacies. Nonetheless, a breastfeeding pattern similar to that from the current study was earlier reported among hospitalised children at this same study location: 18.9% EBF for 0 – 3 months; 48.6% predominant breastfeeding for 0 – 3 months; 24.3% predominant breastfeeding for 4 – 6 months; and 8.1% breastmilk substitutes (Ubesie et al., 2012). Infant feeding with variably fortified ‘akamu’ followed those methods of feeding. A high rate of mixed feeding was observed in the current study where water and breastmilk substitute alone or breastmilk substitute added to ‘akamu’ (described earlier in section 1.2.7.1) were fed the infants in addition to breastmilk as also reported elsewhere (Ukegbu et al., 2010). Moreover, the majority of these infants were on the first birth order, suggesting that their mothers might not have had enough experience with breastfeeding and complementary feeding practices. An earlier study conducted at this same health

institution in southeast Nigeria reported that younger mothers (mothers of low parity by implication in the Nigerian context) had a lower EBF rate which was attributed to inexperience (Uchendu et al., 2009). Inexperience with breastfeeding in mothers was observed as a significant predictor of undernutrition between birth and the first 6 – 8-week postnatal check in a prospective cohort study in southwest Nigeria (Olusanya and Renner, 2013).

At the location for the current project (Igbo land in southeast Nigeria), breastfeeding is a culturally-accepted method of infant feeding with very high initiation rates as in most developing countries, therefore breastfeeding continues even when semi-solid feeds have been introduced to the infant. The most widely used first semi-solid feed to infants in that locality is ‘akamu’ (Jelliffe, 1976, Kazimi and Kazimi, 1979, Uwaegbute, 1991, Ezeofor and Okeke, 2005, Ogunba, 2010), as in other parts of Africa (Mustaphi et al., 2008, Kimani-Murage et al., 2011). Mothers usually add some breastmilk substitutes (the quantities depends on the purchasing power of the family) to enrich the ‘akamu’ fed to infants; the poorer families use ground crayfish and ground processed soybean flour or groundnuts. The current study recorded a fairly high rate of introduction of complementary feeds to the hospitalised infants sooner than the six months recommended by WHO guidelines for optimal growth of infants (World Health Organisation, 2003). The practice of early of introduction of complementary feeds has been generally high in most communities in developing countries. For example, reports show that complementary feeds can be introduced as early as 1 month (Kazimi and Kazimi, 1979, Uvere and Ene-Obong, 2013); between 3.1 and 6 months (Uwaegbute, 1991); after the 4th month among undergraduate mothers (Ogbuji, 2005) in south-east, Nigeria; and before the age of 3 months in poor communities in south-west, Nigeria (Nwankwo, 2002). Similarly, a study on breastfeeding and complementary feeding practices in Kenya reported that 99% of the infants were initially breastfed and about 85% were still breastfeeding by the end of the 11th month. Almost all the infants in that study had been introduced to complementary foods (either liquids or solids) by the age of six months. Liquids were introduced earlier than solids; the mean age of introduction of liquids was one month while that of solids was three and half months (Kimani-Murage et al., 2011). Similarly, a study in Uganda reported that 60.7% of the infants received complementary feeds before they were 6 months old while 39.3% did not until 6 months of age (Turyashemerwa et al., 2009). These authors reported that the factors that strongly influencing complementary feeding practices included maternal socioeconomic and educational level. The current study recorded suboptimal breastfeeding patterns among the hospitalised infants and breastfeeding status

did influence the nutritional status of these hospitalised infants in the current study, though not strongly.

Breastfeeding support practices at the UNTH, Enugu

The UNTH, Enugu is a BHFI accredited health institution and therefore supports breastfeeding through the following practices:

- 1) Placing the hospital's written breastfeeding policy at strategic locations for easy communication to the maternity and paediatric health staff
- 2) In collaboration with the UNICEF, conducting occasional lactation management training workshops for all cadres of health staff
- 3) Keeping each neonate in a cot close to its mother for breastfeeding on demand in the postnatal ward, including those mothers who delivered by caesarean section
- 4) Providing rooms next to the NBSCU containing beds for the ambulatory mothers of neonates admitted in that unit, to either breastfeed directly or hand express or hand-on-pump breastmilk for the nurses/midwives' use in feeding those neonates via oral or nasogastric route, as indicated in their care
- 5) Nurses/midwives from the NBSCU carrying the breastfeeding neonates of non-ambulatory mothers admitted to the postnatal ward located next to that unit, for breastfeeding by their mothers, as and when due.
- 6) Nurses/midwives teaching and assisting mothers, particularly first time mothers of neonates, how to position and feed their neonates on the breasts
- 7) Nurses/midwives teaching and assisting the mothers to practise the skin-to-skin contact (Kangaroo mother care method) for their premature and small-for-date neonates kept in the NBSCU
- 8) Providing a milk kitchen in the NBSCU for regular supplies of constituted breastmilk substitutes to nurses/midwives for feeding the neonates (admitted in any paediatric ward of the hospital) that require supplementary feeding either fully or partly, as indicated in their care
- 9) Forbidding the use of pacifiers and feeding bottles with teats, but rather feeding neonates with easily cleanable cups and spoons
- 10) Purchasing breastmilk substitutes from the market and not receiving them through free or subsidised supplies from formula milk companies (WHO International Code of Marketing of Breastmilk Substitutes, 1981).

However, unnecessary in-hospital formula supplementation could arise from health institutional infra-structural inefficiency. For example, the high rates of formula supplementation observed in hospitalised neonates in the current study indicates the effect of nursing preterm and sick neonates together with healthy neonates who were under observation for some reasons, in the same unit using the same feeding regimen. This problem emanates from the non-existence of a NICU (for critically ill neonates) and a breastmilk bank, at the time of data collection from that hospital. The probable issue with establishing a breastmilk bank is the question of parents (particularly mothers) accepting the feeding of their hospitalised infants with donated breastmilk. Parents are afraid of exposing their infants to HIV infection through ingesting donated breastmilk, despite the general observation of prescribed donated tissue screening measures in hospitals. Moreover, there is a cultural myth in Nigeria (particularly in Igbo land), that using breastmilk from an unknown mother to feed the infant of another mother could transmit diseases, particularly generational diseases. On these grounds, the majority of mothers in a Nigerian study would not give their infants donated breastmilk, others dislike the idea of donating breastmilk and a few has the fear of not having enough for their own infants (Abhulimhen-Iyoha et al., 2015). This suggests the need for public enlightenment on human milk banking and its benefits to disadvantaged infants who need it for survival. Nonetheless, at the NBSCU, individual mothers provide the nurses/midwives with expressed breastmilk either by manual means or using breastmilk pump for the feeding their own infants.

Nonetheless, promoting and supporting EBF practice in mothers of infants, particularly infants admitted to hospital could become a priority through the following activities:

- 1) Making hospital policies that support EBF in hospitalised infants, by adhering to the guidelines in the 'Ten Steps for Successful Breastfeeding'
- 2) Establishing NICUs in secondary and tertiary health institutions, in order to improve in-hospital breastfeeding practices, particularly for preterm and sick neonates
- 3) Effectively enforcing the practice of the 'Baby Friendly Hospital Initiative' (BFHI) recommendations in health facilities, in order to encourage mothers of these infants to choose to continue EBF beyond hospital stay
- 4) Making an intervention form a part of a multi-faceted package of breastfeeding care to meet the BFHI standards

- 5) Providing education and support towards re-lactating mothers who had earlier stopped breastfeeding (for whatever reasons), would stimulate these mothers' intents to restore the breastfeeding behaviour for the good of the pairs
- 6) Rewarding mothers who choose to exclusively breastfeed their infants, both in and outside hospital facilities
- 7) Providing breastmilk banks where consented lactating mothers could donate breastmilk for screening, preserving, and utilisation in feeding infants admitted to hospital

4.5.2 Strengths of the study

First, comparing the growth data of healthy infants with their hospitalised peers in relation to the WHO-CGS reveals the reality of the childhood nutrition situation in Nigeria.

Second, keeping the sample size large in order to increase the power of the study by not making exclusions, though this introduced some 'noise' in the older infants. Third, combining a range of different assessment methods to explore undernutrition prevalence in Nigerian hospitalised infants allowed us to compare more complex assessment tools that were developed for use in developed countries. The dietetics experience of the researcher and her assistant was engaged in explaining the research procedures before obtaining the informed consents of the mothers/carers of the infants who participated in the study. Moreover, the care exercised in taking three measurements of each anthropometric measure and interviewing the mothers/main carers of the infants in the course of completing the infant feeding questionnaires contributed immensely to the reliability of the data collected.

Some other strengths of the study include:

- Research in a developing country where little research is done
- Working with infants younger than 6 months who are little studied
- 'Real world' relevance

4.5.3 Weaknesses of the study

The results of the study and their subsequent interpretations are limited in making generalisations in the study population due to biases introduced by some factors. For example, the high proportions of very young infants who had not started gaining weight since after birth, affected overall weight gain pattern in the hospitalised infants. Moreover, the breastfeeding status of the healthy infants could not compare that of their hospitalised peers because of not using a structured questionnaire in collecting that data at the IWC, UNTH, Enugu. Furthermore, the correlations of nutrition risk and the body composition were weak since most of the hospitalised infants were in their first 3 months of life, whereas undernutrition is usually more common after this peak period of EBF with its immune-protective benefits.

4.5.4 Limitations of the methods

Since this study conducted in a tertiary referral hospital, fewer hospitalised infants over three months old were accessed and therefore most recruited infants were those admitted because of their poor perinatal status. The National Health Insurance Scheme (NHIS) established a few years ago in Nigeria, is still at the stage of being effected for only registered civil servants and the military with their families who pay only one-tenth of their hospital bills. However, adults outside these groups fully pay and children pay half of their hospital bills in tertiary health institutions in Nigeria (at the time of this project). Therefore, parents/main carers accessed medical attention for their infants with morbidity at alternatively cheap sub-standard places of care and only brought their infants to such health facilities when their condition must have deteriorated, as a last resort. Moreover, the discussion on the factors associated with undernutrition in this population was limited because other socio-demographic factors associated with undernutrition in the first six months of life apart from the level of the exclusivity/duration of breastfeeding and age of introduction of complementary feeds were not elicited during the investigation. Finally, the cross sectional design of the investigation did not allow the exploration of a causal relation between the identified factors and undernutrition.

Future Research Directions

Future research is needed using longitudinal data collection, in order to detect changes in the nutritional status in the hospitalised infants over time. A follow-up period would enable testing for accuracy of rating nutrition risk assessments at different times using the different tools by different cadres of paediatric health staff at different levels of healthcare delivery. In addition, monitoring changes in the nutritional status of the hospitalised infants would reveal what happens in the longer term for more definitive outcomes like death. Evaluating this responsiveness to change over time would enable the proper appraisal of the values and benefits of the various assessment tools. The causal pathways underlying the association between the variables that affect nutritional status in the hospitalised infants could be elucidated, in order to better determine the right interventions and effective strategies needed to prevent undernutrition.

4.6 Conclusion from the study

Remarkably, the level of SGNA-rated nutrition risk in the hospitalised infants was low, but using weight-for-age, 5th percentile CWG, length-for-age, weight-for-length, BMI-for-age, MUAC-for-age, and sum of skinfolds-for-age suggested that 7.6 – 16.7% and 7.6 – 14.7% of the hospitalised infants had ‘moderate’ and ‘severe’ undernutrition, respectively. This appears to have been the effects of their diverse medical conditions. ‘MUAC<110mm’ for primary screening plus a ‘sum of skinfolds<90mm’ could be used as secondary assessment to detect undernutrition in early infancy. Furthermore, faulty breastfeeding patterns were prevalent in association with nutritional status in the hospitalised infants, suggesting the need for more support for breastfeeding infants in hospital.

CHAPTER 5 HEALTH STAFF STUDY RESULTS

5.1 Participants of the health staff survey

5.1.1 Recruitment of participants

A CONSORT flow diagram (Moher et al., 2009) shows the progress through the phases of the health staff survey (Figure 5.1). Out of 300 paediatric health staff approached at the chosen health facilities, 233 each received a copy of a structured self-completion questionnaire, but 222 responded. The analyses of the data collected from these respondents (95.3% response rate) generated the results presented in this chapter.

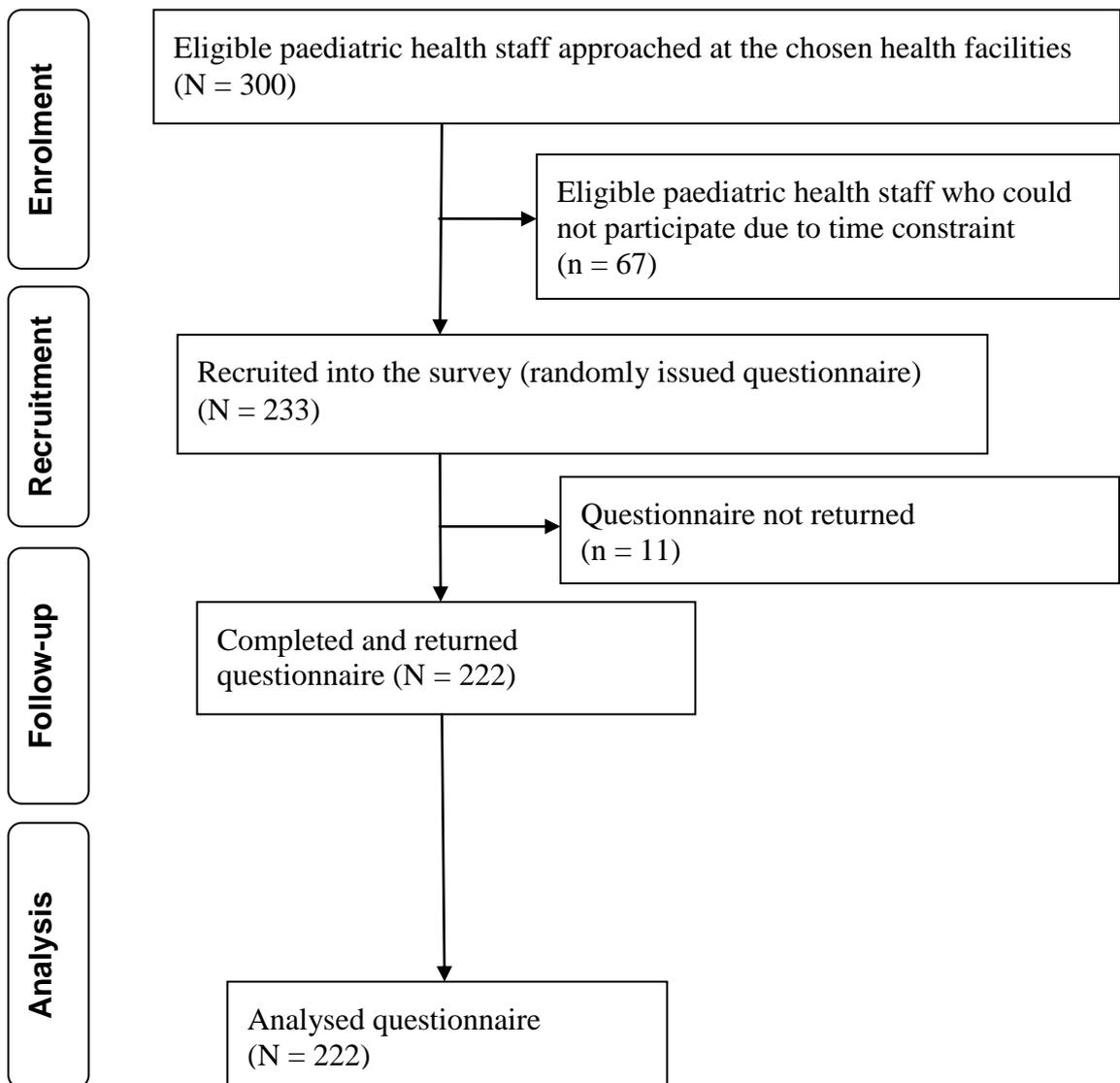


Figure 5.1 Flow diagram of the progress through the phases of the Health Staff Survey
Adapted from: Moher D, Liberati A, Tetzlaff J, Altman DG, the PRISMA Group (2009)

5.1.2 Characteristics of the respondents

Over three-quarters of the respondents were hospital-based; over half were nurses and half were highly experienced professionally. Medical doctors and dietitians/nutritionists constituted over 90% of the hospital-based respondents and nurses constituted a third of the clinic-based and over two-thirds of the highly experienced respondents (Table 5.1).

Table 5.1 Characteristics of the respondents (N = 222)

Profession	N	Location		Years of Experience		
		Hospital	Clinic	<5	5 – 10	>10
Medical doctor	72	65 (90.3)	7 (9.7)	26 (36.1)	34 (47.2)	12 (16.7)
Dietitian/Nutritionist	29	27 (93.1)	2 (6.9)	13 (44.8)	7 (24.1)	9 (31.0)
Nurse	121	81 (66.9)	40 (33.1)	22 (18.2)	18 (14.9)	81 (66.9)
Total	222	173 (77.9)	49 (22.1)	61 (27.5)	59 (26.6)	102 (45.9)
*Chi ² P-value		<0.0001		<0.0001		

*Chi-square trend of association

5.1 Respondents' paediatric healthcare practices

5.1.1 Use of growth charts in monitoring and assessing growth in infants

Overall, about a third of the respondents often plotted and the majority (87.8%) often interpreted growth charts. In addition, over a half identified and treated undernutrition often while the majority (88.7%) did that with confidence (see Table in Annexe 2). Of the growth measures, weight was the most often measured with the highest confidence and highest used; length was moderately measured with high confidence and highly used. However, weight-for-length was fairly measured with high confidence and highly used as a nutrition indicator for wasting, and head circumference was also fairly measured with high confidence and highly used. MUAC was just fairly measured with moderate confidence and fairly highly used; while skinfolds were, the least measured with moderate confidence and moderately used (Table 5.2).

Table 5.2 Use of growth measures by the respondents (N, %) (N = 222)

Growth measure	Often measure	Confidently measure	Often use
Weight	195 (87.8)	214 (96.4)	218 (98.2)
Length	143 (64.4)	192 (86.5)	198 (89.2)
Weight-for-length	117 (52.7)	176 (79.3)	187 (84.2)
Head circumference	119 (53.6)	179 (80.6)	185 (83.3)
MUAC	98 (44.1)	164 (73.9)	170 (76.6)
Skinfolds	56 (25.2)	127 (57.2)	146 (65.8)

MUAC = Mid-upper arm circumference

5.1.2 Referral criteria for nutrition intervention or offer of treatment

Overall, the majority of the respondents indicated that once a child is faltering in weight, there should be a referral for nutrition intervention or offer of treatment, but few responses included the signs of protein energy malnutrition (PEM). For some 126 (56.8%) of the respondents, the criteria for referral or offer of treatment to a child for undernutrition was based on a series of growth measurements taken over time while 86 (38.7%) based it on the use of measurements taken at only one visit. However, 10 (4.5%) of the respondents based it on the two options indicating that it depends on whether the child is being seen for the first time at the clinic.

5.2 Respondents' growth pattern assessment

5.2.1 Results of the plotting exercise on the RTH and WHO charts

The plotting of the given ages with their corresponding weights (2 month-old with a weight of 4.7kg, 4 month-old with a weight of 5.9kg, and 6 month-old with a weight of 7.5kg) mostly recorded, 'correct plotting', fairly 'higher plotting' and least 'lower plotting', with no statistical differences between the chart types (Table 5.3). The WHO charts recorded rather more of 'lower plotting' for weights, but the difference was not significant.

Table 5.3 Categorisation of summary of plots of the given ages and weights on the RTH and WHO charts (N=222)

Plotting category	RTH chart N (%)			WHO chart N (%)			Chi ² P-value
	Lower plotting	Correct plotting	Higher plotting	Lower plotting	Correct plotting	Higher plotting	
Age (months)							
2	8 (3.6)	203 (91.4)	11 (5.0)	6 (2.7)	207 (93.2)	9 (4.1)	1.000
4	10 (4.5)	201 (90.5)	11 (5.0)	7 (3.2)	206 (92.8)	9 (4.1)	0.866
6	6 (2.7)	201 (90.5)	15 (6.8)	8 (3.6)	200 (90.1)	14 (6.3)	0.663
Weight (kg)							
4.7	7 (3.2)	212 (95.5)	3 (1.4)	23 (10.4)	188 (84.7)	11 (5.0)	0.249
5.9	21 (9.5)	199 (89.6)	2 (0.9)	29 (13.1)	190 (85.6)	3 (1.4)	0.298
7.5	2 (0.9)	216 (97.3)	4 (1.8)	18 (8.1)	186 (83.8)	18 (8.1)	0.769

Overall, the majority of the respondents plotted the three ages (2 months, 4 months, and 6 months) and their corresponding weights (4.7kg, 5.9kg and 7.5kg) correctly (without any mistakes on both chart types, thus scoring 100%). However, the RTH chart had significantly more completely correct weight plots than the WHO chart (Table 5.4).

Table 5.4 Total number of correct plots of the given ages and weights on the RTH and WHO charts

Number of correct plots	Age plots N (%)		Chi ² P-value	Weight plots N (%)		Chi ² P-value
	RTH chart	WHO chart		RTH chart	WHO chart	
0/3	10 (4.5)	7 (3.2)	0.419	0 (0.0)	11 (4.9)	<0.0001
1/3	9 (4.1)	4 (1.8)		6 (2.7)	20 (9.0)	
2/3	13 (5.9)	24 (10.8)		27 (12.2)	29 (13.1)	
3/3	190 (85.6)	187 (84.2)		189 (85.1)	162 (73.0)	

Paired-samples T test of association

Overall, the respondents tended to plot the ages and weights better on the RTH than the WHO growth chart since the former was the growth chart in current use in Nigeria during the period of the data collection (Tables 5.5 and 5.6).

Table 5.5 Number of correct plotting of the given ages on the RTH and WHO charts by variable category (N=222)

Variable category	RTH chart N (%)		*Chi ² P-value	WHO chart N (%)		*Chi ² P-value
	N	Correct		N	Correct	
Location						
Hospital-based	173	160 (92.5)	0.880	173	156 (90.2)	0.624
Clinic-based	49	45 (91.8)		49	43 (87.8)	
Profession						
Medical doctor	72	71 (98.6)	0.014	72	66 (91.7)	0.237
Dietitian/Nutritionist	29	28 (96.6)		29	28 (96.6)	
Nurse	121	106 (87.6)		121	105 (86.8)	
Years of Experience						
Low (<5)	61	55 (90.2)	0.966*	61	58 (95.1)	0.022*
Moderate (5 – 10)	59	57 (96.6)		59	55 (93.2)	
High (>10)	102	93 (91.2)		102	86 (84.3)	

*Chi-square trend of association

Table 5.6 Total number of correct plotting of the corresponding weights on the RTH and WHO charts by variable category (N=222)

Variable category	RTH chart N (%)		*Chi ² P-value	WHO chart N (%)		*Chi ² P-value
	N	Correct		N	Correct	
Location						
Hospital-based	173	155 (89.6)	0.255	173	150 (86.7)	0.589
Clinic-based	49	41 (83.7)		49	41 (83.7)	
Profession						
Medical doctor	72	67 (93.1)	0.045	72	65 (90.3)	0.419
Dietitian/Nutritionist	29	28 (96.6)		29	25 (86.2)	
Nurse	121	101 (83.5)		121	101 (83.5)	
Years of Experience						
Low (<5)	61	55 (90.2)	0.196*	61	54 (88.5)	0.093*
Moderate (5 – 10)	59	55 (93.2)		59	55 (93.2)	
High (>10)	102	86 (84.3)		102	82 (80.4)	

*Chi-square trend of association

5.2.2 Application / interpretation of growth trajectories

Ratings of weight gain scenarios by size and chart type according to professional characteristic categories

Overall, the respondents observed a low level of accuracy for slow weight gain and fast weight gain best understood and identified with average size. However, the respondents observed a lower level of accuracy for fast weight gain and slow weight gain best understood and identified with small size (Table 5.7).

Overall, the RTH chart had significantly more completely correct weight plots than the WHO growth chart, and the respondents tended to plot the ages and weights better on the RTH than on the WHO growth chart since the former was the growth chart in current use in Nigeria during the period of the data collection (Table 5.8).

Over two-thirds rated weight faltering and a third rated failure to thrive as slow weight gain while over a third rated catch-up growth as fast weight gain. However, weight faltering was never rated as fast weight gain while half of the respondents rated catch-up growth as slow weight gain (Table 5.9).

The hospital-based respondents were more correct in their rating of the weight gain patterns than the clinic-based respondents, while medical doctors and dietitians/nutritionists were more correct than nurses were. However, the moderately experienced were more correct than the highly experienced respondents were (Table 5.10).

Proposed action to weight gain patterns by size and chart type according to professional characteristic categories

The majority tended not to recognise the need for further action in an infant with slow weight gain, though this was more likely for small-sized children. When presented in the WHO chart format, a higher proportion recognised the need for closer monitoring and referring out for further management. Overall, there was the likelihood of the respondents being worried about a small infant growing fast as an average weight infant growing slowly. The hospital-based respondents were more correct in their proposed actions for weight gain patterns than the clinic-based respondents were, while medical doctors and dietitians/nutritionists more correct than nurses. However, the fairly experienced and moderately experienced were more correct than the highly-experienced respondents (Table 5.11). In summary, the poor ratings of the weight gain patterns that were displayed in the questionnaire led an equally poor application of actions in the management of the affected infants by the respondents.

Table 5.7 Correct ratings of weight gain patterns and proposed actions for weight gain patterns by size N (%)

Size	Weight gain pattern	Correct rating of weight gain pattern	Chi ² P-value	Not worried/ Continue current action	Monitor more/ Refer out	Chi ² P-value
Average	Slow	60 (41.1)	0.592	115 (78.8)	31 (21.2)	0.024
Small		70 (47.0)		100 (67.1)	49 (32.9)	
Average	Steady	59 (39.6)	0.012	130 (87.2)	19 (12.8)	0.614
Small		55 (36.9)		127 (85.2)	22 (14.8)	
Average	Fast	79 (53.0)	<0.0001	140 (94.0)	9 (6.0)	<0.0001
Small		56 (38.4)		116 (79.5)	30 (20.5)	

Table 5.8 Correct ratings of weight gain patterns and proposed actions for weight gain patterns by chart type N (%)

Chart type	Weight gain pattern	Correct rating of weight gain pattern	Chi ² P-value	Not worried/ Continue current action	Monitor more/ Refer out	Chi ² P-value
RTH	Slow	48 (36.9)	<0.0001	124 (57.7)	25 (31.3)	<0.0001
WHO		82 (63.1)		91 (42.3)	55 (68.8)	
RTH	Steady	57 (50.0)	1.000	20 (48.8)	129 (50.2)	0.866
WHO		57 (50.0)		21 (51.2)	128 (49.8)	
RTH	Fast	71 (52.6)	0.328	18 (46.2)	128 (50.0)	0.654
WHO		64 (47.4)		21 (53.8)	128 (50.0)	

Table 5.9 Overall ratings of growth patterns according to weight gain patterns

Rating of growth pattern	Weight gain pattern N (%)				Chi ² P-value
	Slow	Steady	Fast	Total	
Weight faltering	215 (72.9)	80 (27.1)	0 (0.0)	295 (100.0)	<0.0001
Failure to thrive	130 (44.1)	110 (37.3)	55 (18.6)	295 (100.0)	<0.0001
Catch up growth	130 (50.0)	19 (7.3)	111 (42.7)	260 (100.0)	<0.0001

[Correct answers marked in bold]

Table 5.10 Accuracy of ratings of the weight gain patterns scenario and proposed actions according to professional characteristic category N (%)

Variable category	N	Correct rating of weight gain pattern	*Chi ² P-value	Correct proposed action	*Chi ² P-value
Size					
Small	444	185 (41.7)	0.541	207 (46.6)	<0.0001
Average	444	194 (43.7)		386 (86.9)	
Weight Gain Patterns					
Slow	295	130 (44.1)	0.152	80 (27.1)	<0.0001
Steady	298	114 (38.3)		257 (86.2)	
Fast	295	135 (45.8)		256 (86.8)	
Chart Type					
RTH	444	176 (39.6)	0.067	282 (63.5)	0.039
WHO	444	203 (45.7)		311 (70.0)	
Location					
Hospital-based	688	295 (42.9)	0.825	465 (67.7)	0.343
Clinic-based	200	84 (42.0)		128 (64.0)	
Profession					
Medical doctor	288	125 (43.4)	0.317	201 (69.8)	0.273
Dietitian/Nutritionist	116	42 (36.2)		80 (69.0)	
Nurse	484	212 (43.8)		321 (64.5)	
Years of Experience					
Low (<5)	244	116 (47.5)	0.035*	172 (70.5)	0.081*
Moderate (5 – 10)	236	103 (43.6)		160 (67.8)	
High (>10)	408	160 (39.2)		261 (64.0)	

*Chi-square trend of association

5.2.3 Overall accuracy scores

Figure 5.2 and Figure 5.3 show the overall results for all respondents. Table 5.11 shows that chart type and location had no effect on overall accuracy. Slow and fast weight gains were less well recognised than average weight gains. The responses from the medical doctors were more correct, with significant differences between the groups. The responses received from the moderately experienced respondents were most correct.

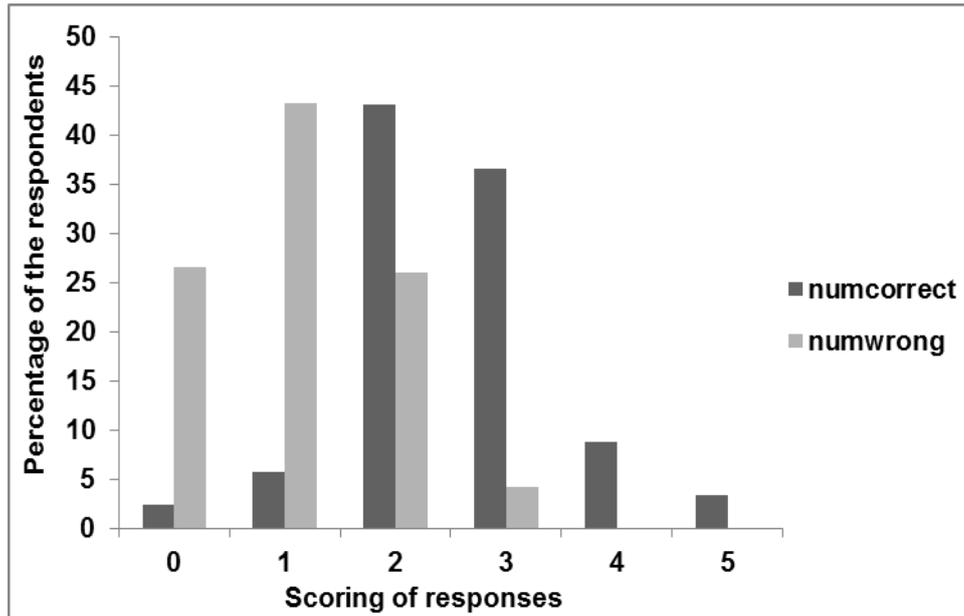


Figure 5.2 Categorisation of response scores

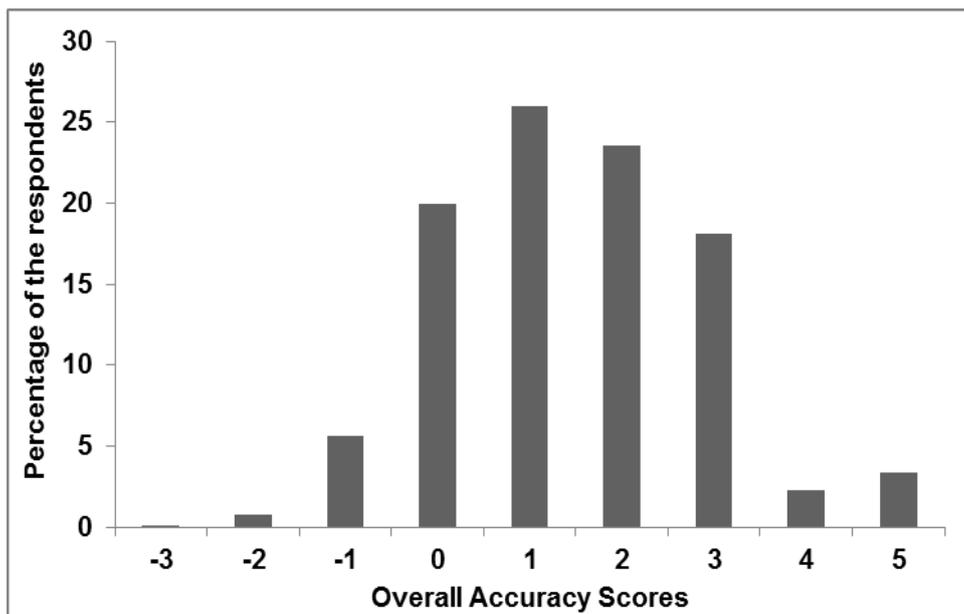


Figure 5.3 Rating of accuracy of response scores

Table 5.11 Overall accuracy scores N (%)

Variable category	Overall accuracy scores			*Chi ² P-value
	Correct (3 to 5)	Partially wrong (0 to 2)	Wrong (-1 to -3)	
Size				
Average	95 (21.4)	226 (50.9)	123 (27.7)	
Small	116 (26.1)	215 (48.4)	113 (25.5)	0.248
Weight gain				
Slow	38 (12.9)	162 (54.9)	95 (32.2)	
Steady	105 (35.2)	139 (46.6)	54 (18.1)	
Fast	68 (23.1)	140 (47.5)	87 (29.5)	<0.0001
Chart Type				
RTH	101 (22.7)	217 (48.9)	126 (28.4)	
WHO	110 (24.8)	224 (50.5)	110 (24.8)	0.454
Location				
Hospital-based	163 (23.7)	348 (50.6)	177 (25.7)	
Clinic-based	48 (24.0)	93 (46.5)	59 (29.5)	0.508
Profession				
Medical doctor	85 (29.5)	149 (51.7)	54 (18.8)	
Dietitian/Nutritionist	23 (19.8)	61 (52.6)	32 (27.6)	
Nurse	103 (21.3)	231 (47.7)	150 (31.0)	0.002
Years of experience				
Low (<5)	57 (23.4)	122 (50.0)	65 (26.6)	
Moderate (5 – 10)	67 (24.8)	122 (51.7)	47 (19.9)	
High (>10)	87 (21.3)	197 (48.3)	124 (30.4)	0.046

*Chi-square trend of association

5.2.4 Respondents' comments on growth charts

Some of the respondents did not make any comment on the growth charts. However, over two-thirds 160 (72.1%) of the respondents commented that the growth charts make an invaluable tool for monitoring infant growth; early detection of undernutrition; and nutrition counselling. Some quotes of the respondents' comments on growth charts included the following:

- 1) "More training and emphasis need to be made to their usage"
- 2) "The growth chart is a good method of assessing growth in children and in fact the most powerful tool"
- 3) "It is not only health professionals that should know about the growth chart, every parent should be aware of it and be taught how to plot it"
- 4) "Growth charts are very important for mothers for them to know when their child's growth is deviating"

5.2.5 Respondents' general comments

Overall, over two-thirds 153 (68.9%) of the respondents made general comments which appreciated and commended the structure/purpose of the questionnaire, the researcher and her interesting but scarce area of research. The survey was received as a challenge to paediatric healthcare practice and a great test of knowledge of health staff, which triggered the readiness to be trained and re-trained for effectiveness in the use of growth charts. The respondents requested for the findings of the survey to be made available to health staff; the introduction of the WHO growth charts in Nigerian hospitals and clinics; and the sensitisation of health staff to maximise the use of growth charts. Some quotes from the respondents' general comments included the following:

- 1) "I appreciate your effort in embarking on this type of study. I strongly believe that if the result is well utilised, it will go a long way in alleviating the problem of undernutrition in infants in Nigeria"
- 2) "During antenatal care, pregnant mothers should know the need for well-baby clinic. The graph should be made as simple as possible so that mothers can plot the graph easily and also detect deviation from normal and report promptly"
- 3) "The questionnaire is so educative, interesting and brain storming. I give a bravo to the researcher, though this questionnaire should not only be for the professionals, mothers should be conversant with the weights of their babies"

5.3 Discussion

The set objectives of this survey were to determine how growth charts are used to detect childhood undernutrition, determine the accuracy in plotting and rating/applying/interpreting weight gain patterns shown on the two growth charts for appropriate action, and test the understanding of growth trajectories displayed on charts.

5.2.6 Main findings

- Most of the respondents were hospital-based, half were nurses, and half were highly experienced
- About a third of the respondents often plotted and the majority often interpreted growth charts, and over a half identified and treated undernutrition often while the majority did that with confidence. Over two-thirds of the respondents commented that the growth charts make an invaluable tool for monitoring infant growth, early detection of undernutrition, and nutrition counselling
- For the majority of the respondents, the criteria for referral or offer of treatment to a child for undernutrition was based on the use of series of measurements
- The respondents tended to plot the ages and weights better on the RTH than the WHO chart (since the former was the growth chart in current use in Nigeria during the period of the data collection)
- The hospital-based respondents were more correct in their rating of the weight gain patterns than the clinic-based respondents
- Ratings of the displayed weight gain patterns was generally poor with an equally poor judgments on respondents' proposed management of the affected infants
- Slow and fast weight gains were less well recognised than average weight gains, the responses from the medical doctors were more correct and the responses received from the less experienced respondents were most correct
- The overall accuracy on considering the plotting exercise, rating of weight gain patterns, and proposed actions, shows a trend towards better performance by the less experienced respondents

Respondent characteristics

The respondents to the survey were mostly hospital-based and highly experienced professionally, because of the calibre/categories of the health staff approached with the questionnaire and the inclusion of referral hospitals at the locations. These respondent characteristics are different from that reported from the few documented health staff studies conducted in African countries. For example, a study in Kenya by Mutoro and Wright (2013) reported responses from healthcare workers, most of who had minimal training, working in community and private hospitals, and mostly fairly experienced professionally. A survey of nurses working at the primary healthcare level in South Africa showed that although over half of them were highly experienced professionally, they had poor knowledge of growth monitoring (Kitenge and Govender, 2014).

Use of growth charts in infants

Health staff responses showed an overall high frequency in their plotting and using growth charts in identifying and treating undernutrition in infants. The growth chart was also highly appreciated as an invaluable tool for monitoring infant growth, early detection of undernutrition, and nutrition counselling. Previous investigations on the use of growth charts focussed on mothers and carers rather than health staff. However, results from studies on health staff use of growth charts in assessing and monitoring the growth of children has been reported ineffective in identifying early childhood undernutrition (Waitzberg et al., 2001). Some workers (Wright, 2002) had attributed the major cause to poor understanding, application and interpretation of growth patterns. Other investigators attributed it to lack of interest and low competency (Griffiths et al., 1996), and poor practice in the application and interpretation of growth charts (Imdad et al., 2011b). The use of particular growth charts has raised some issues in accepting or opting for alternatives, particularly in developing countries. Several factors seem to contribute to the effectiveness of one growth chart against another in identifying infants and children at risk for undernutrition. For example, the 0.5 kg-intervals in the calibrations of the RTH growth chart posed a difficulty in identifying the actual slope of the growth curve, particularly when there is a minor downward trend. This deficiency in the format of the RTH chart adversely influenced health staff plotting of weight measurements and applying and interpreting growth patterns to identify infants at risk for undernutrition. Reports from the developing world confirm this problem: Kenya (Mutoro and Wright, 2013), across Africa (de Onis et al., 2004), Lesotho (Ruel et al., 1991), South Africa (Thandrayen and Saloojee,

2010), and Somalia (Qayad, 2005). These observed deficiencies in the RTH chart are among others which were reported by earlier workers and these provided guidance for the constructing of the WHO growth chart using an improved format (de Onis et al., 2004). Similarly, a study in the UK demonstrated that improving the format of a chart tended to improve the precision of judgement made about weight gain in infancy (Wright et al., 1998).

Referral criteria for nutrition intervention or offer of treatment

The WHO guideline recommends that children identified as severely undernourished be assessed with full clinical examination to confirm the presence of appetite for food and any medical complications (World Health Organisation, 2013). Children who have appetite and therefore are clinically well and alert should be treated as outpatients, while those who have medical complications, severe oedema, or poor appetite should be treated as inpatients. However, the current survey majorly recorded a criterion for referral or offer of treatment to a child for undernutrition based on the use of series of measurements, with few responses based on referral on both serial measurements and measurement at one visit dependent on seeing the child for the first time at the clinic. An opposite was reported from a similar study conducted among healthcare workers in Kenya (Mutoro and Wright, 2013). The Integrated Management of Childhood Illnesses (IMCI) Initiative developed in 1992, jointly promoted by the WHO and UNICEF with the broad strategy to reduce child mortality, morbidity in developing countries recommended that all children be weighed, and their weights plotted on the weight-for-age chart. However, Shrimpton and colleagues assert that a preference for assessing weight-for-age rather than the adequacy of growth velocity is based on the recognition that often the sick child comes to a health facility without having any previous recorded weight with which to compare the current status (Shrimpton, 2012). Moreover, an assessment of the influence of growth charts on healthcare workers' clinical decisions about infants younger than 6 months, reported that favourable growth trend rather than a single measurement showed no difference in concern, referral, or feeding advice (Ahmad et al., 2014). Those investigators warn that inappropriate referrals for undernutrition in this population may increase and adversely affect EBF when using the WHO-based growth charts in developing countries. Thus, suggesting the need for clinical orientation, therefore, advocating improved training for health staff on the implementation and interpretation of WHO-based growth charts using their accompanying guidelines and training materials that recognise and address this possible effect.

Plotting of the given ages/weights of infants by chart types

The overall greater tendency of respondents' plotting of the given ages and weights better on the RTH than on the WHO growth chart suggests familiarity since the former was the growth chart in current use in Nigeria during the period of the data collection. To assess growth, which is an important marker of nutrition and health, there is need for accuracy in plotting of measurements on growth charts. Therefore, it is interesting that the low level of inaccuracies in plotting on the growth chart observed in the current survey contrasts the high levels observed elsewhere in the developing world – 40% reported across Africa (de Onis and Blossner (2003), and 69% reported in Kenya (Mutoro and Wright (2013). Furthermore, health staff in Lesotho were shown to have exhibited poor knowledge and skills in the use of growth charts (Ruel et al. (1991), and plotting of weights and interpretation on the RTH charts were observed to be unsatisfactory at public healthcare clinics in Johannesburg, South Africa (Thandrayen and Saloojee, 2010). Remarkably, the very high level of accuracy recorded in the correct plotting of the given ages and weights suggest that the respondents in the current survey an equally high knowledge of growth charts. However, the type of errors (mainly non-systematic errors) observed in the plotting exercise suggests the influence of distractions during the exercise by the respondents, which may have been the effect of their busy schedules of duty. Similarly, Cooney and colleagues highlighted sources of the errors detected in plotting growth charts such as miscalculation of the age of the child and misreading the scale along the appropriate axis (Cooney et al., 1994). On the other hand, a survey in the UK assessing the possible impact of new design features on health staff plotting and interpretation of growth charts, identified high levels of plotting inaccuracy on two chart formats, with about two-thirds of the respondents making at least one major mistake (Wright et al., 2010). Therefore, Charlton and colleagues demonstrated that frequent training improves health staff accuracy of plotting on the growth chart. During that investigation, the majority of the health staff, including 100% from the trained and 50% from the untrained health facilities, respectively and 47.4% of the community health workers correctly completed the weight-for-age chart (Charlton et al., 2009).

Ratings of weight gain patterns and effect of size

The recorded low level of accuracy in rating of slow weight gain, particularly in an average-sized child in the current survey, suggests that the respondents tended to recognise the extremes of each size category, thereby misclassifying the scenarios and growth patterns by size most of the time. The bold dots of the weights plotted against the ages on the growth charts contained in the questionnaire depicted the presentations of the scenarios very clearly. However, it seems that the several ratings of the growth patterns on the Likert scale tended to have created some double-mindedness in the respondents as regards the most appropriate choice to make. The observed inability of the health staff to appreciate the difference between size and weight gain and rather steady growth, particularly in average sized infants is consistent with the findings from a survey of healthcare workers in Kenya (Wright and Mutoro, 2012). Similarly, the observed misclassification of infants and underestimation of undernutrition in infants had earlier been reported among maternal and child health clinic workers in Somalia (Qayad, 2005). More widely, the United Nations regional classification of the findings from the assessment of problems encountered by healthcare workers, reported the difficulty in interpreting the child's growth curves as the first in the list with the majority recording for the African geographical region (de Onis et al., 2004). The problem of not understanding the concept of a child 'at risk' was also implicated in that report.

The interpretation of growth patterns displayed on charts had earlier been highlighted to be difficult even for postgraduate doctors and therefore posing a technical challenge for healthcare workers (Morley, 1994). For example, the findings from a study conducted in the UK revealed that on self-assessment, over half of the primary care doctors felt unable to detect normal growth while less than two-thirds of the paediatricians felt competent in detecting abnormal growth (Wallace and Kosmala-Anderson, 2006). Similarly, a health staff survey in the UK reported that the minority of the participants failed to recognise abnormal and normal growth patterns, suggestive of no formal training in chart use (Wright et al., 2010). Therefore, frequent use and frequent training of health staff has been demonstrated to improve the interpretation of growth charts by health staff (Charlton et al., 2009). That comparative investigation recorded 84%, 75% and 37% correct interpretation of the growth curve for the community health workers, health staff working at trained and untrained health facilities, respectively.

Ratings of weight gain scenarios and growth patterns, by chart type

The respondents' tendency to better recognise slow weight gain as weight faltering or failure to thrive on the WHO chart format and fast weight gain as catch-up growth better on the RTH chart format suggests chart format deficiency. For example, the errors recorded during the data analysis showed that the 0.5 kg-intervals on the RTH chart appear to have posed a difficulty for respondents in identifying the actual slope of the growth curve, particularly when there is a minor downward trend. This problem had been reported from the developing world, where the RTH is the commonly used growth chart: Lesotho (Ruel et al., 1991), across Africa (de Onis et al., 2004), Somalia (Qayad, 2005), South Africa (Thandrayen and Saloojee, 2010), and Kenya (Mutoro and Wright, 2013). Thus, making chart format deficiency a contributory factor among earlier workers' reports that provided guidance for the constructing of the WHO growth chart using an improved format (de Onis et al., 2004). Similarly, a study in the UK demonstrated that improving the format of a chart tended to improve the precision of judgement made about weight gain in infancy (Wright et al., 1998). However, using the WHO growth chart to assess healthcare workers' interpretation of low weight-for-age plot showed that insufficient account was taken of linear growth trend, clinical and feeding status in undernourished infants younger than 6 months (Ahmad et al., 2014).

Proposed actions for weight gain scenarios, by size and chart type

The majority of the respondents in the current survey tended not to have recognised the need for further action in an infant with slow weight gain, but when plotted on the WHO growth chart a higher proportion recognised the need for closer monitoring and referring out for further management. However, the result of the assessment of the weight gain patterns should be a guide to the appropriate actions for any observed abnormalities in the weight gain of an infant. Therefore, the respondents' inability to identify slow weight gain and weight faltering or failure to thrive by size and chart type reflected in some inappropriate proposed actions. Small size and the format of the WHO chart tends to depict clearer pictures of the weight gain scenarios which enabled informed decisions from around a third of the respondents who proposed to monitor more and refer out an infant with slow weight gain. This proposed action is consistent with the report on child growth monitoring worldwide that described the types of action taken by health staff in case of growth faltering. Those reported action-ratings included hospital referrals (65%), nutrition advice (60%), investigation of the causes of growth faltering (25%), closer follow-up of

growth performance (24%), direct medical care (24%), and home visits (8%) (de Onis et al., 2004).

Overall accuracy scores

The results from the current study show that the application and interpretation of growth trajectories in infants was generally badly done, with the majority of the respondents wrong in all of the ratings and applications. However, the highly experienced respondents were less correct in chart plotting compared to the fairly and moderately experienced health staff and less accurate in interpretation overall. The possible reason for this unexpected finding is that the less experienced health staff would have been more recently trained with more-up-to-date robust training materials (for example the WHO training materials) and the more experienced health staff tend to be less clinically active. This suggests the need for health staff continuing professional development, particularly with increase in years of service, to avoid redundancy in healthcare practice resulting from getting more involved in administrative duties. Disparity in paediatric health knowledge among the categories of health staff surveyed could have affected the performance of the lower cadre of health staff. Hence, the better performance of the medical doctors/residents above the other cadres of health staff surveyed, suggesting the individual assessment of the different categories in future research. Similarly, future surveys should consider health facilities according to their levels of healthcare delivery.

5.2.7 Strengths of the study

Including the WHO growth chart in the structure of the self-completion questionnaire used in the current survey makes it stand out in the comparison of the effects of the old and new charts. The three versions of the self-completion questionnaire displayed infant sizes that varied according to weight gains, and growth patterns on the RTH and WHO chart formats. The permuted design allowed each respondent to answer questions and rate their agreement on the growth patterns displayed by the two scenarios on the RTH and WHO chart formats. The questions tested the respondents' knowledge of varied infant sizes with weight gain patterns (slow, steady and fast) and growth patterns (weight faltering; failure to thrive; catch-up growth). Therefore, each respondent viewed four charts displaying either of the following sets of scenarios on two RTH and two WHO chart formats. Not excluding any category of health staff, kept the sample size and the power of the study robust. The support and cooperation of the management of the representative health

facilities enabled the researcher and her assistant to collect the data with precision. Some of the respondents, particularly the medical doctors expressed excitement over the straightforwardness and clarity of the format of the WHO growth chart and were eager to see it introduced into the paediatric healthcare system of Nigeria. Therefore, the results from the current study present an evidence base for recommending the introduction of the WHO growth chart in Nigeria.

5.2.8 Limitations of the methods

- 1) The administration of a structured questionnaire creates an unnatural situation that may alienate respondents and using this instrument to obtain self-reported information may be inaccurate or incomplete. Therefore, eleven of the 233 copies of the self-completion questionnaire handed out to the surveyed health staff by the researcher were not returned. Moreover, not completing the self-administered questionnaire in a workshop setting gave room for distractions to the responding health staff, which resulted in evitable errors and incompleteness in their responses.
- 2) Being a novel study in Nigeria, there were some oversights to some minute details in the planning of the survey. For example, how to organise the diverse health professional groups located over the vast area covered in the investigation was not considered. Therefore, the wide distances travelled daily by the researcher in order to reach the health staff in their different health facilities in the large area called Enugu city adversely affected her speed and efficiency in completing the other studies contained in her time-bound project.
- 3) Approaching the health staff was not so smooth, even with the assistance of my Nigerian supervisor who is a Senior Consultant Paediatrician at the UNTH, Enugu. Although the researcher attended the paediatric mortality conference sessions at the tertiary health institutions where she was introduced to the health staff, the non-availability of such a common forum at the government-controlled health facilities hindered the process at those locations. However, the collection of 222 out of the 233 copies of the self-completion questionnaire issued to the health staff that consented to participate in the survey was really a labour-intensive task for the researcher.
- 4) The nature and tight schedules of the health staff that responded to the questionnaire appeared to have affected their carefulness and thoughtfulness in its completion, thus reflecting in the observed inconsistencies. However, the response to the questionnaire is not equivalent to the actual practice of the respondents;

therefore, the correlations produced between their responses and actual practice may mask or ignore underlying causes or realities.

- 5) The bulkiness of the questionnaire, including two consent forms appeared to have scared most of the health staff at first sight, but with a closer view, the interesting substance of the questionnaire motivated the respondents to the study.
- 6) The limit of calibrations of weights on the RTH growth chart to 0.5-kilogram intervals would have posed some difficulty in plotting the given weights with lower intervals correctly, but in fact, accuracy levels were good.
- 7) Several ratings of the growth patterns on the Likert scale tended to have created some double mindedness in the respondents as regards the most appropriate choice to make.
- 8) Missing out live paediatric situations makes the survey of health staff more theoretical than practical. Interpreting graphs in a theoretical exercise is not usually the same as when interpreting “in the field”, when there are many patients to see, and clinical and social factors play a major role in decision-making.

5.2.9 Reliability of the data collected

The appreciable size of the current survey sample of varied cadre of health professionals (medical doctors mainly paediatric residents, dietitians/nutritionists and nurses mostly working in paediatric areas) with varied years of experiences dictated the reliability and accuracy of the results. In addition, the chosen levels (tertiary, secondary and primary) of healthcare facilities spread across Enugu city (North, South, East and West) contributed to the representativeness of the target population, giving credence to the data collected. The very high rate of response to the self-completion questionnaire highly reduced the non-response bias to the barest minimum. Therefore, the results are robust from investigating health staff understanding, application, and interpretation of growth patterns in detecting early childhood undernutrition in Enugu city, Nigeria.

5.3 Conclusion from the study

Most growth measures (except weight and length) were not so frequently used by health staff, suggesting that the other measures may only be employed when investigating extreme nutritional abnormalities and for research purposes. Although, the respondents highly self-reported plotting and interpreting growth charts, low accuracy was observed in recognising and worrying about slow weight gain, particularly with average size. Growth trajectories were better understood and interpreted on the WHO than RTH growth chart format, and most correctly so by doctors and moderately experienced respondents. Furthermore, the respondents poorly associated specific growth patterns with different growth syndromes such as weight faltering, failure to thrive or catch-up growth yielded wrong proposed actions. The significant disparity between health staff's intention to use growth trajectories displayed on growth charts to detect undernutrition in early infancy and their knowledge suggests a need for education based on the WHO-GCS. In addition, a significant barrier to using growth charts is lack of hospital policy and inappropriate or out-dated policy. These findings present a challenge for health facilities, therefore suggesting policy making towards periodic quality training for health staff on growth monitoring towards effective application/interpretation of growth patterns in detecting undernutrition in early infancy. Introduction of the new WHO growth charts is highly recommended as the basis of a standardised protocol for the suggested health staff training. Remarkably, contributions from this study to knowledge in the developing world setting include:

- Effectiveness of using three scenarios, two growth charts, and two infant sizes (3x2x2 design) to investigate the health staff use of growth charts in infants
- Evidence-based recommendation for the introduction of the WHO growth chart format in Nigeria

CHAPTER 6 GENERAL DISCUSSIONS AND RECOMMENDATIONS

6.1 Key findings and quality of the evidence from the research project

6.1.1 Key findings

Weight gain pattern in the infants younger than six months

The steady weight gain recorded in the healthy infants, increased in the first half and decreased in the second half of the first six months of life, suggesting a normal growth pattern comparable to the WHO-CGS when the rate of weight gain of healthy infants compared with that of their hospitalised peers. A quarter of the hospitalised infants had subnormal weight gain and 89% showed a decline in CWG since birth. This is suggestive of the effect of morbidity factors on weight gain in the infants, consistent with earlier reports from Africa (Wamani et al., 2006, Sawadogo et al., 2008).

Nutritional risk factors found in the hospitalised infants

The commonest reasons for admission to hospital were sepsis and respiratory tract disorders, as earlier reported among Nigerian infants (Ibeziako and Ibekwe, 2002, Chukwu et al., 2013). The very young infants admitted for neonatal problems were more at risk for undernutrition, suggestive of the influence of perinatal factors (Wamani et al., 2006, Joosten et al., 2010, Olusanya and Renner, 2011). Suboptimal breastfeeding and complementary feeding was a suggested risk for undernutrition in the hospitalised infants, though there was not the expected strong association. Hospitalised infants may have poorer feeding practice because of their poor medical conditions (Sawadogo et al., 2008, Black et al., 2013). However, sub-optimal infant feeding patterns – non-exclusivity, short duration of breastfeeding, and early introduction of complementary feeds – are prevalent in developing countries like Nigeria (Nwankwo, 2002, Uchendu et al., 2009, Ukegbu et al., 2010, Olusanya et al., 2010, Agho et al., 2011, Ubesie et al., 2012, Uvere and Ene-Obong, 2013, Ocheke et al., 2014).

Estimation of undernutrition in the hospitalised infants

Applying the SGNA showed an overall low risk for undernutrition, particularly in the infants admitted younger than 14 days. In contrast, using the crude MUAC (<110mm) and sum of skinfolds (WHO criteria/iPYMS reference) case definitions to generate undernutrition prevalence ranged between 54.8% and 36.4 % /38.1 %, respectively. This suggests that a wide range of prevalence figures for hospital undernutrition exist because of the non-availability of an internationally-accepted criterion for diagnosing undernutrition (Norman et al., 2008). However, applying different thresholds/measures in the current project showed that CWG appeared to be more specific than skinfolds or BMI, in detecting undernutrition. Moreover, the sum of skinfolds could be used as secondary assessment to MUAC specifically to detect wasting (Burden et al., 2005, Briend et al., 2012).

Health staff use of growth charts in infants

Despite an above average self-reported use of growth charts, health staff showed poor recognition of slow weight gains with average size indicate an overall poor practice, confirming previous reports (Wright, 2002, Charlton et al., 2009, Thandrayen and Saloojee, 2010). Moreover, poor health staff association of specific growth patterns often suggest wrong proposed actions (Wallace and Kosmala-Anderson, 2006, Wright et al., 2010, Wright and Mutoro, 2012, Ahmad et al., 2014). The format of the RTH growth chart tended to create a difficulty for health staff to identify slow weight gain while that of the WHO growth chart depicts a clearer picture of growth patterns. This suggests that improving the format of the chart could improve the precision of judgement made about weight gain in infancy (Wright et al., 1998, Mutoro and Wright, 2013). However, lack of motivation and empowerment in the health staff posed a hindrance to the actual practice in the use of growth charts. Therefore, the training of health staff on growth patterns of infants and children would improve the use of growth charts (Charlton et al., 2009, Wright et al., 2010, Ahmad et al., 2014).

6.1.2 Relevance of the employed approach

Generally, the effects of undernutrition are less felt in developed countries than in developing countries, particularly in sub-Saharan Africa, where it contributes highly to the death of under-5 children. The reported population-based undernutrition prevalence rates in this population were low and depended on the methods and quality of the tools/measures employed by the studies. It suggests the need for a holistic approach in a clinical setting to reveal the nutritional state of infants younger than 6 months, particularly the hospitalised infants. Therefore, the employed approach of this research project generated three datasets through the application of complex tools/measures to investigate the problem of undernutrition in this population:

- 1) A normative dataset from compiling the weight velocity of healthy infants, and later transforming the data in relation to the WHO-CGS
- 2) A comparative dataset from using a reference of the weight velocity of the healthy infants to compare that of their hospitalised peers
- 3) A health staff dataset from exploring health staff use of growth patterns to identify undernutrition in young infants

The results from this research project show a picture of the situation of child health services at the study location, which could prompt policy makers, clinicians, dietitians/nutritionists, and health administrators into action to improve the nutrition and health of infants and children. This is in conformity with the evidence argued by other investigators towards the importance of not overlooking, but preventing and managing undernutrition in infants younger than 6 months (Kerac et al., 2015). In addition, the generated datasets are set baselines for further research that would contribute evidence-based strategies to forestall the effects of undernutrition on child health in Nigeria. Overall, the blending of the different methods that constitute this approach, enhanced the effectiveness of the individual methods in identifying nutrition risks in the hospitalised infants. Although the correlative nature of the study design makes its findings (though few), more suggestive than definitive, they nonetheless add to the growing literature on undernutrition in the first six months of life and its possible association with child health and growth.

6.1.3 Significance of the research project

First, nutrition and growth status during the first six months of life should be of great concern since this period falls within the critical time of particular risk for undernutrition and growth failure (Black et al., 2013), irrespective of breastfeeding status (Patwari et al., 2015). Moreover, the high rate of mortality and morbidity associated with undernutrition in this population creates a public health problem worldwide, particularly in developing countries. Hence, outcomes of assessment of the nutrition and growth provide informed decisions towards evolving effective strategies for tackling the problem of undernutrition in this population, for example, prompt referrals for effective treatment and management of cases. Second, nutrition recommendations and interventions focus on children aged 6 – 60 months while neglecting infants younger than 6 months, particularly in developing countries (Patwari et al., 2015). Nonetheless, results from investigations could provide evidence to make attention to this vulnerable group imperative. Just like taking a cue from the MAMI project that stimulated international interest and made a key recommendation for this population in the new 2013 WHO guideline on the management of SAM (World Health Organisation, 2013). Third, addressing the scarcity of disease prevalence data in infants younger than 6 months, particularly hospitalised infants, could provide better and novel ways of detecting undernutrition in this population. Thus, providing evidence for generating and periodically updating normative and disease-prevalence datasets, and enhancing periodic training for paediatric health staff on growth chart use in detecting undernutrition in this population. Finally, as baseline data for health professionals and scientists to carry knowledge even further in the future, results from such a venture could trigger the much-needed studies in child health nutrition, particularly in developing countries.

6.2 Tackling the problem of undernutrition in early infancy

6.2.1 Preventing undernutrition in early infancy

Of utmost interest is the need to develop effective evidence-based strategies for creating awareness of the prevalence of undernutrition in infants, geared towards its prevention. First, adapt health policies and programmes that target the first six months of life, to reduce the incidence of growth faltering, micronutrient deficiencies, and infectious diseases (Bryce et al., 2005, Victora et al., 2010, Black et al., 2013). Second, undertake EBF promotion interventions, to target severe wasting in this population (Becker et al., 2011, Allen, 2012, Lim et al., 2012, Black et al., 2013). Results from a prospective cohort study at the IWC, UNTH, Enugu, demonstrated the effectiveness of individual maternal breastfeeding counselling in promoting EBF and subsequent infant growth, with a record of 38.3% EBF and infant growth above the NCHS/WHO reference (Ezeofor, 2005). Other researchers, however, showed that combining individual and group counselling is more effective (Imdad et al., 2011a). A systematic review further recorded a greater decrease in 'no breastfeeding' rates and suggested an ideal motivating strategy: combining individual with group counselling for lactating mothers to continue breastfeeding (Haroon et al., 2013). On the other hand, maternal factors may also influence breastfeeding success suggesting the need for other strategies. For example, maternal undernutrition could be a contributory factor (Bhutta et al., 2013), as an important determinant of infant growth failure (Shrimpton, 2012). Therefore, suggesting nutritional rehabilitation for the undernourished mother to ensure the success and sustainability of the practice of breastfeeding her infant to promote its growth. Furthermore, a behavioural change communication to mothers could dispel traditional beliefs and cultural practices, thus proffering a holistic solution to the problem.

Third, implement nutrition education through governmental and non-governmental health services within and outside health facilities (that is community-based) for increased effectiveness and sustainability (Turyashemerwa et al., 2009). Fourth, improve the structure of training programmes for paediatric health staff on the use of growth patterns to identify nutrition-related abnormalities in early infancy (Charlton et al., 2009, Wright et al., 2010, Ahmad et al., 2014). Finally, incorporate mandatory nutrition screening of infants at admission and during hospital stay into the policies of health facilities towards early interventions for the identified cases of undernutrition, to forestall complications and

shorten the length of hospital stay (Marino et al., 2006, Secker and Jeejeebhoy, 2007, Secker and Jeejeebhoy, 2012, Benyera and Hyera, 2013). On the other hand, improving child healthcare could contribute to the early detection and management of poor nutritional status from properly documented nutrition and growth records. For example, undernutrition could be predicted using the feeding and growth information contained in a mother held personal child health record (PCHR) booklet used in the UK, rather than the current Nigerian mother-held immunisation card. PCHR is a record of a child's growth, development, and uptake of preventive health services in the UK, designed to enhance communication between parents and health professionals. PCHR is endorsed in the UK National Service Framework for Children and has potential benefits, which extend beyond the direct care of individual children. Overall, the record is found to be retained and used by a high proportion of all mothers throughout the UK in their child's first year of life (Walton et al., 2006). Moreover, an appropriate indicator (for example, MUAC-for-age) could be included in both growth monitoring programmes and integrated management of childhood illnesses to allow a more effective diagnosis of acute malnutrition. This could enable early detection of cases of SAM before complications arise and while cheap outpatient treatment is possible (Collins et al., 2006a). Furthermore, placing more legislation on newborn/child nutrition and child health policies could enforce the mandatory use of growth charts in the prevention, diagnosis, management, and surveillance of nutrition and health-related problems of infants (0 – 6 months old).

6.2.2 Making a correct diagnosis of undernutrition in infants

Increasing the accuracy of nutritional assessment could reduce the challenges of child healthcare practice, particularly in developing countries. The better the diagnosis, the faster and better the infant can be directed to treatment services. Therefore, making the correct diagnosis of undernutrition during nutrition screening at paediatric admission to hospital is of paramount importance. An evaluation of growth trajectories displayed on a growth chart depicting slow weight gain or inadequate weight gain or growth failure, could add important information in making a diagnosis of undernutrition (Joosten and Hulst, 2011). Supporting materials could help present the message better, for example, health educational posters (pictorial displays) containing simplified descriptions of a normal against an abnormal growth pattern that highlight nutrition risks to prompt seeking medical attention for an affected infant (Mwangome et al., 2015). Hence, the growth chart becomes a veritable tool for educating mothers/carers on the consequences of illness on child nutrition and growth. However, the overall poor practice of the surveyed paediatric health staff in growth chart use as part of evidence-proof for introducing the WHO growth charts, suggests the urgency of training for proficiency in WHO-based growth monitoring and identification of infants with nutrition risk.

Therefore, the current project recommends that intensive study and practical experiences should be specified on the WHO-CGS in the academic curriculum of health professional students in universities, schools of nursing, midwifery, and community health officers' training schools as well as medical/health professional registration programmes. This could sensitise health professionals towards the adoption of the WHO-CGS in Nigeria. Prior to this adoption, health staff should be trained using standardised and high quality course materials, for example, using the WHO Child Growth Assessment Course Director's Guide (World Health Organization, 2008). This will make the use of the WHO-CGS effective in the proper classification of infants into their different nutritional states. In addition, making manuals on the use of the new WHO growth charts available, to guide individual health professionals (Dietitians of Canada et al., 2010a) in all hospitals and health centres.

Furthermore, health staff should be motivated and empowered using periodic standardised WHO-evidence-based training to:

- 1) Develop and strengthen the skills and attitudes needed for effective growth monitoring
- 2) Offer intensive practical training in weighing, plotting, interpretation of growth patterns and counselling mothers
- 3) Evolve a simple methodology and develop support materials for health staff training in growth monitoring

Moreover, medical/health professionals of all categories could be sensitised using workshops and seminars towards the implementation of GMP programmes with use of the WHO growth charts. Furthermore, online evaluation surveys on the use of growth charts could be feasible, after ensuring health staff training for proficiency in computer appreciation and internet utility as well as availability of functional computers and accessories.

6.2.3 Practicality and “real world” potential of the various tools/measures used for detecting undernutrition

Although there are presently no criteria for choosing one nutritional screening tool over the other, a paediatrician’s choice depends on the availability of resources and dietetic staff (Huysentruyt et al., 2013). Therefore, it is practicable for paediatric healthcare professionals in a tertiary level referral hospital, even in a developing world setting, to use various tools/measures to detect childhood undernutrition. The current research project has demonstrated through its results that combining a screening tool with anthropometric indicators could identify infants with nutrition risk. The use of a validated screening tool, for example, the SGNA (Secker and Jeejeebhoy, 2007) determines whether an individual meets threshold criteria for undernutrition, thus pointing towards actual diagnosis of undernutrition in infants. On the other hand, applying a single anthropometric measure (for example, MUAC) could be helpful though there is a need for further measurements afterwards. For example, the paediatrician at the clinic uses anthropometric indicators to make a diagnosis and refers any undernourished infant to the clinical dietitian-nutritionist who employs the SGNA in conducting a more detailed nutrition assessment towards providing medical nutrition therapy. However, this procedure could be problematic in the community setting considering the issues arising with the availability of complex measuring equipment, funds, time, personnel, and skills required. Nonetheless, clinicians diagnosing reported growth-faltering problems in a hospital setting would benefit from

using several tools with higher specificity so that ‘false’ positives would not result in unnecessary inpatient admission.

Moreover, infants with morbidity have higher nutrition risk and mortality risk and therefore need more thorough screening and management. Hence, results from the current project show that using field measures (low MUAC-for-age, low weight-for-length, and low weight-for-age Z-scores) are more sensitive while using clinical measures (low CWG, low BMI, and low sum of skinfolds) are more specific. It is not good practice to use a screening method to identify more than 30% of children undernourished. However, the use of clinical measures that capture more undernourished infants is feasible in a hospital setting with the availability of management resources, including complex tools/measures. The use of field measures, particularly MUAC is more cost-effective in the community since management resources are limited there. However, it is not practical for paediatric health staff to calculate, chart, and interpret Z-scores, without the existence of an electronic health records system. This suggests the need for an automated system that calculates and creates a table, for listing and integrating these measures into the hospital electronic medical records (Damiani et al., 2015). Furthermore, initial and update training for paediatric health staff on the operations and use of the automated system would ensure routine use of these measures as part of assessment process of infants.

6.2.4 Supporting lactation in individual hospitalised infants

Earlier investigations in Nigeria reported diverse but similar reasons commonly given by mothers as obstacles to their practicing EBF. The reasons include: ‘insufficient breastmilk’ (37%)/‘the socio-cultural practice of giving water to infants because of hot climate’ (33.1%)/others (29.9%) include ‘mother’s breastmilk is of poor quality’ and ‘baby is not gaining weight adequately’ (Aghaji, 2002). ‘Baby is not satisfied with breastmilk only’ (53.6%)/‘mother cannot express breastmilk for feeding baby when she is not available’ (39.3%)/‘breastfeeding is stressful’ (36.6%)/‘breastfeeding is time consuming’ (33.9%)/‘Insufficient breastmilk’ (25.9%) (Ezeofor, 2005). ‘Insufficient breastmilk’ (58.3%)/‘family pressure influence on very young mothers’ (11.8%)/‘Mother feels that baby is not gaining weight’ (11%) (Uchendu et al., 2009). ‘Breastmilk needs supplementation with artificial formula for fast growth and health of infants’ (66%)/‘Insufficient breastmilk (10%) (Ekanem et al., 2012). ‘Baby continues to be hungry after breastfeeding’ (29%)/‘fear of baby becoming addicted to breastmilk’ (26%)/pressure from mother-in-law’ (25%)/‘maternal breast pains’ (25%) and ‘mother returning to work’ (24%)

(Agunbiade and Ogunleye, 2012). ‘Breastmilk alone will not satisfy a child’s hunger’ (62.8%)/‘child will not grow well or be sickly’ (23.2%) (Nwankwo, 2002).

Undertaking a detailed interview with any mother whose infant is not growing adequately, could reveal the probable cause in relation to feeding. First, ascertain that this mother has had vitamin A supplementation within 6 – 8 weeks postpartum, for onward transmission via breastmilk to her infant to support growth and prevent morbidity (WHO/UNICEF/IVACG, 1997). Other preventive measures include routine immunisations of the infant against communicable diseases, provision of warmth to the infant through enhanced mother-infant contact, and maintenance of clean and healthy nipples for safe and successful breastfeeding. Second, ensuring the initiation and maintenance of breastfeeding and lactation, including postnatal support with the assistance of a nurse/midwife trained in BHFI-modelled lactation management. Thus, increasing exclusivity and duration of breastfeeding to promote optimal growth and protect against morbidity in the infant (Kramer et al., 2001).

Third, ensuring that the infant breastfeeds more frequently throughout the day and night, with each session lasting for longer period to enable the infant to capture the hind milk that is higher in energy density than the foremilk, for increased fat deposition. Fourth, counselling the mother on breastfeeding, including practical demonstration of the technique of correct positioning and attaching the infant to the breast, to ensure successful breastfeeding sessions. Fifth, attaching this mother to another mother who had succeeded in exclusively breastfeeding at least a child in the past, or to a peer breastfeeding counsellor or/and any breastfeeding support group, if any of these exist in her community or workplace. A workplace crèche (where it is available) would offer more support to reduce stress in the working mother. In addition, educating individual family members, particularly the father of the infant could get them actively involved in supporting breastfeeding (Mwangome et al., 2010, Maycock et al., 2013).

However, results from the current project show that breastfeeding was not such a major risk factor as might be expected, possibly because there was supplementation of breastfeeds for many infants due to their illness. The poor health of the hospitalised infants determined both their breastfeeding pattern and growth, instead of their breastfeeding pattern determining their growth. Therefore, the hospitalised infants who were at moderate and high risk for undernutrition were less likely to be exclusively breastfed and had inadequate growth.

6.2.5 Promoting and supporting breastfeeding in paediatric wards

There is a need to increase the exclusivity and duration of breastfeeding, in order to maximise the all-encompassing benefits of optimal infant feeding, including growth in hospitalised infants. Therefore, hospital managers should provide adequate funding for the provision and maintenance of modern equipment for handling expressed-breastmilk, and motivation of paediatric health staff through training to promote and support in-hospital breastfeeding. In addition, the hospital management should celebrate the yearly ‘World Breastfeeding Week’ with organised ‘baby shows’ that use special awards to motivate mothers who are rated by paediatric health staff to have optimally breastfed their infants in hospital. Such awards should be backed with financial benefits and/or packages of infant-care products that could act as incentive to increase breastfeeding rates in hospital and after discharge from hospital. Furthermore, paediatric health staff could use a good hospital-controlled baby crèche to teach working mothers how to continue breastfeeding despite their busy schedules after hospital discharge of their infants.

Basic and update training for paediatric wards’ health staff on the practice of the UNICEF/BFHI ‘Ten Steps for Successful Breastfeeding’ could improve their knowledge, attitude, and practices, and subsequently improve breastfeeding, particularly EBF rates. In turn, BFHI-skilled paediatric wards’ health staff would influence mothers of hospitalised infants through breastfeeding education, including demonstrations and counselling to boost mothers’ efforts towards continued breastfeeding. Using the UNICEF 18-hour course that include practical sessions and counselling skills was effective in changing poor hospital practices, knowledge of health workers and increasing breastfeeding rates at discharge and up to 6 months (Cattaneo and Buzzetti, 2001). A multidisciplinary team of experts recommended expanding the BFHI programme by formulating a specific breastfeeding policy to meet the special needs of preterm and sick infants who require neonatal intensive care (Nyqvist et al., 2013). That early, continuous, and prolonged skin-to-skin contact (Kangaroo mother care method), early initiation of breastfeeding is facilitated; and mothers have access to breastfeeding support during their infants’ whole hospital stay, while her own milk or donor milk (when available) is the optimal infant nutrition. However, there was neither a neonatal intensive care unit nor a breastmilk bank at the UNTH, Enugu, at the time of data collection for the current research project. Therefore, establishing a neonatal intensive care unit may be central to effective interventions in this population. In addition, the hospital management could embark on public enlightenment to address the

cultural problem of parental non-acceptance of donor breastmilk for feeding their hospitalised infants in that locality.

Paediatric wards' health staff should promote and sustain EBF through demonstrating breastmilk-expressing techniques (using hand-express or hands-on-pump or electric pumps) to breastfeeding mothers, in order to ensure continuous infant feeding with breastmilk, even in circumstances that hinder direct breastfeeding. In addition, paediatric wards' health staff should ensure the proper sterilisation of expressed-breastmilk receiving, storing and feeding utensils, to prevent the microbial contamination of breastmilk that will cause gastroenteritis in the neonates. Moreover, the paediatric health staff should educate mothers on how to use easily cleanable or disposable (when affordable) cups and spoons instead of feeding bottles in feeding their infants with expressed breastmilk. The hospital pharmacy personnel should constantly supply sterilising tablets/solutions to the paediatric wards and the maintenance unit should ensure the good functioning of the steel refrigerators used for safe and hygienic storage of the expressed breastmilk. Furthermore, the implementation of a hospital payment policy for breastmilk substitutes could expose breastfeeding mothers to more 'baby friendly' steps. An investigation on the effect of implementing a hospital payment policy for breastmilk substitutes reported that breastfeeding initiation within the first hour increased from 28.7% to 45%, in-hospital EBF rates increased from 17.9% to 41.4%, and the risk of breastfeeding cessation reduced by 8% (Tarrant et al., 2015).

Paediatric wards' health staff should teach and enhance mother-infant contact using the Kangaroo skin-to-skin contact method to provide warmth and nurture to clinically stable infants in the neonatal unit. Staff supervision of maternal cuddling of their infants to provide warmth and directly breastfeed or feed them with expressed breastmilk in specially prepared rooms within the neonatal unit could motivate mothers, thus improving EBF rates. A systematic review evaluated randomised controlled trials that used the Kangaroo skin-to-skin contact method, and reported increased duration of breastfeeding and improved EBF rates prior to hospital discharge (Renfrew et al., 2009). Paediatric wards' health staff should provide education and support towards re-lactating mothers who had earlier stopped breastfeeding their hospitalised infants. In addition, individual counselling of breastfeeding mothers by paediatric health staff should include consideration for infants with special needs, as well as peer and lactation consultant support for continued breastfeeding after discharge. Studies that used peer and lactation consultant support to provide education and support for breastfeeding mothers in hospital and after discharge,

recorded increase in the number of infants receiving their own mother's milk in hospital and after discharge (Renfrew et al., 2009). Furthermore, the paediatric wards' discharge programme should include adequate preparation of parents, information about access to lactation and breastfeeding support (both professional and peer support), and plan for continued follow-up could ensure continuation of EBF up to 6 months.

Overall, hospital organisation of paediatric ward care through acquisition of hospital BFHI accreditation could increase the implementation of the 'Ten steps for better breastfeeding' support services and better breastfeeding outcomes. An institutional-level evaluation corroborated previous findings in demonstrating that increasing the implementation of the BFHI is associated with increased breastfeeding practice (Rosenberg et al., 2008). In addition, hospital introduction of an evidence-based breastfeeding support learning collaborative programme (where it is feasible) could be a motivational tool for health facilities to keep improving their breastfeeding support practices. On facilitating the implementation of the BFHI, participating hospital staff in a breastfeeding support learning collaborative programme received the benefits of other participating sites' excellent experience as a motivation to keep working hard towards implementing evidence-based breastfeeding practices (Freney et al., 2015).

6.2.6 Implications of the findings of the current research project

Child health policy makers' awareness of the problem of undernutrition in young infants would attract the inclusion of this population in the national public health policy developments. All hospitals would screen and treat infants who are undernourished or at risk for undernutrition on admission, to improve the standard of childcare. Screening for nutrition risks and diagnosis of undernutrition in infants would be integrated into child healthcare rather than standing alone. This move would improve surveillance and case finding of infants with SAM as well as make additional efforts at treating SAM as a medical emergency. Moreover, clinicians' awareness of these categories of infants would prompt early optimisation of nutrition support to forestall or rectify the poor nutritional status that delays recovery from underlying disease. Furthermore, periodic WHO-guidelines-enhanced training for health staff would ensure proficiency in growth chart use for detecting early childhood undernutrition. Finally, the motivated and empowered health staff would in turn appropriately educate mothers/carers on ways of identifying and preventing growth faltering in this population.

Researchers could use and later modify the template provided by the current research project to generate normative and disease-prevalent datasets in infants younger than 6 months. First, compiling a normative dataset should only include the exclusively breastfed healthy infants, thus applying the WHO-MGRS approach to make it a true normative dataset. Subsequently, the research units of the individual state ministries of health could compile and regularly updated population representative electronic databases of growth and breastfeeding patterns of healthy breastfed infants. Second, either excluding infants younger than one month or studying only the neonates could make convincing inferences on the nutritional status of hospitalised infants. Third, using a structured interviewer-administered feeding questionnaire and applying all anthropometric measures (not only weight) would generate feeding and growth information from both healthy and hospitalised infants. Fourth, employing both maternal (including socio-demographic, educational, and economic), and infant (including gestational, perinatal, and postnatal) risk factors in predicting undernutrition in early infancy. Fifth, using a structured interviewer-administered questionnaire to elicit information on infant feeding practices among mothers/carers could identify the relationship between risk factors (such as no breastfeeding, infant formula feeding, and partial breastfeeding) and maternal occupation, education, socioeconomic status, parity, type of delivery. Sixth, embarking on multicentre

projects could suggest overall representative population across Nigeria because of the existence of ethnic and cultural diversities that reflect on child care, particularly infant feeding. Seventh, conducting health staff surveys on growth chart use in workshop settings could ensure on-the-spot completion and submission of the questionnaire. Moreover, operational research could adopt the approach of the current research project to generate data for teaching medical and health professionals in Nigerian university hospitals.

6.3 Positioning the data from the current research project

6.3.1 Contributions to the WHO guidelines for the treatment of SAM

The data from the current project contributes to the evidence for adopting the WHO recommendations for the prevention and treatment of SAM in infants younger than 6 months. The recorded undernutrition prevalence rate of 30% in the hospitalised infants suggest that nutrition intervention to forestall further deterioration in nutritional status is imperative. Although the project was conducted in a tertiary referral hospital setting, the result gives a glimpse of the infant nutritional situation in the community served by that hospital. Therefore, supporting community-based care for uncomplicated SAM and recommending inpatient treatment for infants with complicated SAM for stabilisation and appropriate treatment of infections, fluid management, and dietary therapy, allows more affected infants to be reached and is cost-effective (World Health Organisation, 2013). Eventually, an estimated 15% of cases of SAM will need initial hospital-based care, while the rest can recover with only community-based care (Collins et al., 2006b). Moreover, considering the recorded poor practice of the surveyed paediatric health staff, suggests the urgency of training them using the WHO-guideline-based materials to ensure the proper implementation of the WHO guidelines for the treatment of SAM. Enforcing all these could contribute to the impact of the practice of the WHO guidelines for the effective management of infants with SAM, particularly infants younger than 6 months in Nigeria. However, the current research project recommends that the awareness about SAM and CMAM services should be improved, in order to address this most important barrier preventing access to treatment among caregivers, particularly in the most affected communities in Nigeria.

6.3.2 Contributions to the SUN movement

Nigeria is among the SUN countries that are working towards delivering progress and action to scale up nutrition in the first 1,000 days of life, empowering women at every level through improved literacy, socioeconomic status, and access to healthcare and spaced childbirths remains the core focus. Therefore, to tackle the problem of early stunting, the evidence from the current research project could lead to developments in advocacy, commitment building, and partnership alignment for young child nutrition in Nigeria. Thus, contributing to the SUN movement towards a 40% reduction in the number of stunted children by 2025 (Pelletier and Peltó, 2013). Professionals/researchers including paediatricians and child health practitioners, nutrition and dietetics professionals, lactation management specialists, nurses, and midwives could collaborate with business, governmental, non-governmental and donor agencies. The stakeholders could collaborate to form a strong well-informed advocacy aiming to help policy makers prioritise, plan and make informed decisions on resource allocation for nutrition in the national budget.

Using the data from research, such as the current project, could stimulate awareness of early childhood undernutrition issues in both the community and clinical setting, in order to provide better care. Moreover, the reported undernutrition prevalence rate in relation to morbidity in infants could stimulate mothers' determined effort to practice EBF up to 6 months postpartum, irrespective of their infant's health status. Hence, promoting optimal growth and development, and reducing the risk and effect of morbidity, in order to forestall the effects of undernutrition, particularly stunting in infants. Using coherently aligned approaches in a politically enabled, resource-supported environment, and adhering to best practices, the stakeholders could contribute towards improving infant nutrition. For example, ensuring GMP in infants and offering health/nutrition/breastfeeding education to mothers, including promotion of workplace breastfeeding. Furthermore, the stakeholders could directly invest in scaling up nutrition through in-hospital interventions, such as exclusive breastfeeding promotion and nutrition screening/assessment followed with treatment of severe undernutrition in hospitalised infants as part of the preventive process.

6.3.3 Scaling up the findings of the research project for use in practice

The evidence-proven strategies evolving from the current project could be a boost to scaling up coverage of hospital-based nutrition programmes, targeting an accessible group at high risk. The interventions that focus on the first 1000 day-window period of opportunity include:

- 1) Assessing weight gain patterns based on individual infant birthweight for both healthy and hospitalised infants (although this may take a long time to compute a conditional-weight-gain table for use at the clinics and wards), to make an invaluable contribution to effective infant healthcare.
- 2) SGNA-rated screening of all infants on admission to hospital so that the undernourished infants can receive appropriate nutrition interventions provided by a multidisciplinary nutrition team, to prevent further deterioration of their nutritional status, shorten hospital stay and improve health outcomes
- 3) Combining anthropometric measures with other method(s) in order to increase the number of infants identified with nutrition risk and referred for either outpatient or inpatient management.
- 4) Periodic health staff training on the use of growth patterns of infants displayed on growth charts, for early detection and prompt treatment of undernutrition in this population.
- 5) Finally, scaling-up the management of SAM through adequate government funding for hospital-based treatment of severe undernutrition as part of routine health and nutrition services delivery, could contribute to the surveillance system for monitoring trends in nutritional status of the children of that locality.

6.4 Conclusions

The growth of young healthy Nigerian infants fit the WHO-CGS well and the SGNA-rated nutrition risk is low, but other measures suggest undernutrition in up to one third of the hospitalised infants. However, the poor growth observed in the hospitalised infants suggests the effect of faulty breastfeeding patterns in relation to their diverse morbidities. Moreover, the observed high rates of infant formula supplementation at the NBSCU of the UNTH, Enugu, resulted from nursing all neonates together in a unit using the same feeding regimen whether preterm, sick or healthy neonates under observation for medical reasons. This finding leads to the hypothesis that suboptimal breastfeeding patterns might be the cause of undernutrition in early infancy. Furthermore, poor health staff use of growth charts as practical tools, suggests the need to enhance proficiency through training using the WHO-guideline-based materials.

Appendices

Annexe 1: Search terms used for the review of the literature

Annexe 2: Non-critical supporting data

Appendix A: Documents used for the Infant Welfare Clinic Study

A.1 Information sheet for mothers or carers

A.2 Consent form for mothers or carers

Appendix B: Documents used for the Hospital Ward Study

B.1 Information sheet for main carer

B.2 Consent form for main carer

B.3 Paediatric SGNA Questionnaire

Appendix C: Documents used for the Health Staff Study

C.1 Information sheet for Health Staff

C.2 Consent form for Health Staff

C.3 Health Staff Questionnaire A

C.4 Health Staff Questionnaire B

C.5 Health Staff Questionnaire C

Appendix D.1 iPYMS Local Reference for the Comparison of Skinfolts

1. Subscapular skinfolts
2. Triceps skinfolts

Appendix E.1 Nigerian Road-to-Health Chart

Appendix E.2 Data Collecting Form for the Infant Welfare Clinic Study

Annexe 1

Search terms used for the review of the literature

Search for the literature utilised the following subject and text word terms either singly or in combination using the Boolean operators:

- early infancy, neonates, infant(s), early childhood, childhood, children, postnatal period, neonatal period, hospitalised infant(s), hospitalised children
- undernutrition, malnutrition, prevalence nutritional assessment, nutritional status, growth assessment, breastfeeding pattern(s), poor growth, slow growth, low weight gain, weight gain pattern(s), postnatal weight gain, morbidity
- growth chart(s), use of growth chart(s), health professional(s), health worker(s), health staff survey(s), understanding of growth chart(s), comprehension of growth chart(s), application of growth charts(s), interpretation of growth chart(s), health knowledge/attitudes /practices, developed countries, developing countries, Nigeria

OR	AND/OR	AND/OR
early infancy	undernutrition	growth chart(s)
neonates	malnutrition	use of growth chart(s)
infant(s)	prevalence	health professional(s)
early childhood	nutritional assessment	health worker(s)
childhood	nutritional status	health staff survey(s)
children	growth assessment	understanding of growth chart(s)
postnatal period	breastfeeding pattern(s)	comprehension of growth chart(s)
neonatal period	poor growth	application of growth chart(s)
hospitalised infant(s)	slow growth	interpretation of growth chart(s)
hospitalised children	low weight gain	health knowledge/attitudes /practices
	weight gain pattern(s)	developed countries
	postnatal weight gain	developing countries
	morbidity	Nigeria

Annexe 2

Non-critical supporting data

Cut-off for the conditional weight change in the healthy infants (N=411)

Empirically observed percentile	Age at assessment/Conditional weight change		
	6 weeks (n=400)	3 months n=391)	6 months (n=307)
1	-2.7	-3.4	-3.6
5	-1.9	-2.1	-2.2
10	-1.5	-1.6	-1.8

Weight gains in the hospitalised infants (N = 119)

Weight gain percentile	Expected percentile	Observed values N (%)	Relative risk
≤ 1	1	10 (8.4)	8.4
1 – 5	4	17 (14.3)	2.7
5 – 10	5	14 (11.8)	2.4
> 10	90	78 (65.5)	0.7

Frequency of growth chart use by the respondents (N=222)

Variable category	N (%)
Respondents' practice	
Often plot charts	71 (32.0)
Often interpret charts	195 (87.8)
Often identify undernutrition	112 (50.5)
Often treat undernutrition	113 (50.9)
Respondents' attitude	
Confidently treat undernutrition	197 (88.7)

Appendix A.1 Information Sheet for the Infant Welfare Clinic Study



Information Sheet for Mothers or Caregivers

Study Title: Documentation of a population representative dataset of the growth patterns of infants at the University of Nigeria Teaching Hospital (UNTH) Enugu.

This would be achieved by the compilation of the weight measurements of infants attending the Infant Welfare Clinic at the Institute of Child Health, University of Nigeria Teaching Hospital (UNTH) Enugu.

What is the purpose of the study?

To find out how infants normally grow in our environment and compare them with those sick infants on the paediatric wards of the UNTH, Enugu.

Why has my infant been chosen?

Your infant was chosen for this study because he/she has been attending the Infant Welfare Clinic at the Institute of Child Health, University of Nigeria Teaching Hospital (UNTH) Enugu.

Do we have to take part?

No. It is up to you to decide whether to take part. If you decide to take part you will be asked to sign a form that will say that you have been informed about the study and you are happy to participate.

What do we have to do?

If you decide to participate in the study, you will be asked to allow the researcher to copy your infant's weight measurements contained in his/her immunisation card.

Are there any risks or disadvantages of taking part?

We do not anticipate any major risk of disadvantages of taking part in this study. Your infant's immunisation card will immediately be given back to you intact.

Are there any possible benefits of taking part?

The information we get from this study will help us to improve the health of infants.

Will my infant's participation in this study be kept confidential?

Yes. Any information about your infant, which leaves the hospital, will have his/her name and address removed so that he/she cannot be identified by it.

What will happen to the results of the research study?

The results of this study will be presented to managers of the hospital and other staff in UNTH, Enugu. The results of the study are likely to be reported to scientific meetings or published in scientific journals, but without identifying your name or other data able to identify your infant.

Who is organising the study?

The study is organized by the Paediatric Epidemiology and Child Health (PEACH) Unit, Royal Hospital for Sick Children, Yorkhill in Glasgow, which is part of the University of Glasgow and a researcher from the UNTH, Enugu.

The study has approval from the Medical Research Ethics Committee of the UNTH, Enugu.

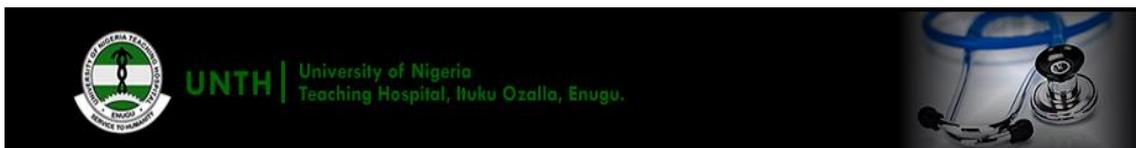
For further information, you can get in contact with:

Ifeyinwa O. Ezeofor: PhD researcher: +44 (0) 141 232 1884;
i.ezeofor.1@research.gla.ac.uk

Professor Charlotte Wright: Professor in Community Child Health: +44 (0) 141 201 6927

Dr Ada Garcia: Lecturer in Human Nutrition: +44 (0) 141 201 0570

Appendix A.2 Consent Form for the Infant Welfare Study



CONSENT FORM FOR MOTHER OR CAREGIVER

Study title: Documentation of a population representative dataset of the growth patterns of infants at the University of Nigeria Teaching Hospital (UNTH), Enugu.

Initials Please

I confirm that I have read and understood the information sheet dated **28/10/2011** for the above study and have had the opportunity to ask questions.

I understand that the participation is voluntary and that we are free to withdraw or not complete parts of the study at any time, without giving any reason, without medical care or legal rights being affected.

I understand that sections of any of my infant's medical notes (not parent's notes) relevant to this study may be looked at by the researchers involved in this study. I give permission for these individuals to have access to my records.

I agree to take part in the above study.

_____	_____	_____
Name of Guardian	Date	Signature
_____	_____	_____
Researcher	Date	Signature

1 for patient; 1 for researcher; 1 to be kept with hospital notes

Appendix B.1 Information Sheet for the Hospital Ward Study



Information Sheet for Main Carer

Study Title: How well does growth and feeding information predict later undernutrition in infants (0 – 26 weeks old) with morbidity?

Your infant and you are being invited to take part in a study. Before you decide it is important for you to understand why the research is being done and what it will involve. Ask us if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

Poor growth in infants (0 – 26 weeks old) had been overlooked because it is assumed that the infant is getting the best nutrition from being fully breastfed at this age. This is even made worse when a disease shows up and also the infant's poor growth not being found out by the use of growth charts. These call for finding ways of using feeding and growth information better in finding out poor growth infants (0 – 26 weeks old) before they fall sick.

Why has my child been chosen?

Your infant was chosen for this study because he/she has been admitted to the paediatric ward of the University of Nigeria Teaching Hospital (UNTH), Enugu.

Do we have to take part?

No. It is up to you to decide whether to take part. If you decide to take part, you will be asked to sign a form that says that you have been informed about the study and you are happy to participate. You are still free to withdraw at any time and without giving a reason. A decision to withdraw at any time, or a decision not to take part, will not affect the standard of care that your infant receives.

What do we have to do?

If you decide to participate in the study, you will be asked to complete a questionnaire about your infant's eating and diet and weight gain before admission.

After that, the researcher will measure:

1. Your infant's **weight, length, head circumference and mid-upper arm circumference**
2. The **thickness of the skin and fat** on his/her arm and shoulder blade with a special instrument. Your infant has to take off his/her top wears for that.

These measurements would take about 20 minutes to complete.

Are there any risks or disadvantages of taking part?

We do not anticipate any major risk of disadvantages of taking part in this study. If your infant becomes very upset or uncooperative with any of them we will not continue with that measurement.

Are there any possible benefits of taking part?

If the measurements or your answers suggest that your infant is at risk of becoming undernourished we will let your clinical team know so they can refer him/her for further assessment or treatment. The information we get from this study will help us to improve infant's health treatment.

Will my infant's participation in this study be kept confidential?

Yes. Any information about your infant, which leaves the hospital, will have his/her name and address removed so that he/she cannot be recognised from it. However, we will let the clinical team looking after you in hospital know all the measurement results, as these may help their clinical assessment.

What will happen to the results of the research study?

The results of this study will be presented to management and staff of the hospital. These results are likely to be reported at scientific meetings or published in scientific journals, but without identifying your infant's name or other data able to identify your infant.

Who is organising the study?

The study is organised by the Paediatric Epidemiology and Child Health (PEACH) Unit, Royal Hospital for Sick Children, Yorkhill in Glasgow, which is part of the University of Glasgow, Scotland and a researcher from the UNTH, Enugu.

The study has approval from the Medical Research Ethics Committee of the UNTH, Enugu.

For further information, you can get in contact with:

Ifeyinwa O. Ezeofor, PhD D researcher: +44 (0) 141 232 1884;
i.ezeofor.1@research.gla.ac.uk

Professor Charlotte Wright: Professor in Community Child Health: +44 (0) 141 201 6927

Dr Ada Garcia: Lecturer in Human Nutrition: +44 (0) 141 201 0570

Appendix B.3 Paediatric SGNA Questionnaire



SGNA QUESTIONNAIRE – INFANTS/TODDLERS

1. a) What type of milk do you give your baby/toddler? (Please check all that apply)

Breastmilk

Formula

Cow's (or goat's) milk → whole fat, 3.25% fat 2% 1% skim

Other kind of milk (explain)

b) How do you feed milk to your baby/toddler? (Please check all that apply)

Breastfeed

Bottle feed

Cup

Feeding tube

2. **Breastfeeding**

Is this your first time breastfeeding? No Yes

Do you alternate the breast that you start each feed with? No Yes

How many times in a 24 hour period do you breastfeed your baby/toddler?

How long does it usually take to breastfeed your baby/toddler? _____
(in minutes)

How do you recognize that your baby/toddler is hungry?

Full? _____

Do you have any concerns related to breast-feeding? No Yes (explain) _____

3. **Bottle-feeding or Tube-feeding**

What is the name of your baby's feeding or formula?

How do you make the feeding or formula? (What are the amounts of expressed breastmilk or formula, water, other things you add?)

How many times in a 24 hour period do you feed your baby/toddler?

What is the average amount that your baby/toddler takes at each feeding? _____ (in ounces or mL)

How long does it usually take to feed your baby/toddler? _____
(in minutes)

g) Do you have any concerns related to bottle or tube-feeding? No Yes
(Explain) _____

Cow's Milk or Other Kinds of Milk

What is the average amount of milk that your baby/toddler drinks in a day? _____ (in ounces or ml)

4. Do you give your baby/toddler other things to drink?

No

Yes → please fill out the chart below:

© Ifeyinwa Obiageli Ezeofor 2015

I give my baby/toddler:	How much of these things does your baby/toddler drink each day? (in ounces or mL)
<input type="checkbox"/> water	
<input type="checkbox"/> fruit juice or fruit drinks	
<input type="checkbox"/> herbal drinks	
<input type="checkbox"/> pop	
<input type="checkbox"/> other (explain)_____	

5. a) What kinds of food does your baby/toddler eat each day?: (please check all that apply)

	Size of the portion eaten
<input type="checkbox"/> cereals and grains (like baby cereal, breakfast cereal, bread, rice, pasta)	
<input type="checkbox"/> vegetables and fruit	
<input type="checkbox"/> meat, fish, chicken, or alternatives (like eggs, tofu, lentils, legumes)	
<input type="checkbox"/> milk products (like cheese, yogurt, pudding, ice cream)	

b) What is the texture of the foods your baby/toddler eats?

- Jarred baby food or homemade foods put in a blender (this is called “pureed”)
 Chopped into tiny pieces the size of ground meat (this is called “minced”, like hamburger meat)
 Cut into small pieces or cubes (this is called “diced”)

6. a) Please pick the word that best describes your baby’s/toddler’s appetite?

- Excellent good fair poor

b) Compared to your infant’s/toddler’s usual intake, has your infant’s/toddler’s intake changed recently?

- No
 Yes → Has it: Increased? Decreased?

How long has it been since it changed? _____ (in days, weeks, or months)

7. Do any of the following feeding or eating problems affect your infant/toddler’s intake?

(Please check all that apply)	No	Yes
Problems with sucking, swallowing, chewing, or biting		
Crying, choking, coughing, gagging, or retching during a meal or at the sight of food or a bottle		
Refusing to eat by hiding the chin in the shoulder, arching the back, biting on the spoon, etc.		
Refusing to swallow food		
Refusing to eat food if it has little pieces or chunks in it (a fear or dislike of food with textures)		
Food allergies, intolerances, special diets: (specify)_____		
Other: (specify)_____		

8. Is anyone else in your family on a special diet?

- No
 Yes → (explain)

Is your baby/toddler also on this diet? No Yes

9. Does your baby/toddler currently have any gastrointestinal problems *that restrict his/her drinking or eating*? (Please check for each problem)

Problem	Never or Almost Never	Every 2-3 days	Daily	How long has your baby/toddler had this problem?	
				< 2 weeks	≥ 2 weeks
Lack or loss of appetite (anorexia)					
Throwing up (vomiting/reflux)					
Diarrhoea					
Constipation					

10. a) Please pick the word that best describes your baby's/toddler's amount of energy or activity?

- High average low

Compared to your baby's/toddler's usual amount of energy or activity, has it changed recently?

- No
 Yes → Has it: Increased? Decreased?

How long has it been since it increased or decreased? _____ (in days, weeks or months)

11. a) How much did your baby/toddler weigh at birth? _____

How long (or tall) was your baby/toddler at birth? _____

When was the last time your baby/toddler was measured by a health professional?

How much does your baby/toddler weigh? _____

How long (or tall) is your baby/toddler? _____

How tall is your/your child's: mother? : _____ father? : _____

PHYSICAL EXAMINATION – INFANTS/TODDLERS

The physical exam supports and adds to findings obtained by the history. Observe areas where adipose tissue and muscle mass are normally present to determine if significant losses have occurred.

WASTING

A lack of adipose tissue indicates severe energy deficit. Are the facial cheeks full and the face round or is the buccal fat reduced and the face flat and narrow? Are the arms full and round and is it difficult to lift folds of skin from the elbow or triceps area, or is the skin loose and easily grasped and pulled away from the elbow or triceps? Is the chest full and round with the ribs not evident, or is there progressive prominence of the ribs with obvious loss of intercostal tissue? Are the gluteal fat pads of the buttocks full and round or is there almost no evident gluteal fat of the buttocks and the skin is deeply wrinkled? Are the legs full and round or are they thin with the skin loose at the thigh and calf?

Site	No Wasting	Moderate Wasting	Severe Wasting
Temple			
Facial cheeks			
Arms			
Chest			
Buttocks			
Legs			

OEDEMA (nutrition-related)

The presence of pitting oedema at the ankles or over the sacrum may indicate hypoproteinemia; however, coexisting disease (i.e. renal, congestive heart failure) modifies the implication of the findings. The presence of oedema should also be considered when evaluating weight change.

Site	Absent	Moderate	Severe
Sacral area (infants or toddlers that are constantly lying down)			
Foot; ankles (mobile infant and toddlers)			

Other physical signs that were observed that are suggestive of malnutrition:

Appendix C.1 Information Sheet for the Health Staff Study



Information Sheet for Health Staff

Study Title: Health staff understanding and application/interpretation of growth charts in identifying undernutrition of infants (0 – 26 weeks old) in Enugu City, Nigeria

You are being invited to take part in a study. Before you decide it is important for you to understand why the research is being done and what it will involve. Ask us if there is anything that is not clear or if you would like more information.

What is the purpose of the study?

Growth charts are complex clinical tools that are, at present, poorly understood and inconsistently used. Undernutrition in infants within the WHO recommended exclusive breastfeeding age (0 – 26 weeks old) had been neglected. This is even confounded by an underlying disease and the ineffective application/interpretation of growth charts in identifying undernutrition in early infancy. There is need to explore the use of growth patterns to identify different nutritional states (including acute illness) by health staff. The purpose of this study is to estimate how health staff understand and apply/interpret growth charts.

Why have I been chosen?

You were chosen for this study because you are one of the members of the health team who should be able to identify and treat undernutrition in infants (0 – 26 weeks old).

Do we have to take part?

No. It is up to you to decide whether to take part. If you decide to take part you will be asked to sign a form that says that you have been informed about the study and you are happy to participate.

What do I have to do?

If you decide to participate in the study, you will be asked to complete a questionnaire about your knowledge, attitude and practice of the use of growth charts in identifying undernutrition in infants (0 – 26 weeks old).

After that, the researcher will issue you with a copy of the questionnaire, which should take about 20 minutes to complete.

Are there any risks or disadvantages of taking part?

We do not anticipate any major risk or disadvantages of taking part in this study. Your identity will not be disclosed to any third party.

Are there any possible benefits of taking part?

Testing the understanding and application/interpretation of growth charts by health staff would help identify the peculiar problematic areas in the use of growth charts in

identifying undernutrition in infants (0 – 26 weeks old). Identifying this missing link would be a guide to improving the quality of training for health staff on growth monitoring and the effective application/interpretation of growth charts in identifying undernutrition in infants (0 – 26 weeks old). Eventually, health staff would impact this knowledge on mothers/carers of infants (0 – 26 weeks old) through nutrition and health counselling.

Will my participation in this study be kept confidential?

Yes. Any information about you, which leaves the hospital, will have your name and address removed so that you cannot be identified by it.

What will happen to the results of the research study?

The results of the study are likely to be reported to scientific meetings or published in scientific journals, but without identifying your name or other data able to identify your infant.

Who is organising the study?

The study is organized by the Paediatric Epidemiology and Child Health (PEACH) Unit, Royal Hospital for Sick Children, Yorkhill in Glasgow, which is part of the University of Glasgow and a researcher from the University of Nigeria Teaching Hospital (UNTH), Enugu.

The study has approval from the Medical Research Ethics Committee of the UNTH, Enugu.

For further information you can get in contact with:

Ifeyinwa O. Ezeofor, PhD researcher: +44 (0) 141 232 1884;
i.ezeofor.1@research.gla.ac.uk

Professor Charlotte Wright: Professor in Community Child Health: +44 (0) 141 201 6927

Dr Ada Garcia: Lecturer in Human Nutrition: +44 (0) 141 201 0570

Appendix C.2 Consent Form for the Health Staff Study



CONSENT FORM FOR HEALTH STAFF

Study title: **Health staff understanding and application/interpretation of growth charts in identifying undernutrition of infants (0 – 26 weeks old) in Enugu City, Nigeria.**

Initials Please

I confirm that I have read and understood the information sheet dated **28/10/2011** for the above study and have had the opportunity to ask questions.

I understand that the participation is voluntary and that we are free to withdraw or not complete parts of the study at any time, without giving any reason, without medical care or legal rights being affected.

I agree to take part in the above study.

_____	_____	_____
Name of Health Staff	Date	Signature
_____	_____	_____
Researcher	Date	Signature

1 for patient; 1 for researcher

Appendix C.3 Health Staff Questionnaire A



Introduction

I am a PhD researcher from the University of Glasgow, Scotland, United Kingdom. I am collecting data on health staff understanding and use/interpretation of growth charts.

The ineffective use of growth charts in identifying undernutrition in early infancy is thought to be the major cause of poor prediction of later undernutrition in infants (0 – 26 weeks old) using growth and feeding information. Therefore, the aim of this investigation is to estimate how health staff understand and use/interpret growth charts and growth monitoring.

The questionnaire should take only 15 – 20 minutes to complete and is meant to represent what happens in real life when a child is brought to your health facility.

You will be asked to look through a series of short case studies with plotted charts and give your opinion on the child's growth pattern and what advice you would give to the family. The information provided would be anonymous and confidential. There are three versions of the questionnaire.

If you have any queries about the investigation contact the undersigned.

Ifeyinwa O. Ezeofor
Researcher

Q version A

Location

Date of assessment

What is your profession?

Years in practice	<5 years	5 -10 years	>10 years
Medical Doctor (please categorise)			
Nutritionist-Dietitian (please categorise)			
Nutritionist (please categorise)			
Nursing officer (please categorise)			
Health educator (please categorise)			
Health visitor (please categorise)			
Other (Specify):			

How often do you plot or look at growth charts?

Every day / Every week / Every month / Less often

How confident do you feel about interpreting growth charts?

Very confident / Fairly confident / Not very confident / Not at all confident

How often would you identify under nutrition in a child?

Every day / Every week / Every month / Less often

How often would you treat under nutrition in a child?

Every day / Every week / Every month / Less often

How confident do you feel about this?

Very confident / Fairly confident / Not very confident / Not at all confident

The table below shows different anthropometric measures used to assess undernutrition. For each method, please tick one answer in each column that applies to you

Anthropometric measures	How often do you measure / calculate	How confident are you about interpreting this?	How useful do you find this?
Weight	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Length/Height	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Weight-for-length/height	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Head circumference	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Mid-Upper Arm Circumference	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Skinfold Thickness	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Other (Specify):			

Could you briefly describe when a child should be referred for (or offered) treatment for undernutrition?

Do you usually do this based on?

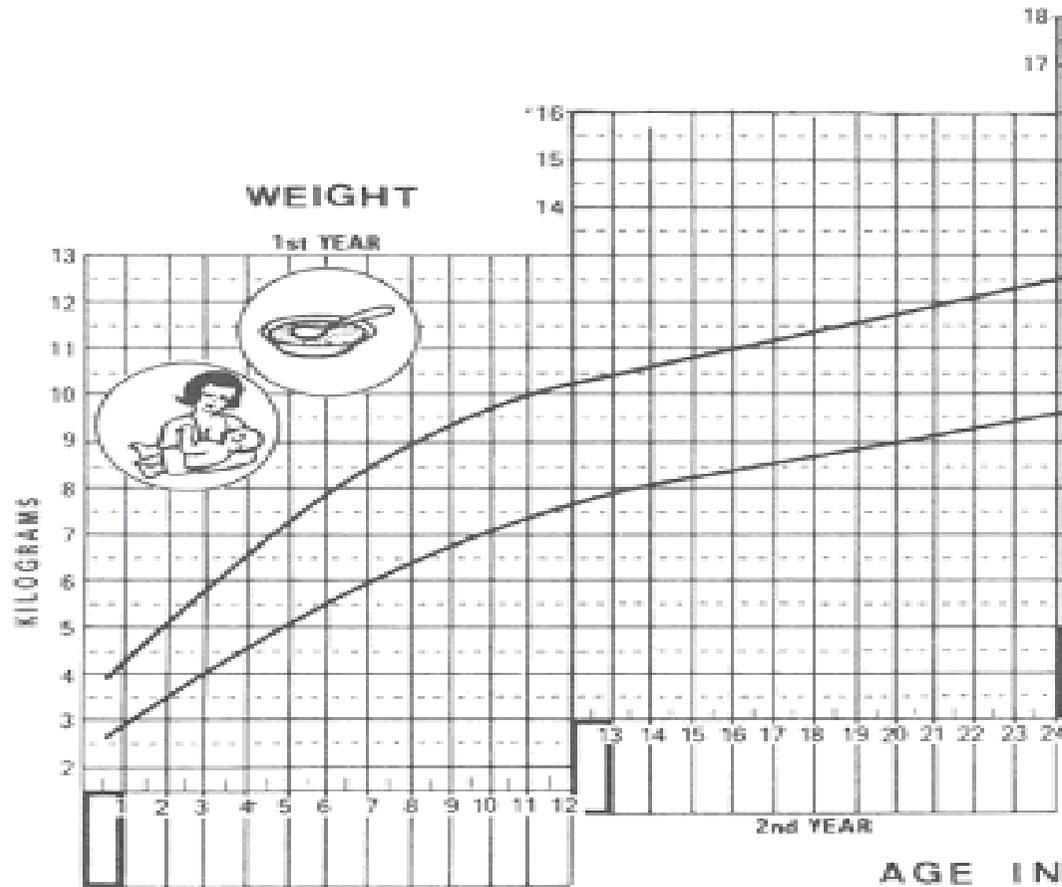
- A. A series of measurements taken over time
- B. Measurements taken at one visit.

Below are two different empty growth charts. Please plot the data provided below

Age	Weight
2 months	4.7 kg
4 months	5.9 kg
6 months	7.5kg

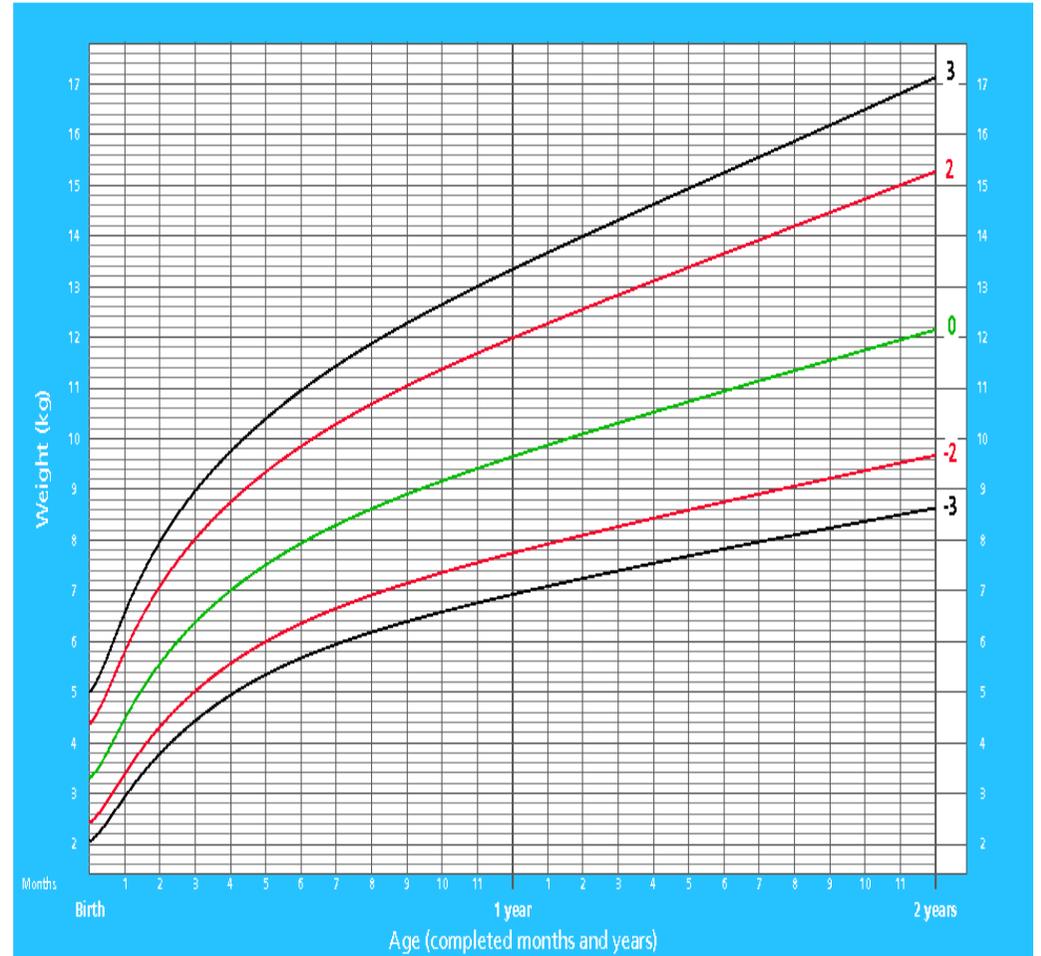
Name

Birth weight kg



Weight-for-age BOYS

Birth to 2 years (z-scores)



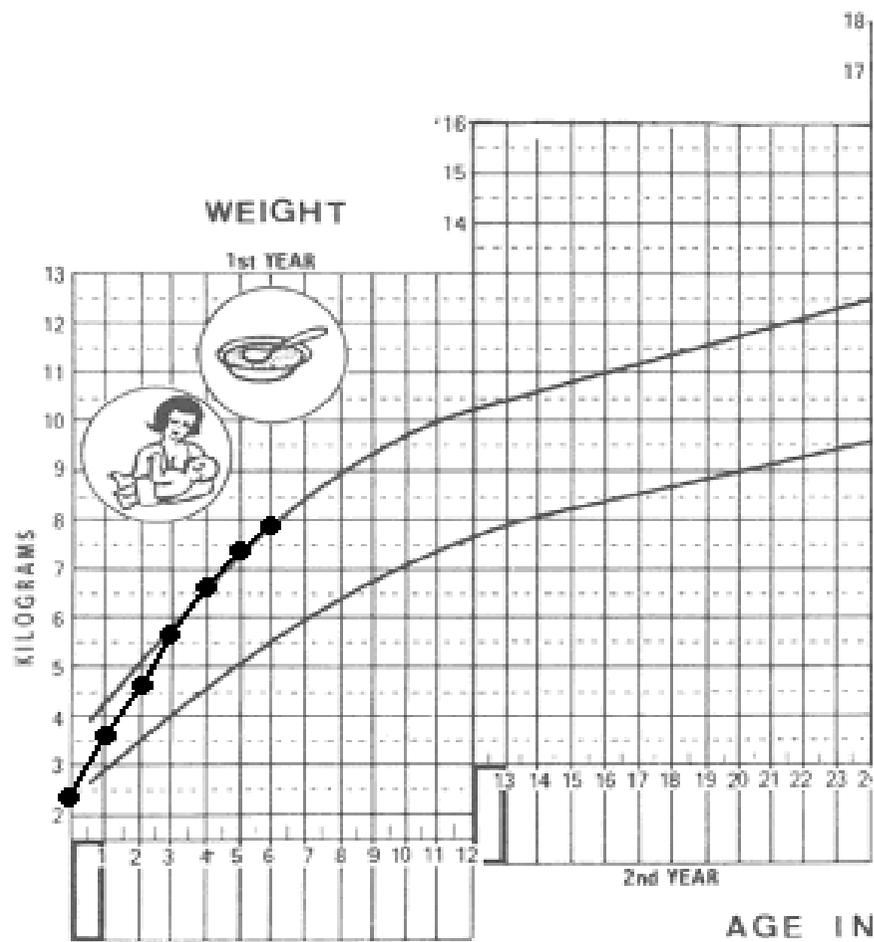
WHO Child Growth Standards

On the following pages are scenarios of different growth patterns of baby boys brought to the well-baby clinic.

For each question, circle only one answer.

Name

Birth weight kg



Scenario A1

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer that applies to you.

a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

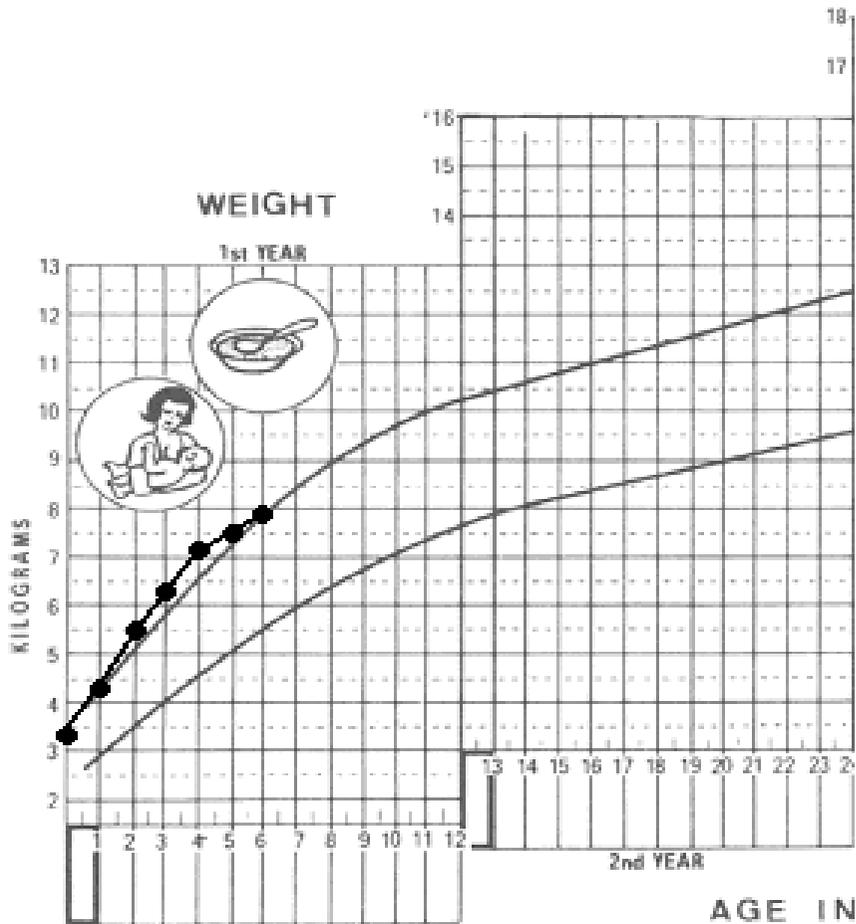
This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Name

Birth weight kg

Scenario A2

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.
 For each of the following questions, circle one answer which applies to you.



a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Weight-for-age BOYS

Birth to 2 years (z-scores)



Scenario A3

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

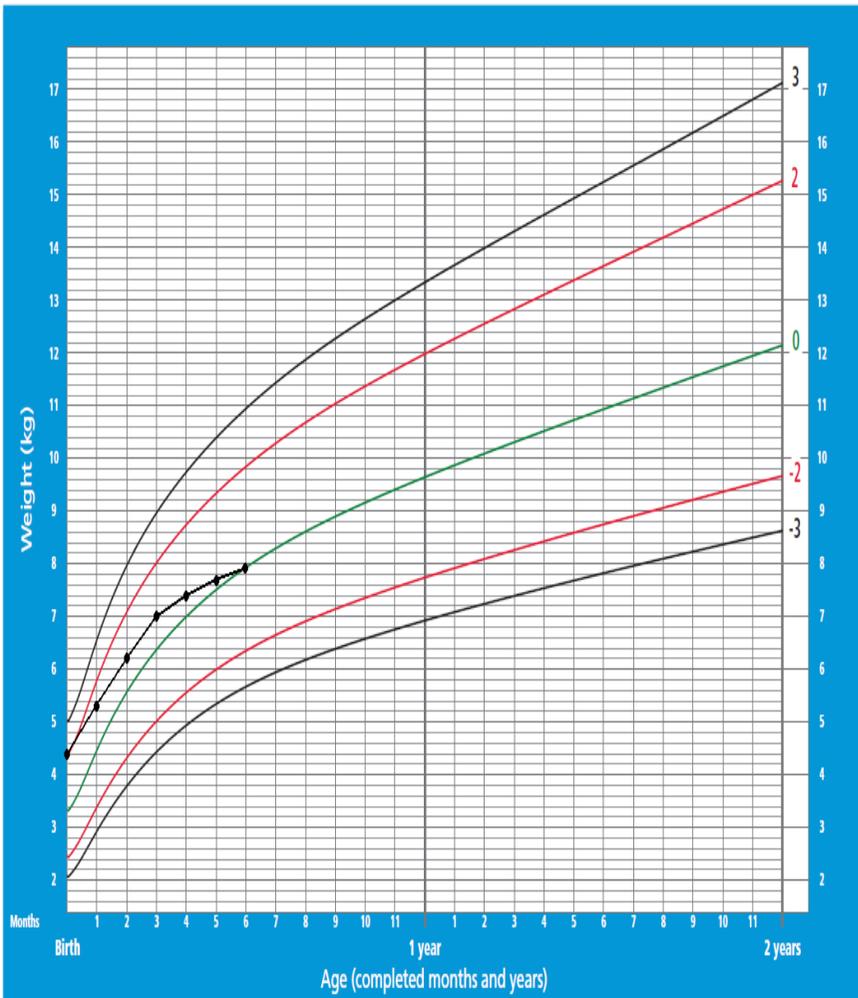
For each of the following questions, circle one answer that applies to you.

a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment



WHO Child Growth Standards

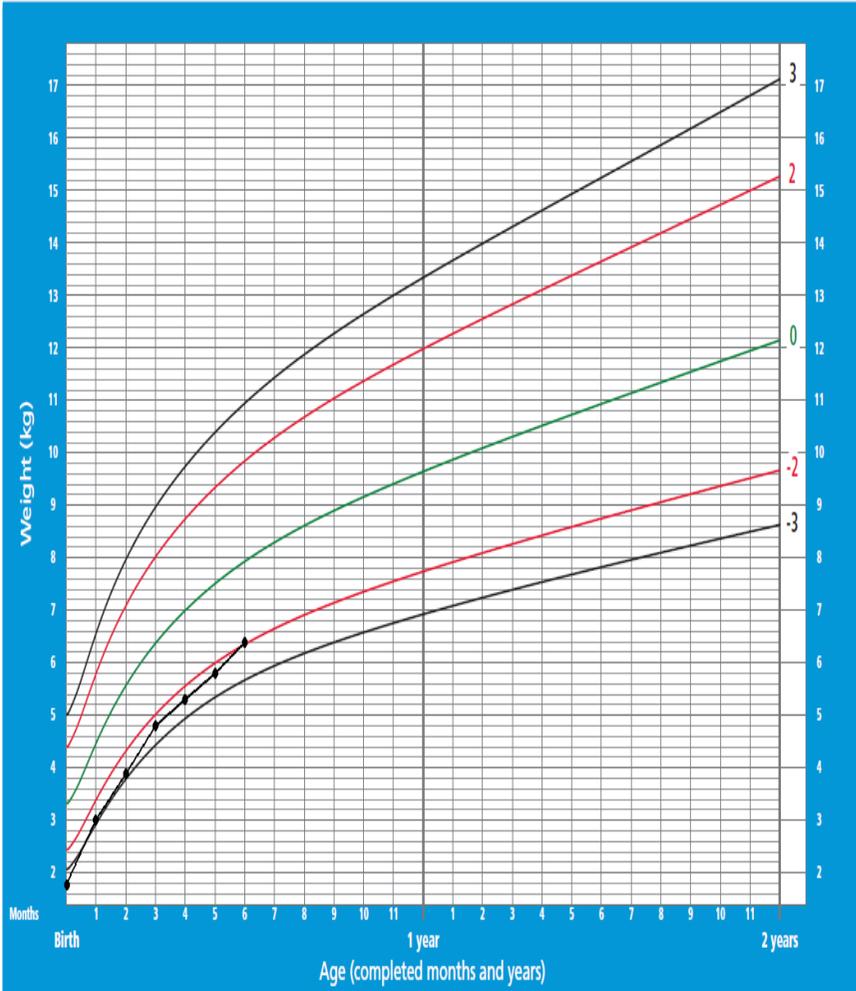
This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Weight-for-age BOYS

Birth to 2 years (z-scores)



Scenario A4



WHO Child Growth Standards

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer that applies to you.

a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Questionnaire A

Have you any comments you would like to make about the growth charts?

In General

Thank you for your help.

Appendix C.4 Health Staff Questionnaire B



Introduction

I am a PhD researcher from the University of Glasgow, Scotland, United Kingdom. I am collecting data on health staff understanding and use/interpretation of growth charts.

The ineffective use of growth charts in identifying undernutrition in early infancy is thought to be the major cause of poor prediction of later undernutrition in infants (0 – 24 weeks old) using growth and feeding information. Therefore, the aim of this investigation is to estimate how health staff understand and use/interpret growth charts and growth monitoring.

The questionnaire should take only 15 – 20 minutes to complete and is meant to represent what happens in real life when a child is brought to your health facility.

You will be asked to look through a series of short case studies with plotted charts and give your opinion on the child's growth pattern and what advice you would give to the family. The information provided would be anonymous and confidential.

If you have any queries about the investigation contact the undersigned.

Ifeyinwa O. Ezeofor

Researcher

Q version B

Location

Date

ID

What is your profession?

Years in practice	<5 years	5 -10 years	>10 years
Medical Doctor (please categorise)			
Nutritionist-Dietitian (please categorise)			
Nutritionist (please categorise)			
Nursing officer (please categorise)			
Health educator (please categorise)			
Health visitor (please categorise)			
Other (Specify):			

How often do you plot or look at growth charts?

Every day / Every week / Every month / Less often

How confident do you feel about interpreting growth charts?

Very confident / Fairly confident / Not very confident / Not at all confident

How often would you identify under nutrition in a child?

Every day / Every week / Every month / Less often

How often would you treat under nutrition in a child?

Every day / Every week / Every month / Less often

How confident do you feel about this?

Very confident / Fairly confident / Not very confident / Not at all confident

The table below shows different anthropometric measures used to assess undernutrition.

For each method, please tick one answer in each column that applies to you

Anthropometric measures	How often do you measure / calculate	How confident are you about interpreting this?	How useful do you find this?
Weight	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Length/Height	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Weight-for-length/height	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Head circumference	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Mid-Upper Arm Circumference	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Skinfold Thickness	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Other (Specify):			

Could you briefly describe when a child should be referred for (or offered) treatment for undernutrition?

Do you usually do this based on?

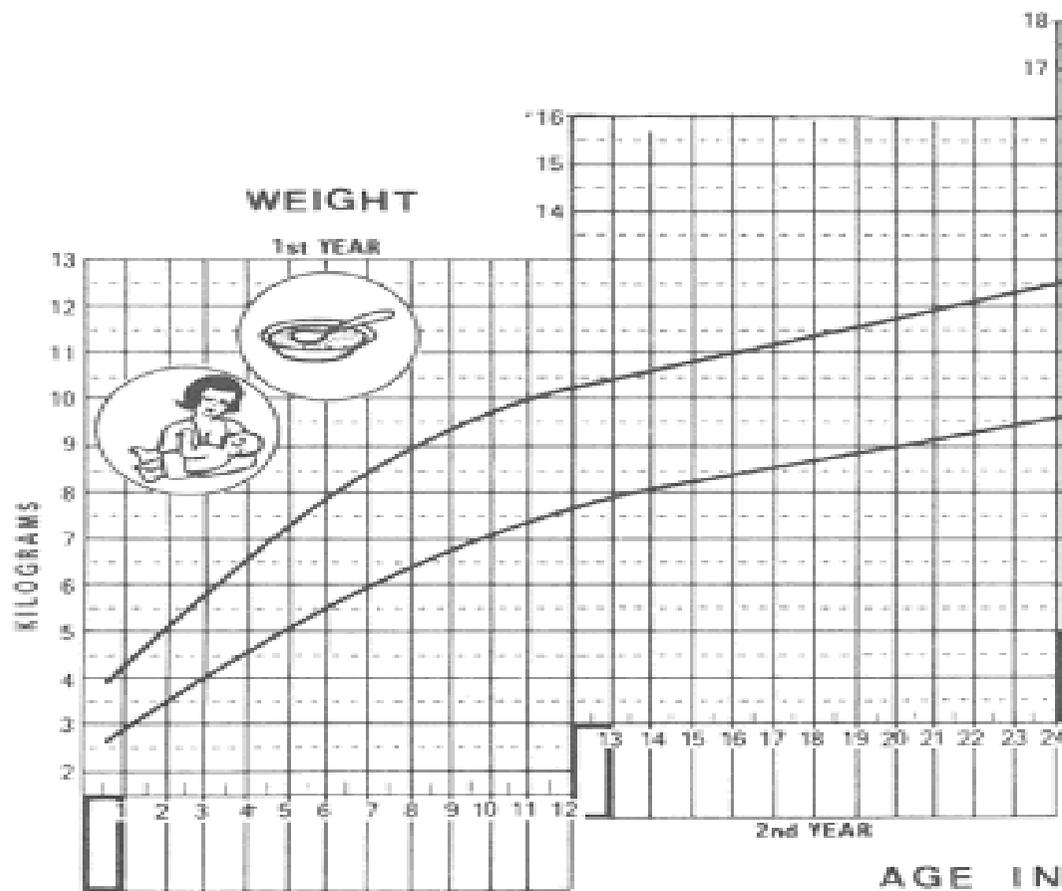
- A. A series of measurements taken over time
- B. Measurements taken at one visit.

Below are two different empty growth charts. Please plot the data provided below

Age	Weight
2 months	4.7 kg
4 months	5.9 kg
6 months	7.5kg

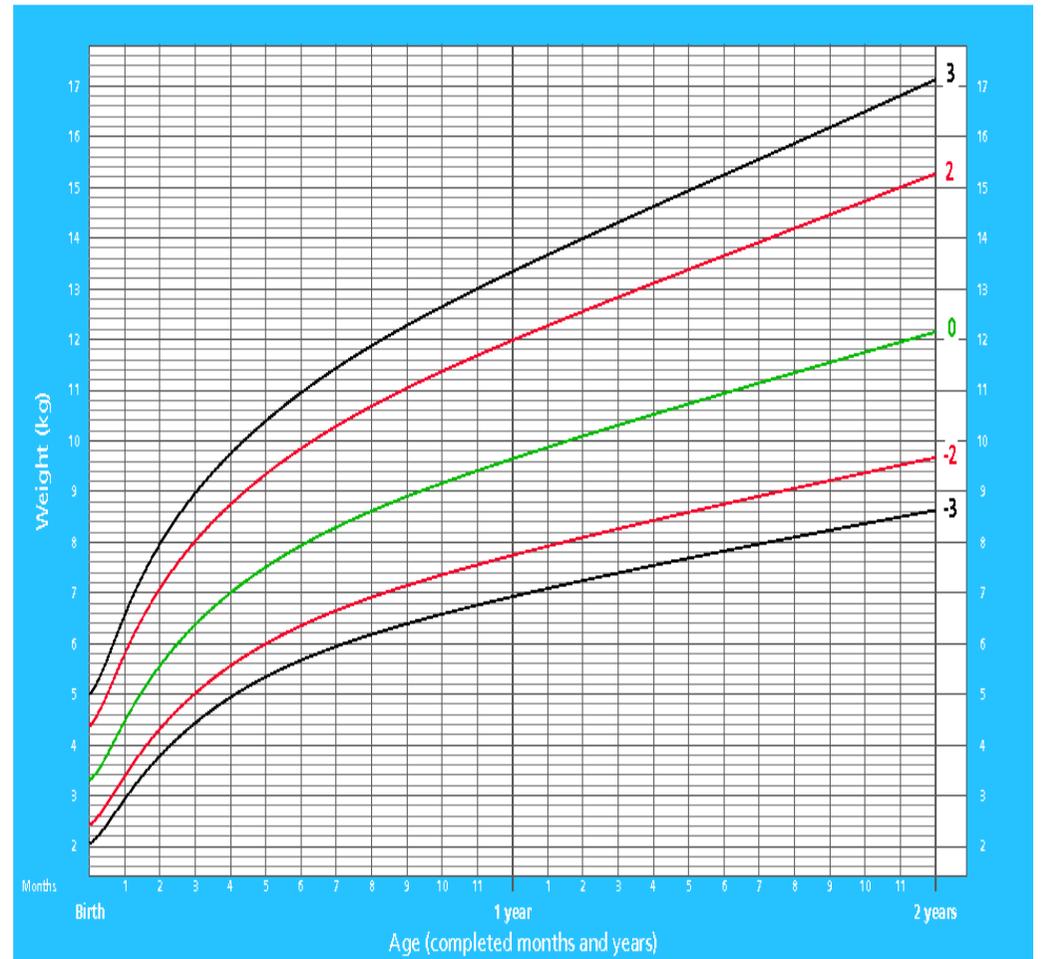
Name

Birth weight kg



Weight-for-age BOYS

Birth to 2 years (z-scores)



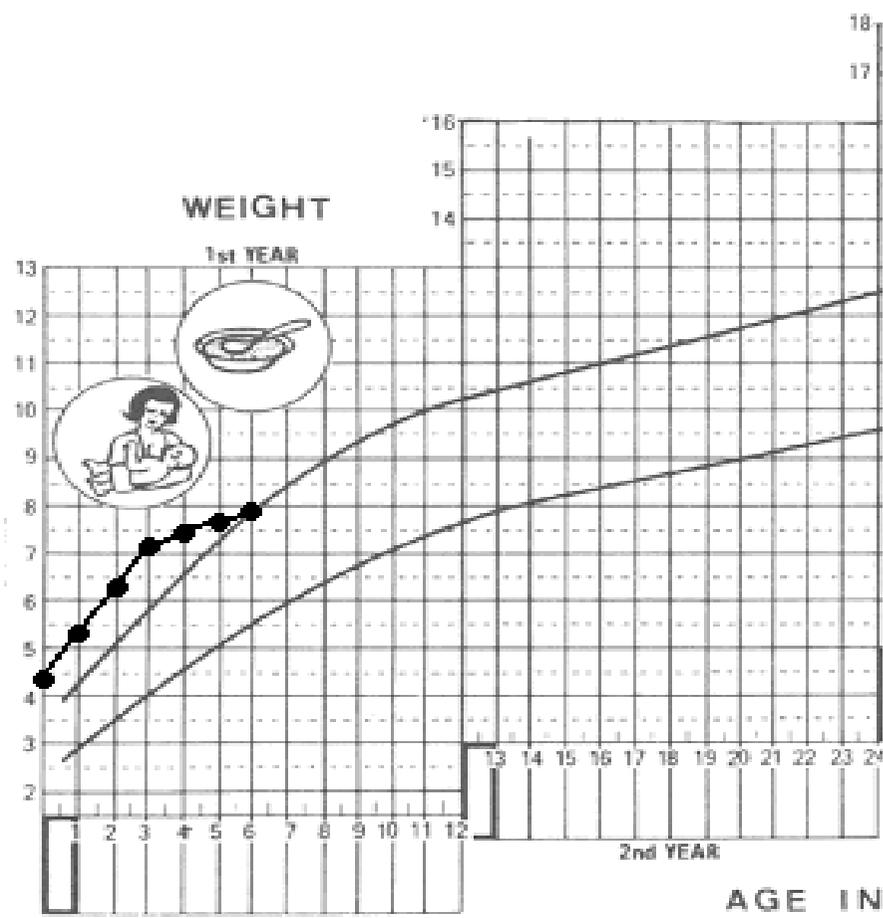
WHO Child Growth Standards

On the following pages are scenarios of different growth patterns of baby boys brought to the well-baby clinic.

For each question, circle only one answer.

Name

Birth weight kg



Scenario B1

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer that applies to you.

a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

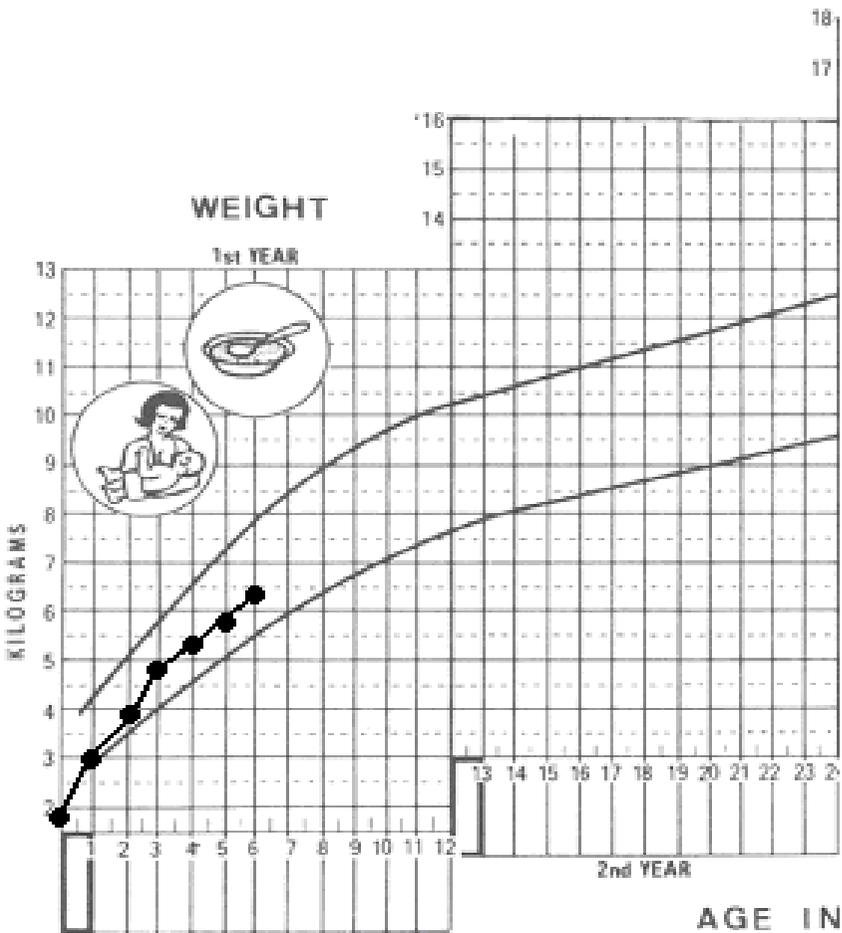
Name

Birth weight kg

Scenario B2

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer that applies to you.



a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

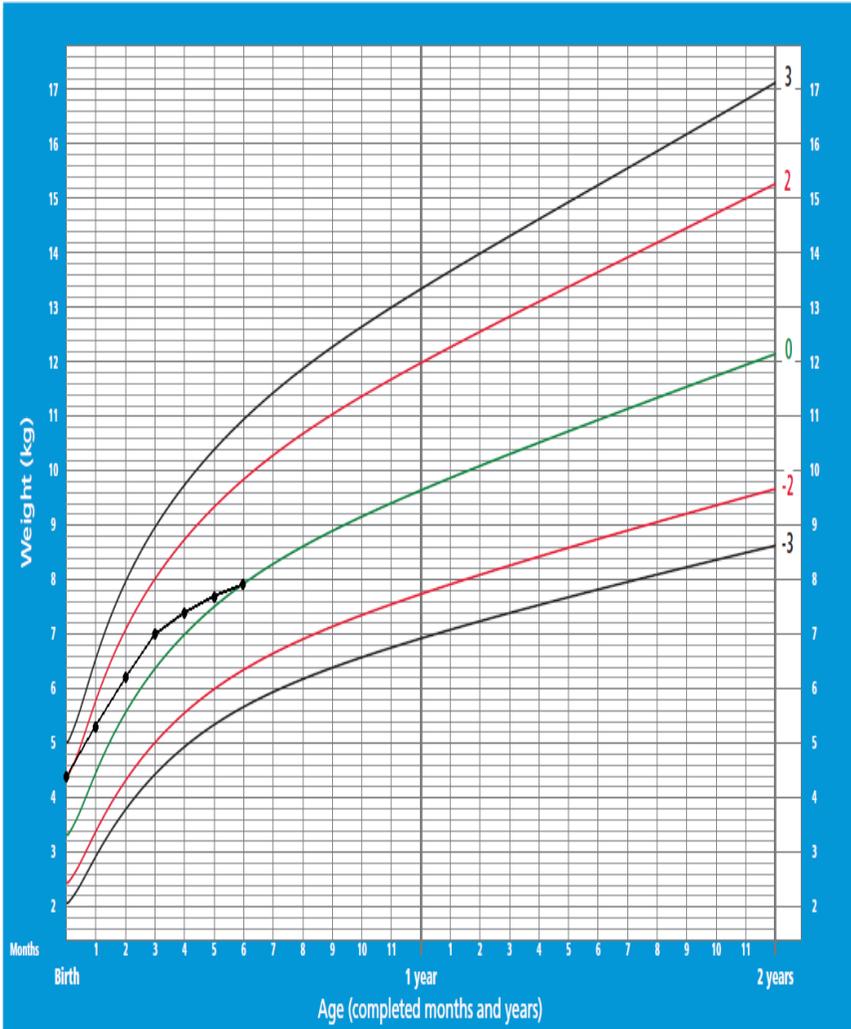
This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Weight-for-age BOYS

Birth to 2 years (z-scores)



Scenario B3



Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer that applies to you.

a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

WHO Child Growth Standards

Weight-for-age BOYS

Birth to 2 years (z-scores)



Scenario B4

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

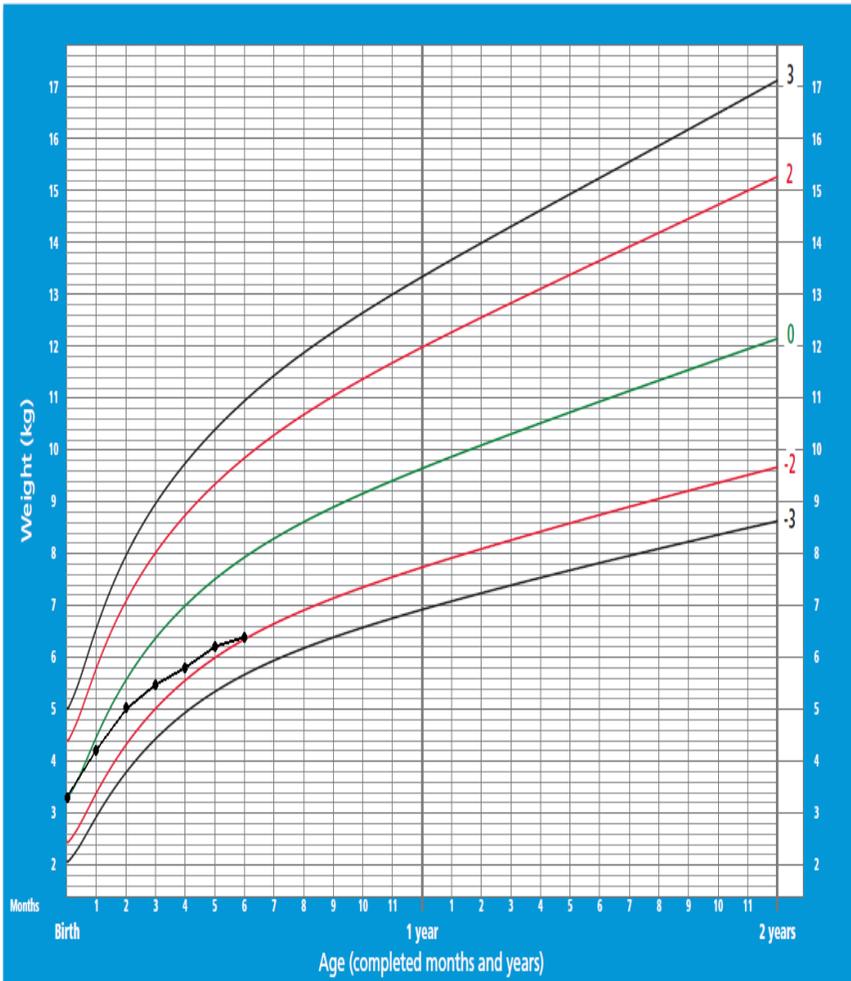
For each of the following questions, circle one answer that applies to you.

a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment



WHO Child Growth Standards

This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Questionnaire B

Have you any comments you would like to make about the growth charts?

In General

Thank you for your help.

Appendix C.5 Health Staff Questionnaire C



Introduction

I am a PhD researcher from the University of Glasgow, Scotland, United Kingdom. I am collecting data on health staff understanding and use/interpretation of growth charts.

The ineffective use of growth charts in identifying undernutrition in early infancy is thought to be the major cause of poor prediction of later undernutrition in infants (0 – 24 weeks old) using growth and feeding information. Therefore, the aim of this investigation is to estimate how health staff understand and use/interpret growth charts and growth monitoring.

The questionnaire should take only 15 – 20 minutes to complete and is meant to represent what happens in real life when a child is brought to your health facility.

You will be asked to look through a series of short case studies with plotted charts and give your opinion on the child's growth pattern and what advice you would give to the family. The information provided would be anonymous and confidential. There are three versions of the questionnaire.

If you have any queries about the investigation contact the undersigned.

Ifeyinwa O. Ezeofor

Researcher

Q version C

Location

Date

What is your profession?

Years in practice	<5 years	5 -10 years	>10 years
Medical Doctor (please categorise)			
Nutritionist-Dietitian (please categorise)			
Nutritionist (please categorise)			
Nursing officer (please categorise)			
Health educator (please categorise)			
Health visitor (please categorise)			
Other (Specify):			

How often do you plot or look at growth charts?

Every day / Every week / Every month / Less often

How confident do you feel about interpreting growth charts?

Very confident / Fairly confident / Not very confident / Not at all confident

How often would you identify under nutrition in a child?

Every day / Every week / Every month / Less often

How often would you treat under nutrition in a child?

Every day / Every week / Every month / Less often

How confident do you feel about this?

Very confident / Fairly confident / Not very confident / Not at all confident

The table below shows different anthropometric measures used to assess undernutrition.

For each method, please tick one answer in each column that applies to you

Anthropometric measures	How often do you measure / calculate	How confident are you about interpreting this?	How useful do you find this?
Weight	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Length/Height	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Weight-for-length/height	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Head circumference	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Mid-Upper Arm Circumference	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Skinfold Thickness	<input type="checkbox"/> <i>Every week</i> <input type="checkbox"/> <i>Every month</i> <input type="checkbox"/> <i>Less often</i> <input type="checkbox"/> <i>Never</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>	<input type="checkbox"/> <i>Very</i> <input type="checkbox"/> <i>Fairly</i> <input type="checkbox"/> <i>Not very</i> <input type="checkbox"/> <i>Not at all</i>
Other (Specify):			

Could you briefly describe when a child should be referred for (or offered) treatment for undernutrition?

Do you usually do this based on?

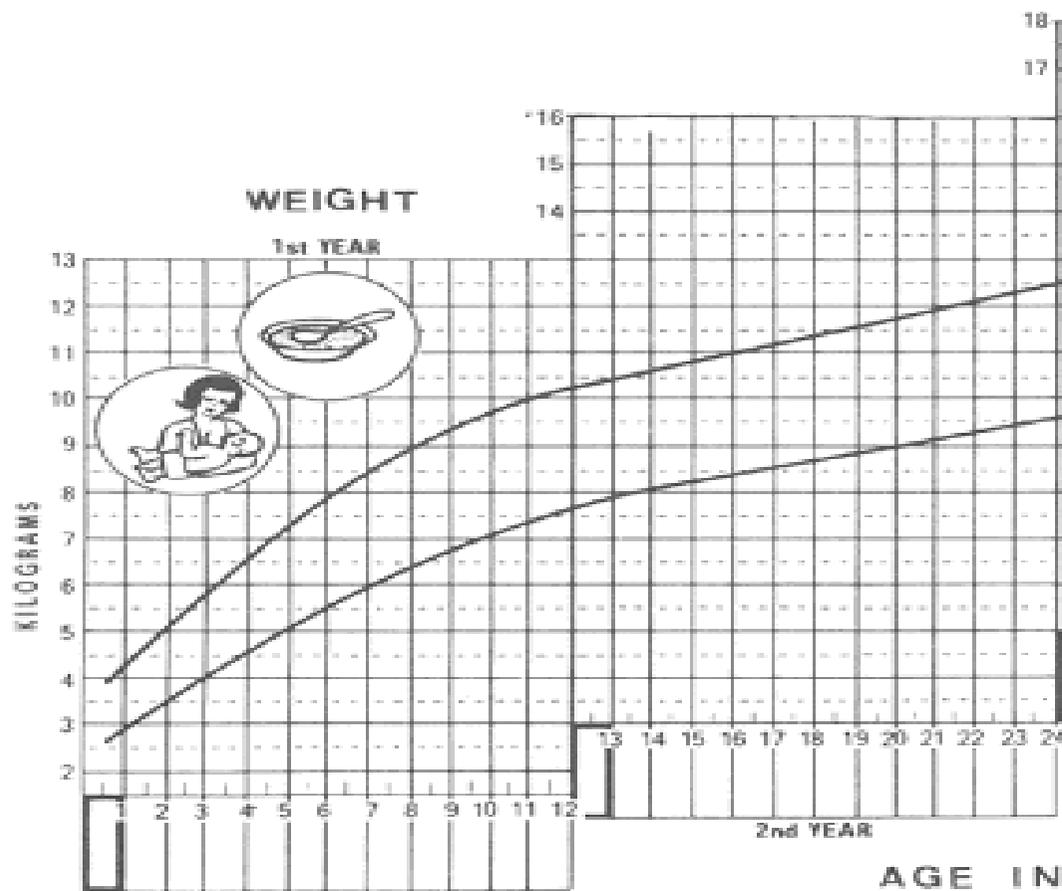
- A. A series of measurements taken over time
- B. Measurements taken at one visit.

Below are two different empty growth charts. Please plot the data provided below

Age	Weight
2 months	4.7 kg
4 months	5.9 kg
6 months	7.5kg

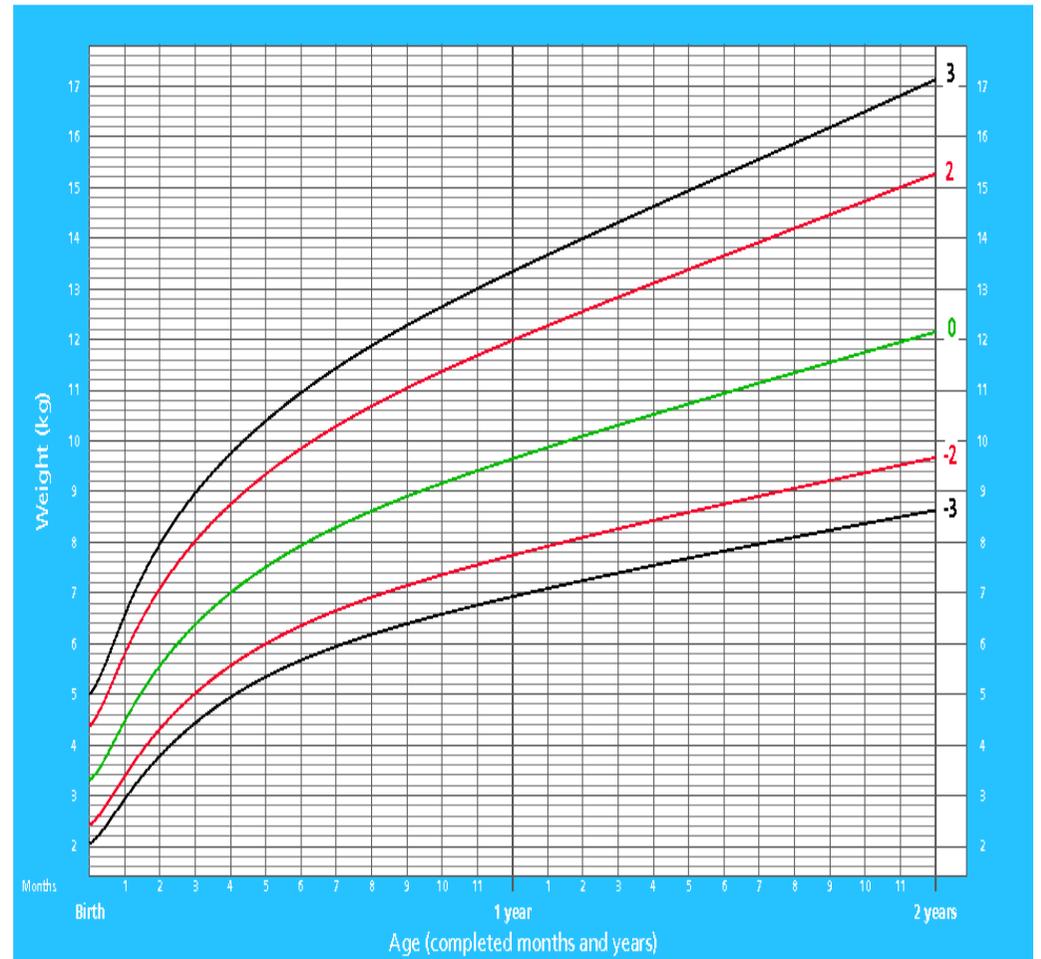
Name

Birth weight kg



Weight-for-age BOYS

Birth to 2 years (z-scores)



WHO Child Growth Standards

On the following pages are scenarios of different growth patterns of baby boys brought to the well-baby clinic.

For each question, circle only one answer.

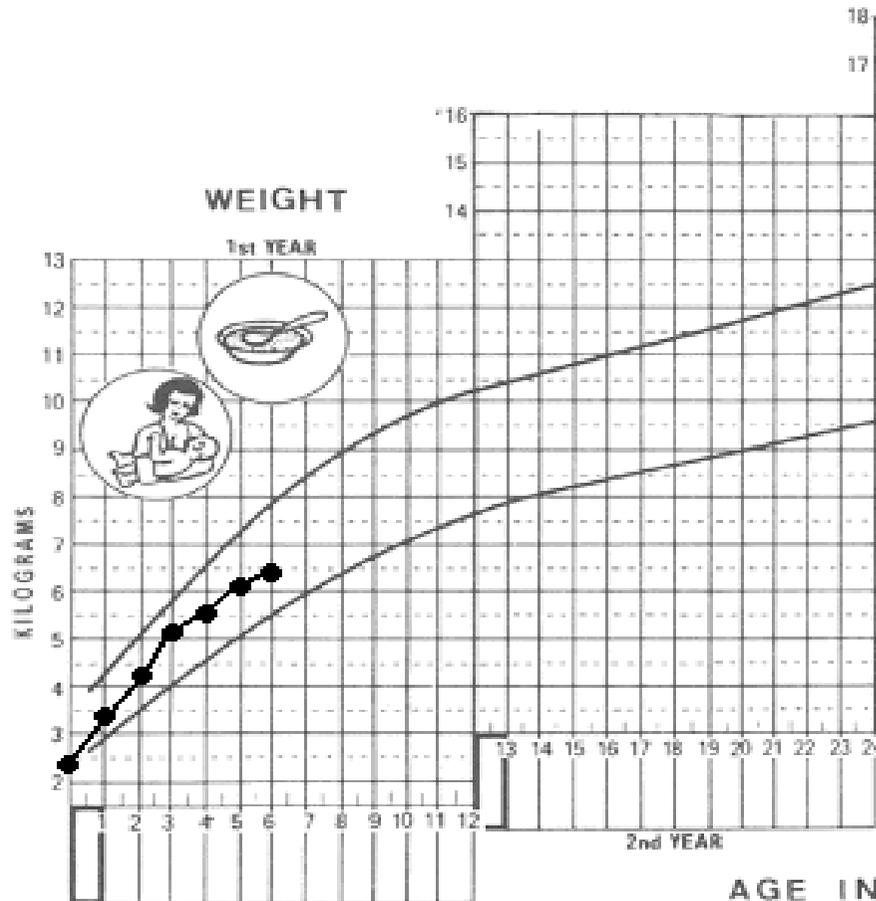
Name

Birth weight kg

Scenario C1

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer which applies to you.



a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

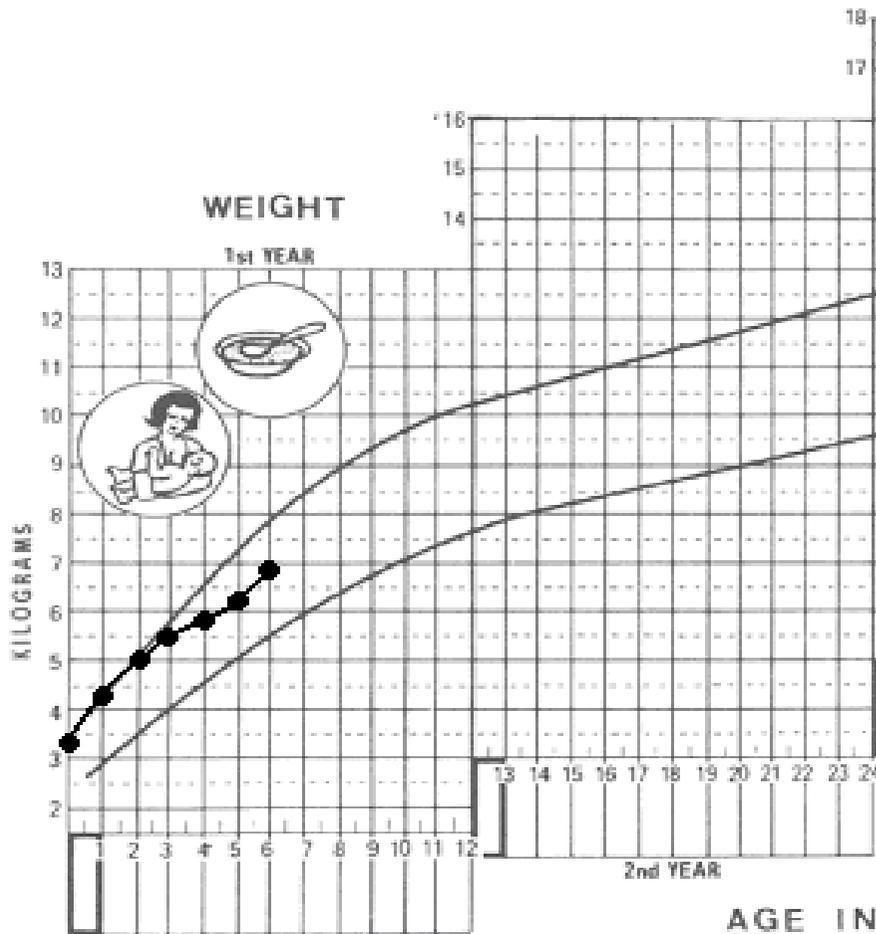
Name

Birth weight kg

Scenario C2

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer which applies to you.



a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

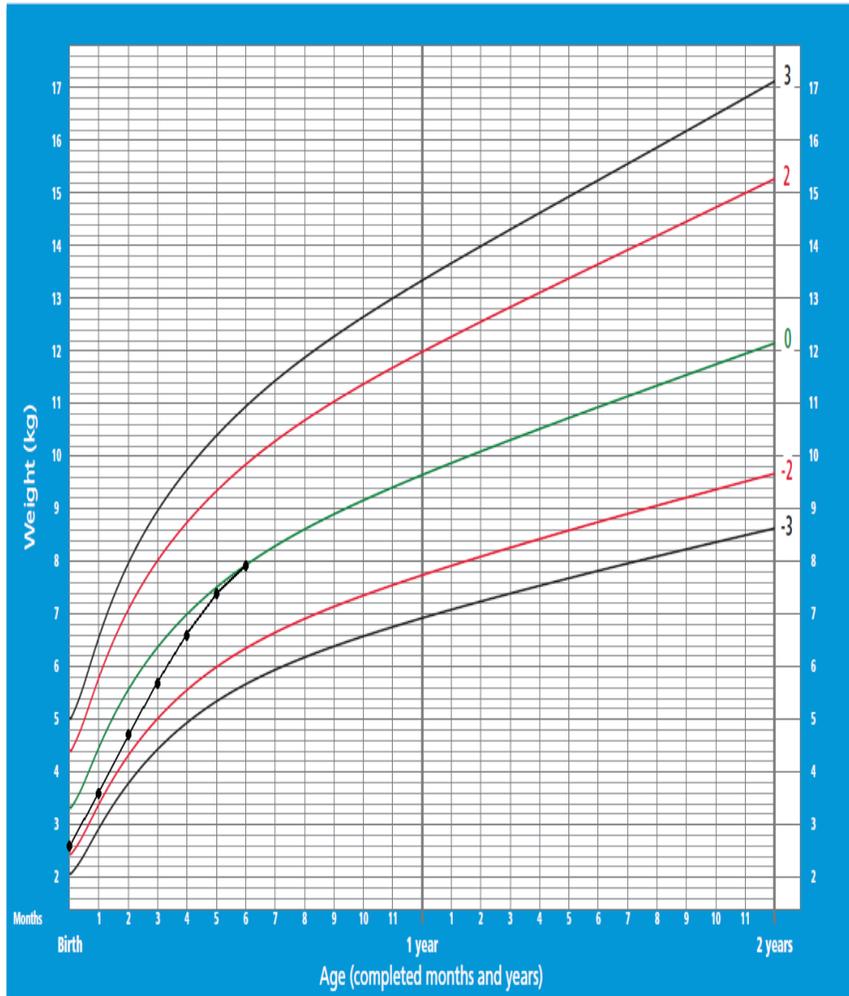
b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Weight-for-age BOYS

Birth to 2 years (z-scores)



WHO Child Growth Standards

Scenario C3

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer which applies to you.

a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

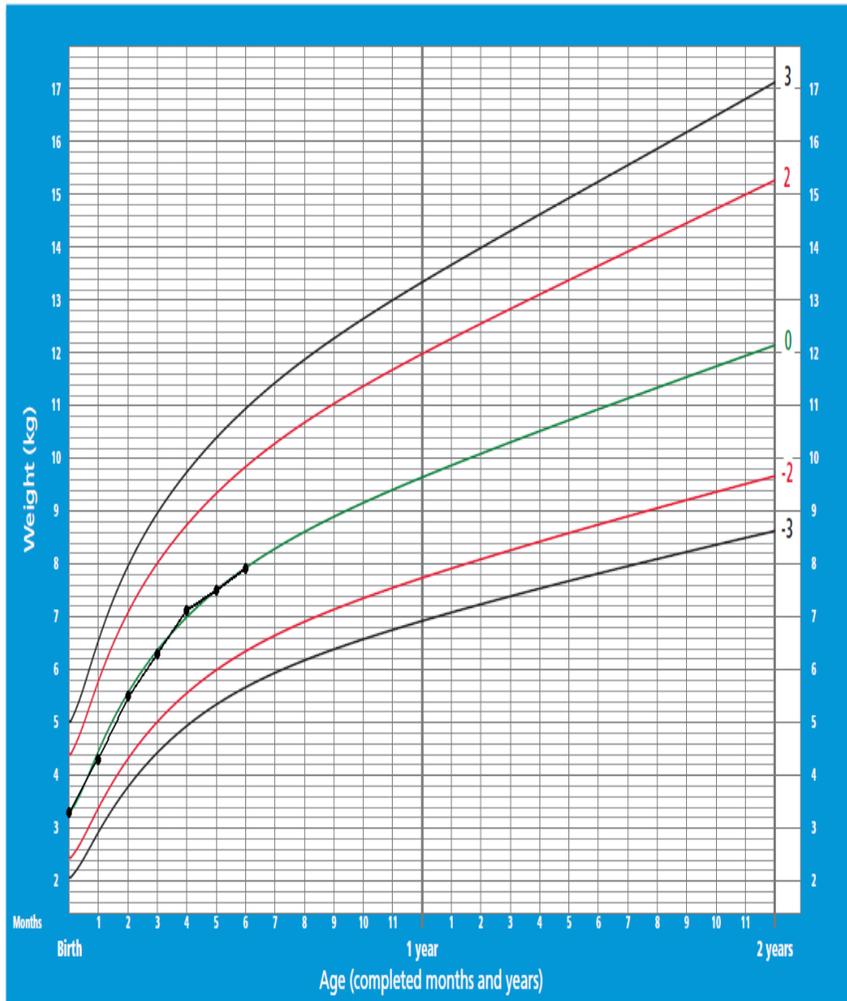
This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Weight-for-age BOYS

Birth to 2 years (z-scores)



Scenario C4



WHO Child Growth Standards

Carefully observe the growth pattern of a baby boy as shown on the plotted growth chart below.

For each of the following questions, circle one answer which applies to you.

a) What is your assessment of his weight gain?

1. Very slow
2. Slow
3. Steady
4. Rapid
5. Very rapid

b) What would you do with this child?

1. Not worried, reduce level of care
2. Continue current care
3. Monitor more closely
4. Refer for / offer further assessment

This child is showing:	Strongly Agree	Agree	Neutral	Disagree	Strongly Disagree
	(1)	(2)	(3)	(4)	(5)
Weight faltering					
Failure to thrive					
Catch up growth					
Obesity					

Questionnaire C

Have you any comments you would like to make about the growth charts?

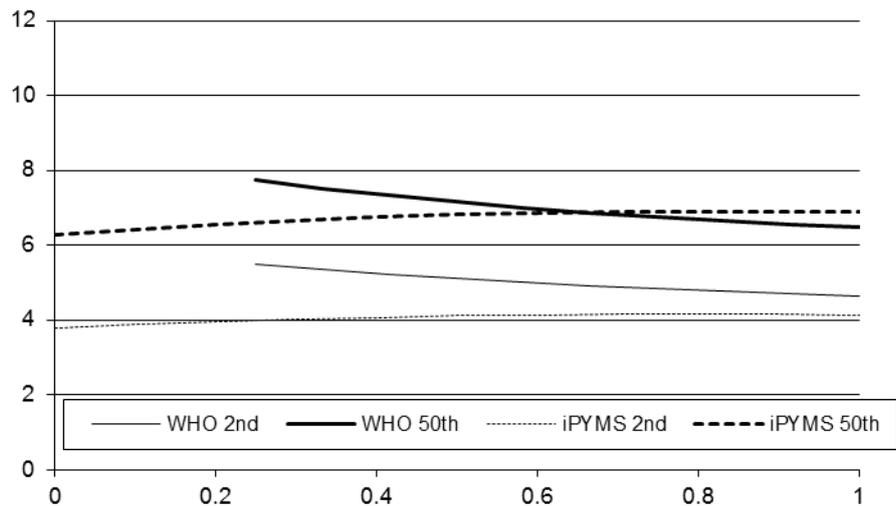
In General

Thank you for your help.

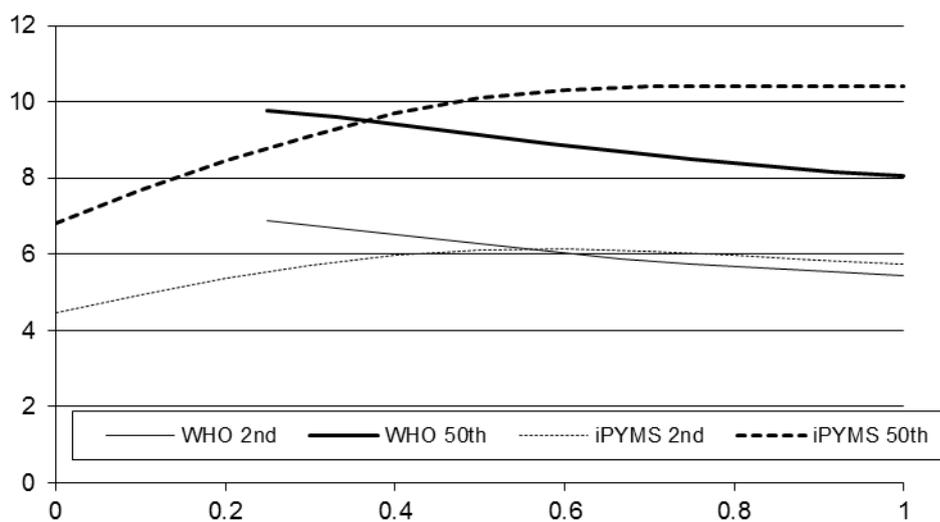
Appendix D.1 iPYS Local Reference for the Comparison of Skinfolds

The graphs compare the 50th and 2nd centiles for the iPYS skinfolds reference (which uses pooled gender) to the WHO 2006 reference using the mean of the male and female values

Subscapular skinfolds



Triceps skinfolds



Appendix E.1 Nigerian Road-to-Health Chart

Front page

CHILD HEALTH CARD

NAME _____ SEX M/F _____

CHILD'S NO: _____

PHC HOUSE NO. _____

MOTHER'S NO. _____

DATE OF BIRTH: _____ WEIGHT AT BIRTH _____

MOTHER'S NAME: _____ House No. _____

FATHER'S NAME: _____ House No. _____

CHILD'S ADDRESS: _____

Ward _____ Village _____

MOTHER'S OTHER CHILDREN

YEAR OF BIRTH	SEX	STATE OF HEALTH

ASK THE MOTHER ABOUT THESE REASONS FOR GIVING THE CHILD EXTRA CARE (make a circle round the right answer)

REASON	TAKE EXTRA CARE
Was the baby less than 2.5 kg at birth?	YES/NO
Is this baby a twin?	YES/NO
Is this baby bottle fed?	YES/NO
Does the mother need more family support?	YES/NO
Are any brothers or sisters underweight?	YES/NO
Are there any other reasons for taking extra care? For example - tuberculosis or leprosy or social problems.	YES/NO

IMMUNISATIONS

	IMMUNISATIONS	DATE GIVEN	DATE NEXT VISIT	REMARK
1	BCG/OPV AT BIRTH			
	OPV1ADPT1 6WEEKS FIRST DOSE			
	OPV2ADPT2 10WEEKS SECOND DOSE			
	OPV3ADPT3 14WEEKS THIRD DOSE			
2	MEASLES 9 MONTHS			
3	MOTHER'S TETANUS TOXOID (or one booster)	TT1	TT2	
		TT3	TT4	
		TT5		
4	HEPATITIS B			
5	YELLOW FEVER			
6	Others			

VIT A

Indicate Date Given				

HOW TO TREAT DIARRHOEA AT HOME

When the child has diarrhoea, he/she loses a lot of body water and salts and this can be dangerous for him/her. As soon as diarrhoea starts, replace the lost fluid and salt by giving him/her a solution prepared as follows:

- Cooking Salt - 1 Level teaspoon
- Sugar - 10 level of teaspoons or 5 cubes
- Cool boiled drinking water - 2 full soft drink (Mineral) bottles.

Slowly give 1 teaspoonful of the solution to your child after each diarrhoea stool. Then take your baby to the health clinic to see the health worker. Continue with breast feeding and normal diet. Do not starve your child.

Illustrations: A child sitting, a hand holding a spoon, and bottles of Salt, Sugar, and water.

Back page

CHILD'S NAME _____

BIRTH TO 1 YEAR

B.C.G. D.P.T. Measles

O.P.V.

2 TO 3 YEARS

WATCH THE DIRECTION OF THE LINE SHOWING THE CHILD'S GROWTH

- GOOD child growing well
- DANGER Not gaining weight, find out why
- VERY DANGEROUS Losing weight, May be ill, needs extra care.

WRITE ON THE CHART Any illness e.g. Diarrhoea, admission to hospital, Solids introduced, Breast feeding stopped, Birth of next child like this

Vit A given • Measles • Diarrhoea • Admitted to hospital • a-z adpt • Extra meals given • Worm medicine

Breast Feeding keys

- E. Exclusive breast Feeding
- BW. breast Feeding with Water
- P. Partial Breast Feeding
- No Breast Feeding

Appendix E.2 Datasheet for the Infant Welfare Clinic Study



Location	Date	ID No	Name of infant	Gender	Gestational age	Date of Birth	Birth weight	Date of measurement at 6 weeks	Weight at 6 weeks	Date of measurement at 3 months	Weight at 3 months	Date of measurement at 6 months	Weight at 6 months	Method of feeding

Appendix E.3 Datasheet for the Hospital Ward Study

Screening Notification – Data Recording



Child's name _____ Sex: Male Female

Date of Birth ____/____/____ Gestation _____ Birthweight _____ Birth Order _____

Diagnosis

Reason for Admission

Date of Admission ____/____/____ Date of assessment ____/____/____

The result of his/her Subjective Global Nutrition Assessment rating suggest that s/he is

Low

Medium

High

Anthropometric Measures	Measurements			
	1 st	2 nd	3 rd	Average
Weight				
Length				
BMI				
Head Circumference				
MUAC				
Triceps Skinfold				
Subscapular Skinfold				

List of References

- A.S.P.E.N 1995. Standards for Nutrition Support: Hospitalized Patients. *Nutr Clin Pract* 10, 26-31.
- A.S.P.E.N 2002. Guidelines for the Use of Parenteral and Enteral Nutrition in Adult and Pediatric Patients. *J Parenter Enteral Nutr*, 26, 1SA-138SA.
- ABHULIMHEN-IYOHA, B. I., OKONKWO, I. R., IDEH, R. C. & OKOLO, A. A. 2015. Mothers' perception of the use of banked human milk for feeding of the infants. *Niger J Paed* 2015, 42, 223-227.
- ABOUL-SEOUD, M. A. & ABOUL-SEOUD, A. L. 2001. Estimation of body fat from skinfold thickness. *Comput Methods Programs Biomed*, 65, 201-6.
- ACC/SCN 2000. Nutrition throughout the Life Cycle. *Fourth Report on the World Nutrition Situation*. Geneva: United Nations Administrative Committee on Coordination/Sub-Committee on Nutrition (ACC/SCN) in collaboration with International Food Policy Research Institute (IFPRI).
- ACF INTERNATIONAL 2015. Severe acute malnutrition management in Nigeria - Challenges, Lessons and The road ahead. *Community-based management of acute malnutrition in Nigeria*. ACF International (ACF) with the support of the Children's Investment Fund Foundation (CIFF).
- ADDO, O. Y. & HIMES, J. H. 2010. Reference curves for triceps and subscapular skinfold thicknesses in US children and adolescents. *Am J Clin Nutr*, 91, 635-42.
- ADELEKAN, D. A. 2003. Childhood nutrition and malnutrition in Nigeria. *Nutrition*, 19, 179-81.
- AGHAJI, M. N. 2002. Exclusive breast-feeding practice and associated factors in Enugu, Nigeria. *West African journal of medicine*, 21, 66-9.
- AGHO, K. E., DIBLEY, M. J., ODIASE, J. I. & OGBONMWAN, S. M. 2011. Determinants of exclusive breastfeeding in Nigeria. *BMC Pregnancy Childbirth*, 11, 2.
- AGOSTONI, C., AXELSON, I., COLOMB, V., GOULET, O., KOLETZKO, B., MICHAELSEN, K. F., PUNTIS, J. W., RIGO, J., SHAMIR, R., SZAJEWSKA, H., TURCK, D., NUTRITION, E. C. O. & EUROPEAN SOCIETY FOR PAEDIATRIC, G. 2005. The need for nutrition support teams in pediatric units: a commentary by the ESPGHAN committee on nutrition. *J Pediatr Gastroenterol Nutr*, 41, 8-11.
- AGUNBIADE, O. & OGUNLEYE, O. 2012. Constraints to exclusive breastfeeding practice among breastfeeding mothers in Southwest Nigeria: implications for scaling up. *International Breastfeeding Journal*, 7, 5.
- AHMAD, U. N., YIWOMBE, M., CHISEPO, P., COLE, T. J., HEIKENS, G. T. & KERAC, M. 2014. Interpretation of World Health Organization growth charts for assessing infant malnutrition: a randomised controlled trial. *J Paediatr Child Health*, 50, 32-9.
- AKINBAMI, F. O., KAMAZAT, K. T., ORINMADEGUN, A. E., TONGO, O., OYEYEMI, L., OKAFOR, O. & AKINYINKA, O. O. 2010. Body mass composition: a predictor of admission outcomes among hospitalised Nigerian under 5 children. *Asia Pac J Nutr*, 19, 295-300.
- AKINYINKA, O. O., SANNI, K. A., FALADE, A. G., AKINDELE, M. O. & SOWUMI, A. 1999. Arm area measurements as indices of nutritional reserves and body water in African newborns. *Afr J Med Med Sci*, 28, 5-8.
- ALLEN, L. H. 2012. Global dietary patterns and diets in childhood: implications for health outcomes. *Ann Nutr Metab*, 61 Suppl 1, 29-37.
- ALLEN, L. H. & GILLESPIE, S. R. 2001. Improving child growth. *What Works? A review of the Efficacy and Effectiveness of Nutrition Interventions* Geneva, Switzerland: United Nations Standing Committee on Nutrition, Geneva, in collaboration with Asian Development Bank, Manila.
- ALVARADO, B. E., ZUNZUNEGUI, M. V., DELISLE, H. & OSORNO, J. 2005. Growth trajectories are influenced by breast-feeding and infant health in an afro-colombian community. *J Nutr*, 135, 2171-8.
- ARGYLE, J. 2003. Approaches to detecting growth faltering in infancy and childhood. *Ann Hum Biol*, 30, 499-519.

- ASHWORTH, A., MORRIS, S. S. & LIRA, P. I. 1997. Postnatal growth patterns of full-term low birth weight infants in Northeast Brazil are related to socioeconomic status. *J Nutr*, 127, 1950-6.
- ASHWORTH, A., SHRIMPTON, R. & JAMIL, K. 2008. Growth monitoring and promotion: review of evidence of impact. *Matern Child Nutr*, 4 Suppl 1, 86-117.
- ATALAH, E., AMIGO, H. & BUSTOS, P. 2014. Does Chile's nutritional situation constitute a double burden? *The American Journal of Clinical Nutrition*, 100, 1623S-1627S.
- AURANGZEB, B., WHITTEN, K. E., HARRISON, B., MITCHELL, M., KEPREOTES, H., SIDLER, M., LEMBERG, D. A. & DAY, A. S. 2012. Prevalence of malnutrition and risk of under-nutrition in hospitalized children. *Clin Nutr*, 31, 35-40.
- BAILEY, R. A. & CHIGBU, P. E. 1997. Enumeration of semi-Latin squares. *Discrete Mathematics*, 167-168, 73-84.
- BAKER, J. P., DETSKY, A. S., WESSON, D. E., WOLMAN, S. L., STEWART, S., WHITEWELL, J., LANGER, B. & JEEJEBHOY, K. N. 1982. Nutritional assessment: a comparison of clinical judgement and objective measurements. *N Engl J Med*, 306, 969-72.
- BAMGBOYE, E. A. & FAMILUSI, J. B. 1990. Mortality pattern at a children's emergency ward, University College Hospital, Ibadan, Nigeria. *Afr J Med Med Sci*, 19, 127-132.
- BARBOSA-SILVA, M. C. G. 2008. Subjective and objective nutritional assessment methods: what do they really assess? *Current Opinion in Clinical Nutrition and Metabolic Care*, 11, 248-254.
- BARBOSA-SILVA, M. C. G., BARROS, A. J. D., POST, C. L. A., WAITZBERG, D. L. & HEYMSFIELD, S. B. 2003. Can bioelectrical impedance analysis identify malnutrition in preoperative nutrition assessment? *Nutrition*, 19, 422-426.
- BASSINGTHWAIGHTTE, M. K. & BALLOT, D. E. 2013. Outcomes of babies born before arrival at a tertiary hospital in Johannesburg, South Africa. *S Afr J CH*, 7, 139-145.
- BECKER, G. E., REMMINGTON, S. & REMMINGTON, T. 2011. Early additional food and fluids for healthy breastfed full-term infants. *Cochrane Database Syst Rev*. 2011/12/14 ed.
- BEDOGNI, G., IUGHETTI, L., FERRARI, M., MALAVOLTI, M., POLI, M., BERNASCONI, S. & BATTISTINI, N. 2003. Sensitivity and specificity of body mass index and skinfold thicknesses in detecting excess adiposity in children aged 8-12 years. *Ann Hum Biol*, 30, 132-9.
- BELLISARI, A. & ROCHE, A. F. 1996. Variable compression of subcutaneous adipose tissue (SAT) by skinfold calipers: Comparison with ultrasonic measurements. *American Journal of Human Biology*, 8, 103-103.
- BEN-JOSEPH, E. P., DOWSHEN, S. A. & IZENBERG, N. 2007. Public understanding of growth charts: a review of the literature. *Patient Educ Couns*, 65, 288-95.
- BENYERA, O. & HYERA, F. L. M. 2013. Outcomes in malnourished children at a tertiary hospital in Swaziland after implementation of the World Health Organisation treatment guidelines. *S Afr J CH*, 7, 135-138.
- BERKLEY, J., MWANGI, I., GRIFFITHS, K., AHMED, I., MITHWANI, S., ENGLISH, M., NEWTON, C. & MAITLAND, K. 2005. Assessment of severe malnutrition among hospitalized children in rural Kenya: comparison of weight for height and mid upper arm circumference. *JAMA*, 294, 591-7.
- BHUTTA, Z. A., AHMED, T., BLACK, R. E., COUSENS, S., DEWEY, K., GIUGLIANI, E., HAIDER, B. A., KIRKWOOD, B., MORRIS, S. S., SACHDEV, H. P. S. & SHEKAR, M. 2008. What works? Interventions for maternal and child undernutrition and survival. *The Lancet*, 371, 417-440.
- BHUTTA, Z. A., DAS, J. K., RIZVI, A., GAFFEY, M. F., WALKER, N., HORTON, S., WEBB, P., LARTEY, A. & BLACK, R. E. 2013. Evidence-based interventions for improvement of maternal and child nutrition: what can be done and at what cost? *The Lancet*, 382, 452-477.
- BINNS, C. W., FRASER, M. L., LEE, A. H. & SCOTT, J. 2009. Defining exclusive breastfeeding in Australia. *Journal of Paediatrics and Child Health*, 45, 174-180.
- BLACK, M. M. & DEWEY, K. G. 2014. Promoting equity through integrated early child development and nutrition interventions. *Annals of the New York Academy of Sciences*, 1308, 1-10.

- BLACK, R. E., VICTORA, C. G., WALKER, S. P., BHUTTA, Z. A., CHRISTIAN, P., DE ONIS, M., EZZATI, M., GRANTHAM-MCGREGOR, S., KATZ, J., MARTORELL, R. & UAUY, R. 2013. Maternal and child undernutrition and overweight in low-income and middle-income countries. *The Lancet*, 382, 427-451.
- BLOSS, E., WAINAINA, F. & BAILEY, R. C. 2004. Prevalence and Predictors of Underweight, Stunting, and Wasting among Children Aged 5 and Under in Western Kenya. *Journal of Tropical Pediatrics*, 50, 260-270.
- BLÖSSNER, M. & DE ONIS, M. 2005. Malnutrition: Quantifying the Health Impact at National and Local Levels. Geneva: World Health Organization.
- BLÖSSNER, M., SIYAM, A., BORGH, E., DE ONIS, M., ONYANGO, A. & YANG, H. 2010. WHO Anthro for Personal Computers: Software for assessing growth and development of the world's children *World Health Organisation Publications*. Geneva: World Health Organisation, 2011. All rights reserved.
- BRHANE, G. & REGASSA, N. 2014. Nutritional status of children under five years of age in Shire Indaselassie, North Ethiopia: Examining the prevalence and risk factors. *Kontakt*, 16, e161-e170.
- BRIEND, A., KHARA, T. & DOLAN, C. 2015. Wasting and stunting--similarities and differences: policy and programmatic implications. *Food Nutr Bull*, 36, S15-23.
- BRIEND, A., MAIRE, B., FONTAINE, O. & GARENNE, M. 2012. Mid-upper arm circumference and weight-for-height to identify high-risk malnourished under-five children. *Matern Child Nutr*, 8, 130-3.
- BRYCE, J., BOSCHI-PINTO, C., SHIBUYA, K. & BLACK, R. E. 2005. WHO estimates of the causes of death in children. *Lancet*, 365, 1147-52.
- BUCENS, I. K. & MACLENNAN, C. 2006. Survey of childhood malnutrition at Dili National Hospital, East Timor. *J Paediatr Child Health*, 42, 28-32.
- BUCENS, I. K., REID, A., BARRETO, A. C., DWIVEDI, V. & COUNAHAN, M. 2013. Three years of paediatric morbidity and mortality at the National Hospital in Dili, East Timor. *J Paediatr Child Health*, 49, 1004-9.
- BURDEN, S. T., STOPPARD, E., SHAFFER, J., MAKIN, A. & TODD, C. 2005. Can we use mid upper arm anthropometry to detect malnutrition in medical inpatients? A validation study. *Journal of Human Nutrition and Dietetics*, 18, 287-294.
- BUTTE, N. F., WONG, W. W., HOPKINSON, J. M., SMITH, E. O. & ELLIS, K. J. 2000. Infant feeding mode affects early growth and body composition. *Pediatrics*, 106, 1355-66.
- CAHILL, G. F. 2006. Fuel Metabolism in Starvation. *Annual Review of Nutrition*, 26, 1-22.
- CAMERON, N. 1980. Conditional standards for growth in height of British children from 5.0 to 15.99 years of age. *Ann Hum Biol*, 7, 331-7.
- CAMERON, N. & HAWLEY, N. L. 2010. Should the UK use WHO growth charts? *Paediatrics and Child Health*, 20, 151-156.
- CAMPANOZZI, A., RUSSO, M., CATUCCI, A., RUTIGLIANO, I., CANESTRINO, G., GIARDINO, I., ROMONDIA, A. & PETTOELLO-MANTOVANI, M. 2009. Hospital-acquired malnutrition in children with mild clinical conditions. *Nutrition*, 25, 540-7.
- CATTANEO, A. & BUZZETTI, R. 2001. Effect On Rates Of Breast Feeding Of Training For The Baby Friendly Hospital Initiative. *BMJ: British Medical Journal*, 323, 1358-1362.
- CHARLTON, K. E., KAWANA, B. M. & HENDRICKS, M. K. 2009. An assessment of the effectiveness of growth monitoring and promotion practices in the Lusaka district of Zambia. *Nutrition*, 25, 1035-46.
- CHERMESH, I., PAPIER, I., KARBAN, A., KLUGER, Y. & ELIAKIM, R. 2011. Identifying patients at risk for malnutrition is a MUST: A multidisciplinary approach. *e-SPEN, the European e-Journal of Clinical Nutrition and Metabolism*, 6, e41-e44.
- CHIGBU, P. E. 1995. *Semi-Latin squares: methods for enumeration and comparison*. Ph.D Doctoral, University of London.
- CHILDREN'S INVESTMENT FUND FOUNDATION 2014. Saving children's lives with care and fortified peanut paste.
- CHUKWU, B., CHINAWA, J., IKEFUNA, A. & EMODI, I. 2013. Pattern and outcome of paediatric medical admissions at the University of Nigeria Teaching Hospital (UNTH), Ituku-Ozalla, Enugu - a five year retrospective review (2007 – 2011). *Nigerian Journal of Paediatrics*, 40, 354-359.

- CLARKE-O'NEILL, S., PETTERSSON, L., FADER, M., DEAN, G., BROOKS, R. & COTTENDEN, A. 2002. A multicentre comparative evaluation: washable pants with an integral pad for light incontinence. *J Clin Nurs*, 11, 79-89.
- COLE, T. 2007. Babies, bottles, breasts: is the WHO growth standard relevant? *Significance*, 4, 6-10.
- COLE, T. J. 1990. The LMS method for constructing normalized growth standards. *European journal of clinical nutrition*, 44, 45-60.
- COLE, T. J. 1995. Conditional reference charts to assess weight gain in British infants. *Arch Dis Child*, 73, 8-16.
- COLE, T. J. 1998. Presenting information on growth distance and conditional velocity in one chart: practical issues of chart design. *Statistics in Medicine*, 17, 2697-2707.
- COLE, T. J. & GREEN, P. J. 1992. Smoothing reference centile curves: the LMS method and penalized likelihood. *Statistics in medicine*, 11, 1305-1319.
- COLLINS, S., DENT, N., BINNS, P., BAHWERE, P., SADLER, K. & HALLAM, A. 2006a. Management of severe acute malnutrition in children. *Lancet*, 368, 1992-2000.
- COLLINS, S., SADLER, K., DENT, N., KHARA, T., GUERRERO, S., MYATT, M., SABOYA, M. & WALSH, A. 2006b. Key issues in the success of community-based management of severe malnutrition. *Food Nutr Bull*, 27, S49-82.
- COONEY, K., PATHAK, U. & WATSON, A. 1994. Infant growth charts. *Arch Dis Child*, 71, 159-60.
- CORREIA, M. I. T. D. & WAITZBERG, D. L. 2003. The impact of malnutrition on morbidity, mortality, length of hospital stay and costs evaluated through a multivariate model analysis. *Clinical Nutrition*, 22, 235-239.
- CROOKSTON, B., ALDER, S., BOAKYE, I., MERRILL, R., AMUASI, J., PORUCZNIK, C., STANFORD, J., DICKERSON, T., DEARDEN, K., HALE, D., SYLVERKEN, J., SNOW, B., OSEI-AKOTO, A. & ANSONG, D. 2010. Exploring the relationship between chronic undernutrition and asymptomatic malaria in Ghanaian children. *Malaria Journal*, 9, 39.
- CROSS, J. H., HOLDEN, C., MACDONALD, A., PEARMAIN, G., STEVENS, M. C. & BOOTH, I. W. 1995. Clinical examination compared with anthropometry in evaluating nutritional status. *Arch Dis Child*, 72, 60-1.
- DAIRO, M. D., FATOKUN, M. E. & KUTI, M. 2012. Reliability of the Mid Upper Arm Circumference for the Assessment of Wasting among Children Aged 12-59 Months in Urban Ibadan, Nigeria. *Int J Biomed Sci*, 8, 140-3.
- DALE, N. M., MYATT, M., PRUDHON, C. & BRIEND, A. 2013. Using mid-upper arm circumference to end treatment of severe acute malnutrition leads to higher weight gains in the most malnourished children. *PLoS One*, 8, e55404.
- DAMIANI, N., MOORE, C. & MIRZAIAN, C. B. 2015. Pediatric Malnutrition: Beyond the Hospital. *ICAN: Infant, Child, & Adolescent Nutrition*, 7, 154-156.
- DANI, V., SATAV, A., PENDHARKAR, J., UGHADE, S., JAIN, D., ADHAV, A. & SADANSHIV, A. 2014. Prevalence of under nutrition in under-five tribal children of Melghat: A community based cross sectional study in Central India. *Clinical Epidemiology and Global Health*, 2, 1-8.
- DANI, V., SATAV, A., PENDHARKAR, J., UGHADE, S., JAIN, D., ADHAV, A. & SADANSHIV, A. 2015. Prevalence of under nutrition in under-five tribal children of Melghat: A community based cross sectional study in Central India. *Clinical Epidemiology and Global Health*, 3, 77-84.
- DE CUNTO, A., PAVIOTTI, G., RONFANI, L., TRAVAN, L., BUA, J., CONT, G. & DEMARINI, S. 2014. Can body mass index accurately predict adiposity in newborns? *Arch Dis Child Fetal Neonatal Ed*, 99, F238-9.
- DE LUCA, A., PILOQUET, H., MANSILLA, M., SIMON, D., FISCHBACH, M., CALDARI, D., DORIGNY, B., INGRAND, P. & HANKARD, R. 2012. Multicenter nutritional screening in hospitalized children. *Arch Pediatr*, 19, 545-6.
- DE ONIS, M. 2013. Update on the implementation of the WHO child growth standards. *World Rev Nutr Diet*, 106, 75-82.
- DE ONIS, M. & BLOSSNER, M. 2003. The World Health Organization Global Database on Child Growth and Malnutrition: methodology and applications. *Int J Epidemiol*, 32, 518-26.

- DE ONIS, M. & BLÖSSNER, M. 1997. WHO Global Database on Child Growth and Malnutrition. Geneva, Switzerland: World Health Organization.
- DE ONIS, M., BLOSSNER, M. & BORGHI, E. 2012a. Prevalence and trends of stunting among pre-school children, 1990-2020. *Public Health Nutr*, 15, 142-8.
- DE ONIS, M., GARZA, C. & HABICHT, J. P. 1997. Time for a new growth reference. *Pediatrics*, 100, E8.
- DE ONIS, M., MONTEIRO, C., AKRE, J. & CLUGSTON, G. 1993. The worldwide magnitude of protein-energy malnutrition: an overview from the WHO Global Database on Child Growth. *Bull World Health Organ*, 71, 703-712.
- DE ONIS, M., NOMMSEN-RIVERS, L. A., BAERUG, A., LARTEY, A., ONYANGO, A., ALBERNAZ, E., BHANDARI, N., MARTINES, J., PRAKASH, N. S. & SAGOE, I. 2006a. Breastfeeding in the WHO Multicentre growth reference study. *Acta Paediatrica*, 95, 16-26.
- DE ONIS, M., ONYANGO, A., BORGHI, E., SIYAM, A., BLOSSNER, M. & LUTTER, C. 2012b. Worldwide implementation of the WHO Child Growth Standards. *Public Health Nutrition*, 15, 1603-1610.
- DE ONIS, M., ONYANGO, A. W., BORGHI, E., GARZA, C. & YANG, H. 2006b. Comparison of the World Health Organization (WHO) Child Growth Standards and the National Center for Health Statistics/WHO international growth reference: implications for child health programmes. *Public Health Nutrition*, 9, 942-947.
- DE ONIS, M., WIJNHOFEN, T. M. & ONYANGO, A. W. 2004. Worldwide practices in child growth monitoring. *J Pediatr*, 144, 461-5.
- DETSKY, A. S., MCLAUGHLIN, J. R., BAKER, J. P., JOHNSTON, N., WHITTAKER, S., MENDELSON, R. A. & JEEJEBHOY, K. N. 1987. What Is Subjective Global Assessment of Nutritional-Status. *Journal of Parenteral and Enteral Nutrition*, 11, 8-13.
- DEWEY, K. G., HEINIG, M. J., NOMMSEN, L. A., PEERSON, J. M. & LONNERDAL, B. 1992. Growth of breast-fed and formula-fed infants from 0 to 18 months: the DARLING Study. *Pediatrics*, 89, 1035-41.
- DEWEY, K. G. & MAYERS, D. R. 2011. Early child growth: how do nutrition and infection interact? *Matern Child Nutr*, 7 Suppl 3, 129-42.
- DEWEY, K. G., PEERSON, J. M., BROWN, K. H., KREBS, N. F., MICHAELSEN, K. F., PERSSON, L. A., SALMENPERA, L., WHITEHEAD, R. G., YEUNG, D. L., ANDERSON, A. M., DEWEY, K. G., FRONGILLO, E., GARZA, C., HASCHKE, F., KRAMER, M. & WINICHAGOON, P. 1995. Growth of Breast-Fed Infants Deviates from Current Reference Data - A Pooled Analysis of Us, Canadian, and European Data Sets. *Pediatrics*, 96, 495-503.
- DIETITIANS OF CANADA, CANADIAN PAEDIATRIC SOCIETY, THE COLLEGE OF FAMILY PHYSICIANS OF CANADA & CANADA, C. H. N. O. 2010a. A health professional's guide for using the new WHO growth charts. *Paediatr Child Health*, 15, 84-90.
- DIETITIANS OF CANADA, CANADIAN PAEDIATRIC SOCIETY, THE COLLEGE OF FAMILY PHYSICIANS OF CANADA & CANADA, C. H. N. O. 2010b. Promoting optimal monitoring of child growth in Canada. Using the New WHO Growth Charts. Collaborative Public Policy Statement. *Canadian Journal of Dietetic Practice and Research*, 71, e1-e3.
- DUERKSEN, D. R., YEO, T. A., SIEMENS, J. L. & O'CONNOR, M. P. 2000. The validity and reproducibility of clinical assessment of nutritional status in the elderly. *Nutrition*, 16, 740-4.
- EDEFONTI, A., PICCA, M., DAMIANI, B., GARAVAGLIA, R., LOI, S., ARDISSINO, G., MARRA, G. & GHIO, L. 2001. Prevalence of malnutrition assessed by bioimpedance analysis and anthropometry in children on peritoneal dialysis. *Perit Dial Int*, 21, 172-9.
- EGATA, G., BERHANE, Y. & WORKU, A. 2013. Seasonal variation in the prevalence of acute undernutrition among children under five years of age in east rural Ethiopia: a longitudinal study. *BMC Public Health*, 13, 864.
- EGATA, G., BERHANE, Y. & WORKU, A. 2014. Predictors of acute undernutrition among children aged 6 to 36 months in east rural Ethiopia: a community based nested case-control study. *BMC Pediatrics*, 14, 91.

- EHRHARDT, S., BURCHARD, G. D., MANTEL, C., CRAMER, J. P., KAISER, S., KUBO, M., OTCHWEMAH, R. N., BIENZLE, U. & MOCKENHAUPT, F. P. 2006. Malaria, Anemia, and Malnutrition in African Children – Defining Intervention Priorities. *Journal of Infectious Diseases*, 194, 108-114.
- EJIANYA, K., COLE, H., NJOKANMA, O. & OKPUNO, G. 2003. Feeding Practices and Weight gain in the first six months of life. *Nig J Paed*, 30, 8-22.
- EKANEM, I. A., EKANEM, A. P., ASUQUO, A. & EYO, V. O. 2012. Attitude of Working Mothers to Exclusive Breastfeeding in Calabar Municipality, Cross River State, Nigeria. *Journal of Food Research* 1.
- EMOND, A., DREWETT, R., BLAIR, P. & EMMETT, P. 2007. Postnatal factors associated with failure to thrive in term infants in the Avon Longitudinal Study of Parents and Children. *Arch Dis Child*, 92, 115-9.
- ENGBRETSSEN, I. M., TYLLESKAR, T., WAMANI, H., KARAMAGI, C. & TUMWINE, J. K. 2008. Determinants of infant growth in Eastern Uganda: a community-based cross-sectional study. *BMC Public Health*, 8, 418.
- ENN/UCL/ACF 2010. Management of Acute Malnutrition in Infants (MAMI) Project. *Technical review: Current evidence, policies, practices & programme outcomes*. Emergency Nutrition Network (ENN), University College London Centre for International Child Health & Development (CIHD), Action Contre la Faim (ACF). Available at <http://www.enonline.net/ourwork/research/mami>.
- ERGIE, C. & ABRAHAM, R. 2000. Growth patterns of exclusively breastfed term infants. *Nig J Paed*, 27, 73-93.
- EZEFOR, I. O. 2005. *Growth pattern of breastfed infants (0 – 24 weeks old) attending the Infant Welfare Clinic of the University of Nigeria Teaching Hospital (UNTH), Enugu*. MSc Human Nutrition MSc Dissertation, University of Nigeria, Nsukka, Nigeria.
- EZEFOR, I. O. & OKEKE, E. C. 2005. Growth pattern of breastfed infants (0 – 24 weeks old) attending the Infant Welfare Clinic of University of Nigeria Teaching Hospital, Enugu. *Nigerian Journal of Nutritional Sciences* 26, 1-9.
- FARR, V. 1966. Skinfold Thickness As An Indication of Maturity of Newborn. *Archives of Disease in Childhood*, 41, 301-&.
- FERNANDEZ, M. A., DELCHEVALERIE, P. & VAN HERP, M. 2010. Accuracy of MUAC in the detection of severe wasting with the new WHO growth standards. *Pediatrics*, 126, e195-201.
- FJELD, E., SIZIYA, S., KATEPA-BWALYA, M., KANKASA, C., MOLAND, K., TYLLESKAR, T. & GROUP, T. P.-E. S. 2008. 'No sister, the breast alone is not enough for my baby' a qualitative assessment of potentials and barriers in the promotion of exclusive breastfeeding in southern Zambia. *International Breastfeeding Journal*, 3, 26.
- FOK, T. F., HON, K. L., NG, P. C., WONG, M. C., SO, H. K., LAU, T. F., CHOW, C. B., LEE, W. H. & HONG KONG NEONATAL MEASUREMENTS WORKING, G. 2006. Normative data for triceps and subscapular skinfold thicknesses of Chinese infants. *Acta Paediatr*, 95, 1614-9.
- FONTES, D., GENEROSO SDE, V. & TOULSON DAVISSON CORREIA, M. I. 2014. Subjective global assessment: a reliable nutritional assessment tool to predict outcomes in critically ill patients. *Clin Nutr*, 33, 291-5.
- FRENEY, E., JOHNSON, D. & KNOX, I. 2015. Promoting Breastfeeding-Friendly Hospital Practices: A Washington State Learning Collaborative Case Study. *J Hum Lact*.
- FRIEDMAN, J., KWENA, A., MIREL, L., KARIUKI, S., TERLOUW, D., PHILLIPS-HOWARD, P., HAWLEY, W., NAHLEN, B., SHI, Y. & TER KUILE, F. 2005. Malaria and nutritional status among pre-school children: Results from cross-sectional surveys in western Kenya *The American Journal of Tropical Medicine and Hygiene*, 73, 698-704.
- GARNER, P., PANPANICH, R. & LOGAN, S. 2000. Is routine growth monitoring effective? A systematic review of trials. *Arch.Dis.Child*, 82, 197-201.
- GERASIMIDIS, K., KEANE, O., MACLEOD, I., FLYNN, D. M. & WRIGHT, C. M. 2010. A four-stage evaluation of the Paediatric Yorkhill Malnutrition Score in a tertiary paediatric hospital and a district general hospital. *Br J Nutr*, 104, 751-6.

- GOMILA, A. A., DE GRANDIS, E. S., VISCONTI, G. B., MONTERO, S. B., BERTERO, M. I., MARIETTI, G., CRESPO, D., PICO, A. N., BIANCHI, M. & GOMILA, H. A. 2009. Nutritional status in children hospitalized in minimum care wards. Hospital de Ninos de la Santisima Trinidad. Cordoba. *Arch Argent Pediatr*, 107, 37-42.
- GOULET, O. 2010. Growth faltering: setting the scene. *Eur J Clin Nutr*, 64, 2-4.
- GRANTHAM-MCGREGOR, S., CHEUNG, Y. B., CUETO, S., GLEWWE, P., RICHTER, L., STRUPP, B. & INTERNATIONAL CHILD DEVELOPMENT STEERING, G. 2007. Developmental potential in the first 5 years for children in developing countries. *Lancet*, 369, 60-70.
- GREK, J. & PUNTIS, J. 2013. Nutritional assessment of acute medical admissions is still done badly despite 'nutrition screening'. *Arch.Dis.Child*, 98, 922-923.
- GRIFFITHS, M. & DEL ROSSO, J. 2007. GROWTH MONITORING AND THE PROMOTION OF HEALTHY YOUNG CHILD GROWTH. *Evidence of Effectiveness and Potential to Prevent Malnutrition*
- GRIFFITHS, M., DICKIN, K. & FAVIN, M. 1996. Promoting the Growth of Children: What Works. Rationale and Guidance for Programs. *The World Bank's Nutrition Toolkit*, Tool Number 4, 1-101.
- GUPTA, D., LAMMERSFELD, C. A., VASHI, P. G., BURROWS, J., LIS.CG & GRUTSCH, J. 2004. Prognostic significance of Subjective Global Assessment (SGA) in advanced colorectal cancer. *Eur J Clin Nutr*, 59, 35-40.
- HADDAD, L., ALDERMAN, H., APPLETON, S., SONG, L. & YOHANNES, Y. 2003. Reducing Child Undernutrition: How Far Does Income Growth Take Us? . *World Bank Economic Review*, 17, 107-131.
- HALL, D. & ELLIMAN, D. 2003. *Health for all Children*, Oxford Medical Publications.
- HALL, D. M. 2000. Growth monitoring. *Arch Dis Child*, 82, 10-5.
- HANKARD, R., BLOCH, J., MARTIN, P., RANDRIANASOLO, H., BANNIER, M. F., MACHINOT, S. & CEZARD, J. P. 2001. Nutritional status and risk in hospitalized children. *Arch Pediatr*, 8, 1203-8.
- HANKARD, R., COLOMB, V., PILOQUET, H., BOCQUET, A., BRESSON, J. L., BRIEND, A., CHOURAQUI, J. P., DARMAUN, D., DUPONT, C., FRELUT, M. L., GIRARDET, J. P., GOULET, O., RIEU, D., SIMEONI, U., TURCK, D. & VIDAILHET, M. 2012. Malnutrition screening in clinical practice. *Pediatrics Archive*, 19, 1110-1117.
- HAROON, S., DAS, J. K., SALAM, R. A., IMDAD, A. & BHUTTA, Z. A. 2013. Breastfeeding promotion interventions and breastfeeding practices: a systematic review. *BMC Public Health*, 13 Suppl 3, S20.
- HARRINGTON, T. A., THOMAS, E. L., FROST, G., MODI, N. & BELL, J. D. 2004. Distribution of adipose tissue in the newborn. *Pediatr Res*, 55, 437-41.
- HARTTGEN, K., KLASSEN, S. & VOLLMER, S. 2013. Economic Growth and Child Undernutrition in sub-Saharan Africa. *Population and Development Review*, 39, 397-412.
- HEALY, M. J. 1974. Notes on the statistics of growth standards. *Ann Hum Biol*, 1, 41-6.
- HEALY, M. J. & GOLDSTEIN, H. 1978. Regression to the mean. *Ann Hum Biol*, 5, 277-80.
- HECHT, C., WEBER, M., GROTE, V., DASKALOU, E., DELL'ERA, L., FLYNN, D., GERASIMIDIS, K., GOTTRAND, F., HARTMAN, C., HULST, J., JOOSTEN, K., KARAGIOZOGLOU-LAMPOUDI, T., KOETSE, H. A., KOLACEK, S., KSIAZYK, J., NISETEO, T., OLSZEWSKA, K., PAVESI, P., PIWOWARCZYK, A., ROUSSEAU, J., SHAMIR, R., SULLIVAN, P. B., SZAJEWSKA, H., VERNON-ROBERTS, A. & KOLETZKO, B. 2015. Disease associated malnutrition correlates with length of hospital stay in children. *Clin Nutr*, 34, 53-9.
- HEIMENDINGER, J. & LAIRD, N. 1983. Growth Changes - Measuring the Effect of An Intervention. *Evaluation Review*, 7, 80-95.
- HENDRICKS, K. M., DUGGAN, C., GALLAGHER, L., CARLIN, A. C., RICHARDSON, D. S., COLLIER, S. B., SIMPSON, W. & LO, C. 1995. Malnutrition in hospitalized pediatric patients. Current prevalence. *Arch Pediatr Adolesc Med*, 149, 1118-22.
- HENDRIKSE, W. H., REILLY, J. J. & WEAVER, L. T. 1997. Malnutrition in a children's hospital. *Clinical Nutrition*, 16, 13-18.
- HULST, J. M., ZWART, H., HOP, W. C. & JOOSTEN, K. F. 2010. Dutch national survey to test the STRONGkids nutritional risk screening tool in hospitalized children. *Clin Nutr*, 29, 106-11.

- HUYSENTRUYT, K., ALLIET, P., MUYSHONT, L., DEVREKER, T., BONTEMS, P. & VANDENPLAS, Y. 2013. Hospital-related undernutrition in children: still an often unrecognized and undertreated problem. *Acta Paediatrica*, 102, e460-e466.
- IANNOTTI, L. L., ZAVALATA, N., LEON, Z. & CAULFIELD, L. E. 2009. Growth and body composition of Peruvian infants in a periurban setting. *Food Nutr Bull*, 30, 245-53.
- IBEZIAKO, S. N. & IBEKWE, R. 2002. Pattern and outcome of admissions in the children's emergency room of the University of Nigeria Teaching Hospital, Enugu. *Nig J Paediatr* 2002, 29, 103-107.
- ILIYAS, M. & MUBASHER, M. 2003. Reproductive Health. In: ILIYAS M, E. (ed.) *Community Medicine & Public Health*. 6th edition ed. Karachi: Time Publishers.
- IMDAD, A., YAKOOB, M. Y. & BHUTTA, Z. A. 2011a. Effect of breastfeeding promotion interventions on breastfeeding rates, with special focus on developing countries. *BMC Public Health*, 11 Suppl 3, S24.
- IMDAD, A., YAKOOB, M. Y. & BHUTTA, Z. A. 2011b. Impact of maternal education about complementary feeding and provision of complementary foods on child growth in developing countries. *BMC Public Health*, 11.
- JEEJEEBHOY, K. N. 2000. Nutritional assessment. *Nutrition*, 16, 585-590.
- JEEJEEBHOY, K. N. 2003. Hospital malnutrition: is a disease or lack of food? *Clinical Nutrition*, 22, 219-220.
- JELLIFFE, D. B. 1976. World trends in infant feeding. *Am J Clin Nutr*, 29, 1227-37.
- JENSEN, G. L., MIRTALLO, J., COMPER, C., DHALIWAL, R., FORBES, A., GRIJALBA, R. F., HARDY, G., KONDRUP, J., LABADARIOS, D., NYULASI, I., CASTILLO PINEDA, J. C. & WAITZBERG, D. 2010. Adult starvation and disease-related malnutrition: a proposal for etiology-based diagnosis in the clinical practice setting from the International Consensus Guideline Committee. *JPEN J Parenter Enteral Nutr*, 34, 156-9.
- JONES, K. D. & BERKLEY, J. A. 2014. Severe acute malnutrition and infection. *Paediatr Int Child Health*, 34 Suppl 1, S1-S29.
- JOOSTEN, K. F. & HULST, J. M. 2008. Prevalence of malnutrition in pediatric hospital patients. *Curr Opin Pediatr*, 20, 590-6.
- JOOSTEN, K. F. & HULST, J. M. 2011. Malnutrition in pediatric hospital patients: Current issues. *Nutrition*, 27, 133-137.
- JOOSTEN, K. F., ZWART, H., HOP, W. C. & HULST, J. M. 2010. National malnutrition screening days in hospitalised children in The Netherlands. *Arch Dis Child*, 95, 141-5.
- JÚLIÚSSON, P. B., ROELANTS, M., HOPPENBROUWERS, K., HAUSPIE, R. & BJERKNES, R. 2011. Growth of Belgian and Norwegian children compared to the WHO growth standards: Prevalence below -2 and above + 2 standard deviations and the effect of breastfeeding. *Arch Dis Child*, 96, 916-921.
- KARAOLIS, N., JACKSON, D., ASHWORTH, A., SANDERS, D., SOGAULA, N., MCCOY, D., CHOPRA, M. & SCHOFIELD, C. 2007. WHO guidelines for severe malnutrition: are they feasible in rural African hospitals? *Arch Dis Child*, 92, 198-204.
- KAZIMI, L. J. & KAZIMI, H. R. 1979. Infant feeding practices of the Igbo, Nigeria. *Ecology of Food and Nutrition*, 8, 111-116.
- KEITH, J. N. 2008. Bedside nutrition assessment past, present, and future: a review of the Subjective Global Assessment. *Nutr Clin Pract*, 23, 410-6.
- KERAC, M., BLENCOWE, H., GRIJALVA-ETERNOD, C., MCGRATH, M., SHOHAM, J., COLE, T. J. & SEAL, A. 2011. Prevalence of wasting among under 6-month-old infants in developing countries and implications of new case definitions using WHO growth standards: a secondary data analysis. *Arch.Dis.Child*, 96, 1008-1013.
- KERAC, M., MWANGOME, M., MCGRATH, M., HAIDER, R. & BERKLEY, J. A. 2015. Management of acute malnutrition in infants aged under 6 months (MAMI): current issues and future directions in policy and research. *Food Nutr Bull*, 36, S30-4.
- KIMANI-MURAGE, E. W., MADISE, N. J., FOTSO, J. C., KYOBUTUNGI, C., MUTUA, M. K., GITAU, T. M. & YATICH, N. 2011. Patterns and determinants of breastfeeding and complementary feeding practices in urban informal settlements, Nairobi Kenya. *BMC Public Health*, 11, 396.
- KINOSIAN, B. & JEEJEEBHOY, K. N. 1995. What is malnutrition? Does it matter? *Nutrition*, 11, 196-7.

- KISMUL, H., SCHWINGER, C., CHHAGAN, M., MAPATANO, M. & VAN DEN BROECK, J. 2014. Incidence and course of child malnutrition according to clinical or anthropometrical assessment: a longitudinal study from rural DR Congo. *BMC Pediatr*, 14, 22.
- KITENGE, G. & GOVENDER, I. 2014. Nurses' monitoring of the Road to Health Chart at primary healthcare level in Makhado, Limpopo province. *S Afr Fam Pract*, 55, 275-280.
- KLASEN, S. 2008. Poverty, undernutrition, and child mortality: Some inter-regional puzzles and their implications for research and policy. *J Econ Inequal*, 6, 89-115.
- KONDRUP, J., ALLISON, S. P., ELIA, M., VELLAS, B., PLAUTH, M., EDUCATIONAL, CLINICAL PRACTICE COMMITTEE, E. S. O. P. & ENTERAL, N. 2003. ESPEN guidelines for nutrition screening 2002. *Clin Nutr*, 22, 415-21.
- KRAMER, C. V. & ALLEN, S. 2015. Malnutrition in developing countries. *Paediatrics and Child Health*, 25, 422-427.
- KRAMER, M. S., CHALMERS, B., HODNETT, E. D., SEVKOVSKAYA, Z., DZIKOVICH, I., SHAPIRO, S., COLLET, J. P., VANILOVICH, I., MEZEN, I., DUCRUET, T., SHISHKO, G., ZUBOVICH, V., MKNUIK, D., GLUCHANINA, E., DOMBROVSKIY, V., USTINOVITCH, A., KOT, T., BOGDANOVICH, N., OVCHNIKOVA, L., HELSING, E. & GROUP, P. S. 2001. Promotion of Breastfeeding Intervention Trial (PROBIT): a randomized trial in the Republic of Belarus. *JAMA*, 285, 413-20.
- KRAMER, M. S., GUO, T., PLATT, R. W., SHAPIRO, S., COLLET, J. P., CHALMERS, B., HODNETT, E., SEVKOVSKAYA, Z., DZIKOVICH, I., VANILOVICH, I. & GROUP, P. S. 2002. Breastfeeding and infant growth: biology or bias? *Pediatrics*, 110, 343-7.
- KRAMER, M. S. & KAKUMA, R. 2012. Optimal duration of exclusive breastfeeding: A systematic review. *Cochrane Database Syst Rev*. 15 August 2012 ed.: John Wiley & Sons, Ltd.
- KUMAR, R., SINGH, J., JOSHI, K., SINGH, H. P. & BIJESH, S. 2014. Co-morbidities in hospitalized children with severe acute malnutrition. *Indian Pediatr*, 51, 125-7.
- KUTI, B., ADEGOKE, S., OYELAMI, O. & OTA, M. 2014. Predictors of prolonged hospitalisation in childhood pneumonia in a rural health centre. *S Afr J CH*, 8, 11-15.
- KYLE, U. G., BOSAEUS, I., DE LORENZO, A. D., DEURENBERG, P., ELIA, M., MANUEL GÓMEZ, J., LILIENTHAL HEITMANN, B., KENT-SMITH, L., MELCHIOR, J.-C., PIRLICH, M., SCHARFETTER, H., M.W.J SCHOLS, A. & PICHARD, C. 2004. Bioelectrical impedance analysis—part II: utilization in clinical practice. *Clinical Nutrition*, 23, 1430-1453.
- LAKIC, N. S. 2002. Classification of Latin squares. *Journal of Agricultural Sciences, Belgrade*, 47, 105-112.
- LAMBERTI, L. M., FISCHER WALKER, C. L., NOIMAN, A., VICTORA, C. & BLACK, R. E. 2011. Breastfeeding and the risk for diarrhea morbidity and mortality. *BMC Public Health*, 11 Suppl 3, S15.
- LIM, S. S., VOS, T., FLAXMAN, A. D., DANAEI, G., SHIBUYA, K., ADAIR-ROHANI, H., AMANN, M., ANDERSON, H. R., ANDREWS, K. G., ARYEE, M., ATKINSON, C., BACCHUS, L. J., BAHALIM, A. N., BALAKRISHNAN, K., BALMES, J., BARKER-COLLO, S., BAXTER, A., BELL, M. L., BLORE, J. D., BLYTH, F., BONNER, C., BORGES, G., BOURNE, R., BOUSSINESQ, M., BRAUER, M., BROOKS, P., BRUCE, N. G., BRUNEKREEF, B., BRYAN-HANCOCK, C., BUCELLO, C., BUCHBINDER, R., BULL, F., BURNETT, R. T., BYERS, T. E., CALABRIA, B., CARAPETIS, J., CARNAHAN, E., CHAFE, Z., CHARLSON, F., CHEN, H., CHEN, J. S., CHENG, A. T., CHILD, J. C., COHEN, A., COLSON, K. E., COWIE, B. C., DARBY, S., DARLING, S., DAVIS, A., DEGENHARDT, L., DENTENER, F., DES JARLAIS, D. C., DEVRIES, K., DHERANI, M., DING, E. L., DORSEY, E. R., DRISCOLL, T., EDMOND, K., ALI, S. E., ENGELL, R. E., ERWIN, P. J., FAHIMI, S., FALDER, G., FARZADFAR, F., FERRARI, A., FINUCANE, M. M., FLAXMAN, S., FOWKES, F. G., FREEDMAN, G., FREEMAN, M. K., GAKIDOU, E., GHOSH, S., GIOVANNUCCI, E., GMEL, G., GRAHAM, K., GRAINGER, R., GRANT, B., GUNNELL, D., GUTIERREZ, H. R., HALL, W., HOEK, H. W., HOGAN, A., HOSGOOD, H. D., 3RD, HOY, D., HU, H., HUBBELL, B. J., HUTCHINGS, S. J., IBEANUSI, S. E., JACKLYN, G. L., JASRASARIA, R., JONAS, J. B., KAN, H., KANIS, J. A., KASSEBAUM, N., KAWAKAMI, N., KHANG, Y. H., KHATIBZADEH, S., KHOO, J. P., KOK, C., LADEN, F., et al. 2012. A comparative risk assessment of burden of disease and injury attributable to 67 risk factors and risk factor

- clusters in 21 regions, 1990-2010: a systematic analysis for the Global Burden of Disease Study 2010. *Lancet*, 380, 2224-60.
- LINNEMAYR, S., ALDERMAN, H. & KA, A. 2008. Determinants of malnutrition in Senegal: Individual, household, community variables, and their interaction. *Economics & Human Biology*, 6, 252-263.
- LIU, L., JOHNSON, H. L., COUSENS, S., PERIN, J., SCOTT, S., LAWN, J. E., RUDAN, I., CAMPBELL, H., CIBULSKIS, R., LI, M. Y., MATHERS, C. & BLACK, R. E. 2012. Global, regional, and national causes of child mortality: an updated systematic analysis for 2010 with time trends since 2000. *Lancet*, 379, 2151-2161.
- LOCHS, H., ALLISON, S. P., MEIER, R., PIRLICH, M., KONDRUP, J., SCHNEIDER, S., VAN DEN BERGHE, G. & PICHARD, C. 2006. Introductory to the ESPEN Guidelines on Enteral Nutrition: Terminology, definitions and general topics. *Clin Nutr*, 25, 180-6.
- LOPRIORE, C., DOP, M. C., SOLAL-CELIGNY, A. & LAGNADO, G. 2007. Excluding infants under 6 months of age from surveys: impact on prevalence of pre-school undernutrition. *Public Health Nutr*, 10, 79-87.
- LUTTER, C. K., DAELMANS, B. M. E. G., DE ONIS, M., KOTHARI, M. T., RUEL, M. T., ARIMOND, M., DEITCHLER, M., DEWEY, K. G., BLASSNER, M. & BORGHI, E. 2011. Undernutrition, Poor Feeding Practices, and Low Coverage of Key Nutrition Interventions. *Pediatrics*, 128, e1418-e1427.
- MAHDAVI, A. M., SAFAIYAN, A. & OSTADRAHIMI, A. 2009. Subjective vs objective nutritional assessment study in children: a cross-sectional study in the northwest of Iran. *Nutr Res*, 29, 269-74.
- MANYIKE, P., CHINAWA, J., UBESIE, A., OBU, H., ODETUNDE, O. & CHINAWA, A. 2014. Prevalence of malnutrition among pre-school children in, South-east Nigeria. *Italian Journal of Pediatrics*, 40, 75.
- MARINO, I., GODDARD, E. & WORMAN, I. 2006. Determining the prevalence of malnutrition in hospitalised paediatric patients. *S Afr Med J*, 96, 993-995.
- MARTELETTI, O., CALDARI, D., GUIMBER, D., MENTION, K., MICHAUD, L. & GOTTRAND, F. 2005. Malnutrition screening in hospitalized children: influence of the hospital unit on its management. *Arch Pediatr*, 12, 1226-31.
- MARTORELL, R. & ZONGRONE, A. 2012. Intergenerational influences on child growth and undernutrition. *Paediatr Perinat Epidemiol*, 26 Suppl 1, 302-14.
- MAYCOCK, B., BINNS, C. W., DHALIWAL, S., TOHOTOA, J., HAUCK, Y., BURNS, S. & HOWAT, P. 2013. Education and support for fathers improves breastfeeding rates: a randomized controlled trial. *J Hum Lact*, 29, 484-90.
- MCCARTHY, H., MCNULTY, H., DIXON, M. & EATON-EVANS, M. J. 2008. Screening for nutrition risk in children: the validation of a new tool. *Journal of Human Nutrition and Dietetics*, 21, 395-396.
- MCDOUGALL, P., DREWETT, R. F., HUNGIN, A. P. S. & WRIGHT, C. M. 2009. The detection of early weight faltering at the 6-8-week check and its association with family factors, feeding and behavioural development. *Archives of Disease in Childhood*, 94, 549-552.
- MEDHIN, G., HANLON, C., DEWEY, M., ALEM, A., TEFAYE, F., WORKU, B., TOMLINSON, M. & PRINCE, M. 2010. Prevalence and predictors of undernutrition among infants aged six and twelve months in Butajira, Ethiopia: the P-MaMiE Birth Cohort. *BMC Public Health*, 10, 27.
- MEHTA, N. M., CORKINS, M. R., LYMAN, B., MALONE, A., GODAY, P. S., CARNEY, L. N., MONCZKA, J. L., PLOGSTED, S. W., SCHWENK, W. F., AMERICAN SOCIETY FOR, P. & ENTERAL NUTRITION BOARD OF, D. 2013. Defining pediatric malnutrition: a paradigm shift toward etiology-related definitions. *JPEN J Parenter Enteral Nutr*, 37, 460-81.
- MEIJERS, J. M. M., VAN BOKHORST-DE VAN DER SCHUEREN, M. A. E., SCHOLS, J. M. G. A., SOETERS, P. B. & HALFENS, R. J. G. 2010. Defining malnutrition: Mission or mission impossible? *Nutrition*, 26, 432-440.
- MENGE, I., ESAMAI, F., VAN REKEN, D. & ANABWANI, G. 1995. Paediatric morbidity and mortality at the Eldoret District Hospital, Kenya. *East Afr Med J*, 72, 165-169.

- MESHARAM, I. I., ARLAPPA, N., BALAKRISHNA, N., LAXMAIAH, A., MALLIKARJUN RAO, K., GAL REDDY, C., RAVINDRANATH, M., SHARAD KUMAR, S. & BRAHMAM, G. N. V. 2012. Prevalence and Determinants of Undernutrition and its Trends among Pre-School Tribal Children of Maharashtra State, India. *Journal of Tropical Pediatrics*, 58, 125-132.
- MILANI, S., WRIGHT, C., PURCELL, O., MACLEOD, I. & GERASIMIDIS, K. 2013. Acquisition and utilisation of anthropometric measurements on admission in a paediatric hospital before and after the introduction of a malnutrition screening tool. *Journal of Human Nutrition and Dietetics*, 26, 294-297.
- MOEENI, V., WALLS, T. & DAY, A. S. 2012. Assessment of nutritional status and nutritional risk in hospitalized Iranian children. *Acta Paediatr*, 101, e446-51.
- MOHER, D., LIBERATI, A., TETZLAFF, J. & ALTMAN, D. G. 2009. *Preferred reporting items for systematic reviews and meta-analyses: the PRISMA statement*.
- MORLEY, D. 1994. Will growth monitoring continue to be part of primary health care? *South African Medical Journal*, Suppl, 15-16.
- MOY, R. J. D., SMALLMAN, S. & BOOTH, I. W. 1990. Malnutrition in a UK children's hospital. *Journal of Human Nutrition and Dietetics*, 3, 93-100.
- MOYEN, E., GANGA-ZANDZOU, P. S., CARDORELLE, A. M., MAMADOU, C. I., CHENAUD, M., ATANDA, L. H. & MOYEN, G. 2011. Nutritional status of hospitalized children at Tourcoing Hospital, France. *Arch Pediatr*, 18, 461-2.
- MUELLER, C., COMPHER, C., ELLEN, D. M., PARENTERAL, T. A. S. F. & DIRECTORS, E. N. B. O. 2011. A.S.P.E.N. Clinical Guidelines: Nutrition Screening, Assessment, and Intervention in Adults. *Journal of Parenteral and Enteral Nutrition*, 35, 16-24.
- MULLER, O. & KRAWINKEL, M. 2005. Malnutrition and health in developing countries. *CMAJ*, 173, 279-86.
- MUSA, T. H., MUSA, H. H., ALI, E. A. & MUSA, N. E. 2014. Prevalence of malnutrition among children under five years old in Khartoum State, Sudan. *Polish Annals of Medicine*, 21, 1-7.
- MUSTAPHI, L., MBHENYANE, X., KHOZA, L. & AMEY, A. 2008. Infant-feeding practices of mothers and the nutritional status of infants in the Vhembe District of Limpopo Province. *S Afr J Clin Nutr*, 21, 36-41.
- MUTORO, A. N. 2011. *Accuracy of growth chart use in assessing and monitoring undernutrition in Kenya*. Masters Research in Nutrition Dissertation, University of Glasgow.
- MUTORO, A. N. & WRIGHT, C. M. 2013. Diagnosing childhood undernutrition and accuracy of plotting growth charts in Kenya. *J Trop Pediatr*, 59, 419-22.
- MWANGOME, M., PRENTICE, A., PLUGGE, E. & NWENEKA, C. 2010. Determinants of Appropriate Child Health and Nutrition Practices among Women in Rural Gambia. *Journal of Health, Population, and Nutrition*, 28, 167-172.
- MWANGOME, M. K., FEGAN, G., FULFORD, T., PRENTICE, A. M. & BERKLEY, J. A. 2012a. Mid-upper arm circumference at age of routine infant vaccination to identify infants at elevated risk of death: a retrospective cohort study in the Gambia. *Bull World Health Organ*, 90, 887-94.
- MWANGOME, M. K., FEGAN, G., MBUNYA, R., PRENTICE, A. M. & BERKLEY, J. A. 2012b. Reliability and accuracy of anthropometry performed by community health workers among infants under 6 months in rural Kenya. *Trop Med Int Health*, 17, 622-9.
- MWANGOME, M. K., FEGAN, G., PRENTICE, A. M. & BERKLEY, J. A. 2015. Maternal perception of malnutrition among infants using verbal and pictorial methods in Kenya. *Public Health Nutr*, 18, 869-76.
- MYATT, M., DUFFIELD, A., SEAL, A. & PASTEUR, F. 2008. The effect of body shape on weight-for-height and mid-upper arm circumference based case definitions of acute malnutrition in Ethiopian children. *Annals of Human Biology*. Informa Life Sci.
- MYATT, M., KHARA, T. & COLLINS, S. 2006. A review of methods to detect cases of severely malnourished children in the community for admission into community-based therapeutic care programs. *Food Nutr Bull*, 27, S7-23.
- NATIONAL POPULATION COMMISSION 2006. Provisional census figures. *Official Gazette Federal Republic Nigeria*. Nigeria: National population commission.

- NIYONGABO, T., MELCHIOR, J. C., HENZEL, D., BOUCHAUD, O. & LAROUZE, B. 1999. Comparison of methods for assessing nutritional status in HIV-infected adults. *Nutrition*, 15, 740-3.
- NJOKANMA, O. F., EGRI-OKWAJI, M. T. C. & BABALOLA, J. O. 2008. Early postnatal growth of preterm low birthweight, appropriately-sized infants. *Nig J Clin Paediatr*, 11, 104-110.
- NORMAN, K., PICHARD, C., LOCHS, H. & PIRLICH, M. 2008. Prognostic impact of disease-related malnutrition. *Clin Nutr*, 27, 5-15.
- NORRIS, S. A., GRIFFITHS, P., PETTIFOR, J. M., DUNGER, D. B. & CAMERON, N. 2009. Implications of adopting the WHO 2006 Child Growth Standards: Case study from urban South Africa, the Birth to Twenty cohort. *Annals of Human Biology*. Informa Life Sci.
- NWANKWO, B. O. 2002. Exclusive Breastfeeding is Undermined by Use of Other Liquids in Rural Southwestern Nigeria. *Journal of Tropical Pediatrics*, 48, 109-112.
- NYQVIST, K. H., HAGGKVIST, A. P., HANSEN, M. N., KYLBERG, E., FRANDBSEN, A. L., MAASTRUP, R., EZEONODO, A., HANNULA, L., HAIK, L. N. & BABY-FRIENDLY HOSPITAL INITIATIVE EXPERT, G. 2013. Expansion of the baby-friendly hospital initiative ten steps to successful breastfeeding into neonatal intensive care: expert group recommendations. *J Hum Lact*, 29, 300-9.
- OCHEKE, I. E., JOHN, C. & PUOANE, T. 2014. Factors influencing the pattern of malnutrition among acutely ill children presenting in a tertiary hospital in Nigeria. *Nigerian Journal of Paediatrics*, 41, 236-330.
- OGBUJI, C. 2005. Health Implications of feeding practices of undergraduate nursing mothers in University of Nigeria, Nsukka. *Journal of Home Economics Research*, 6, 66-71.
- OGUNBA, B. O. 2010. Diet Diversity in Complementary Feeding and Nutritional Status of Children Aged 0 to 24 Months in Osun State, Nigeria: A Comparison of the Urban and Rural Communities. *ICAN: Infant, Child, & Adolescent Nutrition*, 2, 330-335.
- OJUKWU, J. U., OGBU, C. N. & NNEBE-AGUMADU, U. H. 2004. Post-neonatal medical admissions into the Pediatric ward of Ebonyi State University Teaching Hospital, Abakaliki: The initial experience and outcome. *Niger J Pediatr*, 31.
- OKOROMAH, C. A. N., EKURE, E. N., LESI, F. E. A., OKUNOWO, W. O., TIJANI, B. O. & OKEIYI, J. C. 2011. Prevalence, profile and predictors of malnutrition in children with congenital heart defects: a case-control observational study. *Archives of Disease in Childhood*.
- OLANG, B., FARIVAR, K., HEIDARZADEH, A., STRANDVIK, B. & YNGVE, A. 2009. Breastfeeding in Iran: prevalence, duration and current recommendations. *Int Breastfeed J*, 4, 8.
- OLSEN, E. M., PETERSEN, J., SKOVGAARD, A. M., WEILE, B., JORGENSEN, T. & WRIGHT, C. M. 2007a. Failure to thrive: the prevalence and concurrence of anthropometric criteria in a general infant population. *Arch Dis Child*, 92, 109-14.
- OLSEN, E. M., SKOVGAARD, A. M., WEILE, B. & JORGENSEN, T. 2007b. Risk factors for failure to thrive in infancy depend on the anthropometric definitions used: The Copenhagen County Child Cohort. *Paediatric and Perinatal Epidemiology*, 21, 418-431.
- OLSEN, E. M., SKOVGAARD, A. M., WEILE, B., PETERSEN, J. & JORGENSEN, T. 2010. Risk factors for weight faltering in infancy according to age at onset. *Paediatr Perinat Epidemiol*, 24, 370-82.
- OLSEN, I. E., LAWSON, M. L., MEINZEN-DERR, J., SAPSFORD, A. L., SCHIBLER, K. R., DONOVAN, E. F. & MORROW, A. L. 2009. Use of a Body Proportionality Index for Growth Assessment of Preterm Infants. *The Journal of pediatrics*, 154, 486-491.
- OLUGBENGA-BELLO, A. I., ASEKUN-OLARINMOYE, E. O. & A.A, A. 2011. Primary health workers' role in monitoring children's growth and development in Nigeria, West Africa. *Global Journal of Health Science* 3, 30-39.
- OLUSANYA, B. O. & RENNEN, J. K. 2011. Predictors of growth velocity in early infancy in a resource-poor setting. *Early Hum Dev*, 87, 647-52.
- OLUSANYA, B. O. & RENNEN, J. K. 2012. Is home birth a marker for severe malnutrition in early infancy in urban communities of low-income countries? *Maternal & Child Nutrition*, 8, 492-502.
- OLUSANYA, B. O. & RENNEN, J. K. 2013. Pattern and characteristics of growth faltering in early infancy in an urban sub-Saharan African setting. *Pediatr Neonatol*, 54, 119-27.

- OLUSANYA, B. O., WIRZ, S. L. & RENNER, J. K. 2010. Prevalence, pattern and risk factors for undernutrition in early infancy using the WHO Multicentre Growth Reference: a community-based study. *Paediatr Perinat Epidemiol*, 24, 572-83.
- ONYIRIUKA, A. N. & OKOLO, A. A. 2007. Neonatal morbidity pattern in infants born in Benin City to Nigerian mothers with hypertensive disorders in pregnancy. *Niger J Clin Pract*, 10, 294-9.
- OWA, J. A. & ADEJUYIGBE, O. 1997. Fat mass, fat mass percentage, body mass index, and mid-upper arm circumference in a healthy population of Nigerian children. *J Trop Pediatr*, 43, 13-9.
- PADONOU, G., LE PORT, A., COTTRELL, G., GUERRA, J., CHOUDAT, I., RACHAS, A., BOUSCAILLOU, J., MASSOUGBODJI, A., GARCIA, A. & MARTIN-PREVEL, Y. 2014. Factors associated with growth patterns from birth to 18 months in a Beninese cohort of children. *Acta Trop*, 135, 1-9.
- PAES-SOUSA, R., SANTOS, L. M. & MIAZAKI, E. S. 2011. Effects of a conditional cash transfer programme on child nutrition in Brazil. *Bull World Health Organ*, 89, 496-503.
- PARAG, N., MCKERROW, N. H. & NABY, F. 2014. Profile of babies born before arrival at hospital in a peri-urban setting. *S Afr J CH*, 8, 45-53.
- PATWARI, A. K., KUMAR, S. & BEARD, J. 2015. Undernutrition among infants less than 6 months of age: an underestimated public health problem in India. *Matern Child Nutr*, 11, 119-26.
- PAWELLEK, I., DOKOUPIL, K. & KOLETZKO, B. 2008. Prevalence of malnutrition in paediatric hospital patients. *Clin Nutr*, 27, 72-6.
- PELLETIER, D. & PELTO, G. 2013. From efficacy research to large-scale impact on undernutrition: the role of organizational cultures. *Adv Nutr*, 4, 687-96.
- PELLETIER, D. L. & FRONGILLO, E. A. 2003. Changes in Child Survival Are Strongly Associated with Changes in Malnutrition in Developing Countries. *The Journal of Nutrition*, 133, 107-119.
- PETIT, P. L. & VAN GINNEKEN, J. K. 1995. Analysis of hospital records in four African countries, 1975-1990, with emphasis on infectious diseases. *J Trop Med Hyg*, 98, 217-27.
- PICHLER, J., HILL, S. M., SHAW, V. & LUCAS, A. 2014. Prevalence of undernutrition during hospitalisation in a children's hospital: what happens during admission? *Eur J Clin Nutr*, 68, 730-5.
- PINEROS, J. G., BAQUERO, H., BASTIDAS, J., GARCIA, J., OVALLE, O., PATINO, C. M. & RESTREPO, J. C. 2013. Respiratory syncytial virus infection as a cause of hospitalization in population under 1 year in Colombia. *J Pediatr (Rio J)*, 89, 544-8.
- PRADO, E. L. & DEWEY, K. G. 2014. Nutrition and brain development in early life. *Nutr Rev*, 72, 267-84.
- PROST, M. A., JAHN, A., FLOYD, S., MVULA, H., MWAIYEGHELE, E., MWINUKA, V., MHANGO, T., CRAMPIN, A. C., MCGRATH, N., FINE, P. E. & GLYNN, J. R. 2008. Implication of new WHO growth standards on identification of risk factors and estimated prevalence of malnutrition in rural Malawian infants. *PLoS One*, 3, e2684.
- QAYAD, M. G. 2005. Competence of maternal and child health clinic workers in detecting malnutrition in Somalia. *Afr Health Sci*, 5, 319-21.
- QUDSIA, A. & ALIYA, J. 2007. Growth monitoring versus growth charting. *Journal of Pakistan Medical Association*.
- QUIGLEY, M. A., KELLY, Y. J. & SACKER, A. 2007. Breastfeeding and hospitalization for diarrheal and respiratory infection in the United Kingdom Millennium Cohort Study. *Pediatrics*, 119, e837-42.
- RAMACHANDRAN, P. & GOPALAN, H. S. 2009. Undernutrition & risk of infections in preschool children. *Indian J Med Res*, 130, 579-83.
- RAMAKRISHNAN, U., MARTORELL, R., SCHROEDER, D. G. & FLORES, R. 1999. Role of intergenerational effects on linear growth. *J Nutr*, 129, 544S-549S.
- RAMSDEN, L. & DAY, A. S. 2012. Paediatric growth charts: How do we use them and can we use them better? *Journal of Paediatrics and Child Health*, 48, 22-25.
- RASELLA, D., AQUINO, R., SANTOS, C. A. T., PAES-SOUSA, R. & BARRETO, M. L. 2013. Effect of a conditional cash transfer programme on childhood mortality: a nationwide analysis of Brazilian municipalities. *The Lancet*, 382, 57-64.

- REGNAULT, N., BOTTON, J., FORHAN, A., HANKARD, R., THIEBAUGEORGES, O., HILLIER, T. A., KAMINSKI, M., HEUDE, B. & CHARLES, M. A. 2010. Determinants of early ponderal and statural growth in full-term infants in the EDEN mother-child cohort study. *Am J Clin Nutr*, 92, 594-602.
- RENFREW, M. J., CRAIG, D., DYSON, L., MCCORMICK, F., RICE, S., KING, S. E., MISSO, K., STENHOUSE, E. & WILLIAMS, A. F. 2009. Breastfeeding promotion for infants in neonatal units: a systematic review and economic analysis. *Health Technol Assess*, 13, 1-146, iii-iv.
- ROBERFROID, D., KOLSTEREN, P., HOEREE, T. & MAIRE, B. 2005. Do growth monitoring and promotion programs answer the performance criteria of a screening program? A critical analysis based on a systematic review. *Tropical Medicine & International Health*, 10, 1121-1133.
- ROBERFROID, D., PELTO, G. H. & KOLSTEREN, P. 2007. Plot and see! Maternal comprehension of growth charts worldwide. *Tropical Medicine & International Health*, 12, 1074-1086.
- ROCHA, G., ROCHA, E. & MARTINS, C. 2006. The effect of hospitalization on the nutritional status of children. *J Pediatr (Rio J)*, 82, 70-74.
- RODRIGUEZ, G., SAMPER, M. P., OLIVARES, J. L., VENTURA, P., MORENO, L. A. & PEREZ-GONZALEZ, J. M. 2005. Skinfold measurements at birth: sex and anthropometric influence. *Archives of Disease in Childhood - Fetal and Neonatal Edition*, 90, F273-F275.
- RODRIGUEZ, G., SAMPER, M. P., VENTURA, P., MORENO, L. A., OLIVARES, J. L. & PEREZ-GONZALEZ, J. M. 2004. Gender differences in newborn subcutaneous fat distribution. *European Journal of Pediatrics*. Springer-Verlag.
- ROJAS, B. & WHITE, R. F. 1957. The Modified Latin Square. *Journal of the Royal Statistical Society. Series B (Methodological)*, 19, 305-317.
- ROSE, A. M., HALL, C. S. & MARTINEZ-ALIER, N. 2014. Aetiology and management of malnutrition in HIV-positive children. *Arch Dis Child*, 99, 546-51.
- ROSENBERG, K. D., STULL, J. D., ADLER, M. R., KASEHAGEN, L. J. & CRIVELLI-KOVACH, A. 2008. Impact of hospital policies on breastfeeding outcomes. *Breastfeed Med*, 3, 110-6.
- ROSS, E. S., KREBS, N. F., SHROYER, A. L., DICKINSON, L. M., BARRETT, P. H. & JOHNSON, S. L. 2009. Early growth faltering in healthy term infants predicts longitudinal growth. *Early Hum Dev*, 85, 583-8.
- RUEL, M. T., PELLETIER, D. L., HABICHT, J. P., MASON, J. B., CHOBOKOANE, C. S. & MARUPING, A. P. 1991. Comparison of two growth charts in Lesotho: health workers' ability to understand and use them for action. *Am J Public Health*, 81, 610-615.
- SACHS, M., DYKES, F. & CARTER, B. 2005. Weight monitoring of breastfed babies in the UK - centile charts, scales and weighing frequency. *Matern Child Nutr*, 1, 63-76.
- SACKER, A., QUIGLEY, M. A. & KELLY, Y. J. 2006. Breastfeeding and developmental delay: findings from the millennium cohort study. *Pediatrics*, 118, e682-9.
- SAHA, K. K., FRONGILLO, E. A., ALAM, D. S., ARIFEEN, S. E., PERSSON, L. & RASMUSSEN, K. M. 2009. Use of the new World Health Organization child growth standards to describe longitudinal growth of breastfed rural Bangladeshi infants and young children. *Food Nutrition Bulletin*, 30, 137-144.
- SALEEMI, M., ASHRAF, R., MELLANDER, L. & ZAMAN, S. 2001. Determinants of stunting at 6, 12, 24 and 60 months and postnatal linear growth in Pakistani children. *Acta Paediatr*, 90, 1304-1308.
- SANTAFE SANCHEZ, L., SANCHEZ RODRIGUEZ, D., VILLEGAS GALARZA, A. & GONZALEZ-CORREA, C. 2012. Nutritional status among hospitalized children with mixed diagnoses at a referral teaching hospital in Manizales, Colombia. *Nutr Hosp*, 27, 1451-1459.
- SANTOS, I., MATIJASEVICH, A., DOMINGUES, M., BARROS, A., VICTORA, C. & BARROS, F. 2009. Late preterm birth is a risk factor for growth faltering in early childhood: a cohort study. *BMC Pediatrics*, 9, 71.
- SARNI, R. O., CARVALHO MDE, F., MONTE, C. M., ALBUQUERQUE, Z. P. & SOUZA, F. I. 2009. Anthropometric evaluation, risk factors for malnutrition, and nutritional therapy for children in teaching hospitals in Brazil. *J Pediatr (Rio J)*, 85, 223-8.

- SAUNDERS, J., SMITH, T. & STROUD, M. 2015. Malnutrition and undernutrition. *Medicine*, 43, 112-118.
- SAWADOGO, S. P., MARTIN-PREVEL, Y., CAPON, G., TRAORE, S. A. & DELPEUCH, F. 2008. Nutritional status and common infections in infants in Burkina Faso: interest of an 'overall morbidity score'. *Trop Med Int Health*, 13, 345-53.
- SCHAIBLE, U. E. & KAUFMANN, S. H. 2007. Malnutrition and infection: complex mechanisms and global impacts. *PLoS Med*, 4, e115.
- SCHLAUDECKER, E. P., STEINHOFF, M. C. & MOORE, S. R. 2011. Interactions of diarrhea, pneumonia, and malnutrition in childhood: recent evidence from developing countries. *Curr Opin Infect Dis*, 24, 496-502.
- SCHMELZLE, H. R. & FUSCH, C. 2002. Body fat in neonates and young infants: validation of skinfold thickness versus dual-energy X-ray absorptiometry. *Am J Clin Nutr*, 76, 1096-100.
- SCHWARZ, N. G., GROBUSCH, M. P., DECKER, M. L., GOESCH, J., POETSCHKE, M., OYAKHIROME, S., KOMBILA, D., FORTIN, J., LELL, B., ISSIFOU, S., KREMSNER, P. G. & KLIPSTEIN-GROBUSCH, K. 2008. WHO 2006 child growth standards: implications for the prevalence of stunting and underweight-for-age in a birth cohort of Gabonese children in comparison to the Centers for Disease Control and Prevention 2000 growth charts and the National Center for Health Statistics 1978 growth references. *Public Health Nutr*, 11, 714-9.
- SEAL, A. & KERAC, M. 2007. Operational implications of using 2006 World Health Organization growth standards in nutrition programmes: secondary data analysis. *BMJ*, 334, 733-735.
- SECKER, D. J. & JEEJEEBHOY, K. N. 2007. Subjective Global Nutritional Assessment for children. *Am J Clin Nutr*, 85, 1083-9.
- SECKER, D. J. & JEEJEEBHOY, K. N. 2012. How to perform Subjective Global Nutritional assessment in children. *Journal of the Academy of Nutrition and Dietetics*, 112, 424-431.
- SENANAYAKE, M. P., GUNAWARDENA, M. K. S. & PEIRIS, D. S. P. 1997. Maternal comprehension of two growth monitoring charts in Sri Lanka. *Archives of Disease in Childhood*, 76, 359-361.
- SERMET-GAUDELUS, I., POISSON-SALOMON, A. S., COLOMB, V., BRUSSET, M. C., MOSSER, F. O., BERRIER, F. & RICOUR, C. 2000. Simple pediatric nutritional risk score to identify children at risk of malnutrition. *The American Journal of Clinical Nutrition*, 72, 64-70.
- SHETTY, P. 2006. Malnutrition and undernutrition. *Medicine*, 34, 524-529.
- SHRIMPTON, R. 2012. Global Policy and Programme Guidance on Maternal Nutrition: What Exists, the Mechanisms for Providing It, and How to Improve Them? *Paediatric and Perinatal Epidemiology*, 26, 315-325.
- SINGH, A. 2014. Why are economic growth and reductions in child undernutrition so weakly correlated—and what can public policy do? *The Lancet Global Health*, 2, e185-e186.
- SISSAOUI, S., DE LUCA, A., PILOQUET, H., GUIMBER, D., COLOMB, V., PERETTI, N., BOUNIOL, A., BRETON, A., CHOURAQUI, J.-P., COSTE, M.-E., DJEDDI, D., DORIGNY, B., GOULET, O., GOTTRAND, F., HERMOUET, P., LAMBE, C., LEKE, A., LEPRINCE, S., MAS, E., MASSICOT, P., RENARD, P., THOMASSIN, N., TRIOLO, V., TURQUET, A., VANRENTERGHEM, A., FISCHBACH, M., INGRAND, P. & HANKARD, R. 2013. Large scale nutritional status assessment in pediatric hospitals. *e-SPEN Journal*, 8, e68-e72.
- SMITH, L. C. & HADDAD, L. 2002. How Potent Is Economic Growth in Reducing Undernutrition? What Are the Pathways of Impact? New Cross-Country Evidence. *Economic Development and Cultural Change*, 51, 55-76.
- SMITH, L. C. & HADDAD, L. J. 2000. Explaining child malnutrition in developing countries: A cross-country analysis. *Malnutrition in children*. Washington DC: International Food Policy Research Institute (IFPRI).
- SOETERS, P. B., REIJVEN, P. L., VAN BOKHORST-DE VAN DER SCHUEREN, M. A., SCHOLS, J. M., HALFENS, R. J., MEIJERS, J. M. & VAN GEMERT, W. G. 2008. A rational approach to nutritional assessment. *Clin Nutr*, 27, 706-16.
- STEIBER, A. L., KALANTAR-ZADEH, K., SECKER, D., MCCARTHY, M., SEHGAL, A. & MCCANN, L. 2004. Subjective Global Assessment in chronic kidney disease: a review. *J Ren Nutr*, 14, 191-200.
- STEPHENSON, C. B. 1999. Burden of infection on growth failure. *J Nutr*, 129, 534S-538S.

- STEPHENSON, G. R., MORETTI, E. W., EL-MOALEM, H., CLAVIEN, P. A. & TUTTLE-NEWHALL, J. E. 2001. Malnutrition in liver transplant patients - Preoperative subjective global assessment is predictive of outcome after liver transplantation. *Transplantation*, 72, 666-670.
- STEVENS, G. A., FINUCANE, M. M., PACIOREK, C. J., FLAXMAN, S. R., WHITE, R. A., DONNER, A. J., EZZATI, M. & NUTRITION IMPACT MODEL STUDY, G. 2012. Trends in mild, moderate, and severe stunting and underweight, and progress towards MDG 1 in 141 developing countries: a systematic analysis of population representative data. *Lancet*, 380, 824-34.
- STRATTON, R. J., GREEN, C. J. & ELIA, M. 2003. Disease-related malnutrition: an evidence based approach to treatment. Cambridge, United Kingdom: CABI Publishing.
- SUBRAMANYAM, M. A., KAWACHI, I., BERKMAN, L. F. & SUBRAMANIAN, S. V. 2010. Socioeconomic Inequalities in Childhood Undernutrition in India: Analyzing Trends between 1992 and 2005. *Plos One*, 5.
- SUBRAMANYAM, M. A., KAWACHI, I., BERKMAN, L. F. & SUBRAMANIAN, S. V. 2011. Is economic growth associated with reduction in child undernutrition in India? *PLoS Med*, 8, e1000424.
- TANNER, J. M. 1963. The Regulation of Human Growth. *Child Development*, 34, 817-847.
- TANNER, J. M. & WHITEHOUSE, R. H. 1962. Standards for subcutaneous fat in British children. Percentiles for thickness of skinfolds over triceps and below scapula. *Br Med J*, 1, 446-50.
- TARRANT, M., LOK, K. Y. W., FONG, D. Y. T., WU, K. M., LEE, I. L. Y., SHAM, A., LAM, C., BAI, D. L., WONG, K. L., WONG, E. M. Y., CHAN, N. P. T. & DODGSON, J. E. 2015. Effect on Baby-Friendly Hospital Steps When Hospitals Implement a Policy to Pay for Infant Formula. *Journal of Human Lactation*.
- TARWA, C. & DE VILLIERS, F. 2007. The use of the Road to Health Card in monitoring child health. *South African Family Practice*, 49, 15-15d.
- TEDDLIE, C. & YU, F. 2007. Mixed Methods Sampling: A Typology With Examples. *Journal of Mixed Methods Research*, 1, 77-100.
- THANDRAYEN, K. & SALOOJEE, H. 2010. Quality of care offered to children attending primary health care clinics in Johannesburg. *SAJCH South African Journal of Child Health*, 4, 73-77.
- TURCK, D., MICHAELSEN, K. F., SHAMIR, R., BRAEGGER, C., CAMPOY, C., COLOMB, V., DECSI, T., DOMELLOF, M., FEWTRELL, M., KOLACEK, S., MIHATSCH, W., MORENO, L. A. & VAN GOUDOEVER, J. 2013. World Health Organization 2006 child growth standards and 2007 growth reference charts: A discussion paper by the committee on Nutrition of the European Society for Pediatric Gastroenterology, Hepatology, and Nutrition. *J Pediatr Gastroenterol Nutr*, 57, 258-64.
- TURYASHEMERWA, F., KIKAFUNDA, J. & AGABA, E. 2009. Prevalence of early childhood malnutrition and influencing factors in peri urban areas of Kabarole district, Western Uganda. *African Journal of Food, Agriculture, Nutrition Development*, 9, 1684-5358.
- UBESIE, A. C., IBEZIAKO, N. S., NDIOKWELU, C. I., UZOKA, C. M. & NWAFOR, C. A. 2012. Under-five protein energy malnutrition admitted at the University of Nigeria Teaching Hospital, Enugu: a 10 year retrospective review. *Nutr J*, 11, 43.
- UCHENDU, U., IKEFUNA, A. & EMODI, I. 2009. Factors associated with exclusive breastfeeding among mothers seen at the University of Nigeria Teaching Hospital, Enugu, Nigeria. *S Afr J Child Health*, 3, 14-19.
- UKEGBU, A. U., EBENEKE, E. U. & UKEGBU, P. O. 2010. Breastfeeding pattern, anthropometry and health status of infants attending child welfare clinics of a teaching hospital in Nigeria. *S Afr J Clin Nutr*, 23, 191-196.
- ULANDER, K., GRAHN, G. & JEPPSSON, B. 1993. Subjective assessment of nutritional status-validity and reliability of a modified Detsky index in a Swedish setting. *Clin Nutr*, 12, 15-9.
- UNICEF 1998. *UNICEF: The State of the World's Children 1998*, New York Oxford University Press for the UNICEF.
- UNICEF 2012. *UNICEF: The State of the World's Children*, New York, UNICEF.
- UVERE, P. O. & ENE-OBONG, H. N. 2013. Complementary Local Foods for Infants in Developing Countries. In: WATSON, R. R., GIMBLE, G., PREEDY, V. R. & ZIBADI, S. (eds.) *Nutrition in Infancy*. New York: Springer.

- UWAEGBUTE, A. C. 1991. Weaning practices and weaning foods of the Hausas, Yorubas and Ibos of Nigeria. *Ecology of Food and Nutrition*, 26, 139-153.
- VAN BUUREN, S., VAN DOMMELEN, P., ZANDWIJKEN, G. R., GROTE, F. K., WIT, J. M. & VERKERK, P. H. 2004. Towards evidence based referral criteria for growth monitoring. *Arch Dis Child*, 89, 336-41.
- VICTORA, C. G., ADAIR, L., FALL, C., HALLAL, P. C., MARTORELL, R., RICHTER, L. & SACHDEV, H. S. 2008. Maternal and child undernutrition: consequences for adult health and human capital. *The Lancet*, 371, 340-357.
- VICTORA, C. G., DE ONIS, M., HALLAL, P. C., BLOSSNER, M. & SHRIMPSON, R. 2010. Worldwide timing of growth faltering: revisiting implications for interventions. *Pediatrics*, 125, e473-80.
- VOLLMER, S., HARTTGEN, K., SUBRAMANYAM, M. A., FINLAY, J., KLASSEN, S. & SUBRAMANIAN, S. V. 2014. Association between economic growth and early childhood undernutrition: evidence from 121 Demographic and Health Surveys from 36 low-income and middle-income countries. *Lancet Global Health*, 2, E225-E234.
- WAITZBERG, D. L., CAIAFFA, W. T. & CORREIA, M. I. 2001. Hospital malnutrition: the Brazilian national survey (IBRANUTRI): a study of 4000 patients. *Nutrition*, 17, 573-80.
- WALLACE, L. M. & KOSMALA-ANDERSON, J. 2006. A training needs survey of doctors' breastfeeding support skills in England. *Matern Child Nutr*, 2, 217-31.
- WALTON, S., BEDFORD, H. & DEZATEUX, C. 2006. Use of personal child health records in the UK: findings from the millennium cohort study. *BMJ*, 332, 269-270.
- WAMANI, H., ÅSTRÖM, A. N., PETERSON, S., TUMWINE, J. K. & TYLLESKÄR, T. 2006. Predictors of poor anthropometric status among children under 2 years of age in rural Uganda. *Public Health Nutrition*, 9, 320-326.
- WELLS, J. C. 2014. Toward body composition reference data for infants, children, and adolescents. *Adv Nutr*, 5, 320S-9S.
- WESSNER, S. & BURJONRAPPA, S. 2014. Review of nutritional assessment and clinical outcomes in pediatric surgical patients: does preoperative nutritional assessment impact clinical outcomes? *J Pediatr Surg*, 49, 823-30.
- WHO-MGRS 2006. Assessment of differences in linear growth among populations in the WHO Multicentre Growth Reference Study. *Acta Paediatr Suppl*, 450, 56-65.
- WHO 2001. The optimal duration of exclusive breastfeeding: results of a WHO systematic review. *Indian Pediatr*, 38, 565-567.
- WHO INTERNATIONAL CODE OF MARKETING OF BREASTMILK SUBSTITUTES 1981. International Code of Marketing of Breastmilk Substitutes. In: ORGANIZATION, W. H. (ed.). Geneva, Switzerland: World Health Organization.
- WHO MULTICENTRE GROWTH REFERENCE STUDY GROUP & DE ONIS, M. 2006. WHO Child Growth Standards based on length/height, weight and age. *Acta Paediatrica*, 95, 76-85.
- WHO/UNICEF 2003. *Global Strategy for Infant and Young Child Feeding*, Geneva, Switzerland, World Health Organization, 20 Avenue Appia, 1211 Geneva 27, Switzerland
- WHO/UNICEF 2009. *WHO child growth standards and identification of severe acute malnutrition in infants and children*, Geneva, Switzerland, World Health Organisation.
- WHO/UNICEF/IVACG 1997. Vitamin A Supplements: A Guide to Their Use in the Treatment and Prevention of Vitamin A Deficiency and Xerophthalmia. In: ORGANISATION, W. H. (ed.). Geneva, Switzerland: World Health Organisation.
- WHO/UNICEF/WFP/SCN 2007. *COMMUNITY-BASED MANAGEMENT OF SEVERE ACUTE MALNUTRITION*.
- WIKIPEDIA. 2014. Nigeria [Online]. Available: (<http://en.wikipedia.org/wiki/Nigeria>).
- WORLD HEALTH ORGANISATION 1986. *The growth chart. A tool for use in infant and child health care*, Geneva, World Health Organization.
- WORLD HEALTH ORGANISATION 2007. *Indicators for assessing infant and young child feeding practices - PART 1 DEFINITIONS*, Washington, DC, US, World Health Organization
- WORLD HEALTH ORGANISATION 1991. Indicators for Assessing Breastfeeding Practices: Report of an informal meeting.
- WORLD HEALTH ORGANISATION 1995. *The Use and Interpretation of Anthropometry: Report of a WHO Expert Committee*, Geneva, WHO Expert Committee on Physical Status.

- WORLD HEALTH ORGANISATION 1999a. *Management of Severe Malnutrition: A manual for Physicians and Other Senior Health Workers*, Geneva, Geneva : World Health Organization.
- WORLD HEALTH ORGANISATION 1999b. The World Health Report 1999 - Making a Difference. Switzerland: World Health Organisation.
- WORLD HEALTH ORGANISATION 2003. Global Strategy on Infant and Young Child Feeding. 55th World Health Assembly. *Geneva*.
- WORLD HEALTH ORGANISATION 2012a. Response to the Food and Health Crisis in the Sahel.
- WORLD HEALTH ORGANISATION 2012b. Third Nutrition Guideline Expert Advisory Group (NUGAG) Meeting of the Subgroup of Nutrition in the Life Course and Undernutrition - Area Acute Malnutrition. Geneva, Switzerland.
- WORLD HEALTH ORGANISATION 2013. *Guideline: Updates on the management of severe acute malnutrition*, Geneva, Switzerland, World Health Organisation.
- WORLD HEALTH ORGANIZATION 2001. The optimal duration of exclusive breastfeeding *Report of the expert consultation*. Geneva, Switzerland: World Health Organization.
- WORLD HEALTH ORGANIZATION 2008. *Training Course on Child Growth Assessment. WHO Child Growth Standards*, Geneva, Switzerland, World Health Organisation, Department of Nutrition for Health and Development.
- WRIGHT, C., AVERY, A., EPSTEIN, M., BIRKS, E. & CROFT, D. 1998. New chart to evaluate weight faltering. *Arch Dis Child*, 78, 40-43.
- WRIGHT, C., LAKSHMAN, R., EMMETT, P. & ONG, K. K. 2008. Implications of adopting the WHO 2006 Child Growth Standard in the UK: two prospective cohort studies. *Arch Dis Child*, 93, 566-9.
- WRIGHT, C. M. 2002. The use and interpretation of growth charts. *Current Paediatrics*, 12, 279-282.
- WRIGHT, C. M. 2005. Growth charts for babies. *BMJ*, 330, 1399-400.
- WRIGHT, C. M., BOOTH, I. W., BUCKLER, J. M., CAMERON, N., COLE, T. J., HEALY, M. J., HULSE, J. A., PREECE, M. A., REILLY, J. J. & WILLIAMS, A. F. 2002. Growth reference charts for use in the United Kingdom. *Arch.Dis.Child*, 86, 11-14.
- WRIGHT, C. M. & GARCIA, A. L. 2012. Child under nutrition in affluent societies: what are we talking about? *Proceedings of the Nutrition Society*, 71, 545-555.
- WRIGHT, C. M., MATTHEWS, J. N. S., WATERSTON, A. & AYNLEY-GREEN, A. 1994a. What is a normal rate of weight gain in infancy? *Acta Paediatrica*, 83, 351-356.
- WRIGHT, C. M. & MUTOLO, A. N. 2012. Accuracy of growth chart use in monitoring and assessing under-nutrition in Kenya. *Archives of Disease in Childhood*, 97, A46-A46.
- WRIGHT, C. M., PARKINSON, K. & SCOTT, J. 2006a. Breast-feeding in a UK urban context: who breast-feeds, for how long and does it matter? *Public Health Nutrition*, 9, 686-691.
- WRIGHT, C. M. & PARKINSON, K. N. 2004. Postnatal weight loss in term infants: what is "normal" and do growth charts allow for it? *Arch Dis Child Fetal Neonatal Ed*, 89, F254-F257.
- WRIGHT, C. M., PARKINSON, K. N. & DREWETT, R. F. 2006b. The influence of maternal socioeconomic and emotional factors on infant weight gain and weight faltering (failure to thrive): data from a prospective birth cohort. *Arch Dis Child*, 91, 312-7.
- WRIGHT, C. M., SACHS, M., SHORT, J., SHARP, L., CAMERON, K. & MOY, R. J. 2012. Designing new UK-WHO growth charts: implications for health staff use and understanding of charts and growth monitoring. *Matern Child Nutr*, 8, 371-9.
- WRIGHT, C. M., WATERSTON, T. & GREEN, A. A. 1994b. THE THRIVE INDEX: A METHOD OF IDENTIFYING AND QUANTIFYING ABNORMAL WEIGHT GAIN IN EARLY CHILDHOOD. *Pediatr Res*, 35, 263-263.
- WRIGHT, C. M., WILLIAMS, A. F. & COLE, T. J. 2013. Advances in growth chart design and use: The UK experience growth chart expert group. *World Review of Nutrition and Dietetics*. S. Karger AG, Basel.
- WRIGHT, C. M., WILLIAMS, A. F., ELLIMAN, D., BEDFORD, H., BIRKS, E., BUTLER, G., SACHS, M., MOY, R. J. & COLE, T. J. 2010. Using the new UK-WHO growth charts. *BMJ*, 340, c1140.

- WUEHLER, S. E., HESS, S. Y. & BROWN, K. H. 2011. Accelerating improvements in nutritional and health status of young children in the Sahel region of Sub-Saharan Africa: review of international guidelines on infant and young child feeding and nutrition. *Matern Child Nutr*, 7 Suppl 1, 6-34.
- WYSZYNSKI, D. F., PERMAN, M. & CRIVELLI, A. 2003. Prevalence of hospital malnutrition in Argentina: preliminary results of a population-based study. *Nutrition*, 19, 115-9.
- XIONG, X., WIGHTKIN, J., MAGNUS, J. H., PRIDJIAN, G., ACUNA, J. M. & BUEKENS, P. 2007. Birth weight and infant growth: optimal infant weight gain versus optimal infant weight. *Matern Child Health J*, 11, 57-63.
- YAMAUTI, A. K., OCHIAI, M. E., BIFULCO, P. S., DE ARAUJO, M. A., ALONSO, R. R., RIBEIRO, R. H. & PEREIRA-BARRETTO, A. C. 2006. Subjective global assessment of nutritional status in cardiac patients. *Arq Bras Cardiol*, 87, 772-7.
- ZIEGLER, E. E. & NELSON, S. E. 2010. Growth Charts Compared. In: LUCAS, A., MAKRIDES, M. & ZIEGLER, E. E. (eds.) *Importance of Growth for Health and Development* Kuala Lumpur: Nestec Ltd., Vevey/S. Karger AG, Basel.
- ZIEGLER, E. E. & NELSON, S. E. 2012. The WHO growth standards: strengths and limitations. *Current Opinion in Clinical Nutrition & Metabolic Care*, 15.
- ZUGUO, M. & GRUMMER-STRAWN, L. M. 2011. Comparison of Changes in Growth Percentiles of US Children on CDC 2000 Growth Charts With Corresponding Changes on WHO 2006 Growth Charts. *Clinical Pediatrics*, 50, 402-407.

Author Biography

Presentations made at meetings from the results contained in this thesis

Short Oral Presentation at the Yorkhill Research Day, University of Glasgow Royal Hospital for Sick Children, Yorkhill, Glasgow G3 8SJ (9th November 2012)



Prevalence of undernutrition in infants aged less than 6 months admitted to hospital in Enugu, Nigeria

Ezeofor IO, Garcia AL and Wright CM

Yorkhill Research Day
9th November 2012



Poster Presentation at the International Union of Nutritional Sciences (IUNS) 20th International Congress of Nutrition held in Granada, Spain (September 2013)





Very young Nigerian infants fit into the WHO Child Growth Standards well, as long as they are healthy

Ezeofor IO, Ibeziako SN, Garcia AL, Wright CM
 Peach Unit, University of Glasgow, Royal Hospital for Sick Children, Yorkhill, Glasgow G3 8SJ, United Kingdom

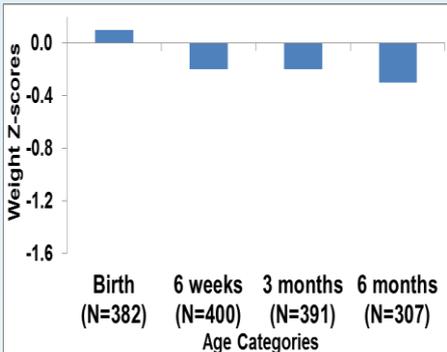
Background and Objectives:
 The WHO Child Growth Standards are already widely adopted but it is important to establish how well individual population fit to them. We aimed to assess the growth of very young infants compared to the WHO Child Growth Standards at the University of Nigeria Teaching Hospital, Enugu, south-east Nigeria from February to July 2012.

Methods:

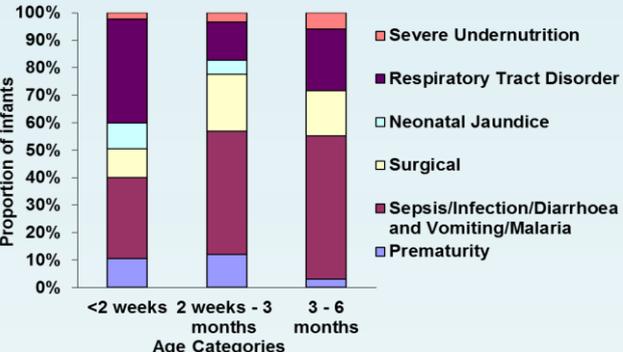
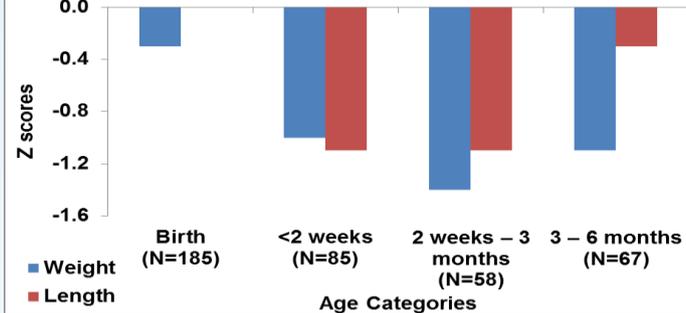
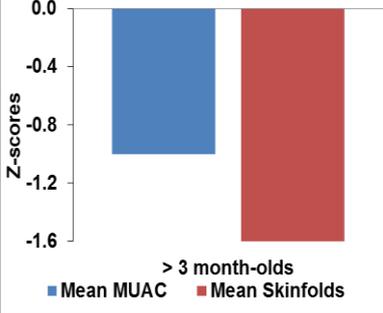
1. The retrospective weight Z-scores of healthy infants seen in a well baby clinic were collected
2. Weight, length, mid-upper-arm-circumference (MUAC) and skinfolds (triceps and subscapular) measurements of infants 0 – 26 weeks old admitted to hospital were taken
3. All data were expressed as Z-scores compared to the WHO Child Growth Standards

Results:

Well baby clinic weights were close to the expected WHO values at all ages:



Sepsis (28.6%) and respiratory tract disorders (27.1%) were the commonest diagnoses, the latter more in the very young infants:

Of the 210 hospitalized infants, 43% were under 2 weeks old. Mean weight and length Z-scores tended to be low, the latter lowest in the older infants

The mean MUAC and skinfold Z-scores for > 3 month-olds also tended to be low

Conclusions:
 The weight and length Z-scores of healthy young Nigerian infants fit into the WHO Child Growth Standards well. The poor weight gain observed in the hospitalized group is likely to be the effect of their medical conditions.

Keywords: malnutrition, skinfolds, growth standards

Acknowledgement : Ford Foundation International Fellowships Program, New York, USA

PO2365

Poster Presentation at the 2nd International Conference on Nutrition held in Barcelona, Spain (January/February 2014)



NGC-0147

Slow weight gain is strongly associated with morbidity in children under six months, but health staff fail to recognise it

Ezeofor IO¹; Ibeziako SN²; Garcia AL¹; Wright CM¹

¹University of Glasgow, Royal Hospital for Sick Children, Yorkhill, Glasgow G3 8SJ
²Senior Lecturer, College of Medicine, University of Nigeria, Nsukka / Consultant Paediatrician, University of Nigeria Teaching Hospital (UNTH), Enugu, Nigeria

Background

Young infants are weighed regularly and plotted on a Road-to-Health (RTH) or similar charts, but it is not clear whether early morbidity is associated with slow weight gain or whether health staff recognise it.

Setting

University of Nigeria Teaching Hospital (UNTH), Enugu, Nigeria

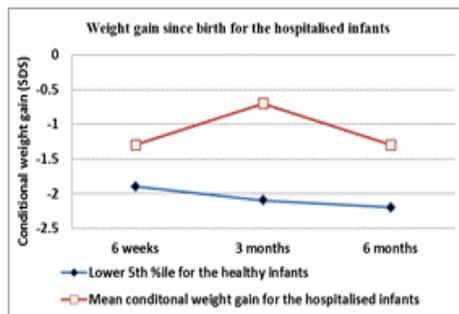
Infant Welfare Clinic/Hospital Ward Studies

Aim:

To compare the weight gain of very young Nigerian infants admitted to hospital to their healthy peers.

Method:

Weights were collected for 210 infants aged < 6 months admitted to the University of Nigeria Teaching Hospital, Enugu and from the RTH charts of 411 infants attending the well-baby clinic of that hospital from 0-6 months. Norms for conditional weight gain from birth were calculated using the well-baby clinic data.



Results:

The 5th percentile for conditional weight gain in the healthy infants was -1.9SD at 6 weeks and -2.2SD at 6 months; this was used as threshold for slow weight gain. Half the hospitalised infants (114, 54.3%) were aged under 1 month. The commonest reasons for admission were sepsis (41%) and respiratory infections (26%). Their mean conditional weight gain since birth was low (see figure) and 23% had weight gain since birth below the slow weight gain threshold.

Key words: health staff, growth patterns, morbidity, infants

Acknowledgement: Ford Foundation International Fellowships Program, New York, USA

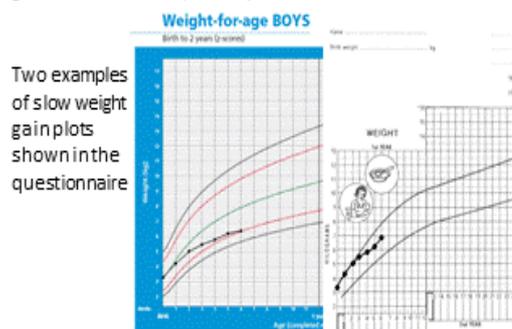
Health Staff Study

Aim

To assess whether health staff recognise slow weight gain when plotted on growth charts

Method:

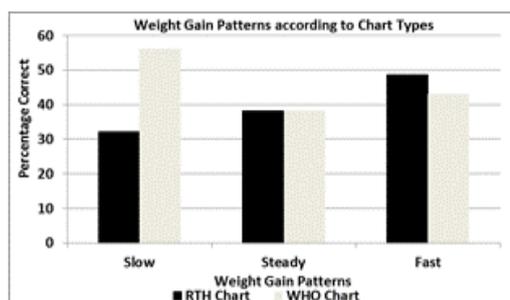
Paediatric health staff completed a questionnaire involving viewing 4 of 12 variant plotted-charts, showing a 2SD-fall, steady growth or catch-up and were asked to rate the weight gain shown as "slow", "steady" or "fast".



Two examples of slow weight gain plots shown in the questionnaire

Results:

Of the 222 health staff surveyed, 55% were nurses and 78% were hospital-based; 88% often interpreted growth charts. only 32% recognised slow weight gain when presented on the RTH format and 56% on the WHO (P<0.001; see figure). Fast weight gain was also poorly recognised. Staff were as likely to be as worried about a small infant growing fast as an average weight infant growing slowly.



Conclusions

A quarter of infants hospitalized age under 6 months had fallen more than 2SD in weight, but such falls tend to be unrecognized by health staff, particularly when presented on the Road to Health chart format

Poster Presentation at the International Symposium on Understanding Moderate Malnutrition in Children for Effective Interventions held in Vienna, Austria (May 2014)



Poster 10

Slow weight gain is strongly associated with morbidity in children under six months, but health staff fails to recognise it

Ezeofor IO¹; Ibeziako SN²; Garcia AL¹; Wright CM¹

¹University of Glasgow, Royal Hospital for Sick Children, Yorkhill, Glasgow G3 8SJ
²Senior Lecturer, College of Medicine, University of Nigeria, Nsukka / Consultant Paediatrician, University of Nigeria Teaching Hospital (UNTH), Enugu, Nigeria

Background

Young infants are weighed regularly and plotted on a Road-to-Health (RTH) or similar charts, but it is not clear whether early morbidity is associated with slow weight gain or whether health staff recognise it.

Setting

University of Nigeria Teaching Hospital (UNTH), Enugu, Nigeria

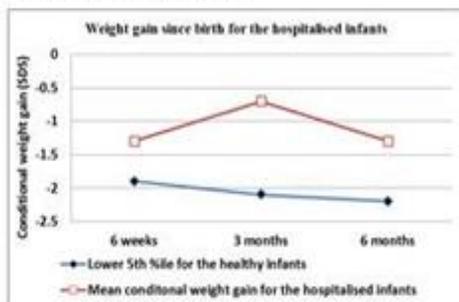
Infant Welfare Clinic and Hospital Ward Studies

Aim:

To compare the weight gain of very young Nigerian infants admitted to hospital to their healthy peers.

Method:

Weights were collected for 210 infants aged < 6 months admitted to the University of Nigeria Teaching Hospital, Enugu and from the RTH charts of 411 infants attending the well-baby clinic of that hospital from 0-6 months. Norms for conditional weight gain from birth were calculated using the well-baby clinic data.



Results:

The 5th percentile for conditional weight gain in the healthy infants was -1.95SD at 6 weeks and -2.25SD at 6 months; this was used as threshold for slow weight gain. Half the hospitalised infants (114, 54.3%) were aged under 1 month. The commonest reasons for admission were sepsis (41%) and respiratory infections (26%). Their mean conditional weight gain since birth was low (see figure) and 23% had weight gain since birth below the slow weight gain threshold.

Key words: health staff, growth patterns, morbidity, infants

Acknowledgement: Ford Foundation International Fellowships Program, New York, USA

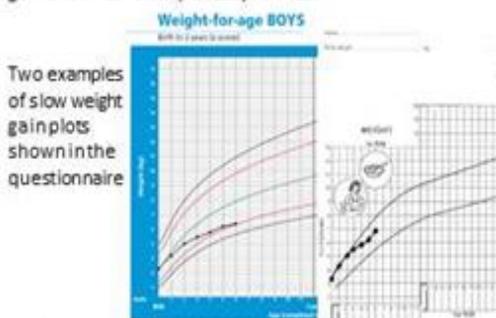
Health Staff Study

Aim

To assess whether health staff recognise slow weight gain when plotted on growth charts

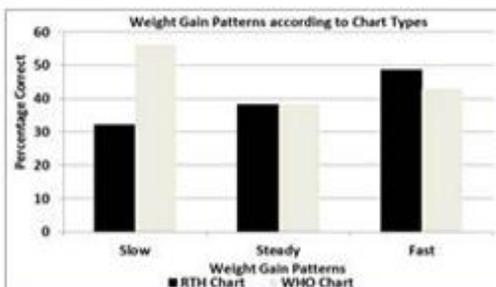
Method:

Paediatric health staff completed a questionnaire involving viewing 4 of 12 variant plotted-charts, showing a 2SD-fall, steady growth or catch-up and were asked to rate the weight gain shown as "slow", "steady" or "fast".



Results:

Of the 222 health staff surveyed, 55% were nurses and 78% were hospital-based; 88% often interpreted growth charts. Only 32% recognised slow weight gain when presented on the RTH format and 56% on the WHO ($P < 0.001$; see figure). Fast weight gain was also poorly recognised. Staff were as likely to be as worried about a small infant growing fast as an average weight infant growing slowly.



Conclusions

A quarter of infants hospitalized age under 6 months had fallen more than 2SD in weight, but such falls tend to be unrecognized by health staff, particularly when presented on the Road to Health chart format